

research report

August 2011



Australian
Farm Institute

Farm Level Modelling of Greenhouse Emission Mitigation and Sequestration Options for the Australian Wool Industry

A report prepared by The Australian Farm Institute with
funding from Australian Wool Innovation Limited



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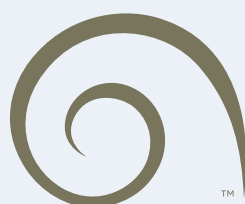


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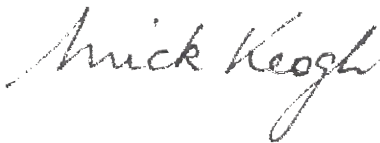
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Foreword

The implementation of Australian policies which will impose a cost on greenhouse emissions will bring about some important changes to the business environment in which Australian sheep and wool producers operate. Energy costs will increase, and this will have implications for a range of farm input costs, although some uncertainty surrounds future cost impacts on fuel. At the same time, the Australian Government's recently legislated Carbon Farming Initiative creates potential opportunities for those landholders voluntarily choosing to participate in carbon markets by becoming producers of offsets.

Exactly how the challenges and opportunities associated with greenhouse policies will play out for individual sheep businesses is still very uncertain, but it is clear that those involved in the sheep and wool industries need to gain a good understanding of these issues and consider how they may impact on their businesses in the future.

The research reported here provides an initial assessment of these issues, based on stated government policies. It provides a good starting point for those interested in gaining a better understanding of the implications of these issues, bearing in mind that some uncertainty remains.



Mick Keogh

Executive Director

Australian Farm Institute

August 2011

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Executive Summary

To examine the impact of a carbon price on the future profitability of sheep farms in Australia, financial modelling was carried out. The modelling used data obtained from ABARE farm surveys to create simple spreadsheet models of two sheep farms in each of the Pastoral, High Rainfall and Wheat/Sheep production zones.

These models were first used to develop a baseline or business-as-usual (BAU) projection of farm cash income into the future, using historical rates of productivity growth for each different farm enterprise.

Modelling was then carried out to analyse the potential financial impacts of the introduction of a carbon price on sheep farm businesses. One impact will arise because a carbon price will result in higher energy costs which will result in increased inputs costs for farm businesses using energy and energy-dependent inputs such as freight or fertiliser. A second impact will arise because post-farm supply chains and domestic downstream processors will face higher energy costs and potential emission costs, and these will be transferred back to farmers in higher charges or lower prices.

The BAU results provided a projection of future farm cash income, in the absence of a carbon price. The carbon price policy that has been announced by the Australian Government was then imposed on the farm financial models by creating a linkage

between the price of carbon, the impact of that carbon price on electricity and fuel prices, and the resultant impact of changes in fuel and electricity prices on the cost of a range of farm inputs and post-farm costs.

The carbon price that was modelled commenced at \$23/tonne CO₂-e in the year 2012–13, and increased as projected in Australian Government Treasury modelling that has been released as part of the background information associated with the Government's Clean Energy Future proposal (Australian Government Treasury 2011).

Given the static nature of the modelling (no assumptions were made of likely production responses by farmers), the results are best interpreted as providing an indication of the challenge the policy will present for sheep farm businesses, rather than projecting actual future outcomes. Over the longer term, it would be anticipated that farm business managers will make changes (where possible) to moderate the impacts of the policy. Such changes may not be feasible in the short term.

Table E.1 displays the projected changes in farm input costs and farm cash income for each of the six sheep farm businesses in year 1 and year 3 (assuming the emissions associated with on-road heavy vehicle fuel use are subject to a carbon price in year 3).

Table E.1: Projected changes in farm input costs and farm cash income for each of the six sheep farm businesses in year 1 and year 3.

Farm location and turnover	Carbon Price	Year 1	Year 3
		\$23.00	\$25.36
High rainfall zone \$100,000–\$200,000 t/o	Cost – processor (\$)	\$184	\$1004
	Cost – farm (\$)	\$671	\$984
	Cost total (\$)	\$855	\$1989
	Cost change (%)	0.7%	1.7%
	Farm cash income change (%)	–3.0%	–6.6%
High rainfall zone \$400,000 t/o	Cost – processor (\$)	\$827	\$4453
	Cost – farm (\$)	\$2322	\$3699
	Cost total (\$)	\$3149	\$8152
	Cost change (%)	0.6%	1.5%
	Farm cash income change (%)	–1.9%	–4.6%
Wheat/Sheep zone \$100,000–\$200,000 t/o	Cost – processor (\$)	\$185	\$984
	Cost – farm (\$)	\$885	\$1280
	Cost total (\$)	\$1070	\$2264
	Cost change (%)	0.8%	1.6%
	Farm cash income change (%)	–7.7%	–14.8%
Wheat/Sheep zone \$400,000 t/o	Cost – processor (\$)	\$932	\$4823
	Cost – farm (\$)	\$2568	\$4292
	Cost total (\$)	\$3499	\$9115
	Cost change (%)	0.5%	1.4%
	Farm cash income change (%)	–2.8%	–6.8%
Pastoral zone \$100,000–\$200,000 t/o	Cost – processor (\$)	\$205	\$1116
	Cost – farm (\$)	\$981	\$1293
	Cost total (\$)	\$1186	\$2409
	Cost change (%)	0.9%	1.7%
	Farm cash income change (%)	–9.8%	–18.1%
Pastoral zone \$400,000 t/o	Cost – processor (\$)	\$572	\$3121
	Cost – farm (\$)	\$2913	\$3953
	Cost total (\$)	\$3485	\$7074
	Cost change (%)	0.7%	1.5%
	Farm cash income change (%)	–2.6%	–5.0%

Table E.2: Cumulative farm cash income arising from CFI scenarios compared with business-as-usual farm cash income after 30 years for model farms participating in offset markets.

Farm	Offset scenario	Mandatory market	Voluntary market
Pastoral zone, more than \$400,000 annual turnover	Methane mitigation	-27%	-37%
	Environmental plantings	-58%	-309%
High Rainfall zone, more than \$400,000 annual turnover	Soil carbon sequestration	-54%	-103%
	Single species farm forestry	145%	-5%
Wheat/Sheep zone, more than \$400,000 annual turnover	Environmental plantings	-13%	-32%
	Nitrification inhibitor	-14%	-14%

The results identify that, even at relatively low carbon prices, the projected impact on farm cash income is significant, especially for those smaller-scale sheep farm businesses that are operating on narrow profit margins. This is particularly the case in the event that on-road heavy vehicle fuel use is subject to a carbon price from 2014 onwards.

To gain a better understanding of the implications of the Carbon Farming Initiative (CFI) for sheep farm businesses, financial modelling was carried out for a range of different CFI Offset scenarios for the sheep farm businesses included in the above analysis.

The CFI offset scenarios examined included the use of a technology to reduce methane emissions from sheep, the use of coated nitrogen fertilisers, the planting of tree lots with mixed species, and the planting of single species tree plantations. The

projected financial results of each offset scenario are presented below. The results are shown as cumulative farm cash income in year 30, compared with cumulative farm cash income for the BAU case in year 30.

Based on the assumptions used in this analysis, only single species tree plantations in the high rainfall zone result in farm cash income exceeding that projected under the BAU scenario. This result is not surprising, as single species tree plantations in the high rainfall zone are projected to result in carbon sequestration rates per hectare that are more than ten times higher than any other CFI offset scenario. It would require a substantial reduction in CFI offset project transaction costs and a large increase in sequestration or mitigation rates for any of the other scenarios to approach a break-even return from a farm business perspective.



1. Introduction

The Australian Government has proposed the introduction of policies that will impose a cost on greenhouse emissions through the introduction of an emissions trading scheme (ETS). The ETS, intended to start on 1 July 2012, is proposed to commence with a government-fixed annual carbon price which would continue for three years, before being converted into a market-based emissions trading scheme, although initially with some constraints on carbon prices. It is proposed that agricultural emissions will be excluded from the proposed ETS, meaning farm businesses will not be required to pay for greenhouse gas emissions associated with on-farm activities.

The implementation of significant greenhouse emission mitigation policies in Australia will usher in a new era for many sectors of the Australian economy. It will mean that organisations involved in activities that generate greenhouse gas emissions will progressively be required to pay the full cost that those emissions are estimated to impose on the environment. This will create an economic incentive for those organisations to either (1) reduce the volume of emissions they create, or (2) to invest in actions that are recognised as reducing emissions (mitigation) or sequestering greenhouse gases from the atmosphere (sequestration), and in that manner reducing the net emissions attributed to their organisation.

One measure in the package announced by the Australian Government as part of the preferred climate change policy is the 'Carbon Farming Initiative' (CFI), an initiative that will create a legislative framework for the recognition of emission offsets (either mitigation or sequestration), with a focus on those offsets produced through actions by farmers. This will provide opportunities for farmers to generate revenue by participating in carbon markets.

The CFI consultation paper, released in November 2010, identified a range of activities in livestock, crop and forestry production where the opportunity exists for farmers to take action that will either sequester greenhouse gases from the atmosphere (forestry development or soil carbon sequestration) or will mitigate the amount of greenhouse gases that would normally be produced (livestock and crop production and land management).

A technical group, termed the Domestic Offsets Integrity Committee (DOIC) has been established, and this group will have the role of assessing proposed methodologies to ensure that they meet the requirements of the National Carbon Offset Standard.

Farmers participating in the CFI will be required to adopt and implement these methodologies, will be subject to a regular audit, and will have to complete periodical returns that will be submitted to the scheme administrator. If these returns confirm that the landholder has met the scheme requirements, the landholder will receive CFI offset credits, equivalent in number (less a risk management buffer) to the calculated tonnes of emission reduction achieved as a result of adopting the approved methodology.

Ownership of these credits will be recognised in an official register (much like the system used for shares), and these credits will be tradable and confer rights on the owner similar to rights associated with the ownership of any property.

The demand side of the market for these CFI credits will consist of companies or individuals that are required to participate in the ETS (mandatory market) or companies and individuals that voluntarily decide to take action to reduce the net greenhouse emissions attributable to, or associated with their activities (voluntary market).

It is important to recognise that the ‘carbon market’ that currently exists in Australia is what is termed a voluntary carbon market. Current purchasers of carbon offset credits are not required to do so by law, but choose to do so for a variety of reasons. Up until the implementation of the CFI this market has been unregulated, and consumers and other participants have had no real way of ensuring that claims made about carbon-neutrality or emission offsets are credible. The implementation of the CFI will effectively regulate this market, in that a company or individual making a claim about carbon neutrality in the future will have to be able to validate this by demonstrating they have purchased CFI offset credits. If they are unable to do this, they will be liable to prosecution under Australian laws relating to false advertising.

Once the mandatory market or ETS commences in 2012, some CFI offsets will be able to be traded into that market, and sold to those companies which are required to participate in the ETS. These will be those offsets associated with;

- new forestry plantations
- the mitigation of emissions from livestock, livestock wastes and nitrogen fertiliser.

CFI offsets that will only be able to be sold into voluntary carbon markets will be;

- those associated with soil carbon sequestration
- the mitigation of emissions as a consequence of avoided deforestation.

This is because, as a consequence of ratifying the Kyoto Protocol, Australia has opted not to include soil carbon emissions or sequestration on agricultural land in the national greenhouse inventory, due to current calculation methodologies that do not allow the impacts of natural factors such as drought or bushfire to be separated from the impacts of human actions. Unless international emission accounting rules associated with soil carbon sequestration change, CFI offset credits associated with soil carbon sequestration will only be able to be sold into voluntary carbon markets.

Whether or not certain CFI offset credits can be marketed into voluntary or mandatory carbon markets is a significant issue for farmers, because of the large difference in prices for offset credits in these two markets. Offset credits able to be sold into mandatory carbon markets (such as the European Union ETS or the New Zealand ETS) typically trade at values close to A\$20 per credit, whereas offset credits sold into voluntary carbon markets typically trade at values of around \$3–\$5 per credit, where a credit represents one tonne of carbon dioxide equivalent mitigation or sequestration.

The CFI consultation paper identifies a range of activities that it is anticipated will be the subject of accredited methodologies that will be able to be implemented by farmers to earn CFI offset credits. These methodologies will be in a form similar to the documentation associated with Quality Assurance systems, or international quality standards such as those published by the International Standards Organisation. They will document the processes that farmers need to undertake (such as record keeping and reporting) to become participants in the CFI, and identify audit and other requirements associated with accreditation under the scheme.

The CFI is designed to comply with the National Carbon Offset Standard (NCOS), which provides guidance on what constitutes an offset, and the requirements of schemes set up to recognise such offsets.

The NCOS specifies that for actions to be recognised as an offset, the scheme under which they are produced needs to meet the following criteria;

- **Additional:** A project must result in carbon sequestration or abatement that would not have occurred in the absence of the scheme.
- **Permanence:** The scheme must be able to demonstrate that the abatement or sequestration will be maintained for 100 years.
- **Leakage:** The scheme must not result in additional emissions being produced elsewhere as a result.

- **Measurable and verifiable:** Systems must be in place to accurately measure or estimate the abatement or sequestration, and must be verified by an independent third party.
- **Conservative:** The scheme must result in conservative estimates of sequestration or abatement.
- **Internationally consistent:** Estimation systems must be consistent with international estimation standards and reporting practices adopted under the United Nations Framework Convention on Climate Change.
- **Peer-reviewed science:** Supporting evidence must be peer-reviewed science that has been subject to peer review and subsequently published in a reputable journal.

The extent to which any proposed methodology meets these criteria will be decided by the DOIC, which will be guided by policy and documentation already made available by the Australian Government.

The opportunity for farmers to generate revenue from carbon markets by mitigating greenhouse gas emissions or sequestering carbon dioxide from the atmosphere does, however, carry some risks.

The permanence requirements of the CFI apply to any sequestration activities. This means they apply to carbon sink forests and soil carbon sequestration, but not to mitigation activities such as an action which reduced livestock methane production for a certain period. The broad principles outlined in the CFI consultation paper are that the permanence requirements mean that a carbon store has to be capable of being retained for 100 years to be considered permanent, and therefore to be eligible for recognition as an action generating CFI offset credits. In the event that sequestration actions are reversed by human actions (such as tree removal or soil cultivation) there is a requirement to pay back CFI offset credits equivalent to the amount of carbon lost. In the event that carbon stocks are removed through natural events (drought or bushfire) there will be a requirement to replenish carbon stocks, but no requirement to relinquish CFI offset credits. However, no additional CFI credits

would be earned by the project until carbon stocks again exceeded their pre-event levels, and the cost of restoring carbon stocks would not be able to be redeemed through the sale of offsets.

Permanence requirements will also place constraints on future land use or land use change. If a farmer opts into the CFI at a point in time, it could be assumed that the decision has been made because it is financially profitable at a particular carbon price. This is weighed up against the opportunity of another, alternative land use. However, should a future change in relative prices make another land use more profitable, the farmer would be constrained from undertaking this land use due to the permanence requirements (ITS Global 2010).

As mentioned above, it is the Australian Government's intention that during the initial stages of the carbon price mechanism (a period of three years) the price of carbon will be fixed annually by the government, with an initial price of \$23 per tonne CO₂-e. During the fixed-price phase of the carbon price mechanism, covered entities can use Kyoto-compliant CFI offsets to meet up to 5% of their emission reduction obligation. The Australian Government has said it will purchase CFI offsets that are not compliant with the Kyoto Protocol, and can't be counted toward Australia's emission reduction obligation. However, the government has not stipulated what price it will pay for non-Kyoto offsets.

From the perspective of a farm business manager, these proposals and developments create a series of dilemmas. Farmers will have available a range of options, with different potential market returns associated with these. Conversion of land to forestry, for example, appears likely to have the potential to generate significant revenue but will probably mean that other activities are excluded on that area of land. Sequestering soil carbon, on the other hand, appears likely to generate much less revenue but could be carried out in conjunction with livestock grazing, meaning total revenue generated from that area could be higher.

Timing participation in the carbon market will also be important, given the likely long-term nature of contractual arrangements. Farmers entering the

carbon market at an early stage or under certain contract arrangements may find they are 'locked in' to lower prices and are unable to take advantage of future higher carbon prices.

An additional dilemma associated with engagement in the carbon offsets market is that it inevitably involves revenue and expenditure flows over an extended period of time, and it is therefore not a simple task to make profitability comparisons between conventional farm production and offset

production, especially given the permanence requirements associated with sequestration offsets.

Given these dilemmas and uncertainties, the research outlined here involves financial modelling of a range of different options and scenarios, to assist woolgrowers, the wool industry and policy-makers in gaining a better understanding of the complexity of the decisions that will confront them in the not too distant future.



2. Modelling the Implications of an ETS for Farm Businesses

This section of the research involves modelling the impact of the ETS on sheep businesses. There are two potential impacts of the ETS. The first arises because a carbon price will result in higher energy costs which will increase the costs of farm inputs that are energy or energy-dependent. The second set of costs will arise because downstream processors such as meatworks will face higher energy costs and potential emission costs, and these extra costs will largely be transferred back to farmers, given that processors are exposed to international market prices.

2.1 Methodology

To gain a better understanding of the implications of the introduction of the ETS and potential offsets markets for farm businesses, financial modelling was carried out under a range of different assumptions and scenarios. The methodology utilised for this modelling has been described in a previous publication (Keogh & Thompson 2008). It essentially involves the development of farm financial models based on available farm survey data, and the use of those models to test different scenarios. This research project involved the development of six financial models for typical small and large-scale sheep-specific enterprises in three production zones, and the use of those models to analyse the implications of the introduction of a carbon price and the adoption of various offset options that could be used to generate offset credits under the proposed CFI.

The assumptions underlying the following analysis need to be carefully considered, and the outcomes need to be qualified by stressing that they represent the potential impact of this particular policy measure and associated assumptions when

considered in isolation; rather than as part of a dynamic and interrelated economic system. The modelling reported here is relatively static, in that no change in farmer decision-making, enterprise mix or farm input use is assumed to occur. The modelling approach used also does not attempt to incorporate some of the inevitable flow-on impacts of a carbon price in either the wider economy, or within the agriculture sector.

The results provide an indication of the potential scale of opportunity or challenge that each policy option presents to agriculture, rather than a projection of likely future farm returns.

As noted earlier, the Australian Government has proposed to introduce an ETS that will impose a cost on greenhouse emissions. The ETS, to commence on 1 July 2012, will initially involve a government-fixed carbon price (\$23 per tonne CO₂-e in 2012–13 increasing by 5% per annum) which will continue for three years, before being converted into a market-based ETS.

During the initial stages of the policy, it is proposed that those direct emitters of greenhouse gases in the stationary energy, fugitive emissions and waste sector, which produce net emissions in excess of 25,000 tonnes carbon dioxide equivalent (CO₂-e) per annum, will be required to pay for their emissions at the rate specified by the policy. These businesses will first be required to use standard calculation methodologies to estimate their annual greenhouse emissions (as is currently the case under the National Greenhouse and Energy Reporting Scheme), and then will be required to pay to the government an amount equivalent to the tax rate multiplied by the net tonnes of greenhouse emissions generated by their business each year.

These businesses will have the option of either paying the tax, or reducing net emissions through the purchase of eligible offsets, such as those generated by farmers participating in the CFI, or a combination of both of these.

As a consequence, it is assumed that CFI offset prices per tonne CO₂-e will be essentially similar to the carbon tax or price under a 'mandatory' scenario. A progressively increasing tax will be imposed by the government each year, which will result in an increase in the carbon price, creating greater incentives for businesses to reduce their net emissions.

In the first analysis, a base-case (business-as-usual) scenario was developed for each of the model farms, which assumed that no ETS is introduced. It was then assumed that the ETS is introduced, and further analysis was conducted to project the potential impact of that policy on future farm profitability, over a multi-year period. The difference between the two projections provides an estimate of the likely impact of a carbon policy on future farm profitability, all other factors remaining unchanged.

In a second set of analyses, the potential implications arising from participation in the Carbon Farming Initiative was investigated. It was assumed that agriculture remains an uncovered sector under the ETS, allowing businesses in the sector to remain providers of CFI offsets. CFI offsets are therefore able to be sold by farmers into the carbon market, and are not required to reduce net on-farm emissions. The following scenarios were considered in this modelling:

- **CFI Mandatory** – CFI offsets can be sold to those businesses participating in the mandatory carbon prices, at per tonne CO₂-e prices equal to the mandatory carbon price market.
- **CFI Voluntary** – CFI offsets can only be sold to those individuals and businesses participating in the voluntary carbon market, at a per tonne CO₂-e price of \$5.

Different CFI offset scenarios were investigated in this analysis, appropriate to the environmental characteristics of farms in each of the production zones. For example, it is assumed that a farm business located in the Pastoral zone will receive lower average annual rainfall than a farm in the Wheat/Sheep zone, and therefore soil carbon sequestration will not be a viable option for the Pastoral zone farm.

Additional analyses were also carried out examining the impact of changes in the costs associated with mitigation technologies, and the financial implications of the adoption of a mitigation technology that also generates productivity gains for the farm enterprise.

Timeframe

The modelling commences in 2012, and projects forward to 2042, and assumes an emission cost is imposed from 2013 onwards (that is the financial year 2012–13).

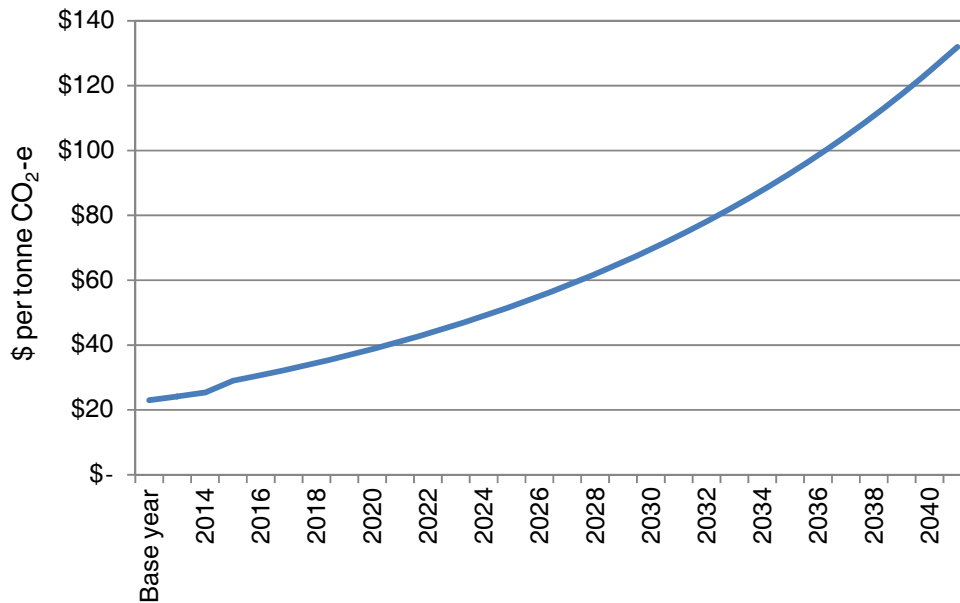
National emission reduction targets

It was assumed that, based on Australia's stated international commitments, the Australian Government will adopt greenhouse emission targets to achieve a reduction in emissions of 5% by 2020, compared to national emission levels in 2000. The significance of this target is that it, in turn, will determine likely future carbon prices.

Carbon price assumption

A key variable in modelling the impact of these policy measures is the potential price or cost that will apply to greenhouse emissions. The carbon price assumptions used in this modelling are those projected by the Australian Treasury (Australian Government Treasury 2011). The Treasury modelling projected the future level and trajectory of carbon prices that would be necessary to achieve a reduction in emissions of 5% by the year 2020. As it is assumed the carbon policy is introduced in 2013, for the year 2012 the carbon price is set to zero. The projected carbon prices are shown in Figure 1.

Figure 1: Carbon prices under scenarios of a 5% national emission reduction target and a carbon price starting at \$23 per tonne CO₂-e.



Electricity and fuel price increase assumptions

Fuel prices were assumed to start at \$1.40 per litre in 2012, and increases in the cost of fuel over time arising from the carbon price were estimated based on the carbon dioxide emissions associated with fuel combustion. Petrol combustion generates approximately 2.3 kg CO₂ per litre, while diesel generates 2.7 kg CO₂ per litre (Department of Sustainability, Environment, Water, Population and Communities 2010). Using an average of 2.5 kg carbon dioxide generated per litre of fuel combusted equates to a 2.5 cent per litre increase in the cost of fuel for every \$10 increase in the price of carbon. Because the government intends to impose a carbon price on on-road heavy vehicles from 2014, the change in fuel price is assumed to be zero from 2012 until 2014.

Electricity generation creates (on average) 1 tonne of carbon dioxide equivalence per megawatt hour of electricity. The base price of electricity is assumed to be \$100 per megawatt hour in 2012. The cost of electricity increases in proportion with the increase in the carbon price.

Model farms

The modelling reported here assesses the impact of the implementation of the ETS in the general economy for six model sheep farms. The financial models for these farms were developed using data obtained from ABARES for sheep-specific enterprises, being farm businesses that generate over 50% of total income from the sale of sheep or wool, or a combination of the two.

Two sheep enterprise models were developed using data from each of the Pastoral, Wheat/Sheep and High Rainfall zones. For each zone, a model was developed using average data from enterprises with annual turnover of between \$100,000 and \$200,000, and a second model was developed using average data from farm businesses with gross income in excess of \$400,000 per annum. This provided models representative of both small-scale and large-scale sheep enterprises within each of these three production zones.



Figure 2: High rainfall, wheat/sheep and pastoral production regions of Australia.

Source: Australian Natural Resources Atlas (2002).

Table 1: Characteristics of model sheep farms derived from ABARES data.

Production zone	Pastoral zone		Wheat/sheep zone		High rainfall zone	
Farm size	\$100,000– \$200,000	\$400,000 +	\$100,000– \$200,000	\$400,000 +	\$100,000– \$200,000	\$400,000 +
Land area (Ha)	19,814	7,049	1,244	4,958	784	2,318
Sheep flock	2,770	11,406	1,854	7,660	2,182	8,077
Beef herd	115	402	36	149	76	433
Total receipts (\$)	\$149,898	\$611,354	\$151,625	\$760,719	\$147,249	\$717,506
Total costs (\$)	\$138,469	\$477,983	\$138,407	\$638,719	\$119,140	\$554,056

Source: ABARES (2010).

It is assumed in the modelling that the sheep enterprises will face higher costs (as a consequence of the carbon policy), but will not receive higher prices due to the need to remain competitive in global markets.

To estimate the potential impact of the carbon price on the cost of farm inputs, itemised annual revenue and expenditure data was extracted for the two different sized farms in each production zone. The data published by ABARES reports itemised average farm revenues and expenditures (all expressed in 2010–11 dollars) based on details of actual farm revenues and expenditures obtained through annual surveys of a sample of Australian farms. To negate abnormal seasonal variation, data were obtained for the years from 2006 to 2010 inclusive, and the results averaged to provide a single-year model for each of the farms included in the study. The data for each farm are outlined in Table 1 above.

Impact on farm input costs

Farm input items which will have their costs impacted by an increase in energy prices were identified. For each of these farm inputs, the responsiveness of the cost of each to a change in fuel or electricity costs was based on an estimate of the proportion of the total cost of the input that is fuel or electricity.

Table 2 below provides a summary of the farm input items, the cost of which is likely to be impacted by increases in fuel and energy costs, and an estimate of the percentage flow-on effect of increases in fuel and energy costs that will be reflected in the future cost of these inputs for farmers. For example, if fuel prices are estimated to rise by 10% as a result of the ETS, then freight costs are estimated to rise by 2% (ie 20% of 10%), because fuel is estimated to make up 20% of the cost of providing a freight service.

In a number of instances (such as fertilisers, crop and pasture chemicals and fodder) while the cost of the actual product may only be marginally affected by the imposition of a price on carbon (as fertilisers and chemicals are internationally priced), it is likely that the costs reported by farmers include road freight delivery costs, and in some cases (such as fertilisers) there may also be significant spreading costs included in this cost item. It is therefore projected that these cost items will increase as a carbon price is introduced, as a consequence of the fuel costs associated with their delivery and application.

It should be noted that it was assumed that the cost of fuel, oil and grease used on-farm would not be affected by the ETS, because the government has stated that fuel used for on-farm purposes will not have a 'carbon cost' added to it. No attempt was made to estimate how much farm fuel might be used for heavy on-road transport, and therefore potentially attract a carbon cost from 2014. It should also be noted that while freight costs are shown to be responsive to changes in fuel prices, this relationship only applies from 2014 onwards in the modelling.

Over future years, it was assumed that the costs for farmers of all other (non-energy related) farm inputs

will remain constant, with no inflation factor being applied. This approach was adopted not because it is assumed that farm input costs will remain constant in the future, but because the critical issue for farm businesses is changes in the relative cost of farm inputs compared to the prices received for farm outputs. The focus of this research is to assess the impacts of the policy measure on farm businesses, all other things being equal. By holding non-energy related farm input costs and future farm revenues constant in nominal terms (aside from assumed productivity growth), the results provide a picture (in current dollar terms) of the relative impact of the carbon policy on farm businesses as emission costs change in the future.

It was assumed that agricultural processors (such as sheepmeat processors) with emissions of more than 25,000 tonnes of CO₂-e will have a cost imposed on their factory emissions and will also face increased energy-related costs. These costs will be associated with wastewater management, transport and electricity usage. Being largely trade-exposed, it was assumed that these increased costs will be passed on to farmers in the form of higher processing costs or lower livestock prices. Previous research by ABARE (Tulloh et al. 2009) analysed the input use of the processing sector, and estimated that their additional costs if an ETS was introduced

Table 2: Estimated flow-on impacts of increases in fuel and electricity prices.

Expenditure item	Responsiveness to fuel price changes (%)	Responsiveness to electricity price changes (%)
Contracts – cropping	20%	0%
Contracts – livestock	10%	0%
Crop and pasture chemicals	20%	0%
Electricity	0%	100%
Fertiliser	10%	0%
Fodder	10%	0%
Freight	20%	0%
Fuel oil and grease	0%	0%
Handling and marketing	20%	5%
Livestock materials	10%	0%
Other materials	10%	0%
Repairs and maintenance	10%	10%
Water charges	0%	10%

(with a carbon price of \$20/tonne CO₂-e) would be \$0.72 per head for sheep, \$7.60 per head for beef cattle, and \$2.34 per tonne of grains, in 2007–08 dollars. These processing costs were converted to 2010–11 dollars in order to be consistent with the model farm data collected from ABARES, and adjusted in proportion to changes in the assumed carbon price.

ABARES data used to generate the model farms provided a total for the number of sheep and cattle sold each year by these farms. This number was used to estimate processor costs for each farm under a carbon price scenario, because while the sheep and cattle may not be sold directly to the processor, it is assumed the additional cost of processing will be passed-back to the farmer. In the case of grains, ABARES data provided an estimate of the receipts from grain sold, and the price received per tonne of grain. From this information, the number of tonnes of grain produced was calculated, and used to calculate changes in grain processor costs over time for the model farms. In the case of wool, no increase in processor costs were assumed because most wool is exported in greasy form and processed offshore.

Productivity growth

An important variable under consideration in this research was the rate of productivity growth assumed for the sheep industry over future years.

This is important because applying a cost to carbon will result in increases in farm costs, but will not change farm revenue. The agriculture sector in Australia has dealt with such challenges over many years through productivity growth, which in essence involves increasing units of output per unit of input. Historical rates of productivity growth for sub-sectors of agriculture, as estimated by ABARE (Nossal & Goody 2009), are shown in Table 3.

The analysis reported here assumes that, in the future, sheep farm productivity growth rates will be maintained at 0.3% per annum, and will not change as a result of the introduction of a tax or price on carbon.

2.2 Results

The projected changes in total farm costs for each of the model sheep farms are shown in Table 4, relative to a ‘business-as-usual’ case where no ETS is introduced. The results are shown for the initial year (when the ETS commences), for year 3 (when it is assumed the on-road fuel used by heavy vehicles will be subject to a carbon price), and then each five years. The results assume there is no response by farmers to the additional costs (such as a change in inputs) therefore they project the size of the challenge the ETS will present, rather than future farm cash income levels.

Table 3 Average annual input, output and total factor productivity (TFP) growth in broadacre industries 1977–78 to 2006–07.

	TFP growth (%)	Output growth (%)	Input growth (%)
Total broadacre	1.5	0.8	-0.6
Cropping	2.1	3.1	1.0
Mixed crop-livestock	1.5	0.1	-1.5
Beef	1.5	1.7	0.1
Sheep	0.3	-1.4	-1.8

Source: Nossal and Goody (2009).

Table 4: Relative changes in farm costs and farm cash income under an ETS.

	Change in total farm costs and farm cash income									
	Year 1	Year 3	Year 5	Year 10	Year 15	Year 20	Year 25	Year 30		
Carbon Price	\$23.00	\$25.36	\$30.74	\$41.14	\$55.05	\$73.67	\$98.59	\$131.93		
High rainfall zone \$100,000–\$200,000 t/o										
Cost – processor (\$)	\$184	\$1,004	\$1,218	\$1,629	\$2,180	\$2,918	\$3,905	\$5,225		
Cost – farm (\$)	\$671	\$984	\$1,179	\$1,547	\$2,027	\$2,652	\$3,459	\$4,499		
Cost total (\$)	\$855	\$1,989	\$2,396	\$3,176	\$4,208	\$5,569	\$7,364	\$9,724		
Cost change (%)	0.7%	1.7%	2.0%	2.7%	3.5%	4.7%	6.2%	8.2%		
Income change (%)	-3.0%	-6.6%	-7.6%	-9.0%	-10.8%	-12.9%	-15.6%	-18.8%		
Cost – processor (\$)	\$827	\$4,453	\$5,398	\$7,223	\$9,666	\$12,936	\$17,311	\$23,166		
Cost – farm (\$)	\$2,322	\$3,699	\$4,426	\$5,801	\$7,592	\$9,912	\$12,904	\$16,740		
Cost total (\$)	\$3,149	\$8,152	\$9,824	\$13,024	\$17,258	\$22,848	\$30,214	\$39,906		
Cost change (%)	0.6%	1.5%	1.8%	2.4%	3.1%	4.1%	5.5%	7.2%		
Income change (%)	-1.9%	-4.6%	-5.3%	-6.4%	-7.6%	-9.1%	-10.9%	-13.2%		
Cost – processor (\$)	\$185	\$984	\$1,193	\$1,596	\$2,136	\$2,859	\$3,826	\$5,120		
Cost – farm (\$)	\$885	\$1,280	\$1,533	\$2,012	\$2,637	\$3,450	\$4,501	\$5,855		
Cost total (\$)	\$1,070	\$2,264	\$2,726	\$3,609	\$4,774	\$6,309	\$8,327	\$10,975		
Cost change (%)	0.8%	1.6%	2.0%	2.6%	3.4%	4.6%	6.0%	7.9%		
Income change (%)	-7.7%	-14.8%	-16.3%	-17.7%	-19.7%	-22.3%	-25.6%	-29.7%		
Cost – processor (\$)	\$932	\$4,823	\$5,847	\$7,825	\$10,472	\$14,013	\$18,753	\$25,096		
Cost – farm (\$)	\$2,568	\$4,292	\$5,135	\$6,730	\$8,807	\$11,497	\$14,964	\$19,406		
Cost total (\$)	\$3,499	\$9,115	\$10,982	\$14,555	\$19,278	\$25,510	\$33,717	\$44,502		
Cost change (%)	0.5%	1.4%	1.7%	2.3%	3.0%	4.0%	5.3%	7.0%		
Income change (%)	-2.8%	-6.8%	-7.6%	-8.8%	-10.1%	-11.8%	-13.9%	-16.5%		
Cost – processor (\$)	\$205	\$1,116	\$1,353	\$1,811	\$2,423	\$3,243	\$4,339	\$5,807		
Cost – farm (\$)	\$981	\$1,293	\$1,550	\$2,037	\$2,673	\$3,503	\$4,579	\$5,972		
Cost total (\$)	\$1,186	\$2,409.34	\$2,903	\$3,847	\$5,096	\$6,745	\$8,919	\$11,779		
Cost change (%)	0.9%	1.7%	2.1%	2.8%	3.7%	4.9%	6.4%	8.5%		
Income change (%)	-9.8%	-18.1%	-19.9%	-21.5%	-23.8%	-27.0%	-31.0%	-36.0%		
Cost – processor (\$)	\$572	\$3,121	\$3,784	\$5,063	\$6,776	\$9,067	\$12,134	\$16,238		
Cost – farm (\$)	\$2,913	\$3,953	\$4,727	\$6,189	\$8,092	\$10,555	\$13,728	\$17,801		
Cost total (\$)	\$3,485	\$7,074	\$8,511	\$11,252	\$14,867	\$19,622	\$25,863	\$34,039		
Cost change (%)	0.7%	1.5%	1.8%	2.4%	3.1%	4.1%	5.4%	7.1%		
Income change (%)	-2.6%	-5.0%	-5.8%	-7.1%	-8.7%	-10.6%	-13.0%	-15.9%		

The results displayed in the Table 4 above indicate that projected cost impacts for all sheep farms are broadly similar, with the larger-scale farms generally projected to experience proportionally lower cost increases, although higher cost increases in dollar terms. By year five, most of the model farms are projected to experience cost increases of approximately 2% as a result of the impact of the ETS.

What is noteworthy in relation to these results is that these cost increases can have a substantial impact on farm profitability (expressed as farm cash margins), especially for the smaller farms which all have a relative small operating margin based on ABARES data. In the case of the smaller Pastoral zone farm, for example, a 2% increase in farm input costs (year 5) is projected to result in a 19.9% decrease in farm cash margins, all other things being equal, whereas for the larger Pastoral zone farm, a 1.8% increase in farm input costs results in a 5.8% decrease in farm cash margins.

This is highlighted in Figure 3 below, which shows the percentage change in farm input costs (above the origin) and the related percentage change in farm cash margins (below the origin) for the smaller (red) and the larger (blue) pastoral zone farm included in the modelling reported here. It highlights that in percentage terms, both farms experience similar percentage changes in input costs as the carbon price increases, but the smaller farm experiences a much greater percentage decrease in farm cash margins as the carbon price increases.

The changes projected in farm cash margins (see Table 4 and Figure 3) are based on an assumption that no changes occur to historical rates of productivity growth in the sheep industry, over the period for which projections have been made. The assumed rate of productivity growth in this instance was 0.3% per annum, as reported by ABARES for the period from 1978 to 2007.

Further analysis was carried out to analyse the sensitivity of the projections to changes in assumed rates of productivity growth in the sheep industry. Such analysis also provides an indication of the extent to which annual sheep industry productivity growth rates would need to increase to 'cancel out' the projected effects of the proposed carbon policy.

For the large turnover farms (\$400,000+ annual turnover) in each of the three production zones (High Rainfall, Wheat/Sheep and Pastoral zones), the assumed annual rates of productivity growth for both sheep and wool production from 2012 onwards were increased in order to observe the sensitivity of projections of change in farm cash income in the future to different assumptions about future sheep productivity growth rates. Figure 4 displays the results of this analysis for the three farms, ten years after the introduction of a carbon price. The ten year timeframe was chosen in order to provide an opportunity for higher assumed productivity growth rates to have some impact. In this analysis, assumed productivity growth rates for all other farm enterprises were kept constant, and only sheep and wool productivity growth rates were adjusted.

The results highlight that an increase in assumed productivity growth rates is projected to reduce the impact of the carbon price on farm cash incomes over time, but even at historically very high assumed rates of productivity (3.5% per annum) the impact of the carbon price for all three farms is at best stabilised, but does not recover to match the BAU scenario (farm cash margins in the absence of a carbon price). The results also highlight that even relatively small initial improvements in productivity growth rates can be important in moderating reductions in farm cash incomes, and that the industry will need to pursue productivity growth with increased vigour because it represents the main avenue for the sector to offset the longer-term impacts of a carbon price on farm profitability.

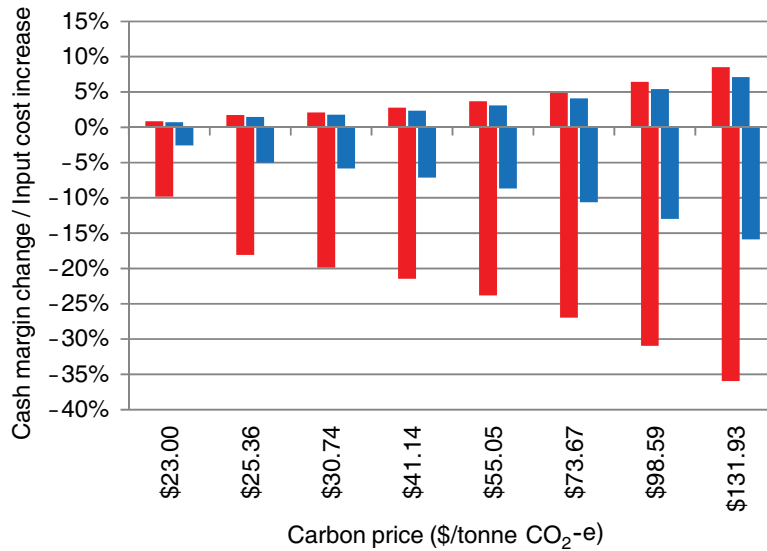


Figure 3: Percentage changes in input costs (above origin) and farm cash margins (below origin) for the smaller (red) and larger (blue) pastoral zone farms.

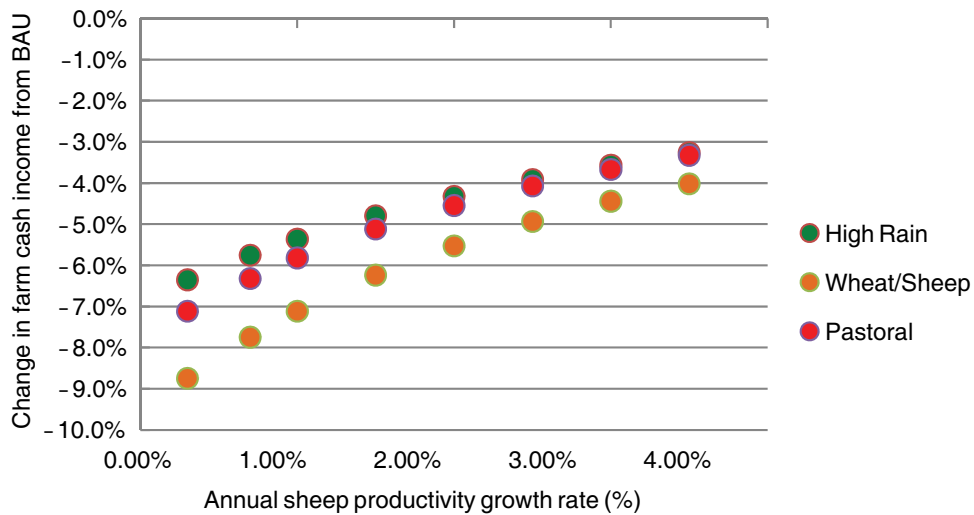


Figure 4: Effect of different rates of assumed sheep industry productivity growth on percentage changes in farm cash margins 10 years after the introduction of a carbon price for large-scale sheep farms in each production zone.

3. The Implications of the Carbon Farming Initiative

To gain a better understanding of the implications of the CFI for farm businesses, financial modelling was carried out under a range of different assumptions and scenarios. The methodology used for this modelling is similar to that described above, with the use of the same farm financial models for sheep-specific farms located in the Pastoral, High Rainfall and Wheat/Sheep zones. In each case, the implication of undertaking different emission mitigation or carbon sequestration activities was analysed.

3.1 Methodology

The assumptions underlying this analysis need to be carefully considered, and it should be stressed that the results represent the potential implications of this particular set of assumptions. The model is not dynamic, and as such does not incorporate flow-on impacts of the implementation of a carbon price such as a change in enterprise mix. The results provide an indication of the potential scale of challenges or opportunities that would face a sheep farm business, and are not a projection of how farm business managers would respond under the scenario under examination.

It is assumed the Australian Government implements an ETS from 2013 onwards (that is the financial year 2012–13). It is assumed, in this analysis, that the government selects an emission reduction goal of 5% of 2000 levels by 2020.

It is assumed that, under the ETS, those direct emitters of greenhouse gases in the stationary energy, fugitive emissions and waste sector, which produce net emissions in excess of 25,000 tonnes CO₂-e per annum, will be required to purchase emission permits equivalent to the amount of emissions they create, and surrender these permits to the government when submitting their annual

greenhouse emission return. These businesses will be required to use standard calculation methodologies to estimate their net annual greenhouse emissions (as is currently the case under the National Greenhouse and Energy Reporting Scheme). These businesses will have the option of either paying to purchase emission permits, or reducing the net emissions attributed to their organisation through the purchase of eligible offsets (such as those generated by farmers participating in the CFI) or international offsets, or a combination of all of these.

As a consequence, it is assumed that offset prices per tonne CO₂-e (for those offsets accepted in the mandatory market) will be essentially similar to the carbon tax or price. A progressively increasing tax will be imposed by the government for the first three years, which will result in an increase in the carbon price, creating greater incentives for businesses to reduce their net emissions.

The second set of analyses assumes that farm offsets are not able to be sold to emitters participating in the mandatory carbon market, and will therefore only be able to be sold into the voluntary carbon market. This provides a comparison of the financial implications of participating in the voluntary market, which is where non-Kyoto Protocol compliant offsets must be sold. The government has stated that only those offsets which are deemed compliant with Australia's obligations under the Kyoto Protocol can be sold into the mandatory market.

In each instance, the base-case (business-as-usual) scenario against which the CFI scenarios were compared was the projected farm results under the ETS. The impact on farm cash margin when the farm business participates in the offset market is analysed under a scenario where agriculture is not

a covered sector under the ETS, and therefore does not incur a cost for greenhouse emissions associated with farm activities.

Other analyses were also carried out to examine the growth in farm productivity that would need to be associated with a particular mitigation technology in order to achieve levels of farm cash income equivalent to that under the base-case. In addition, analysis was carried out of the sensitivity of farm cash incomes to assumed sequestration rates and carbon prices.

Timeframe

The modelling commences in 2012, and projects forward to 2042 (30 years), and assumes an emission cost is imposed from 2013 onwards (that is the financial year 2012–13).

National emission reduction targets

It was assumed that, based on Australia's stated international commitments, the Australian Government will adopt greenhouse emission targets to achieve a reduction in emissions of 5% by 2020, compared to national emission levels in 2000. The significance of this target is that it will determine likely future carbon prices.

Carbon price assumptions

The proposed carbon price commences at \$23/tonne CO₂-e in the year 2012–13, increasing at 5% for the first two years. In 2014–15 it is proposed that the carbon price mechanism will move to a flexible emission trading scheme (ETS). Australian Government Treasury modelling (2011) estimates the carbon price will continue to increase at 5% in real terms each year.

The Department of Climate Change and Energy Efficiency (Australian Government 2011) released a discussion paper on the estimates of abatement under the CFI, concluding that the voluntary carbon price will be \$3 per tonne CO₂-e in 2013, rising to \$5 per tonne CO₂-e in 2020. The price of offsets on the voluntary market is assumed to be \$5 per tonne CO₂-e across the entire modelling period.

The following two scenarios were considered:

- **CFI Mandatory** – An ETS is introduced on an economy-wide basis in 2012. Farm businesses can elect to participate in the CFI to generate offsets which can be sold into the mandatory carbon market. The price for CFI offsets is the prevailing carbon price under the ETS.
- **CFI Voluntary** – An ETS is introduced on an economy-wide basis in 2012. Farm businesses can elect to participate in the CFI to generate offsets which can only be sold into the voluntary carbon market. The price offered for offsets in the voluntary market is assumed to be \$5/tonne CO₂-e.

Electricity and fuel price increase assumptions

As outlined above, fuel prices were assumed to start at \$1.40 per litre in 2012, and increases in the cost of fuel over time are estimated according to the carbon dioxide emissions from fuel combustion, starting in 2014–15.

The base price of electricity is assumed to be \$100 per megawatt hour in 2012. The cost of electricity is also assumed to increase in proportion with the increase in the carbon price.

Model farms

The larger model farms, which have an annual turnover of more than \$400,000, were utilised for these scenarios. One farm model was used from each of the Pastoral, High Rainfall and Wheat/Sheep zones. The reason for selecting only the larger farms in each region was that these larger farm models are more likely to be representative of those farms that will participate in the CFI, given the initial capital cost and land area that CFI offset projects are likely to require.

Impact on input costs

The same relationships between changes in energy prices and farm input costs which were used in the earlier analysis were also used in this analysis. For each of the relevant farm inputs, an estimate was made of the potential flow-on cost impacts of increases in fuel or electricity costs, based on an approximation of the significance of fuel

or electricity in the provision of those goods or services, and these are outlined above in Table 2.

Farm greenhouse emissions

In order to calculate a baseline from which to estimate the potential impact of mitigation options for participation in the CFI offset market, the greenhouse gas emissions arising from each of the farms included in this analysis were estimated using the FarmGAS Calculator (Australian Farm Institute 2009).

The FarmGAS Calculator estimates ‘farm-created’ greenhouse gas emissions using the methodologies specified by the Australian Government, which are utilised to estimate Australia’s National Greenhouse Gas Inventory (NGGI). The NGGI is prepared in accordance with the Intergovernmental Panel on Climate Change emission calculation Guidelines. The methodology applied to agriculture contains both Australian-specific and IPCC default methodologies and emissions factors. The FarmGAS Calculator has enterprise-specific calculators for beef production, sheep production, intensive livestock production (feedlot and piggery) dryland and irrigated cropping, horticulture and environmental plantings on-farm.

To estimate emissions for each enterprise, some general assumptions about farm operations needed to be made, and available physical information about each farm was obtained from ABARES, including fertiliser use. Emissions associated with nitrogen fertiliser applied to crops are very much dependent on factors such as crop type, crop yield, percentage nitrogen in the fertiliser, and whether the crop is dryland or irrigated. The greenhouse gas estimations are relatively consistent when considering nitrogen fertiliser applied to pastures. If the fertiliser used was assumed to be applied to crops, various assumptions would need to be made for each farm which could significantly affect estimated emissions. In the interest of consistency in greenhouse emission estimates between model farms it was assumed that all nitrogen fertiliser was applied to pastures.

Details of the flock structure for each farm, about assumptions made and individual enterprise emissions are included in Appendix 1.

Emission mitigation

Because the production environment is so different in each of the three zones where the model farms are located, the sequestration or mitigation options available vary considerably. For each of the model farms, a scenario was developed involving a CFI offset methodology that may be applicable to reduce emissions from sheep and wool farms in that region, or to sequester additional carbon.

3.1.1 Pastoral zone – methane mitigation

The farm located in the Pastoral zone is assumed to have a lower annual rainfall than farms in the other production zones, with production reliant on grazing of native grasslands and shrublands. Because sheep production in this zone is extensive rather than intensive, emission mitigation options such as manure management or feeding supplements are not feasible. Consequently, a different methane mitigation option was modelled, more suited to large-scale broadacre wool and sheepmeat production in the Pastoral zone.

For the purposes of this modelling, it was assumed that a hypothetical technology is available which involves treating sheep with a rumen bolus which releases a methane reducing chemical for twelve months. When using a 65 g ceramic bolus, researchers in the European Union found that it had a 100% retention rate but because of its dimensions is only suitable for lambs heavier than 25 kg. Boluses of reduced dimensions were developed for smaller lambs, but had a lower retention rate of 91.5% (Ghirardi et al. 2007). It is assumed a bolus of smaller dimensions (12 mm long x 42 mm wide) is developed which has methane mitigation properties, and can be applied to all sheep.

It was assumed this bolus results in a 20% reduction in enteric methane emissions from treated sheep. The bolus is assumed to be applied to all sheep on the farm, and requires annual replacement. The emission reduction resulting from application of the bolus applies only to enteric methane emissions, so the overall reduction in emissions will be less than 20% of the total farm emissions.

While at the time of writing there is no commercially-available bolus for use in sheep that

reduces methane output, the cost of a bolus for the purpose of electronic identification of sheep is \$3.95 per bolus. This was the bolus cost that was assumed to also apply under this scenario. The current pattern of annual sheep sales and purchases is assumed to remain consistent throughout the period of the modelling. In addition to the bolus cost, the required applicator has a cost of \$51.20 (for the entire flock), but there are no other costs assumed to be associated with the system as application of the bolus was assumed to be carried out in conjunction with other sheep handling activities, for example lamb-marking.

Costs and receipts associated with offsets – methane mitigation

In addition to the costs of implementing a mitigation technology on-farm, there are costs associated with participating in a carbon market. These costs can include a project design cost, which involves the compilation of relevant data as identified under a specific offset methodology. In this scenario, it is assumed the farmer can use a 'framework' methodology already developed and approved under the CFI, and therefore faces no methodology-development costs or project design costs.

A legal practitioner is assumed to be required to verify the contract documentation associated with the project, at a cost of \$2000 as an initial establishment cost. There are also likely to be ongoing operational costs associated with opting to participate in the CFI, such as accreditation, the cost

of record keeping and compiling annual statements, and the costs associated with required system verification. An attempt has been made to develop a realistic estimate these costs, which are detailed in Table 5 below.

Following the approval of the project, it is assumed that the introduction of the system of project monitoring and report preparation would require an accredited person to train the farmer and help establish record-keeping procedures. It is also assumed that the accredited person would need to supervise the initial application of the bolus to the sheep. The cost of the accredited person is assumed to be \$1500 per day, with two days allocated for training and additional time for the supervision of the bolus application. It is assumed that 1000 sheep are able to be verified each day. For example, 11,000 sheep would require 11 days for bolus application and supervision, at a cost of \$16,500 for the accredited person.

Following the initial application of the bolus, it is assumed that it is not necessary for the whole flock to be verified each year, because reports prepared by the farmer will be able to be checked in conjunction with physical verification. A random check of 10% of the flock is assumed to take place every year, with a maximum of 1000 sheep able to be checked in a day. It is assumed the farmer will need to prepare statements each year outlining compliance with the methodologies approved for the project. This is assumed to take two days each year, with an assumed cost of the farmers' time of \$1000 per day.

Table 5: Costs associated with reporting and verification of greenhouse gas mitigation for a Pastoral zone farm with more than \$400,000 annual turnover, participating in the CFI utilising a methane mitigation technology.

Item	Cost
Initial training	\$3000 one-off cost
Legal advice (contract)	\$2000 one-off cost
Initial verification	\$1500/day one-off cost
Annual statement preparation	\$1000/day each year
Annual verification	\$1500/day each year
Audit	\$1500/day every third year

While on-farm verification is assumed to take place each year, an audit of all reports and documents associated with the project is assumed to take place every three years by an approved, independent third party. This audit is assumed to take two days for completion and at a cost of \$1500 per day.

3.1.2 Pastoral zone – environmental plantings

The farm located in the Pastoral zone is assumed to have a lower annual rainfall than farms in the other production zones, with production reliant on grazing of native grasslands and shrublands. While one offset option for the farm is methane mitigation, another option for this farm is to generate offsets through the planting of trees. With relatively low annual rainfall, it is assumed that the farm business invests in multi-species, multi-layer environmental plantings which have a slower growth rate (and therefore carbon sequestration rate) than some single-species plantations but are better adapted to the pastoral zone. This type of tree plantation may also provide co-benefits including shelter or fodder for stock, salinity reduction or biodiversity benefits.

The model farm is assumed to be located in the Channel Country of Queensland, and the soil type is assumed to be ‘clay gidgee’, characterised by sandy clay loams, clay loams and desert loams and areas of gidgee (*Acacia cambagei*) shrublands on the low areas.

To estimate the carbon sequestration rate associated with this type of tree plantation, the FarmGAS Calculator was used (Australian Farm Institute 2009). This Calculator draws data from the Commonwealth Government National Carbon Accounting Toolbox, which estimates above-ground carbon sequestration for the national greenhouse gas inventory.¹

The growth rate of trees varies considerably over time, so to determine an average annual carbon sequestration rate, the total carbon sequestration for a period of 100 years was calculated and a yearly average calculated. According to the FarmGAS Calculator, the average annual rate of sequestration for an environmental tree planting within the

channel country of Queensland is 1.15 tonnes CO₂-e per hectare.

There are significant costs associated with establishing farm forestry, including purchasing and planting the seedlings, weed control, fencing and fertiliser. Private Forests Tasmania (2005) provide some cost estimates for the establishment of forests, specific to Blackwood, Eucalypts and Radiata Pine. The cost per hectare for these tree species vary considerably, and are outlined below.

Table 6: Establishment costs for various tree species.

Tree species	Establishment cost (/ha)
Blackwood (<i>Acacia melanoxylon</i>)	\$2130–\$3620
Eucalyptus species	\$1260–\$2375
Radiata Pine (<i>Pinus radiata</i>)	\$1235–\$2510

Source: Private Forests Tasmania (2005).

A mixed-species environmental planting in the Pastoral zone is not specific to any of the estimations outlined above, therefore it was assumed the average of the above costs should be used, which is \$2188 per hectare.

Because this cost is quite significant, it is assumed that the process (and cost) of establishing trees on the model farm is undertaken in stages. It was assumed that approximately 1% of the farm area is planted to trees every year until a maximum of 10% of the farm is planted to biodiversity plantings. The total area of the model farm is 70,494 hectares, so it is assumed every year starting in 2013, about 700 hectares is planted to trees, until a total of 7000 hectares has been planted.

One of the characteristics of the Pastoral zone is low rainfall, which introduces a risk that a proportion of the trees planted will die. It is assumed that about 10% of the trees planted each year die, and need to be replaced. To factor this additional cost into the model, the establishment cost (\$2188 per hectare) was increased by 10%. Given these additional plantings will be replacing

¹ Australian Government Department of Climate Change and Energy Efficiency, available www.climatechange.gov.au/government/initiatives/ncat.aspx

carbon lost from the offset project; it means the farm will not be eligible to generate additional offsets for the replacement trees.

Costs and receipts associated with offsets – environmental plantings

In addition to the costs of establishment, there are costs associated with participating in a carbon market, as discussed in a previous section. It was assumed that the same initial and annual costs detailed in Table 5 above were applicable under this scenario.

3.1.3 High Rainfall zone farm – soil carbon sequestration

Despite being smallest in size of the three model farms, the High Rainfall zone farm has more than 8000 head of sheep in total. This reflects the higher carrying-capacity and productivity of the model farm located in a zone with higher average annual rainfall. Two offset scenarios were developed to reflect the different production characteristics of this farm. The first is the generation of offsets through soil carbon sequestration, and the second is the establishment of a carbon sink forestry plantation using a single tree species.

There are two broad strategies available for increasing soil carbon levels. The first involves adopting management strategies that optimise plant growth and the retention of soil organic matter. The second involves adding extra carbon to the soil, using additives such as imported biological material or biochar. The following analysis focuses primarily on the first option, due to the large number of uncertainties surrounding the costs and outcomes associated with the use of ‘imported’ carbon.

Chan et al. (2008) estimate that total carbon sequestration potential from pasture land, cropping land and rangelands in Australia amounts to 4.9 million tonnes of carbon, or 18 million tonnes CO₂-e per year. However, research in Australia, including that conducted by Meat & Livestock Australia (Henry & Dalal 2010), suggest that soil carbon sequestration is highly variable between regions and between paddocks, so the uniform soil organic carbon (SOC) increase modelled in this analysis should be considered as an informative example rather than practical reality.

As outlined in the Table 7 below, various ranges of soil carbon sequestration rates have been found under different farm management regimes. Given

Table 7: Literature review of management practices and reported soil organic carbon sequestration rates associated with these practices.

Category	Management practice	Carbon sequestration (tC/ha/yr)	Reference
Crop management	Irrigation	0.05-0.15	Lal et al. 2003, Chan et al. 2010
	Fallow elimination	0.10-0.30	Lal et al. 2003, Chan et al. 2010
Conservation tillage	Stubble retention	0-0.4	Lal et al. 2003, Chan 2008, Chan et al. 2010
	Reduced tillage	0-0.4	Lal et al. 2003, Chan et al. 2010
	No-tillage	0-0.4	Lal et al. 2003, Chan et al. 2008, Chan et al. 2010
Pasture management	Fertiliser management	0.30	Conant et al. 2001, Chan et al. 2010
	Grazing management	0.35	Conant et al. 2001, Chan et al. 2010
	Irrigation	0.11	Conant et al. 2001, Chan et al. 2010
	Introduction of legumes	0.75	Conant et al. 2001, Chan et al. 2010
	Sown pasture	0.50	Gifford et al. 1992
	Average for improved pasture management	0.55	Chan et al. 2008

Source: Adapted from Chan et al. (2008); Chan et al. (2010).

the model farm used in this analysis is sheep-specific, it is assumed that pasture management is the practice selected to generate soil carbon offsets.

The soil carbon sequestration scenario examined here involved the sowing of improved pastures with high legume content on the farm. It is also assumed that this improved pasture requires additional fertiliser to be applied at regular intervals, in order for soil carbon sequestration rates to be maintained over the longer term.

The cost of establishing improved pasture has been estimated by NSW Industry and Investment (2005) at \$175/hectare, although this is considered to be a conservative estimate. Because this cost is quite high, it is assumed that the legume-based pastures are established gradually on the farm, at a rate of 10% of the total farm area every second year, to a maximum of 50% of the farm or 1159 hectares.

It is assumed that single superphosphate is applied every two years on the grazing land that is sown to improved pastures, to enable soil carbon sequestration levels to keep increasing. Superphosphate is assumed to cost \$400 per tonne delivered to the farm and spread, and is applied at a rate of 100 kg per hectare. In addition, it is assumed the farmer does not increase stocking rates despite having established improved pasture, in order to enable a buildup of soil carbon to occur.

The average soil carbon sequestration rate for pasture management activities was estimated by Chan et al. (2008) to be 0.55 tC/ha/pa (2.02 t CO₂-e/ha/pa), and Chan states that this rate of increase could be maintained for fifty years, assuming that the improved pasture was initially established on an area of relatively degraded soil.

For the modelling exercise, it was assumed that soil carbon sequestration is only occurring on the area that has been sown to improved pasture, and that on the rest of the land soil carbon is being maintained, but not increased. Soil carbon offsets are therefore only assumed to be generated from the area of land that has been sown to improved pasture. The area of land sown to improved pasture increases over time at a rate of 231 hectares each two years, with 468 tonnes CO₂-e sequestered per annum for each 231 hectares.

Costs and receipts associated with offsets – soil carbon sequestration

There are additional costs associated with opting to sell soil carbon offsets, such as accreditation, compiling annual statements, insurance and verification. Estimates of these costs are detailed in Table 8 below.

Following the approval of the soil carbon sequestration project, it is assumed that the introduction of the system of project monitoring and report preparation would require an accredited person to train the farmer and help establish record-keeping procedures. The cost of the accredited person is assumed to be \$1500 per day, with two days allocated for training.

It is assumed that an accredited person must also verify the establishment of the pastures at the start of the project, at a cost of \$1500 per day. This verification is assumed to take three days, with a total cost of \$4500. Because the farm business is assumed to be planting 10% of the farm area to improved pastures every second year, the initial verification is also assumed to be required for every year where more legume pastures are established. This means verification occurs five times in the first ten years of the scheme, each time an additional 10% of the farm is planted to legumes.

The assumed cost of soil testing was estimated based on quotations provided by several soil testing organisations. According to Chan et al. (2010) the Leco soil test is the most accurate. It was considered unlikely that any landholder would need to have estimated soil sequestration verified with direct soil sampling every year. Rather, verification is assumed to only take place every three years.

It was assumed for the modelling exercise that soil testing would need to be carried out over the entire farm area, to avoid the possibility that one area of a farm was being conservatively managed to achieve soil carbon sequestration, while the remainder of the property is overstocked and soil carbon is being lost. It is unlikely a scheme would allow farmers to register paddock-size areas as sequestration units, but would instead require them to include the entire property in any scheme. The rate of soil sampling required every three years is assumed

to be a minimum of 20 samples, or one sample per four hectares; whichever is greatest. This may be a conservative figure however. Research by Meat & Livestock Australia (Henry & Dalal 2010) recommended within homogenous grazing management, 10 samples throughout one soil type, on a grid with random origin; is the minimum requirement. No assumptions regarding soil type variation is made for this model farm.

There is an associated labour cost associated with soil sampling. It is assumed that the cost of labour to collect samples is \$780 per day, with four samples able to be taken each hour and a working day consisting of 6.5 hours. Consequently, the assumed cost of labour per soil sample is \$30.

The farmer is expected to need to prepare a statement each year outlining compliance with the methodologies approved for the project. This is assumed to take two days each year, with an assumed cost of the farmers' time of \$1000 per day.

While on-farm verification is assumed to take place each year, an audit of all reports and documents associated with the project is assumed to take place every three years by an approved, independent third party. This audit is assumed to take two days for completion and at a cost of \$1500 per day.

3.1.4 High Rainfall zone – single species forestry

Another offset option for the farm with annual turnover of more than \$400,000 located in the High Rainfall zone is carbon sink forestry. The

High Rainfall zone is better suited to single-species tree plantations which have potential for higher carbon sequestration rates than mixed species environmental plantings.

It was assumed the tree species selected by the farm business for the forestry plantation is Tasmanian Blue Gum (*Eucalypts globules*), growing in red earths. To estimate the carbon sequestration rate associated with this type of tree plantation, the FarmGAS Calculator was used (Australian Farm Institute 2009). This Calculator draws data from the Commonwealth Government National Carbon Accounting Toolbox, which estimates above-ground carbon sequestration for the national greenhouse gas inventory.²

The growth rate of trees varies considerably over time, so to determine an average annual carbon sequestration rate, the total carbon sequestration for a period of 100 years was calculated and a yearly average taken. According to the FarmGAS Calculator, the average annual rate of sequestration for a Tasmanian Blue Gum plantation within the east Gippsland region of Victoria is 26.3 tonnes CO₂-e per hectare.

There are significant costs associated with establishing farm forestry, including the seedlings, weed control, fertiliser and fencing. Taking an average of the cost estimates provided by Private Forests Tasmania (2005), the cost is assumed to be \$2188 per hectare. This is a significant

2 Australian Government Department of Climate Change and Energy Efficiency, available www.climatechange.gov.au/government/initiatives/ncat.aspx

Table 8: Costs assumed to be associated with soil carbon sequestration offsets.

Item	Cost
General soil test	\$75 per sample
Leco soil carbon test	\$28 per sample
Initial accreditation	\$3000 one-off cost
Legal advice (contract)	\$2000 one-off cost
Annual statement preparation	\$1000 per year
Annual insurance	\$500 per year
Soil sampling	Assume \$780 per day labour costs, with operator collecting four samples per hour and working 6.5 hours per day. Total = \$30 per sample.

establishment cost, so it is assumed that the farm business establishes 5% of the total farm area to forestry in the first year of the scheme, and another 5% of the total farm area in the second year of the scheme. Therefore the total area of the farm set aside for forestry is 10% of the total farm area, or 232 hectares.

The risk of a significant number of trees dying due to drought isn't as high in the High Rainfall region as it might be in other regions such as the Pastoral zone. However, rainfall is not guaranteed and some loss of trees can be expected even in the High Rainfall zone as a result of drought or pests. It is assumed that 5% of the trees planted need to be replaced in the following year. To account for this, the cost of establishment (\$2188 per hectare) was increased by 5%.

Costs and receipts associated with offsets – carbon sink forestry

In addition to the costs of establishing the trees on-farm, there are costs associated with participating in a market for CFI offsets. These have been identified in Table 5, above.

It is assumed that an accredited person must also verify the establishment of the trees at the start of the project, at a cost of \$1500 per day. This verification is assumed to take three days, with a total cost of \$4500. Because the farm business is assumed to be planting 5% of the farm area to trees each in the first and second year to spread the cost of establishment, the initial verification is also assumed to be required for both years where more trees are planted.

Following the initial verification of each plot of trees, it is assumed that subsequent annual verifications will require a shorter period for inspection. It is assumed one day is sufficient for review, at a cost of \$1500, each year that the farm business is participating in the scheme.

3.1.5 Wheat/Sheep zone – environmental plantings

One option for the farm with annual turnover of more than \$400,000 located in the Wheat/Sheep zone is carbon sequestration through environmental

plantings. The model farm was assumed to be located in the Central Wheatbelt of Western Australia. The soils in South-Western Australia have a reputation for being sandy with low fertility, largely due to the age of the soils and degree of weathering (Anderson & Garlinge 2000).

The soil type of this farm is assumed to have a relatively high sand content (more than 60%) and therefore the most likely forestry plantation is mixed-species, multi-layer trees which are adapted to the local conditions. This type of tree plantation may also provide co-benefits including shelter for stock, salinity reduction or biodiversity benefits.

To estimate the carbon sequestration rate associated with this type of tree plantation, the FarmGAS Calculator was used (Australian Farm Institute 2009). This Calculator draws data from the Commonwealth Government National Carbon Accounting Toolbox, which estimates above-ground carbon sequestration for the national greenhouse gas inventory.³

The growth rate of trees varies considerably over time, so to determine an average annual carbon sequestration rate, the total carbon sequestration for a period of 100 years was calculated and a yearly average taken. According to the FarmGAS Calculator, the average annual rate of sequestration for an environmental tree planting within the Central Wheatbelt of Western Australia is 1.37 tonnes CO₂-e per hectare.

An average establishment cost for these trees is assumed to be \$2188 per hectare. Because this cost is quite significant, it is assumed that the process (and cost) of establishing trees on the model farm occurs in stages. It is assumed that approximately 1% of the farm area is planted to trees every year until a maximum of 10% of the farm is planted. The total area of the model farm is 4958 hectares, so it is assumed every year starting in 2013, about 50 hectares is planted to trees, until a total of 500 hectares have been planted.

There is a risk that a proportion of the trees planted will be lost. It is assumed that about 10% of the

³ Australian Government Department of Climate Change and Energy Efficiency, available www.climatechange.gov.au/government/initiatives/ncat.aspx

trees planted each year die, and need to be replaced. To factor this additional cost into the model, the establishment cost (\$2188 per hectare) is increased by 10%. Given these additional plantings will be replacing carbon lost from the offset project; it means the farm will not be eligible to generate additional offsets for the replacement trees.

Costs and receipts associated with offsets – environmental plantings

In addition to the costs of establishing the trees on-farm, there are costs associated with participating in the CFI offset market. These have been detailed in Table 5, above.

It is assumed that an accredited person must also verify the establishment of the trees at the start of the project, at a cost of \$1500 per day. This verification is assumed to take one day, because the total area of trees being established each year is about 50 hectares. However because the farm business is assumed to be planting 1% of the farm area to trees each year to spread the cost of establishment over several years, the initial verification is also assumed to be required for every year where more trees are planted. This means verification occurs for the first ten years of the scheme (2013–22).

Following the initial verification of each plot of trees, it is assumed that subsequent annual verification will be necessary, requiring one day for review at a cost of \$1500 per day for each year that the farm business is participating in the scheme.

3.1.6 Wheat/Sheep zone – nitrification inhibitors

A significant implication of the introduction of a carbon price mechanism is the increasing cost of farm inputs, as outlined above in Chapter 2. It is therefore important to consider ways to improve input use efficiency, particularly high-value inputs such as nitrogen fertiliser. It is estimated that wheat plants only assimilate 41% of nitrogen applied (Chen et al. 2008).

There are three pathways for the loss of nitrogen, which are volatilisation, leaching and denitrification. Volatilisation is the gaseous loss

of ammonia to the atmosphere, leaching is the movement of nitrate into the soil beyond the root zone and denitrification is the gaseous loss of nitrous oxide into the atmosphere (Laycock 2009). To improve the efficiency of utilisation of applied nitrogen, factors such as the timing, rate and source of nitrogen fertiliser are all important, however a further option is the use of a nitrification inhibitor.

A nitrification inhibitor prevents or slows the conversion of ammonium to nitrate and hence the production of nitrous oxide (Chen et al. 2008). There have been variable responses to the use of nitrification inhibitors, which are related to climatic conditions, moisture and temperature; and conditions within the soil such as fertiliser history and the nitrification potential of the soil (Barth 2006, Kelliher et al. 2008).

An inhibitor which is available in Australia is 3, 4-dimethyl pyrazole phosphate (DMPP) which suppresses nitrification by inhibiting the growth of bacteria for a period of time. Usually applied with urea, the timing of the application of DMPP is one factor that will influence its effectiveness in reducing nitrous oxide emissions.

The offset scenario under investigation here involved the use of a nitrification inhibitor. Research by Suter et al. (2010) has shown that soil texture, soil pH, organic carbon content and temperature are all factors that affect the efficacy of DMPP. Research is also underway in Western Australia on the action of DMPP in high anion exchange soils which have the ability to retain negatively charged ions such as nitrogen (Walker 2011).

The results obtained by Suter et al. (2010) for sandy soils (more than 70% sand content) are used as the assumed rate of nitrous oxide emission reduction achieved under this scenario. At a temperature of 25 °C and DMPP applied with urea, nitrous oxide emissions were reduced by 64% with an application of 2.81 ug DMPP /g soil and by 89% with an application of 11.5 ug DMPP /g soil applied. In other research using Australian soils, Suter et al. (2010) applied a commercial product of urea plus DMPP at a rate of 0.71 ug DMPP /g soil. At 25 °C nitrous oxide emissions were reduced by 14%, at 15 °C emissions reduced by 61%. From these results, it is

clear that as the application rate of DMPP increases, there is generally a corresponding increase in the mitigation achieved. In addition, DMPP may work more efficiently at lower temperatures.

While it isn't possible to determine the exact soil type and characteristics of the model farm, some assumptions can be made from results obtained from previous research. It is assumed the model farm is located in the Central Wheatbelt of Western Australia, and has soils with relatively high percentage of sand. DMPP is applied as a commercially available product which has 1.84 kg of DMPP per tonne of urea, which equates to 0.71 ug DMPP /g soil. The premium for this fertiliser is \$160 to \$180 /tonne which is a 10% cost increase on the price for normal urea (Walker 2011). While the nitrous oxide emission reduction for this product hasn't been researched widely on Western Australian soils, for the purpose of this research it is assumed the DMPP application can achieve nitrous oxide emission reductions of approximately 37% on the basis that temperatures during the production of winter wheat will fluctuate between 15 and 25 °C and the soil type in the Central Wheatbelt may be more sandy than the soils used in previous research. Emissions from fertiliser application had been estimated at 43.6 tonnes CO₂-e for the farm in the Wheat/Sheep zone. A 37% reduction in these emissions represents 16.13 tonnes offsets each year.

The cost of the DMPP fertiliser is estimated to add 10% to the current cost of fertiliser for the farm business. ABARES farm data indicates that \$65,461 is spent on fertiliser each year, although there was no differentiation of nitrogen or other fertilisers. It was assumed for the modelling exercise that all this was nitrogen fertiliser, so an additional \$6546.10 is assumed to be spent on the protected nitrogen fertiliser each year.

Costs and receipts associated with offsets – nitrification inhibitors

In addition to the costs of applying a nitrification inhibitor, there are costs associated with participating in the CFI offset market, as identified previously in Table 5.

3.2 Results

3.2.1 Pastoral zone farm with methane mitigation

For the farm located in the Pastoral zone of Australia, with annual turnover of more than \$400,000, two mitigation scenarios were considered. The first was the assumed hypothetical technology which involves a mini-bolus that releases a methane reducing chemical into the rumen of sheep for twelve months, resulting in a 20% reduction in enteric methane emissions. The reduction in methane emissions was assumed to be able to be sold as a CFI offset. This scenario was modelled under a carbon price assumed for a voluntary market of \$5/tonne CO₂-e (voluntary market) and the carbon price associated with the mandatory market.

The impact on farm cash income under these two carbon prices is detailed below in Figure 5. In this figure, cumulative farm cash income is shown, to provide a long-term perspective on how the farm cash income compares with the business-as-usual case (BAU). No discount has been applied to future year's income, so the cumulative farm cash income result is in nominal dollars.

It is clear from these results that the most profitable CFI Offset scenario for the farm business is one where it is able to sell offsets into the mandatory market. However, even under the most profitable CFI offset scenario, farm cash income for the farm does not match that projected for the business under the business-as-usual scenario. Whilst the higher carbon price in later years sees the CFI mandatory scenario 'catching up' somewhat to the business-as-usual scenario, cumulative farm cash income is still 27% lower by 2042. Under the CFI voluntary scenario, cumulative farm cash income is 37% below the business-as-usual

It is interesting to consider whether a productivity gain associated with the mitigation technology might be able to raise the cumulative farm cash income to a level similar to the business-as-usual case (where no productivity gain is obtained because the bolus is not applied). A scenario was established to investigate this, increasing the

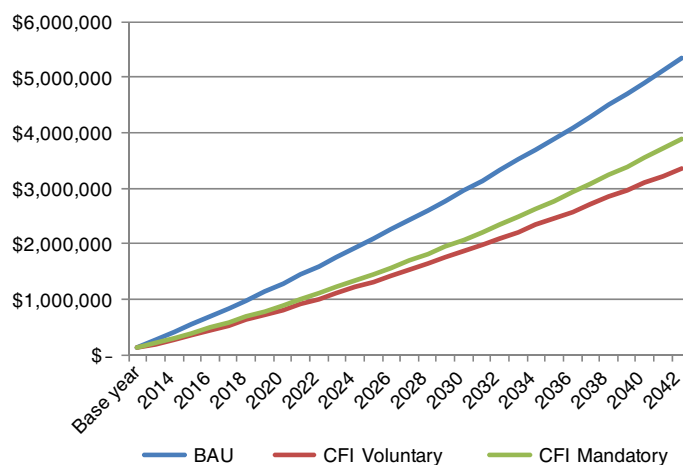


Figure 5: Cumulative farm cash income for a Pastoral zone farm utilising methane mitigation.

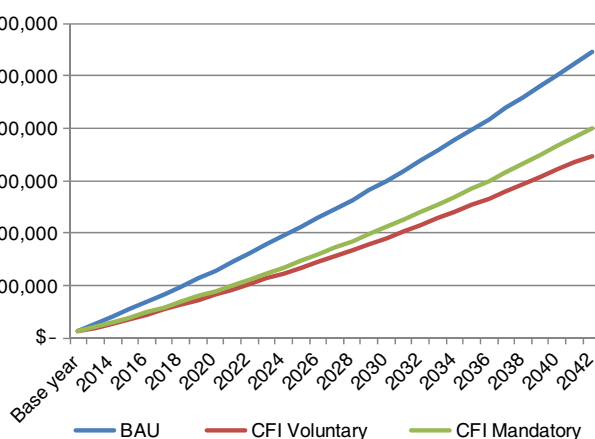


Figure 6: Cumulative farm cash income for a Pastoral zone farm utilising methane mitigation and achieving a 33% productivity gain from the mitigation technology.

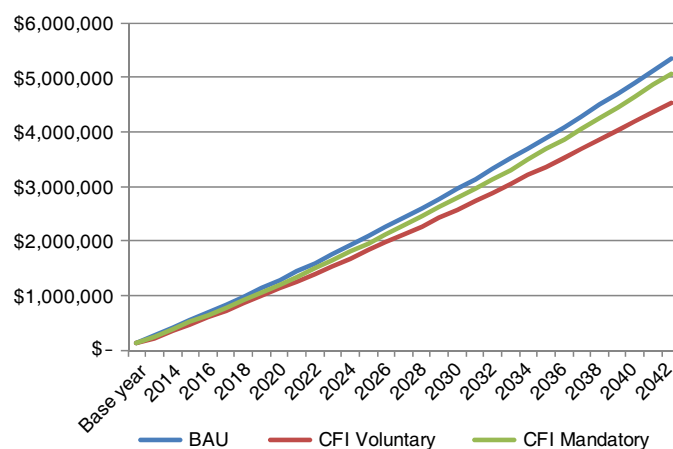


Figure 7: Cumulative farm cash income for a Pastoral zone farm adopting methane mitigation with a low-cost bolus (\$0.50 per head).

assumed productivity rate for sheepmeat production from 0.3% to 0.45% (a 50% increase).

Even with a 50% productivity gain assumed to be associated with the mitigation technology, cumulative farm cash income does not match that associated with the business-as-usual case. The results of this analysis are outlined above in Figure 6. After 30 years the farm cash income is still 27% below that under the business-as-usual scenario.

Another alternative to consider is a case where the cost of the mitigation technology was significantly lower. In order to investigate this, the cost of the bolus was reduced gradually to determine at what price farm cash income recovered to a similar level as the business-as-usual case, assuming the same carbon price scenarios and participation scenarios. Even at a price of \$0.50 per bolus, the cumulative farm cash income for the business does not reach the level of the base-case. The farm cash income with the bolus cost of \$0.50 is shown in Figure 7.

It is clear that the cost of the technology is one of the most critical factors in whether participation in a CFI offset market is financially viable, under this scenario. Even under a scenario where the mitigation technology costs only 50 cents and offsets can be sold into the mandatory market, the cumulative farm cash income is still projected to be 5% below the business-as-usual case over forty years.

From the results, it appears that a higher price for offsets in the mandatory market would bring the farm cash income to levels similar to that under the business-as-usual case. However, this is not the case because as the carbon price increases, farm input costs also increase. This creates a situation where the farm business would be selling offsets into the mandatory market for a higher price, but still not generating sufficient income to cover the escalation occurring in farm input costs.

To highlight this, the assumed carbon price was tripled under the scenario where the farm is generating offsets through the use of the mini-bolus creating a 20% emission reduction. The cost of the bolus is \$3.95, and it is assumed the farmer can access the mandatory market, receiving offset prices

equal to three times the carbon price assumed by Treasury under the 5% emission reduction scenario. The resulting cumulative farm cash income is shown in Figure 8. It confirms that the higher offset revenue does not compensate for higher input costs, even under much higher carbon prices.

It is interesting to consider what the price of offsets would need to be for cumulative farm cash income to reach business-as-usual levels. In order to investigate this, the carbon price in the mandatory market would need to be kept the same, but prices for offsets in the voluntary market inflated. This scenario prevents farm input costs increasing, but allows the revenue from sale of offsets to increase. To equal farm cash income under the business-as-usual scenario, the voluntary carbon market price would need to be approximately \$220/tonne. However, it should be emphasised that this scenario is very unrealistic, because it is unlikely businesses would pay more for offsets that can't be used to meet emission reduction obligations, particularly if they can buy cheaper emission units in a mandatory market.

3.2.2 Pastoral zone farm with environmental plantings

For the farm located in the Pastoral zone of Australia, two mitigation scenarios were considered. The first was the assumed hypothetical technology which involves a mini-bolus that releases a methane reducing chemical into the rumen of sheep for twelve months, resulting in a 20% reduction in enteric methane emissions. The results from this scenario are outlined above. The second offset scenario considered was one where the farm business established farm forestry, consisting of multi-species environmental plantings.

The impact of participating in an offset market is analysed under two carbon price scenarios. The first assumes that offsets can only be sold into the voluntary market, where offsets are valued at \$5/tonne CO₂-e. The second carbon price scenario reflects carbon prices determined as being necessary to achieve a reduction in emissions of 5% by the year 2020 (Australian Government Treasury 2008). This scenario is labelled 'mandatory offset market'.

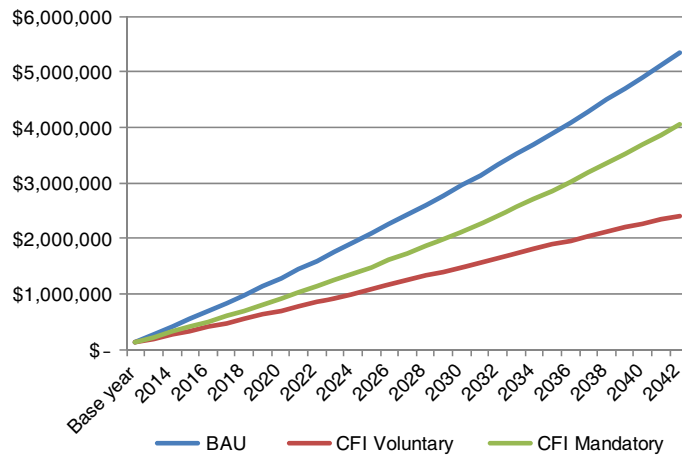


Figure 8: Cumulative farm cash income for a Pastoral zone farm, selling CFI offsets arising from methane mitigation. The assumed carbon price is three times that projected by Treasury.

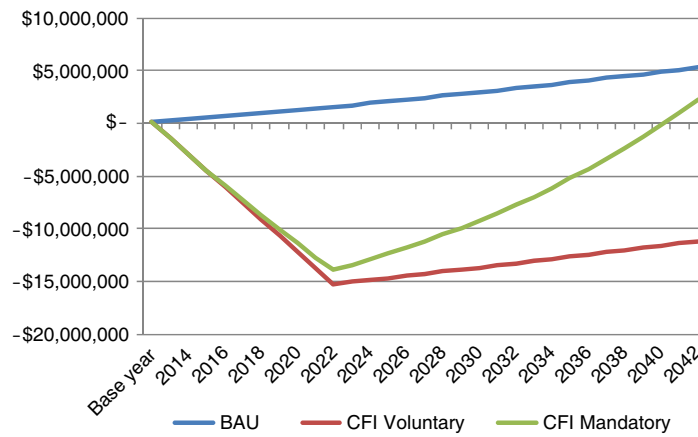


Figure 9: Cumulative farm cash income for a pastoral zone farm, generating offsets through farm forestry.

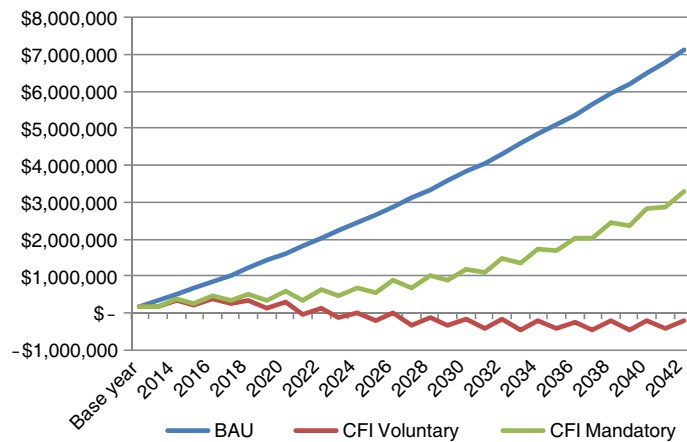


Figure 10: Cumulative farm cash income for a High Rainfall zone farm, generating offsets through soil carbon sequestration.

Because of the significant establishment costs associated with the initial planting of tree seedlings, it was assumed that the farmer slowly increased the area of farm forestry, increasing it by 1% of the total farm area for the first 10 years of the scheme. It was assumed that 700 hectares of trees were planted each year, until a total of 7000 hectares was established as farm forestry. The significant costs over this period are reflected in the cumulative farm cash income, which falls significantly from 2013 until 2022. In the year 2023, farm cash income starts to recover, however over the entire modelling period the cumulative farm cash income does not reach the same level as the business-as-usual case. This is detailed above in Figure 9.

The carbon price has a significant impact on the cumulative farm cash income, as evidenced by the large difference between the cumulative farm cash income for the voluntary offset market and that of the mandatory carbon price scenario. Under the voluntary offset market, where offsets are priced at \$5 /tonne CO₂-e, the cumulative farm cash income does not recover, being 309% below that under the business-as-usual case by 2042. In comparison, cumulative farm cash income under the mandatory carbon market scenario is 58% lower than the business-as-usual case by 2042.

Analysing the carbon price that would need to be applied to offsets in order for cumulative farm cash income to be equal to business-as-usual levels highlights this cannot occur if the carbon price is applied economy-wide. This is because farm inputs which are energy-dependent increase in cost, negating the increased revenue from sale of offsets. The only way to investigate this question is to inflate the price of offsets on the voluntary market. If offsets can be sold into the voluntary market for \$150 /tonne, cumulative farm cash income will reach business-as-usual levels in year 2030, 17 years after the introduction of a carbon price. At a price of \$200 /tonne, cumulative farm cash income reaches business-as-usual levels in 2027, 14 years after the introduction of a carbon price.

3.2.3 High Rainfall farm with soil carbon sequestration

For the farm located in the High Rainfall zone of Australia, with annual turnover of more than \$400,000, two mitigation scenarios were considered. The first was the establishment of legume-based improved pastures for the purpose of soil carbon sequestration. There are significant establishment costs associated with the introduction of improved pastures and the ongoing cost of soil sampling is also significant.

Analysis of this scenario identified that farm cash income for the High Rainfall farm under voluntary and mandatory carbon price scenarios falls significantly when participating in the offset scheme. By the year 2042, under a mandatory carbon price cumulative farm cash income is 54% below the business-as-usual case under a mandatory carbon price. Cumulative farm cash income by the year 2042 is 103% below the business-as-usual case under a voluntary carbon price. This result is shown in Figure 9 below.

Fertiliser application and soil sampling and testing costs are the most significant additional costs for the farm participating in the offset scheme. Further modelling was carried out to determine the sensitivity of this analysis to the assumed costs of soil sampling and testing.

In this scenario, the rate of soil sampling required every three years is assumed to be a minimum of 20 samples, or one sample per 10 hectares; whichever is greatest. The results show little improvement in the cumulative farm cash income. By the year 2042, under a mandatory carbon price, cumulative farm cash income is 49% below the base-case. Cumulative farm cash income by the year 2042 is 98% below the business-as-usual case under a voluntary carbon price. This shows that fertiliser application rates would need to decrease significantly, or the reporting and verification assumptions outlined above would need to decrease; for the farm in the High Rainfall zone to achieve farm cash income levels similar to that of the business-as-usual case.

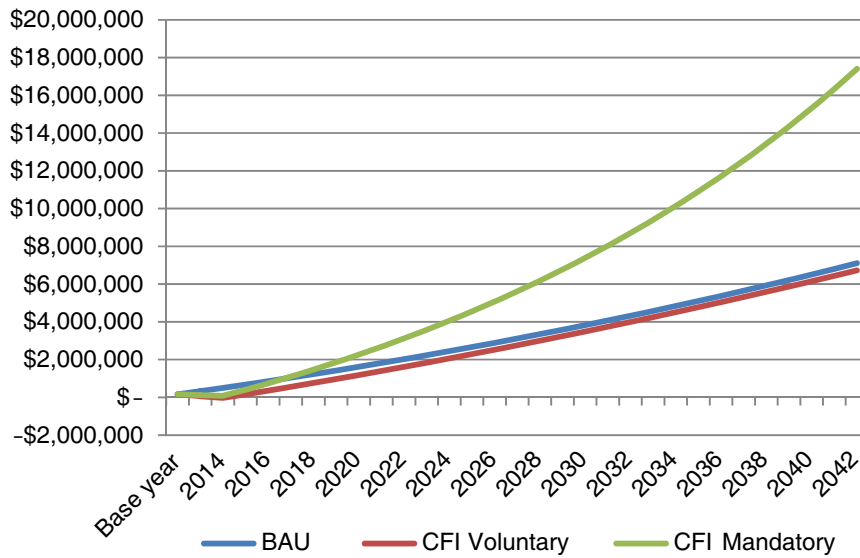


Figure 11: Cumulative farm cash income for a High Rainfall zone farm generating CFI offsets through farm forestry.

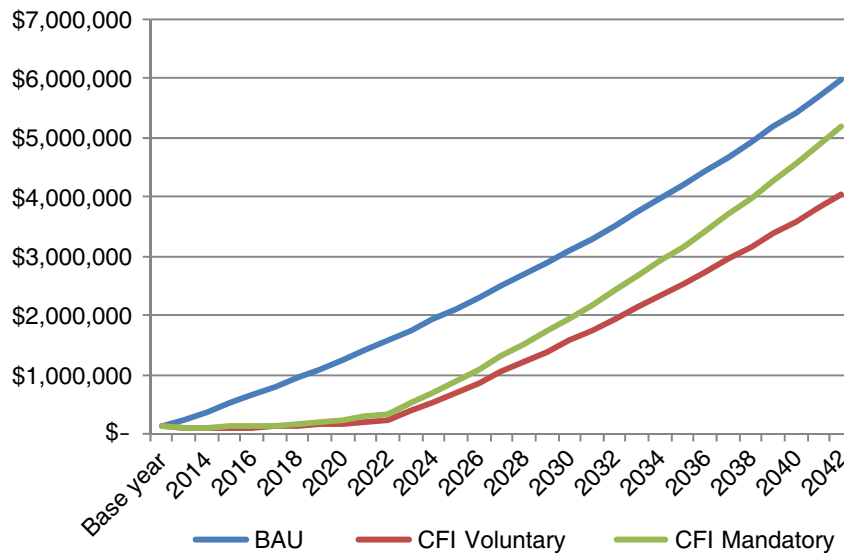


Figure 12: Cumulative farm cash income for a Wheat/Sheep zone farm creating CFI offsets through environmental plantings.

For the cumulative farm cash income in this scenario to reach business-as-usual levels, the price of offsets on the voluntary market would need to reach \$130 /tonne. As discussed, this is not a realistic scenario, particularly for soil carbon offsets. It is unlikely businesses would purchase offsets on the voluntary market which can't be used to meet their emission reduction obligations, especially if emission units can be purchased from the mandatory market at a lower price. While unlikely, there could be some demand for offsets from the voluntary market if there is a prospect that these offsets would in future be accepted into the mandatory market. However, with soil carbon offsets in Australia, unless international accounting methodologies are changed this will not be the case.

3.2.4 High Rainfall farm with single-species forestry

A second CFI offset scenario examined for the High Rainfall zone farm was the establishment of farm forestry for carbon sequestration. The scenario in this case assumed the establishment of a single-species plantation of Tasmanian Blue Gums. This result is shown in Figure 11 above.

Under a the scenario where the farm is able to sell the offsets generated into the mandatory carbon market, cumulative farm cash income reaches the same level as the business-as-usual case by the year 2017, and then progressively exceeds the business-as-usual scenario. The reason cumulative farm cash income is below that of business-as-usual in the first four years of the scheme, is because in these years forestry is being established, which has significant costs associated with it. The farm business recovers from this cost relatively quickly under the carbon price associated with the mandatory carbon price scenario.

If the farm business was only able to sell the offsets generated by the farm forestry into the voluntary market, where offsets are priced at \$5 /tonne CO₂-e, cumulative farm cash income is projected to be 5% below business-as-usual by the year 2042.

From the analysis, the farm business is able to achieve farm cash incomes much higher than the business-as-usual case if it can sell all the offsets generated into the mandatory market. In

this case, cumulative farm cash income is 50% above the business-as-usual case in 2020, 48% above business-as-usual by 2030 and 145% above business-as-usual in 2042.

It is important to note, however, that if the option to sell offsets into the mandatory market was removed due to legislative change to either the definitions of what is a compliant offset or even the existence of the carbon price mechanism; farm cash income could be expected to decrease significantly. Without buyers for the offsets generated, the market price could also be expected to fall, affecting farm cash incomes. In addition, there are significant risks associated with bushfire or disease reducing the carbon stock. If this were to occur, the farm business would need to re-establish the trees, at significant cost. These uncertainties need to be considered in any long-term farm business planning, before electing to participate in an offset scheme.

3.2.5 Wheat/Sheep farm with environmental plantings

For the farm located in the Wheat/Sheep zone, cumulative farm cash income falls when the farm business participates in the offset scheme outlined above regardless of whether offsets can be sold into the mandatory or voluntary market. The establishment cost of planting the trees, even when spread over ten years, is prohibitive and the farm cash income does not recover to the business-as-usual level. Cumulative farm cash income is 32% below business-as-usual by the year 2042, when participating in the voluntary market. If the farm is able to sell offsets into the mandatory market under this scenario, by the year 2042 cumulative farm cash income is 13% below business-as-usual. This result is shown in Figure 12 above.

To investigate the carbon price required for cumulative farm cash income to reach business-as-usual levels for the Wheat/Sheep zone farm with environmental plantings, the voluntary offset price was inflated.

The carbon price associated with the mandatory market was kept the same, to avoid calculated farm input costs increasing and distorting the analysis. At a voluntary offset price of \$150 /tonne, cumulative

farm cash income reaches business-as-usual levels in 2033, which is 20 years after the introduction of the carbon price. This result highlights that the relatively low sequestration rates attributed to environmental mixed-species plantings (by the NCAT methodology) makes it extremely difficult for a CFI offset project based on this methodology to return a positive cashflow. It would, of course, be unrealistic to have voluntary offset prices at this level while the mandatory carbon market prices remained much lower.

3.2.6 Wheat/Sheep farm with nitrous oxide mitigation

For the scenario involving a farm located in the Wheat/Sheep zone of Australia, nitrous oxide mitigation does not deliver enough offsets for a CFI offset project based on this technology to be cashflow positive. The number of offsets able to be generated is relatively low (16.13 tonnes CO₂-e), which means the cumulative farm cash income associated with marketing these offsets into either the voluntary or mandatory market is essentially similar. By 2042 cumulative farm cash income for the farm under this scenario remains 14% below business-as-usual. This result is displayed in Figure 13 below.

Analysis was carried out to determine how much nitrous oxide abatement the DMPP fertiliser needs to deliver, before cumulative farm cash income

reaches the same level as business-as-usual. Various different emission mitigation scenarios were examined, however, even when it was assumed that the DMPP fertiliser reduced emissions by 90%, it did not result in a marked change in farm profitability. Even with this assumed level of mitigation, by 2042 cumulative farm cash income was still projected to be either 14% or 13% below business-as-usual farm cash income, when these offsets were sold in the voluntary or the mandatory carbon market respectively.

A scenario under which the use of DMPP fertiliser provided both a significant increase in productivity (a 25% boost) and a 37% emission reduction was also analysed to gain some idea of the associated productivity gain that would be necessary to make profitable a CFI offset project based on this technology. The results showed that the productivity gain reduced the loss associated with this scenario, but only to a small degree. If the farm was able to sell offsets into the mandatory market, cumulative farm cash income under this scenario was projected to be 12% below business-as-usual by the year 2042. This result is shown below in Figure 14.

To be profitable, analysis suggests that a CFI offset project based on nitrification inhibitors would need to receive \$1700 per tonne for those offsets. This is not a realistic price assumption for such offsets.

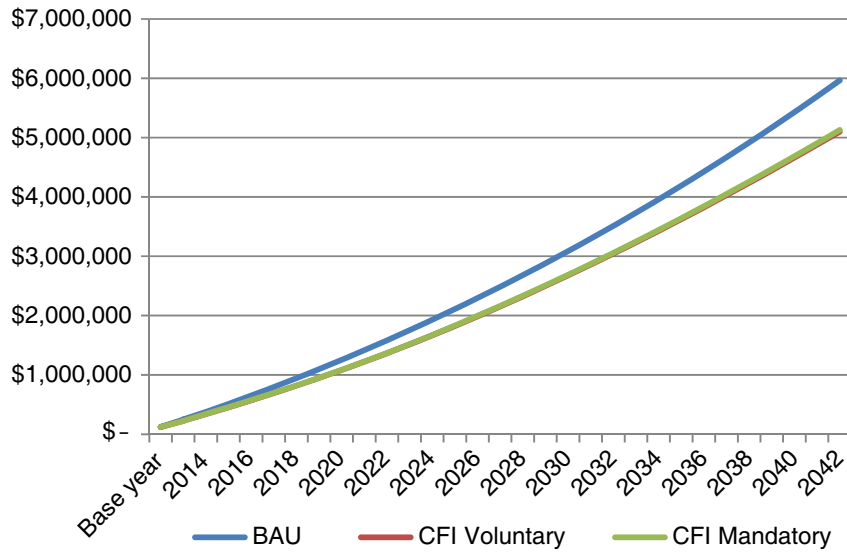


Figure 13: Cumulative farm cash income for a Wheat/Sheep zone farm generating CFI offsets through reduced nitrous oxide emissions.

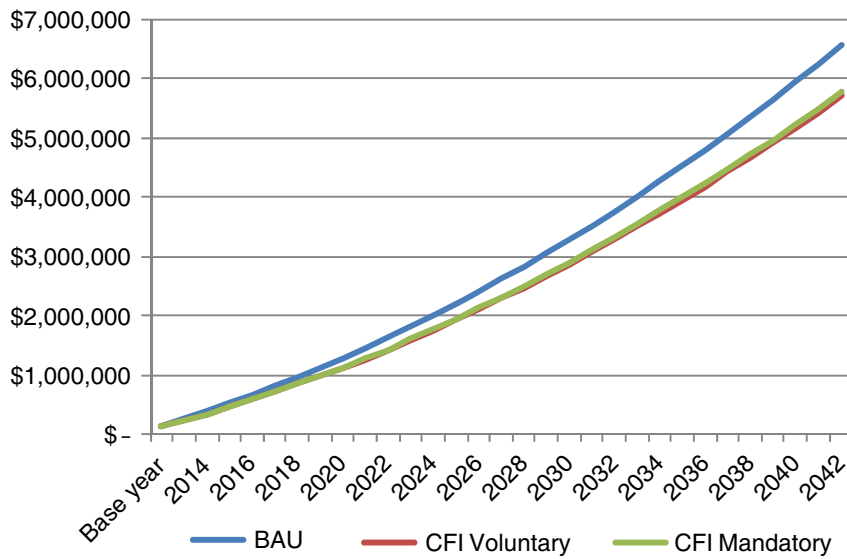


Figure 14: Cumulative farm cash income for a Wheat/Sheep zone under a scenario involving the adoption of DMPP fertiliser and a 25% productivity gain for the grain enterprise.

4. Discussion

From the analysis carried out, it is clear that the introduction of policies which impose a price on carbon will result in increases in input costs for all Australian sheep farms. A key factor determining the magnitude of these costs increases will be the extent to which farm businesses and associated supply chains rely on energy-related inputs.

In the early stages of the proposed policy (during which period cost increases will be experienced for electricity, some chemicals and fertilisers and rail freight) the impact of these input cost increases will be limited. However, the expansion of a carbon price to on-road fuel emissions after 2014 would, if implemented, accelerate the rate of increase of farm input costs and put significant and increasing negative pressure on sheep farm profit margins after that time.

In the absence of changes to both farm and post-farm input utilisation and cost structures, farm businesses will be forced to absorb these additional costs, given that few if any farm businesses are price-makers, as opposed to price-takers. Over an extended period it is possible that the Australian dollar exchange rate will reduce and this would assist sheep farm profitability, but official forecasts

do not presume that this will occur for some time. Similarly, innovations that enable reduced electricity or fuel use are possible, but these do not seem likely within the next decade

The ability of the farm business to absorb the increase in input cost is very much dependent on the profit margins of those businesses. Those with a relatively high profit margin will be better able to absorb additional costs, while those with relatively low profit margins will not.

This means that the imposition of the carbon policy is likely to add to structural adjustment pressures on small-scale sheep businesses, because statistics show that these businesses tend to operate with smaller profit margins than large-scale sheep businesses. This is highlighted in Table 9, below, which shows the average revenue generated per dollar of farm inputs by sheep farms of different sizes and in different locations. This data is derived from ABARES farm survey data.

The analysis of revenue per dollar input cost and corresponding change in farm cash income as input costs increase, provides a strong indication of the importance of productivity, particularly for smaller

Table 9: Revenue generated per \$1 input cost for the sheep farm businesses included in this analysis.

Sheep farm location and size	Revenue/\$1 input cost
Pastoral zone, \$100,000–\$200,000 annual turnover	\$1.08
Pastoral zone, more than \$400,000 annual turnover	\$1.28
High Rainfall zone, \$100,000–\$200,000 annual turnover	\$1.24
High Rainfall zone, more than \$400,000 annual turnover	\$1.30
Wheat/Sheep zone, \$100,000–\$200,000 annual turnover	\$1.10
Wheat/Sheep zone, more than \$400,000 annual turnover	\$1.19

farms. It is evident from these model farms that improving the amount of revenue generated per dollar input cost is of critical importance. While it is instructive to compare productivity between different size farms in the same production zone, it is perhaps less instructive to compare between zones. This is because each zone has its own environmental characteristics which limit or drive productivity, and may be a strong determinate of how the farm responds to changes in costs. What the analysis highlights, however, is that productivity gains will be increasingly important as the carbon price climbs.

However there is an additional challenge for sheep-specific farms in trying to compensate for increased farm input costs associated with a carbon price. Selecting sheep that are more productive in terms of liveweight gain can be counterproductive for wool fineness, and vice versa. This means that in pursuing enhanced rates of productivity growth, sheep producers will need to make careful decisions about the relative importance of sheepmeats and wool production as a source of farm revenue.

This question is complicated with the realisation that a carbon price is likely to have a significant impact on the costs faced by domestic meat processors, but these additional costs will not be as significant for sheep destined for the live export market, or for wool (which is essentially processed off shore in locations that do not have a carbon price). This means the relative returns from live sheep sales, sheepmeats and wool are likely to change over time, further complicating decisions about sheep selection to improve flock productivity.

This potentially means that farms which sell a large proportion of sheep for slaughter each year will be impacted as processor costs steadily increase (and are passed back to farmers) due to the impact of the carbon price. The proportion of total stock numbers (sheep and cattle) that are being sold by average farms in different regions each year are detailed below in Table 19. These results are based on ABARES data, and provide an indication of how greater reliance on sheepmeats markets may impact on the profitability of sheep farms.

It is interesting to note the large difference between the percentage of stock sold for the large and the small farms in the Pastoral zone. Data was averaged over five years in an attempt to avoid seasonal variation having a significant impact on the data, however there was a number of significant drought events over this period, which may have distorted the reported averages.

The importance of productivity was discussed above, however another option for the woolgrower to potentially recover some of the reduction in farm cash income as a result of a carbon price, is participation in an offsets scheme. Single species tree plantings in a High Rainfall region was the only CFI offset scenario under which cumulative farm cash income was equal to or above the business-as-usual case.

An additional issue for sheep producers considering participating the offset market by planting trees, is the carbon sequestered must be maintained for a period of 100 years (maturity plus 70 years). This introduces significant risk to the business, because

Table 10: Stock sold each year as a percentage of total stock numbers, according to ABARES data.

Farm	Percentage stock sold each year
Pastoral zone, \$100,000–\$200,000 annual turnover	40%
Pastoral zone, more than \$400,000 annual turnover	28%
High Rainfall zone, \$100,000–\$200,000 annual turnover	45%
High Rainfall zone, more than \$400,000 annual turnover	45%
Wheat/Sheep zone, \$100,000–\$200,000 annual turnover	54%
Wheat/Sheep zone, more than \$400,000 annual turnover	54%

if there is bushfire, pests or extended drought and some of the trees die, this carbon must be replaced or paid for.

Re-establishment of the trees will come at significant cost, and the farm business will not be able to generate CFI offsets from these trees until they grow beyond their previous level. Alternatively the landholder can ‘pay back’ the carbon by returning any offsets generated by the trees, however these offsets may have already been sold. In this instance, the landholder will need to purchase sufficient offsets to cover the reduction in carbon, presumably at a higher price.

If a landholder is ordered to relinquish offsets to cover a loss of carbon, and does not manage to return sufficient offsets, the land where the offsets were generated will be subject to a carbon maintenance obligation. This is an arrangement whereby future landowners would be required to maintain carbon stocks, and this obligation would be linked to the land. When selling land on which a CFI sequestration offset project has been established, the land owner would have two options. One would be to transfer the project to the purchaser who would become responsible for reporting on the project and receive the credits. Alternatively, they would terminate the project and return all the offsets generated. All obligations under the CFI would be noted on the land title. This means that if a land owner decides to sell their land before the end of the 100 year period, there are several considerations and potential costs associated.

There is another offset option available under the CFI which has not been considered in this modelling, which is reduced emissions from avoided deforestation. The United Nations (UN) has established a program to reduce emissions from developing countries through reduced deforestation and forest degradation (REDD). The Verified Carbon Standard has developed methodologies for reduced emissions from deforestation which can be used by any country to generate offsets for sale into voluntary markets globally. The methodologies developed under the Verified Carbon Standard follow closely those for the UN REDD program.

The contract period for the voluntary emissions reduction from avoided deforestation projects is 25 years, which is much shorter than that of reforestation (100 years). Therefore, this may appear an easier option for landholders wanting to generate offsets through forestry, however there are eligibility criteria and restrictions which need to be considered in this option.

Developed countries (such as Australia) are not eligible to count REDD emission reductions toward their emission liability under the Kyoto Protocol. This means that if Australia implements a policy such as the carbon price mechanism to reduce emissions under Kyoto Protocol obligations, offsets from voluntary projects to reduce emissions through avoided deforestation are unlikely to be included in a carbon mechanism. The offsets generated by these projects would therefore only be able to be sold into voluntary carbon markets at a reduced price.

Another offset option considered in the analysis was that of a bolus resulting in a reduction in methane emissions. As discussed above, one of the requirements for an offset project to be recognised is additionality, which requires that the project involves activities that are beyond ‘business-as-usual’. The draft legislation for the introduction of the CFI (Carbon Credits (Carbon Farming Initiative) Bill 2011) states that approval will not be given to projects that include:

‘...abatement practices and activities that are already widely used by farmers or other land holders.’

Once a methodology has been approved for an offset period, the methodology applies for a period of seven years, called a ‘crediting period’ during which the landholder can receive offsets. At the end of the period the methodology and project is reassessed. If a technology like the hypothetical bolus used in this analysis was widely taken up by farmers, the question arises as to whether it would still be eligible as an offset activity. The draft legislation does state that:

‘...activities that are common because of the scheme should not fail the additionality test. In assessing whether a project is common practice, the Minister will factor out the impact of the scheme.’

However, if a product is very successful at reducing emissions and the technology can be produced at a low cost making it financially beneficial to use, there is a risk that it may be regarded as common practice and no longer eligible as an offset activity. This is worth considering for the farm business manager when factoring offset income into the long-term business plan for the enterprise.

From the analysis conducted, it is clear that productivity will be a significant determinant of the ability of sheep and wool farm businesses to remain viable following the introduction of a carbon price. Farm cash income will fall under a carbon price mechanism, due to increasing input costs.

In particular, processor costs are likely to be significantly impacted by the introduction of a carbon price. Farm business managers considering participating in the CFI as a means of reducing the impact of a carbon price need to carefully weigh the additional costs and long-term land use change associated with an offset market. Under the carbon price scenarios modelled in this analysis, the CFI offset options modelled in this analysis do not represent a financially viable option for farms located in the Pastoral or Wheat/Sheep zones. Sheep farms located in the High Rainfall zone may have a profitable option available in CFI participation through forestry, however the risks associated with participation are significant and need to be considered in addition to the financial analysis outlined above.

5. References

- ABARES (2010), *Agsurf database*, accessible at: <http://www.abareconomics.com/interactive/agsurf/index.htm>
- Anderson, WK, Garlinge, JR (2000), *The Wheat Book: Principles and Practice*, Department of Agriculture, Western Australia.
- Australian Farm Institute (2009), *FarmGAS Calculator*, available www.farminstitute.org.au
- Australian Government Department of Climate Change and Energy Efficiency (2009), *Emissions Intensive, Trade Exposed assistance*, available at: <http://www.climatechange.gov.au/government/initiatives/cprs/carbon-price-design/eite.aspx>, accessed 29 April 2011.
- Australian Government Department of Sustainability, Environment, Water, Population and Communities (2010), *Reducing greenhouse gas emissions*, available at: <http://www.environment.gov.au/settlements/transport/fuelguide/environment.html>, accessed 28 April 2011.
- Australian Government Treasury (2008), *Australia's Low Pollution Future: The Economics of Climate Change Mitigation*, Commonwealth of Australia, Canberra.
- Australian Government Treasury (2011), *Strong Growth, Low Pollution: Modelling a Carbon Price*, Australian Government, Canberra.
- Australian Natural Resources Atlas (2002), *Agriculture – Sheep/Wool Industry*, available at: <http://www.anra.gov.au/topics/agriculture/sheep-wool/index.html>, accessed 28 April 2011.
- Barth, G (2006), *Influence of soil properties on the effect of 3,4-dimethylrazole – phosphate as nitrification inhibitor*, Technischen Universitat Munchen; in H Suter, D Chen, L Huilin, R Edis and C Walker (2010), *Comparison of the ability of the nitrification inhibitors DCD and DMPP to reduce nitrification and N₂O emissions from nitrogen fertilisers*, 19th World Congress of Soil Science, 1–6 August 2010, Brisbane, Australia.
- Carbon Credits (Carbon Farming Initiative) Bill 2011, available at: <http://parlinfo.aph.gov.au/parlInfo/search/display/display.w3p;query=Id%3A%22legislation%2Fbillhome%2Fr4543%22>, accessed 23 May 2011.
- Chan, KY, Cowie, A, Kelly, G, Bhupinderpal-Singh, Slavich, P (2008), Scoping paper: soil organic carbon sequestration potential for agriculture in NSW, NSW Department of Primary Industries, Orange, NSW.
- Chan, KY, Oats, A, Liu, DL, Prangnell, R, Poile, G, Conyers, MK (2010), *A farmer's guide to increasing soil organic carbon under pastures*, Industry and Investment NSW, Wagga Wagga, NSW.
- Chen, D, Suter, H, Islam, A, Edis, R, Freney, JR, Walker, CN (2008), Prospects of improving the efficiency of fertiliser nitrogen in Australian agriculture: a review of enhanced efficiency fertilisers, *Australian Journal of Soil Research*, CSIRO Publishing, vol. 46, no. 4, pp. 289–301.
- Ghirardi, JJ, Caja, G, Flores, C, Garin, D, Hernandez-Jover, M, Bocqueir (2007), Suitability of electronic mini-boluses for early identification of lambs, *Journal of Animal Sciences*, vol. 85, no. 1, pp. 248–57.

- Henry, B, Dalal, R (2010), *Preliminary report: sampling methodology for estimating the impacts of pasture type and management on soil carbon stocks in grazing lands*, Meat & Livestock Australia.
- ITS Global (2010), *Low Carbon Growth Plan for Australia: a critique of the report by ClimateWorks Australia*, ITS Global, Melbourne Australia.
- Kelliher, FM, Clough, TJ, Clark, H, Rys, G, Sedcole, JR (2008), The temperature dependence of dicyandiamide (DCD) degradation in soils: A data synthesis, *Soil Biology and Biochemistry*, vol. 40, issue 7, July, pp. 1878–82; in H Suter, D Chen, L Huilin, R Edis and C Walker (2010), *Comparison of the ability of the nitrification inhibitors DCD and DMPP to reduce nitrification and N₂O emissions from nitrogen fertilisers*, 19th World Congress of Soil Science, 1–6 August 2010, Brisbane, Australia.
- Keogh, M, Thompson, A (2008), *Preliminary modelling of farm level impacts of the Australian greenhouse emissions trading scheme*, Research Report, Australian Farm Institute, Surry Hills, Australia.
- Laycock, J (2009), *Slow release and stabilised nitrogen*, Grains Research and Development Corporation, Canberra.
- Nossal, K, Gooday, P (2009), Raising productivity growth in Australian agriculture, *ABARE Issues Insights*, 09.7, Canberra.
- NSW Industry and Investment (2005), *Autumn Legume Pasture*, NSW DPI Farm Enterprise Budget, Orange, NSW.
- Private Forests Tasmania (2005), *Farm Forestry Series*, available at: http://www.privateforests.tas.gov.au/publications/farm_forestry_info_sheets, accessed 4 May 2011.
- Suter, H, Chen, D, Huilin, L, Edis, R, Walker, C, (2010), *Reducing N₂O emissions from nitrogen fertilizers with the nitrification inhibitor DMPP*, 19th World Congress of Soil Science, 1–6 August 2010, Brisbane, Australia.
- Tulloch, C, Ahammad, H, Mi, R, Ford, M (2009), Effects of the Carbon Pollution Reduction Scheme on the economic value of farm production, *ABARE Issues Insights*, 09.6, Canberra.
- Walker, C (2011), *pers comm.*, Wednesday, 11 May 2011, Incitec Pivot Australia.

Appendix 1: Farm Income and Expenses and Greenhouse Gas Emission Estimates

A.1. Pastoral zone sheep farm, gross income \$100,000–\$200,000 pa

Table A1: Revenue and expenditure – Pastoral zone, \$100,000–\$200,000 turnover.

Expenditure	Amount (\$)	Revenue	Amount (\$)
Accounting services	–	Barley receipts	413
Advisory services	–	Beef cattle sold	14,788
Agistment	407	Canola receipts	–
AI stud fees and herd testing	–	Cotton receipts	–
Beef cattle purchased	5,366	Dairy cattle sold	–
Contracts – cropping	–	Field peas receipts	–
Contracts – livestock	2,658	Grain legumes receipts	–
Crop and pasture chemicals	498	Livestock transfers – outward	–
Dairy cattle purchased	–	Lupins receipts	–
Dairy supplies	–	Milk receipts excluding freight	–
Electricity	2,508	Other crop receipts	–
Fertiliser	1,091	Off-farm contracts	1,077
Fodder	5,349	Off-farm sharefarming	–
Freight	5,825	Oilseeds receipts	–
Fuel oil and grease	11,515	Other farm income	6,855
Handling and marketing	5,649	Other livestock sold	6,117
Insurance	–	Rice receipts	–
Interest paid	11,172	Sheep sold	50,160
Land rent	3,784	Sorghum receipts	–
Leasing charges	–	Total wool gross receipts	67,450
Livestock materials	–	Wheat receipts	3,038
Livestock transfers – inwards	–	Total revenue	149,898
Other administration expenses	8,035		
Other livestock purchased	23		
Other materials	–		
Other costs	18,667		
Payments to sharefarmers	–		
Produce purchased for resale	–		
Repairs and maintenance	14,744		
Seed	–		
Shearing crutching	17,341		
Sheep purchased	13,480		
Shire and PPB rates	3,956		
Stores and rations	720		
Telephone	–		
Vet fees	182		
Wages for hired labour	5,485		
Water charges	14		
Total costs	138,469		

Greenhouse emissions

Given this farm is in the pastoral region, it is assumed to be in the Channel Country region of Queensland. It is assumed that the beef cattle enterprise is not a breeding enterprise, but rather beef stores purchased for fattening and sale. This is because the enterprise is sheep-specific, not mixed livestock.

ABARES data was provided on fertiliser use, with an average total tonnes of nitrogen fertiliser of zero, as such it is assumed that no fertiliser is applied to pastures. The ABARES data provides a total number of sheep at 2770 and details of how many sheep are bought and sold. However it does not provide detailed information in terms of when sheep are sold and which categories are sold or bought. In light of this, a flock structure is constructed using the information provided.

The total number of sheep for this enterprise is 2770 total head at 30 June, which is assumed to be the starting month of analysis. Therefore the total number of sheep in the first month (June) of the analysis will be equal to the ABARES data estimate for total head of sheep. As such, with a lambing rate of 59% (provided by ABARES data) there are 1738 breeding ewes, 50 maiden ewes, 900 weaned lambs, 62 wethers and 20 rams on the farm. It is also assumed that sheep numbers are relatively constant, that is they are not affected by mortality rates.

According to NNGI default assumptions, in Queensland lambing is assumed to occur in spring and autumn in equal parts. Therefore 512 lambs are assumed to be born in spring, 513 in autumn. User-entered data is utilised in the FarmGAS Calculator rather than NNGI defaults, to ensure the emissions are estimated as closely as possible to the ABARES data rather than defaults.

The average wool produced is provided by ABARES data as 4.9 kg/head. This is assumed for all adult sheep, for lambs/hoggets it is assumed to be 2 kg/head.

In terms of sales and purchases, it is assumed that of the 900 weaned lambs and hoggets available at the start of the calendar year, all are sold in winter. The remaining sales (according to ABARES data) are allocated to breeding ewes, with purchases also allocated to breeding ewes. The flock structure is outlined below.

Table A2: Flock structure of the sheep enterprise for the Pastoral zone farm with \$100,000–\$200,000 annual turnover.

Class	June	July	August	September	October	November	December	January	February	March	April	May
Breeding Ewes (with lamb during the period)	1,738	1,738	1,738	1,738	1,738	1,738	1,738	1,738	1,738	1,738	1,738	1,738
Maiden Ewes (1-2 yo to be joined next year)	50	50	50	50	50	50	50	50	50	50	50	50
Other Ewes (2 year & older not joined)	0	0	0	0	0	0	0	0	0	0	0	0
Lambs/Hoggets (Weaned - to 1 year old)	900	900	900	1,412	1,412	1,412	512	512	512	1,025	1,025	1,025
Rams	20	20	20	20	20	20	20	20	20	20	20	20
Wethers (more than 12 months old)	62	62	62	62	62	62	62	62	62	62	62	62
Total number of head per month	2,770	2,770	2,770	3,282	3,282	3,282	2,382	2,382	2,382	2,895	2,895	2,895
Total DSE's per month	4,188	4,188	4,188	4,495	4,495	4,495	3,955	3,955	3,955	4,263	4,263	4,263

Estimated greenhouse gas emissions from this enterprise are shown below, and outlined in the 'Revised' section of the FarmGAS Calculator because ABARES data is selected for the greenhouse gas calculations rather than NNGI defaults.

Table A3: Estimated greenhouse gas emissions for the Pastoral zone farm with \$100,000–\$200,000 annual turnover.

Revised Emissions	Tonnes /year	Total CO ₂ -e	/ Hectare	/ DSE	/ Ewe
<i>Methane (CH₄) from Enteric =</i>	14.17	297.60	0.50	0.07	0.17
<i>Methane (CH₄) from manure & urine =</i>	0.02	0.33	0.00	0.00	0.00
<i>Total Methane (CH₄) =</i>	14.19	297.94	0.50	0.07	0.17
<i>Nitrous Oxide (N₂O) from manure & urine =</i>	0.07	21.74	0.04	0.01	0.01
Total	319.68	0.53	0.08	0.18	

For the beef stores enterprise, it is assumed the steers are between 12 and 24 months, and those sold are sold in winter. The total number of store cattle on the property is 115 according to ABARES, as shown below.

Table A4: Herd structure of the beef stores enterprise for the Pastoral zone farm with \$100,000–\$200,000 annual turnover.

	Class/Age	June	July	August	September	October	November	December	January	February	March	April	May
Steers	12-24 months	115	115	90	90	90	90	90	90	90	90	90	90

Table A5: Estimated greenhouse gas emissions for the beef stores enterprise the Pastoral zone farm with \$100,000–\$200,000 annual turnover.

Revised Emissions	Tonnes /year	Total CO ₂ -e	/ Hectare	/ DSE	/ Head
<i>Methane (CH₄) from Enteric =</i>	8.42	176.80	1.77	0.23	1.88
<i>Methane (CH₄) from manure & urine =</i>	0.01	0.13	0.00	0.00	0.00
<i>Total Methane (CH₄) =</i>	8.43	176.93	1.77	0.23	1.88
<i>Nitrous Oxide (N₂O) from manure & urine =</i>	0.04	11.58	0.12	0.02	0.12
Total CO₂ e	188.51	1.89	0.25	2.00	

The total emissions for the farm are therefore a combination of those from the sheep and beef stores enterprises, estimated at 508.2 tonnes CO₂-e.

A.2. Pastoral zone sheep farm, gross turnover of \$400,000+ pa

Table A6: Revenue and expenditure – Pastoral zone, \$400,000+ turnover.

Expenditure Item	Amount (\$)	Revenue Item	Amount (\$)
Accounting services	–	Barley receipts	1,513
Advisory services	–	Beef cattle sold	51,104
Agistment	2,870	Canola receipts	–
AI stud fees and herd testing	–	Cotton receipts	–
Beef cattle purchased	23,404	Dairy cattle sold	–
Contracts – cropping	3,042	Field peas receipts	–
Contracts – livestock	11,065	Grain legumes receipts	425
Crop and pasture chemicals	2,311	Livestock transfers – outward	–
Dairy cattle purchased	–	Lupins receipts	–
Dairy supplies	–	Milk receipts excluding freight	–
Electricity	6,200	Other crop receipts	1,479
Fertiliser	1,613	Off-farm contracts	4,093
Fodder	14,765	Off-farm sharefarming	72
Freight	17,451	Oilseeds receipts	–
Fuel oil and grease	32,700	Other farm income	59,165
Handling and marketing	20,319	Other livestock sold	9,403
Insurance	–	Rice receipts	–
Interest paid	42,489	Sheep sold	168,127
Land rent	6,434	Sorghum receipts	–
Leasing charges	–	Total wool gross receipts	305,452
Livestock materials	–	Wheat receipts	10,521
Livestock transfers – inwards	–	Total revenue	611,354
Other administration expenses	19,799		
Other livestock purchased	14		
Other materials	–		
Other costs	59,511		
Payments to sharefarmers	2,472		
Produce purchased for resale	–		
Repairs and maintenance	54,106		
Seed	2,014		
Shearing crutching	72,387		
Sheep purchased	31,511		
Shire and PPB rates	12,374		
Stores and rations	7,117		
Telephone	–		
Vet fees	507		
Wages for hired labour	31,109		
Water charges	400		
Total costs	477,984		

Greenhouse emissions

Given this farm is in the pastoral region, it is assumed to be in the Channel Country region of Queensland. It is assumed that beef cattle enterprise is not a breeding enterprise, but rather beef stores purchased for fattening and sale. This is because the enterprise is sheep-specific, not mixed livestock.

ABARES data was provided on fertiliser use, with an average total tonnes of nitrogen fertiliser of 0.3 tonnes nitrogen. It is assumed that this nitrogen fertiliser is applied to pastures.

The ABARES data provides a total number of sheep at 11,406 head and details of how many sheep are bought and sold. However it does not provide detailed information in terms of when sheep are sold and which categories are sold or bought. In light of this, a flock structure is constructed using the information provided.

The total number of sheep for this enterprise is 11,406 total head at 30 June, which is assumed to be the starting month of analysis. With a lambing rate of 72% (provided by ABARES data) there are 5650 breeding ewes, 500 maiden ewes, 3000 weaned lambs, 2156 wethers and 100 rams on the farm. It is also assumed that sheep numbers are relatively constant, that is they are not affected by mortality rates.

According to NGGI default assumptions, in Queensland lambing is assumed to occur in spring and autumn in equal parts. Therefore 2034 lambs are assumed to be born in spring, 2034 in autumn. User-entered data is utilised in the FarmGAS Calculator rather than NGGI defaults, to ensure the emissions are estimated as closely as possible to the ABARES data rather than defaults.

The average wool produced is provided by ABARES data as 5 kg/head. This is assumed for all adult sheep, for lambs/hoggets it is assumed to be 2 kg/head.

In terms of sales and purchases, it is assumed that of the 3000 weaned lambs and hoggets available at the start of the calendar year, 2221 are sold in winter. The remaining sales (according to ABARES data) are allocated to other ewes, with purchases also allocated to ewes. The flock structure is outlined below.

Table A7: Flock structure of the Pastoral zone sheep enterprise with more than \$400,000 annual turnover.

Class	June	July	August	September	October	November	December	January	February	March	April	May
Breeding Ewes (with lamb during the period)	5,650	5,650	5,650	5,650	5,650	5,650	5,650	5,650	5,650	5,650	5,650	5,650
Maiden Ewes (1-2 yo to be joined next year)	500	500	500	500	500	500	500	500	500	500	500	500
Other Ewes (2 year & older not joined)	0	0	0	0	0	1,322	1,322	1,322	1,322	1,322	1,322	1,322
Lambs/Hoggets (Weaned - to 1 year old)	3,000	3,000	3,000	5,034	5,034	5,034	2,813	2,813	2,813	4,847	4,847	4,847
Rams	100	100	100	100	100	100	100	100	100	100	100	100
Wethers (more than 12 months old)	2,156	2,156	2,156	2,156	2,156	2,156	2,156	2,156	2,156	2,156	2,156	2,156
Total number of head per month	11,406	11,406	11,406	13,440	13,440	14,762	12,541	12,541	12,541	14,575	14,575	14,575
Total DSE's per month	16,056	16,056	16,056	17,276	17,276	18,863	17,530	17,530	17,530	18,751	18,751	18,751

Estimated greenhouse gas emissions from this enterprise are shown below, and outlined in the 'Revised' section of the FarmGAS Calculator because ABARES data is selected for the greenhouse gas calculations rather than NGGI defaults.

Table A8: Estimated greenhouse gas emissions for the Pastoral zone sheep enterprise with more than \$400,000 annual turnover.

Revised Emissions	Tonnes /year	Total CO ₂ -e	/ Hectare	/ DSE	/ Ewe
<i>Methane (CH₄) from Enteric =</i>	69.44	1,458.15	2.43	0.08	0.26
<i>Methane (CH₄) from manure & urine =</i>	0.08	1.64	0.00	0.00	0.00
<i>Total Methane (CH₄) =</i>	69.51	1,459.79	2.43	0.08	0.26
<i>Nitrous Oxide (N₂O) from manure & urine =</i>	0.36	111.50	0.19	0.01	0.02
Total	1,571.29		2.62	0.09	0.28

For the beef stores enterprise, it is assumed the steers are between 12 and 24 months, and those sold are sold at the end of winter. The total number of store cattle on the property is 402 according to ABARES, as shown below.

Table A9: Estimated greenhouse gas emissions for the Pastoral zone sheep enterprise with more than \$400,000 annual turnover.

Revised Emissions	Tonnes /year	Total CO ₂ -e	/ Hectare	/ DSE	/ Head
<i>Methane (CH₄) from Enteric =</i>	32.45	681.35	6.81	0.23	1.88
<i>Methane (CH₄) from manure & urine =</i>	0.02	0.50	0.01	0.00	0.00
<i>Total Methane (CH₄) =</i>	32.47	681.86	6.82	0.23	1.88
<i>Nitrous Oxide (N₂O) from manure & urine =</i>	0.15	44.97	0.45	0.02	0.12
Total CO₂ e		726.83	7.27	0.25	2.00

Total estimated emissions from the farm include estimated emissions from the sheep and beef stores enterprises, plus emissions estimated from nitrogen fertiliser application to pastures. Emissions from pastures are estimated to be 0.7 tonnes CO₂-e. Therefore the total emissions for this farm are estimated to be 2298.8 tonnes CO₂-e.

A.3. High Rainfall zone sheep farm, gross annual turnover \$100,000–\$200,000 pa

Table A10: Revenue and expenditure – High Rainfall zone, \$100,000–\$200,000 turnover.

Expenditure Item	Amount (\$)	Revenue Item	Amount (\$)
Accounting services	–	Barley receipts	584
Advisory services	–	Beef cattle sold	18,603
Agistment	201	Canola receipts	–
AI stud fees and herd testing	–	Cotton receipts	–
Beef cattle purchased	3,180	Dairy cattle sold	–
Contracts – cropping	2,840	Field peas receipts	–
Contracts – livestock	627	Grain legumes receipts	42
Crop and pasture chemicals	2,295	Livestock transfers – outward	–
Dairy cattle purchased	–	Lupins receipts	–
Dairy supplies	–	Milk receipts excluding freight	–
Electricity	1,555	Other crop receipts	2,790
Fertiliser	10,023	Off-farm contracts	1,187
Fodder	7,747	Off-farm sharefarming	–
Freight	2,462	Oilseeds receipts	1,286
Fuel oil and grease	8,076	Other farm income	5,260
Handling and marketing	5,148	Other livestock sold	–
Insurance	–	Rice receipts	–
Interest paid	11,091	Sheep sold	63,540
Land rent	3,118	Sorghum receipts	–
Leasing charges	–	Total wool gross receipts	53,381
Livestock materials	–	Wheat receipts	576
Livestock transfers – inwards	–	Total revenue	147,249
Other administration expenses	5,700		
Other livestock purchased	–		
Other materials	–		
Other costs	17,660		
Payments to sharefarmers	–		
Produce purchased for resale	–		
Repairs and maintenance	10,904		
Seed	1,530		
Shearing crutching	9,368		
Sheep purchased	6,990		
Shire and PPB rates	5,082		
Stores and rations	16		
Telephone	–		
Vet fees	928		
Wages for hired labour	2,448		
Water charges	151		
Processor cost	–		
Total costs	119,140		

Greenhouse emissions

It is assumed this high rainfall farm is located in the East Gippsland region of Victoria. It is assumed that the beef cattle enterprise is not a breeding enterprise, but rather beef stores purchased for fattening and sale. This is because the enterprise is sheep-specific, not mixed livestock.

ABARES data was provided on fertiliser use, with an average total tonnes of nitrogen fertiliser of 1.12 tonnes nitrogen. It is assumed that this nitrogen fertiliser is applied to pastures.

The ABARES data provides a total number of sheep at 2182 head and details of how many sheep are bought and sold. However it does not provide detailed information in terms of when sheep are sold and which categories are sold or bought. In light of this, a flock structure is constructed using the information provided.

The total number of sheep for this enterprise is 2182 total head at 30 June, which is assumed to be the starting month of analysis. With a lambing rate of 82% (provided by ABARES data) there are 1151 breeding ewes, 181 maiden ewes, 600 weaned lambs, 200 wethers and 50 rams on the farm at the start of the period of analysis. It is also assumed that sheep numbers are relatively constant, that is they are not affected by mortality rates.

According to NNGI default assumptions, in Victoria lambing is assumed to occur at the following rates: 25% in spring, 8% in summer, 21% in autumn, 29% in winter. A total of 944 lambs are assumed to be born across the year. User-entered data is utilised in the FarmGAS Calculator rather than NNGI defaults, to ensure the emissions are estimated as closely as possible to the ABARES data rather than defaults.

The average wool produced is provided by ABARES data as 3.8 kg/head. This is assumed for all adult sheep, for lambs/hoggets it is assumed to be 2 kg/head.

In terms of sales and purchases, ABARE data indicates 974 sheep are sold and 79 purchased throughout the year. The flock structure is outlined below.

Table A11: Flock structure of the sheep enterprise for a farm with \$100,000–\$200,000 annual turnover in the High Rainfall zone of Australia.

Class	June	July	August	September	October	November	December	January	February	March	April	May
Breeding Ewes (with lamb during the period)	1,151	1,151	1,151	1,151	1,151	1,151	1,151	1,151	1,151	1,151	1,151	958
Maiden Ewes (1-2 yo to be joined next year)	181	181	181	181	0	0	0	0	0	0	0	79
Other Ewes (2 year & older not joined)	0	0	0	0	0	0	0	0	0	0	0	0
Lambs/Hoggets (Weaned - to 1 year old)	600	933	933	1,220	1,220	1,020	912	912	912	1,153	1,153	1,153
Rams	50	50	50	50	50	50	50	50	50	50	50	50
Wethers (more than 12 months old)	200	200	200	200	200	0	0	0	0	0	0	0
Total number of head per month	2,182	2,515	2,515	2,802	2,621	2,221	2,113	2,113	2,113	2,354	2,354	2,240
Total DSE's per month	3,193	3,393	3,393	3,565	3,384	3,064	2,999	2,999	2,999	3,144	3,144	2,837

Table A12: Estimated greenhouse gas emissions for the sheep enterprise for a farm with \$100,000–\$200,000 annual turnover in the High Rainfall zone of Australia.

Revised Emissions	Tonnes /year	Total CO ₂ -e	/ Hectare	/ DSE	/ Ewe
<i>Methane (CH₄) from Enteric =</i>	14.44	303.22	0.51	0.10	0.27
<i>Methane (CH₄) from manure & urine =</i>	0.00	0.07	0.00	0.00	0.00
<i>Total Methane (CH₄) =</i>	14.44	303.30	0.51	0.10	0.27
<i>Nitrous Oxide (N₂O) from manure & urine =</i>	0.19	59.77	0.10	0.02	0.05
Total	363.06	363.06	0.61	0.11	0.32

The emissions from the sheep enterprise are estimated to be 363.06 tonnes CO₂-e.

For the beef stores enterprise, it is assumed the steers are between 12 and 24 months in age, with 76 head at June 30 and 5 steers bought and 32 sold in November.

The estimated emissions from the stores enterprise are 123.03 tonnes CO₂-e.

Table A13: Estimated greenhouse gas emissions for the beef stores enterprise for a farm with \$100,000–\$200,000 annual turnover in the High Rainfall zone of Australia.

Revised Emissions	Tonnes /year	Total CO ₂ -e	/ Hectare	/ DSE	/ Head
<i>Methane (CH₄) from Enteric =</i>	4.73	99.39	0.99	0.21	1.65
<i>Methane (CH₄) from manure & urine =</i>	0.00	0.02	0.00	0.00	0.00
<i>Total Methane (CH₄) =</i>	4.73	99.40	0.99	0.21	1.65
<i>Nitrous Oxide (N₂O) from manure & urine =</i>	0.08	23.62	0.24	0.05	0.39
Total CO₂ e	123.03	123.03	1.23	0.26	2.04

It is estimated that 4.8 tonnes of CO₂-e are generated from the nitrogen fertiliser application to pastures. The total emissions for the farm are therefore estimated to be 490.9 tonnes CO₂-e.

A.4. High Rainfall zone sheep farm, gross annual turnover \$400,000+ pa

Table A14: Revenue and expenditure – High Rainfall zone, \$400,000+ turnover.

Expenditure Item	Amount (\$)	Revenue Item	Amount (\$)
Accounting services	–	Barley receipts	5,984
Advisory services	–	Beef cattle sold	126,989
Agistment	3,018	Canola receipts	–
AI stud fees and herd testing	–	Cotton receipts	–
Beef cattle purchased	22,835	Dairy cattle sold	–
Contracts – cropping	12,996	Field peas receipts	–
Contracts – livestock	2,785	Grain legumes receipts	1,033
Crop and pasture chemicals	13,194	Livestock transfers – outward	–
Dairy cattle purchased	–	Lupins receipts	–
Dairy supplies	–	Milk receipts excluding freight	–
Electricity	4,772	Other crop receipts	17,456
Fertiliser	50,236	Off-farm contracts	3,477
Fodder	34,120	Off-farm sharefarming	1,586
Freight	13,555	Oilseeds receipts	11,965
Fuel oil and grease	26,805	Other farm income	29,123
Handling and marketing	23,641	Other livestock sold	274
Insurance	–	Rice receipts	–
Interest paid	54,886	Sheep sold	266,819
Land rent	12,690	Sorghum receipts	–
Leasing charges	–	Total wool gross receipts	243,762
Livestock materials	–	Wheat receipts	9,038
Livestock transfers – inwards	–	Total revenue	717,506
Other administration expenses	18,720		
Other livestock purchased	20		
Other materials	–		
Other costs	69,925		
Payments to sharefarmers	1,300		
Produce purchased for resale	–		
Repairs and maintenance	40,905		
Seed	5,972		
Shearing crutching	46,520		
Sheep purchased	38,833		
Shire and PPB rates	15,606		
Stores and rations	162		
Telephone	–		
Vet fees	2,615		
Wages for hired labour	37,426		
Water charges	519		
Total costs	554,056		

Greenhouse emissions

It is assumed this high rainfall farm is located in the East Gippsland region of Victoria. It is assumed that the beef cattle enterprise is not a breeding enterprise, but rather beef stores purchased for fattening and sale. This is because the enterprise is sheep-specific, not mixed livestock.

ABARES data was provided on fertiliser use, with an average total tonnes of nitrogen fertiliser of 6.43 tonnes nitrogen. It is assumed that this nitrogen fertiliser is applied to pastures.

The ABARES data provides a total number of sheep at 8077 head and details of how many sheep are bought and sold. However it does not provide detailed information in terms of when sheep are sold and which categories are sold or bought. In light of this, a flock structure is constructed using the information provided.

The total number of sheep for this enterprise is 8077 total head at 30 June, which is assumed to be the starting month of analysis. With a lambing rate of 89% (provided by ABARES data) there are 4100 breeding ewes, 777 maiden ewes, 2000 weaned lambs, 1000 wethers and 200 rams on the farm at the start of the period of analysis. It is also assumed that sheep numbers are relatively constant, that is they are not affected by mortality rates.

According to NGGI default assumptions, in Victoria lambing is assumed to occur at the following rates: 25% in spring, 8% in summer, 21% in autumn, 29% in winter. A total of 3649 lambs are assumed to be born across the year. User-entered data is utilised in the FarmGAS Calculator rather than NGGI defaults, to ensure the emissions are estimated as closely as possible to the ABARES data rather than defaults.

The average wool produced is provided by ABARES data as 4 kg/head. This is assumed for all adult sheep, for lambs/hoggets it is assumed to be 2 kg/head.

In terms of sales and purchases, ABARE data indicates 3700 sheep are sold and 463 purchased throughout the year. The flock structure is outlined below.

Table A15: Flock structure of the sheep enterprise for the High Rainfall zone farm with more than \$400,000 annual turnover.

Class	June	July	August	September	October	November	December	January	February	March	April	May
Breeding Ewes (with lamb during the period)	4,100	4,100	4,100	4,100	4,100	4,100	4,100	4,100	4,100	4,100	4,100	2,563
Maiden Ewes (1-2 yo to be joined next year)	777	777	777	777	777	777	777	777	777	777	777	777
Other Ewes (2 year & older not joined)	0	0	0	0	0	0	0	0	0	0	0	0
Lambs/Hoggets (Weaned - to 1 year old)	2,000	3,189	3,189	4,214	4,214	4,214	4,542	4,542	4,542	4,403	4,403	4,403
Rams	200	200	200	200	200	200	200	200	200	200	200	200
Wethers (more than 12 months old)	1,000	1,000	300	300	300	300	300	300	300	300	300	300
Total number of head per month	8,077	9,266	8,566	9,591	9,591	9,591	9,919	9,919	9,919	9,780	9,780	8,243
Total DSE's per month	11,777	12,490	11,790	12,405	12,405	12,405	12,602	12,602	12,602	12,519	12,519	9,445

The estimated emissions from the sheep enterprise are 1430.81 tonnes CO₂-e.

Table A16: Estimated greenhouse gas emissions for the High Rainfall zone farm with more than \$400,000 annual turnover.

Revised Emissions	Tonnes /year	Total CO ₂ -e	/ Hectare	/ DSE	/ Ewe
<i>Methane (CH₄) from Enteric =</i>	57.09	1,198.88	2.00	0.10	0.30
<i>Methane (CH₄) from manure & urine =</i>	0.01	0.30	0.00	0.00	0.00
<i>Total Methane (CH₄) =</i>	57.10	1,199.18	2.00	0.10	0.30
<i>Nitrous Oxide (N₂O) from manure & urine =</i>	0.75	231.63	0.39	0.02	0.06
Total	1,430.81	2.38	0.12	0.36	

For the beef stores, ABARES data indicates a total of 433 head at June 30, which are assumed to be steers between 12 and 24 months. In November, 35 steers are purchased and 170 are sold.

Table A17: Herd structure of the beef stores enterprise for the High Rainfall zone farm with more than \$400,000 annual turnover.

Two mobs may be selected	Class/Age	June	July	August	September	October	November	December	January	February	March	April	May
Steers	12-24 months	433	433	433	433	433	298	298	298	298	298	298	298

The estimated emissions from the beef stores enterprise are 720.13 tonnes CO₂-e.

Table A18: Estimated greenhouse gas emissions for the beef stores enterprise for the High Rainfall zone farm with more than \$400,000 annual turnover.

Revised Emissions	Tonnes /year	Total CO ₂ -e	/ Hectare	/ DSE	/ Head
<i>Methane (CH₄) from Enteric =</i>	27.75	582.75	5.83	0.21	1.65
<i>Methane (CH₄) from manure & urine =</i>	0.00	0.09	0.00	0.00	0.00
<i>Total Methane (CH₄) =</i>	27.75	582.85	5.83	0.21	1.65
<i>Nitrous Oxide (N₂O) from manure & urine =</i>	0.44	137.28	1.37	0.05	0.39
Total CO₂ e	720.13	7.20	0.25	2.03	

Emissions from the application of nitrogen fertiliser to pastures is estimated to generate 27.4 tonnes CO₂-e. Therefore the total emissions estimated for the whole farm are 2178.3 tonnes CO₂-e.

A.5. Wheat/Sheep zone sheep farm, gross annual turnover \$100,000–\$200,000 pa

Table A19: Revenue and expenditure – Wheat/Sheep zone, \$100,000–\$200,000 turnover.

Expenditure Item	Amount (\$)	Revenue Item	Amount (\$)
Accounting services	–	Barley receipts	3,276
Advisory services	–	Beef cattle sold	7,288
Agistment	553	Canola receipts	–
AI stud fees and herd testing	–	Cotton receipts	–
Beef cattle purchased	1,726	Dairy cattle sold	–
Contracts – cropping	4,020	Field peas receipts	–
Contracts – livestock	528	Grain legumes receipts	129
Crop and pasture chemicals	5,454	Livestock transfers – outward	–
Dairy cattle purchased	–	Lupins receipts	–
Dairy supplies	–	Milk receipts excluding freight	–
Electricity	2,070	Other crop receipts	3,258
Fertiliser	12,855	Off-farm contracts	1,242
Fodder	5,757	Off-farm sharefarming	379
Freight	3,339	Oilseeds receipts	628
Fuel oil and grease	11,864	Other farm income	10,447
Handling and marketing	5,206	Other livestock sold	21
Insurance	–	Rice receipts	42
Interest paid	15,890	Sheep sold	70,226
Land rent	2,335	Sorghum receipts	–
Leasing charges	–	Total wool gross receipts	44,931
Livestock materials	–	Wheat receipts	9,758
Livestock transfers – inwards	–	Total revenue	151,625
Other administration expenses	7,834		
Other livestock purchased	7		
Other materials	–		
Other costs	16,027		
Payments to sharefarmers	703		
Produce purchased for resale	–		
Repairs and maintenance	13,267		
Seed	1,408		
Shearing crutching	8,925		
Sheep purchased	8,941		
Shire and PPB rates	5,206		
Stores and rations	71		
Telephone	–		
Vet fees	617		
Wages for hired labour	1,905		
Water charges	1,899		
Total costs	138,407		

Greenhouse emissions

Given this farm is in the wheat/sheep region, it is assumed to be in the central wheat belt of Western Australia. It is assumed that the beef cattle enterprise is not a breeding enterprise, but rather beef stores purchased for fattening and sale. This is because the enterprise is sheep-specific, not mixed livestock.

ABARES data was provided on fertiliser use, with an average total tonnes of nitrogen fertiliser of 1.74 tonnes nitrogen. It is assumed that this nitrogen fertiliser is applied to pastures.

The ABARES data provides a total number of sheep at 1854 head and details of how many sheep are bought and sold. However it does not provide detailed information in terms of when sheep are sold and which categories are sold or bought. In light of this, a flock structure is constructed using the information provided.

The total number of sheep for this enterprise is 1854 total head at 30 June, which is assumed to be the starting month of analysis. With a lambing rate of 81% (provided by ABARES data) there are 1046 breeding ewes, 50 maiden ewes, 600 weaned lambs, 98 wethers and 60 rams on the farm at the start of the period of analysis. It is also assumed that sheep numbers are relatively constant, that is they are not affected by mortality rates.

According to NNGI default assumptions, in Western Australia lambing is assumed to occur at the following rates: 12% in spring, 8% in summer, 12% in autumn, 46% in winter. A total of 847 lambs are assumed to be born across the year. User-entered data is utilised in the FarmGAS Calculator rather than NNGI defaults, to ensure the emissions are estimated as closely as possible to the ABARES data rather than defaults.

The average wool produced is provided by ABARES data as 4 kg/head. This is assumed for all adult sheep, for lambs/hoggets it is assumed to be 2 kg/head.

In terms of sales and purchases, ABARE data indicates 1005 sheep are sold. All the weaned hoggets and lambs are sold, all the maiden ewes, all the other ewes and 500 of the breeding ewes are sold in January. The flock structure is outlined below.

Table A20: Flock structure of the sheep enterprise for a farm with \$100,000–\$200,000 annual turnover in the Wheat/Sheep zone of Australia.

Class	June	July	August	September	October	November	December	January	February	March	April	May
Breeding Ewes (with lamb during the period)	1,046	1,046	1,046	1,046	1,046	1,046	1,046	446	446	446	446	446
Maiden Ewes (1-2 yo to be joined next year)	50	50	50	50	50	0	0	0	0	0	0	0
Other Ewes (2 year & older not joined)	0	0	114	114	114	0	0	0	0	0	0	0
Lambs/Hoggets (Weaned - to 1 year old)	600	1,089	856	989	989	489	581	581	581	714	714	714
Rams	60	60	60	60	60	60	60	60	60	60	60	60
Wethers (more than 12 months old)	98	98	98	98	98	98	98	98	98	98	98	98
Total number of head per month	1,854	2,343	2,224	2,357	2,357	1,693	1,785	1,185	1,185	1,318	1,318	1,318
Total DSE's per month	2,780	3,073	3,070	3,150	3,150	2,663	2,719	1,519	1,519	1,598	1,598	1,598

Table A21: Estimated greenhouse gas emissions for the sheep enterprise for a farm with \$100,000–\$200,000 annual turnover in the Wheat/Sheep zone of Australia.

Revised Emissions	Tonnes /year	Total CO ₂ -e	/ Hectare	/ DSE	/ Ewe
<i>Methane (CH₄) from Enteric =</i>	11.04	231.77	0.39	0.10	0.29
<i>Methane (CH₄) from manure & urine =</i>	0.00	0.05	0.00	0.00	0.00
<i>Total Methane (CH₄) =</i>	11.04	231.82	0.39	0.10	0.29
<i>Nitrous Oxide (N₂O) from manure & urine =</i>	0.20	62.27	0.10	0.03	0.08
Total	294.09	294.09	0.49	0.12	0.37

A total of 294.09 tonnes CO₂-e are estimated to be generated by the sheep enterprise.

For the beef stores enterprise, below is the herd structure used, and estimated greenhouse gas emissions.

Table A22: Herd structure of the beef stores enterprise for a farm with \$100,000–\$200,000 annual turnover in the Wheat/Sheep zone of Australia.

	Class/Age	June	July	August	September	October	November	December	January	February	March	April	May
Steers	12-24 months	36	36	27	27	27	27	27	27	27	27	27	27

Table A23: Estimated greenhouse gas emissions for the beef stores enterprise for a farm with \$100,000–\$200,000 annual turnover in the Wheat/Sheep zone of Australia.

Revised Emissions	Tonnes /year	Total CO ₂ -e	/ Hectare	/ DSE	/ Head
<i>Methane (CH₄) from Enteric =</i>	1.98	41.59	0.42	0.18	1.46
<i>Methane (CH₄) from manure & urine =</i>	0.00	0.01	0.00	0.00	0.00
<i>Total Methane (CH₄) =</i>	1.98	41.60	0.42	0.18	1.46
<i>Nitrous Oxide (N₂O) from manure & urine =</i>	0.03	8.52	0.09	0.04	0.30
Total CO₂ e	50.12	50.12	0.50	0.22	1.76

A total of 50.12 tonnes CO₂-e are estimated for the beef stores enterprise.

7.2 tonnes CO₂-e are estimated to be generated from the nitrogen fertiliser applied to pastures. In total, the emissions from the whole farm are 351.41 tonnes CO₂-e.

A.6. Wheat/Sheep zone sheep farm, gross annual turnover \$400,000 pa

Table A24: Revenue and expenditure – Wheat/Sheep zone, \$400,000+ turnover.

Expenditure Item	Amount (\$)	Revenue Item	Amount (\$)
Accounting services	–	Barley receipts	27,930
Advisory services	–	Beef cattle sold	50,174
Agistment	5,514	Canola receipts	–
AI stud fees and herd testing	–	Cotton receipts	–
Beef cattle purchased	14,541	Dairy cattle sold	–
Contracts – cropping	18,741	Field peas receipts	–
Contracts – livestock	3,695	Grain legumes receipts	1,877
Crop and pasture chemicals	25,343	Livestock transfers – outward	–
Dairy cattle purchased	–	Lupins receipts	–
Dairy supplies	–	Milk receipts excluding freight	–
Electricity	5,097	Other crop receipts	18,735
Fertiliser	65,461	Off-farm contracts	9,220
Fodder	32,235	Off-farm sharefarming	2,021
Freight	21,871	Oilseeds receipts	22,216
Fuel oil and grease	42,001	Other farm income	40,043
Handling and marketing	23,152	Other livestock sold	2,072
Insurance	–	Rice receipts	–
Interest paid	72,798	Sheep sold	292,096
Land rent	12,375	Sorghum receipts	55
Leasing charges	–	Total wool gross receipts	222,304
Livestock materials	–	Wheat receipts	71,976
Livestock transfers – inwards	–	Total revenue	760,719
Other administration expenses	17,469		
Other livestock purchased	17		
Other materials	–		
Other costs	61,289		
Payments to sharefarmers	2,717		
Produce purchased for resale	–		
Repairs and maintenance	46,852		
Seed	7,099		
Shearing crutching	52,439		
Sheep purchased	57,549		
Shire and PPB rates	14,991		
Stores and rations	1,000		
Telephone	–		
Vet fees	1,556		
Wages for hired labour	30,681		
Water charges	2,236		
Total costs	638,719		

Greenhouse emissions

Given this farm is in the wheat/sheep region, it is assumed to be in the central wheat belt of Western Australia. It is assumed that the beef cattle enterprise is not a breeding enterprise, but rather beef stores purchased for fattening and sale. This is because the enterprise is sheep-specific, not mixed livestock.

ABARES data was provided on fertiliser use, with an average total tonnes of nitrogen fertiliser of 10.2 tonnes nitrogen. It is assumed that this nitrogen fertiliser is applied to pastures.

The ABARES data provides a total number of sheep at 1854 head and details of how many sheep are bought and sold. However it does not provide detailed information in terms of when sheep are sold and which categories are sold or bought. In light of this, a flock structure is constructed using the information provided.

The total number of sheep for this enterprise is 7660 total head at 30 June, which is assumed to be the starting month of analysis. With a lambing rate of 81% (provided by ABARES data) there are 4193 breeding ewes, 300 maiden ewes, 2000 weaned lambs, 967 wethers and 200 rams on the farm at the start of the period of analysis. It is also assumed that sheep numbers are relatively constant, that is they are not affected by mortality rates.

According to NGGI default assumptions, in Western Australia lambing is assumed to occur at the following rates: 12% in spring, 8% in summer, 12% in autumn, 46% in winter. A total of 3396 lambs are assumed to be born across the year. User-entered data is utilised in the FarmGAS Calculator rather than NGGI defaults, to ensure the emissions are estimated as closely as possible to the ABARES data rather than defaults.

The average wool produced is provided by ABARES data as 4.4 kg/head. This is assumed for all adult sheep, for lambs/hoggets it is assumed to be 2 kg/head.

In terms of sales and purchases, ABARE data indicates 4113 sheep are sold and 893 purchased throughout the year. The flock structure is outlined below.

Table A25: Flock structure of the sheep enterprise for the Wheat/Sheep zone farm with \$400,000+ annual turnover.

Class	June	July	August	September	October	November	December	January	February	March	April	May
Breeding Ewes (with lamb during the period)	4,193	4,193	4,193	4,193	4,193	4,193	4,193	4,193	4,193	4,193	4,193	4,193
Maiden Ewes (1-2 yo to be joined next year)	300	300	1,193	1,193	1,193	193	193	193	193	193	193	193
Other Ewes (2 year & older not joined)	0	0	0	0	0	0	0	0	0	0	0	0
Lambs/Hoggets (Weaned - to 1 year old)	2,000	3,929	1,929	2,432	2,432	2,432	2,767	2,767	2,767	3,270	3,124	3,124
Rams	200	200	200	200	200	200	200	200	200	200	200	200
Wethers (more than 12 months old)	967	967	967	967	967	0	0	0	0	0	0	0
Total number of head per month	7,660	9,589	8,482	8,985	8,985	7,018	7,353	7,353	7,353	7,856	7,710	7,710
Total DSE's per month	11,453	12,610	12,303	12,605	12,605	10,638	10,839	10,839	10,839	11,141	11,053	11,053

Table A26: Estimated greenhouse gas emissions for the sheep enterprise for the Wheat/Sheep zone farm with \$400,000+ annual turnover.

Revised Emissions	Tonnes /year	Total CO ₂ -e	/ Hectare	/ DSE	/ Ewe
<i>Methane (CH₄) from Enteric =</i>	50.75	1,065.70	1.78	0.09	0.25
<i>Methane (CH₄) from manure & urine =</i>	0.01	0.22	0.00	0.00	0.00
<i>Total Methane (CH₄) =</i>	50.76	1,065.92	1.78	0.09	0.25
<i>Nitrous Oxide (N₂O) from manure & urine =</i>	0.92	286.15	0.48	0.02	0.07
Total	1,352.07		2.25	0.12	0.32

The estimated emissions from the sheep enterprise are 1352.07 tonnes CO₂-e.

For the beef stores enterprise, ABARES data indicates 149 head of cattle are present at 30 June, with 25 bought and 70 sold in November.

Table A27: Herd structure of the beef stores enterprise for the Wheat/Sheep zone farm with \$400,000+ annual turnover.

Two mobs may be selected	Class/Age	June	July	August	September	October	November	December	January	February	March	April	May
Steers	12-24 months	149	149	149	149	149	104	104	104	104	104	104	104

Table A28: Estimated greenhouse gas emissions for the beef stores enterprise for the Wheat/Sheep zone farm with \$400,000+ annual turnover.

Revised Emissions	Tonnes /year	Total CO ₂ -e	/ Hectare	/ DSE	/ Head
<i>Methane (CH₄) from Enteric =</i>	8.73	183.24	1.83	0.19	1.49
<i>Methane (CH₄) from manure & urine =</i>	0.00	0.03	0.00	0.00	0.00
<i>Total Methane (CH₄) =</i>	8.73	183.27	1.83	0.19	1.49
<i>Nitrous Oxide (N₂O) from manure & urine =</i>	0.12	38.73	0.39	0.04	0.32
Total CO₂ e	222.00		2.22	0.23	1.81

The estimated emissions from the beef stores enterprise are 222 tonnes CO₂-e.

From the application of nitrogen fertiliser to pastures, emissions are estimated to be 43.6 tonnes CO₂-e. Therefore the total emissions from the farm are estimated to be 1617.6 tonnes CO₂-e.

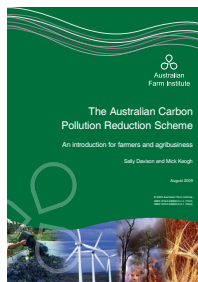
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