Chapter 3

Challenges and opportunities for current and future farm enterprises

Introduction

3.1 Submissions and evidence to the Inquiry emphasised the innovative nature of Australian farmers in working with a variable climate:

> The Australian agricultural sector is one of the most efficient and well-managed in the world. Australian farmers, given the volatility of climatic conditions and the landscape have become highly experienced at land and water management practices. They continue to innovate in terms of land management practices, with due consideration of their operations towards sustainable and environment best practice.[1]

3.2 This chapter discusses the opportunities and challenges that climate change presents to the Australian agricultural sector. The chapter starts with a discussion of adaptation by Australian agricultural enterprises to climate change. The discussion then turns to opportunities and challenges for the agricultural sector in relation to mitigating and offsetting greenhouse gas emissions. The chapter concludes with a brief consideration of assessing mitigation and adaptation strategies to avoid perverse outcomes.

Adapting to climate change

3.3 During the course of the Inquiry, the committee was told of the prospects of the Australian agricultural sector to adapt to climate change. The submission of the Agricultural Alliance on Climate Change (AACC) noted that 'some production activities will be better able than others to respond; generally speaking it will be the more intensive activities that are more capable of adapting to a changing climate'.[2] The AACC's submission went on to state:

> Policies that support farmers to adapt to and build in resilience to climate change impacts are preferred to those that prescribe certain areas of the landscape unsuitable for agricultural industries.[3]

---

1 Westpac Banking Corporation, *Submission 28*, p. 2. See also: National Farmers' Federation (NFF), *Submission 24*, p. 5; Department of Agricultural, Fisheries and Forestry and the Department of Climate Change (DAFF/DCC), *Submission 34*, p. 10; and Mr Tim Wiley, *Committee Hansard*, 30 June 2008, p. 39.

2 *Submission 37*, p. 8, quoting from J. Sherrard, A. Tate and N. Boele: *Agricultural Alliance on Climate Change: Issues Paper*, July 2007. Available at: http://www.climateinstitute.org.au/images/stories/agribusinesspaper.pdf, accessed 12 November 2008.

3 *Submission 37*, p. 10.

3.4 In contrast, Mr Ian Bowie noted that the Australian agricultural sector 'has gone so far already in adapting to climates that are normally dry, often hot and subject to extremes of drought, flood, fire and plagues and it is hard to see where further it may go'.[4]

3.5 In its submission, the Commonwealth Scientific and Industrial Research Organisation (CSIRO) highlighted that the uncertainty associated with projecting future climate means that adaptation to climate change will need to take a flexible, risk-based approach that incorporates future uncertainty and provides strategies that will be able to cope with a range of possible local climate changes:

> Initial efforts in preparing adaptation strategies should focus on equipping primary producers with alternative adaptation options suitable for the range of uncertain future climate changes and the capacity to evaluate and implement these as needed, rather than focussing too strongly yet on exactly where and when these impacts and adaptations will occur.
>
> Adaptation measures will have to reflect and enhance current 'best-practices' designed to cope with adverse conditions such as drought. Marginal production areas are amongst the most vulnerable and will likely be amongst the first areas in which the impacts of climate change will exceed adaptive capacity.[5]

3.6 The joint submission of the Department of Agriculture, Fisheries and Forestry (DAFF) and Department of Climate Change (DCC) outlined some of the decision making tools being developed to assist farmers to manage climate risks. For example the *Managing Climate Variability Program* (MCVP) which aims to enhance adaptation responses to a variable climate:

> The program's top priority is to provide more accurate and reliable climate information, forecasts and tools to enable farmers and natural resource managers to reduce their exposure to risk from climate change …
>
> The MCVP has contributed to the development of seasonal climate forecasting tools that assist managers to make decisions which maximise climate opportunities and reduce costs in poor seasons.[6]

---

4 *Submission 2*, p. 4.

5 *Submission 32*, p. 4. The CSIRO's submission draws heavily from a report the Commonwealth Scientific and Industrial Research Organisation (CSIRO) prepared for Land & Water Australia: C.J. Stokes and S.M. Howden (eds), *Overview of climate change adaptation in the Australian agricultural sector*, February 2008. Available at: http://www.csiro.au/resources/AgricultureAdaptationReport2008.html#1, accessed 12 November 2008. See also: Bureau of Rural Sciences, *Farming profitably in a changing climate: a risk-management approach*, February 2006, p. 7. Available at: http://affashop.gov.au/product.asp?prodid=13353, accessed 14 November 2008; and Victorian Department of Primary Industries, *Submission 27*, p. 14.

6 *Submission 34*, p. 13. See also: Bureau of Meteorology, *Submission 7*, pp 5-6.

3.7 In its Interim Report the committee noted the need for downscaling of climate projections to a local level to be of greater use to farmers. The committee also noted the need for improved communication of climate projections to farmers and others in the agricultural sector.[7] As the committee heard during the course of the Inquiry, the availability of this type of information is a key factor in assisting farmers to manage the risks of climate change. Mr Hamish Munro, a Councillor of the Cattle Council of Australia described for the committee the importance of being able to access reliable long term projections:

> Some of the climate models that you can readily access on the internet at the moment are quite good for one or two days, but I think we need more research into longer term models because, for websites, anything that is seven to 10 days is merely speculative for them. They are not close to what actually happens within that short time frame. I think we need to be able to progress having these short-term models and work through to longer-term models so that we can actually predict some of these impacts on pastures, animal production and also what ramifications climate change is going to have for consumers as well as producers.[8]

3.8 To this end, the committee was also told about the development of better information systems which would provide farmers with a more comprehensive suite of information on which to make management decisions. The Bureau of Meteorology discussed the concept of a 'Climate Projections Online' database, which could be a key resource in improving risk management:

> Such a database would have the ability to provide a wealth of information from several models, enabling better estimations of risk than by using one model alone, and hence improve risk management. Such a future climate database is a key to planning adaptation in the longer term for all primary industry and natural resource managers. Such a detailed database has already been developed for the United States.[9]

3.9 Ms Nicolette Boele of the AACC suggested the establishment of an agency to coordinate the types of data farmers will require for making management decisions:

> To give one example, the Bureau of Meteorology is a fabulous organisation that is permanently funded to provide data about weather – and now they have the carriage of some water issues. What we do not have is a bureau of environmental observation and forecasting or something which looks at permanent, ongoing methodologically consistent soil sampling, as an example, across the jurisdictions – a central data repository, something which could even assist in the delivery of drought assistance. It could help farmers with information about the commodities or their sectors, how the soils are changing over time and how the ecosystems are working in their

---

7 Senate Rural and Regional Affairs and Transport Committee, *Climate change and the Australian agricultural sector: Interim Report* (Interim Report), September 2008, p. 13.

8 *Committee Hansard*, 1 July 2008, p. 4.

9 *Submission 7*, p. 6.

> areas. We do not have that. We would actually come in line with most [Organisation for Economic Cooperation and Development] countries in having something like that. I have looked at the system in the Netherlands; it could be something we could use here in Australia. That sort of body would be invaluable to helping those agricultural industries … understand what is happening on their land and how they should be changing what they do and over what time period.[10]

3.10 The committee was told of a number of approaches that are available to farmers in order to adapt to changing climate conditions. For the purposes of discussion, the committee has divided these approaches into three categories:

- adapting current farming enterprises to suit new climate conditions;
- building resilient farm management systems; and
- diversifying farming options.

3.11 Each of these strategies is discussed below.

Adapting current farming enterprises to changing climate conditions

3.12 There are a number of adaptive strategies available to agricultural enterprises to assist in adapting to changing climate conditions. Some examples put before the committee include: increasing water use efficiency; selecting cultivars, species and breeds to suit changing climate conditions; and moving production as climate shifts.

Increasing water use efficiency

3.13 Increased competition for water resources means that farming enterprises will need to improve water use efficiency in order to adapt to climate change.[11]

3.14 Horticulture is a prime example of an industry which will need to improve water use efficiency in order to remain viable in a changing climate. The CSIRO highlighted this point in its submission:

> Water demand will increase for most crops growing under warmer conditions. Changes in rainfall and evaporation are likely to reduce soil moisture and runoff in much of southern and eastern Australia. Increased water demand combined with reduced water supply poses significant challenges. Increasing water use efficiency practices will be paramount.[12]

3.15 Improving irrigation systems is one means by which farmers can increase water use efficiency. Members of the committee visited 'Jedburgh' the farm of Scott and Jo McCalman at Warren in western NSW, an area that receives highly variable

---

10 *Committee Hansard* , 1 July 2008, p. 23.

11 See for example Mr Ian Bowie, *Submission 2*, p. 5; Queensland Government, *Submission 30*, p. 12; and CSIRO, *Submission 32*, p. 6.

12 CSIRO, *Submission 32*, p. 14. See also: Queensland Government, *Submission 30*, p. 11.

455 mm average annual rainfall which has been well below average for the last seven years. Mr McCalman told members of the committee how water use efficiency at the property had been improved by replacing flood irrigation techniques with the use of an overhead lateral move irrigator. The overhead lateral move irrigator offers a number of advantages over previous flood irrigation techniques, primarily the control in the application of water to a field. While water needs to be applied more frequently with the overhead lateral move irrigator, a smaller volume of water is required. The lateral move irrigator is automated and can be programmed to water at the most advantageous times, such as at night or to supplement rainfall. In addition, as the soil is not being waterlogged, as is the case with flood irrigation, there is less nutrient loss from the soil. Mr McCalman also described how being better able to control water application, and improved water use efficiency, also increased cropping options, for example, with the possibility of introducing crops which are not amenable to flood irrigation. Mr McCalman also noted that at times there are difficulties in regional areas in finding staff, so the fact the overhead lateral move irrigator is automated and reduces staffing requirements is an advantage. Finally, the amount of infrastructure and preparation for putting in crops is greatly reduced with the overhead lateral move irrigator compared with flood irrigation.

3.16 Dr Ian Johnsson of Meat and Livestock Australia, outlined for the committee some of the research work being done to identify genes in plants that assist water use efficiency:

> …we are looking at trying to increase drought tolerance in a number of species, seeing whether we can find gene markers to help select and increase the rate of genetic progress in that area. All of the pasture breeding programs and forage breeding programs in Australia these days have water use efficiency as one of their major selection criteria.[13]

3.17 The committee also notes the evidence of Professor Michael Young of the Wentworth Group of Concerned Scientists:

> I would add a caution around increases in water use efficiency. At the moment we allocate water to water supply systems and to farmers in gross terms. We do not require them to account for the amount they return to a system…When you increase water use efficiency then people use more water.[14]

3.18 Professor Young explained that as irrigators improve water efficiency it stops leaks and seepages back into the system. Inefficient systems may result in half an irrigators' allocation draining back into the system, and, as a result, that water is then available for other downstream users. Improvements in efficiency mean that irrigators

13 *Committee Hansard*, 1 July 2008, p. 11. See also: NFF, Answers to Questions on Notice, 31 July 2008.

14 *Committee Hansard*, 1 July 2008, pp 44-45.

would use all of their water allocation without any being returned to the system, and as a result, downstream users are deprived of the use of that water.[15]

Selecting cultivars, species and breeds to suit changing climate

3.19 A number of submissions highlighted the importance of selecting crop cultivars and species, and livestock breeds which suit new climatic conditions as a means for agricultural industries to adapt to climate change.[16]

3.20 Apple and Pear Australia Limited (APAL) noted that the main adaptive strategy of the pome fruit industry will be to move to fruit varieties with a lower chilling requirement.[17]

3.21 Growcom stated that the number of vegetable cultivars available is an important factor in making vegetable production more adaptable to climate change:

> considerable difference exists in tipping points of fruit versus vegetable production, the many varieties/cultivars and short maturing time of vegetable species makes vegetable production more adaptable to climate change than fruit production.[18]

3.22 The Victorian Department of Primary Industries also noted that changing livestock breeds could be an adaptation option for the livestock industry.[19]

Moving production as climate shifts

3.23 Several submissions discussed the prospects for moving agricultural industries as climatic zones shifted. In general, it appeared that this may be a viable option for some industries, but not necessarily for all agricultural industries. The AACC indicated that some agricultural activities would be able to relocate, effectively moving as the climate does, but they will be in the minority.[20]

3.24 Mr Ian Bowie noted the CSIRO predictions for a southward shift in climate, but stated that there may not be a corresponding shift in agricultural zones:

---

15 *Committee Hansard*, 1 July 2008, p. 45.

16 See for example Victorian Department of Primary Industries, *Submission 27*, pp 14-15; and Agricultural Alliance on Climate Change, *Submission 37*, pp 7-8.

17 *Submission 23*, p. 3.

18 *Submission 31*, attachment: Growcom, *Growcom horticulture and climate change workshop report*, 25 January 2008, p. 5. See also: Queensland Government, *Submission 30*, p. 10; and CSIRO, *Submission 32*, p. 14.

19 *Submission 27*, p. 14.

20 *Submission 37*, p. 8, quoting from J. Sherrard, A. Tate and N. Boele: *Agricultural Alliance on Climate Change: Issues Paper*, July 2007. Available at: http://www.climateinstitute.org.au/images/stories/agribusinesspaper.pdf, accessed 12 November 2008.

> …a climatic shift equivalent to Albury coming to have a climate similar to Tamworth's present climate may have little impact on potential temperate pasture production around Albury because potentials for this are already depressed by temperature and moisture limitations.
>
> Similarly …for (the few) areas in the north which have soils and terrain that might be suitable for more intensive agriculture, it appears that even in the limited areas where rainfalls might increase, seasonality will not decrease. The prospects for more intensive agriculture in the north remain very limited and very localised.[21]

3.25 APAL explained in its submission that there was very little scope for the industry to move regions as climate change impinged on its growing areas:

> …the overall effects on horticultural production in Australia may be greater than in many temperate regions of the northern hemisphere due to the marginal nature of some fruit growing areas and the lack of extensive higher altitude or higher latitude regions where chilling requirements may continue to be met under warmer conditions.[22]

3.26 The Queensland Government also noted the impact that warmer temperatures would have on the production of temperate fruits and some vegetables which required winter chilling. While noting that rising temperatures are a constraint to moving horticulture north, the Queensland Government submission did note that there are opportunities in relation to tropical and subtropical crops:

> For tropical and subtropical crops such as avocadoes, mangoes and bananas, increasing temperatures will provide opportunities for production to occur in regions which are currently too cold for economic yields and quality.[23]

3.27 The CSIRO indicated that there is potential for relocation within the viticulture industry:

> The water demand of winegrape vines will increase in a warmer climate while rainfall and, more importantly, runoff to water storages is projected to decrease. Shifting to cooler sites can alleviate some of the warming impact. As vineyards have a life of 30+ years, planning for this should begin now.[24]

Resilient farming systems

3.28 The committee received evidence and submissions about changing farm management practices as a means of agricultural industries adapting to climate change:

---

21 *Submission* 2, p. 3.

22 *Submission 23*, p. 3, quoting from an article by Kevin Hennessy of the CSIRO.

23 *Submission 30*, p. 10.

24 *Submission 32*, p. 14.

> Farmers have become much more adept at managing and preparing for extreme conditions, such as drought or floods. They are employing practices which include conservation till, zero or minimal tillage, direct drilling, geo-positioning, stubble retention and a variety of on-farm water management strategies.[25]

3.29 To this end, the committee spent a significant amount of time during this Inquiry investigating the use of perennial cropping and grazing systems as a means of agricultural enterprises adapting to climate change. As the committee learnt, some farmers have been using these systems for many years, but in recent years there has been a growing interest amongst farmers in perennial systems.[26]

Perennial cropping and fodder shrubs

3.30 The committee was told of the potential for perennial systems to improve soil conditions, and hence agricultural productivity. The committee also arranged for subcommittees to visit 'Pine Crest', the farm of Murray, Jenny and Kyle Carson in the Binnu district of Western Australia, and the McCalman's property 'Jedburgh' to see first hand the perennial pastures systems that have been introduced on those properties and to report back to the committee.

3.31 The committee also heard substantial evidence about the potential of these systems as a way of creating permanent carbon sinks from agricultural soils. The potential for agricultural soils is discussed at length in the next section of the chapter on Mitigating and offsetting greenhouse gas emissions.

3.32 The submission of the Australian Soil Carbon Accreditation Scheme (ASCAS) detailed how traditional farming practices have degraded agricultural land and reduced the organic carbon content of soil:

> In little over 200 years of European settlement, more than 70 percent of Australian agricultural land has become seriously degraded. Despite efforts to implement 'best practice' in soil conservation, the situation continues to deteriorate.
>
> On average, 7 tonnes of topsoil is lost for every tonne of wheat produced. This ratio has most likely worsened in recent years due to an increased incidence of erosion on unprotected topsoils, coupled with declining yields.
>
> Over the last 50 years, the organic carbon content of Australian agricultural soils has declined between 50% and 80%.

---

25 Westpac Banking Corporation, *Submission 28*, p. 2. See also: Victorian Department of Primary Industries, *Submission 27*, pp 14-15; and Agricultural Alliance on Climate Change, *Submission 37*, pp 7-8.

26 See Mr Bob Wilson, *Committee Hansard*, 30 June 2008, p. 38; Mr Tim Wiley, *Committee Hansard*, 30 June 2008, p. 42; and Dr Christine Jones, Founder of the Australian Soil Carbon Accreditation Scheme, *Committee Hansard*, 30 June 2008, p. 53.

> Soil carbon is the prime determinant of agricultural productivity, landscape function and water quality. Carbon losses of this magnitude therefore have immeasurable economic and environmental implications.[27]

3.33 The ASCAS submission went on to explain how perennial groundcover improves soil conditions and increases the carbon content of soil:

> The soluble carbon exuded into the rhizosphere by perennial groundcover plants and/or transported deep into soil by mycorrhizal fungi, provides energy for the vast array of microbes and soil invertebrates that produce sticky substances enabling soil particles to be glued together into lumps (aggregates). When soil is well aggregated, the spaces (pores) between the aggregates allow the soil to breathe, as well as absorb moisture quickly when it rains. A healthy topsoil should be 'more space than stuff'…[28]

3.34 Mr Bob Wilson provided evidence to the committee about his own experience in working with perennial species in Lancelin in Western Australia:

> As a farmer, in 1985 I realised that the traditional annual based agricultural system that we were working with was failing. I moved to trial some new and innovative perennial systems that were based around a fodder shrub called tagasaste, which is a deep rooted perennial shrub. Over a period of years we planted around 1,000 hectares on the farm. By 2003 we started planting some subtropical perennial grasses, again to try and adapt what was happening with our past system so as to move from an annual based system to a more perennial based farming system.[29]

3.35 Mr Tim Wiley provided evidence to the committee about preliminary work being done in the Binnu district of Western Australia comparing perennial pasture systems to annual systems:

> We had a project that started in 2006 in the Binnu area, the worst affected area, where we got the farmers to record the actual stock movements so we could work out exactly how much each paddock carried for a 12-month period. We picked farmers who were just starting to put in the perennials – the first innovators. It turned out to be the mother of all droughts. What that data said was that it did not matter what we did, any traditional annual pasture would not have grown enough to prevent the wind erosion we saw over the 10-month period. Even I was surprised how good the perennials were. We were actually carrying four to six sheep per hectare equivalents and had ground cover and had no erosion. So these innovations carried more stock in the worst drought ever than those farmers carried on annual pastures in a normal year. That gives us hope for the farmers but even for me. The only thing that kept us sane during that drought was to go out and see those patches of green.

---

27 *Submission 42*, p. 2.

28 *Submission 42*, p. 3.

29 *Committee Hansard*, 30 June 2008, p. 38.

> One of the other innovations we did only last year was to do with approaches to cropping. There is a farmer over here doing pasture cropping and growing wheat over these summergrowing perennial pastures…I came over and saw it last year and we went back and put a trial in and, remarkably, we found that the wheat on certain perennials out-yielded the wheat on annual pastures.[30]

3.36 The committee also notes the work by Scott and Jo McCalman on their property, 'Jedburgh' in Warren, NSW, an ASCAS soil monitoring site:

> … that farm had been conventionally zero tilled for 15 years prior to the rain this summer. It was then miraculously covered in perennial grasses that just appeared. Scott McCalman … decided that he was not going to kill his grasses, that he was actually going to crop into them. He had heard about pasture cropping, and he just decided that he was going to do that. He saved $70 a hectare by not spraying out those grasses. When we measured the nutrient levels in his paddock this year prior to him sowing his crop, the phosphorous levels had gone up by a factor of five. The agronomist actually thought there was a laboratory error in the data. We relooked at that and at bare areas compared with areas under the grass, and it was correct that available phosphorous had gone up by a factor of five.
>
> … Phosphorous fertilisers had been used over time, under 15 years of zero till in that area, and they just formed a phosphorous bank that had been inaccessible.[31]

3.37 The committee also heard evidence from Mr Kevin Goss of the Future Farm Industries Cooperative Research Centre (Future Farm Industries CRC) on the work that organisation is doing investigating the role of perennial plants in cropping and grazing systems, and also the potential for new woody crops:

> We are well advanced with a prime lamb livestock production system called EverGraze, which is for the high rainfall environments…between 500 and 600 millimetres…we bring in perennial pasture plants in unique combinations – including perennial legumes, summer active perennial grasses, winter active perennial plants like chicory – we bring in much improved animal genetics capable of lambing percentages way above current levels and we introduce a tall perennial grass or shrub to provide a much better nursery environment for the many more lambs that are involved so that we do not see the deaths of twins and triplets. The management system is a much tighter rotation that matches the livestock's

---

30 *Committee Hansard*, 30 June 2008, pp 39-40. The Binnu area has hot summers and mild winters (a Mediterranean climate). The area has long term average annual rainfall from 400mm on the coast to 275mm on the eastern fringe. Winter rainfall is dominant, and summers are mostly dry, but can occasionally be wet. There are strong winds regularly in summer, autumn and early winter.

31 Dr Jones, *Committee Hansard*, 30 June 2008, pp 45-46. 'Jedburgh' is in north-west NSW. The region has a highly variable 455 mm average annual rainfall, which has been well below average for the last seven successive years.

> nutritional requirements with the feed availability… Our benchmarking in western Victoria demonstrates that it is running at about 50 per cent above best practice in production in the district and it is also making a major reduction in leakage to groundwater in that environment, which is a very good thing from a dryland salinity viewpoint.[32]

3.38 Mr Goss also told the committee about two other programs that the Future Farm Industries CRC is conducting: EverCrop, which is looking at the introduction of drought tolerant perennials in the non-crop phase of a cycle; and Enrich, which is looking at the potential of new perennial forage plants on marginal soils where cropping is probably not going to be an option.[33]

3.39 Meat and Livestock Australia indicated to the committee that it is investing in research in pasture management systems, and particularly perennial pastures because of the sustainability of those systems.[34]

3.40 The committee was told of the success of perennial grasses in areas of low rainfall:

> Our crop yields are the same or better than under conventionally managed farming, and the improvement in yield is better the more marginal the area because perennials provide so much change to soil biology.[35]

3.41 The committee also heard evidence that perennial pasture systems are likely to reduce the need for herbicides:

> …most of these crops are grown with no herbicide whatsoever because perennial grass prevents weeds from coming through; you have complete ground cover. The better the ground cover, the better the crop. So we find that the thicker the perennial grasses, the more vigorously they grow, the more they condition the soil and the better the crop grows – that is, the annual crop that you plant into the perennial pasture.[36]

3.42 Mr Goss of the Future Farming Industries CRC also noted the benefits of using legumes in perennial pasture systems as a means of improving the nitrogen content of soil:

> In the wheat belt we have started a program called EverCrop…it is particularly looking at broadening the footprint of legumes, which we increasingly see as being important because farmers at some point may

---

32 *Committee Hansard*, 30 June 2008, pp 85-86.

33 *Committee Hansard*, 30 June 2006, p. 86.

34 Dr Ian Johnsson, General Manager, Livestock Production Innovation, Meat and Livestock Australia, *Committee Hansard*, 1 July 2008, p. 11.

35 Dr Jones, *Committee Hansard*, 30 June 2006, p. 43. See also: Dr Jones, *Committee Hansard*, 30 June 2008, p. 49.

36 Dr Jones, *Committee Hansard*, 30 June 2008, p. 43. See also: Mr Wiley, *Committee Hansard*, 30 June 2008, p. 42.

> have to substitute legume generated nitrogen to some extent for applied nitrogen if oil prices stay the way they are.[37]

3.43 When questioned as to the challenges presented by perennial pastures systems, the committee received the following impressive response from Dr Jones:

> I am going to give you an emotional response and say that for some of the farmers I have worked with it is almost like a love affair, because they get so excited. They send me amazing emails saying: 'Christine, you would not believe what is happening on our place. We are so excited and we have not been this happy for a long time.' …We have now got children in a lot of these families going out and collecting grasses that they find on the side of the road and sending them to me in the mail to ask what they are because they want to plant them on the farm. They say: 'Will this be good for Dad to plant wheat into? Is this one a weed or is it a good grass?'[38]

3.44 Mr Wiley emphasised that one of the real issues for farmers wanting to introduce these systems is the input costs:

> We see some hope and systems that could work in the future. The problem is finance – the equity is shot; the banks' nerves are shot. So if these things work, how do we actually redevelop agriculture? How do we fund it? I cannot see that government would pay the bill for what is required to totally redevelop agriculture even in our little part of the world.[39]

Diversifying agricultural enterprises

3.45 Another option for farmers to adapt to climate change is to diversify their enterprises to provide more options in the face of climate change. One example of diversification that the committee received evidence on is the role that forestry can play as part of an integrated agricultural enterprise.

Forestry

3.46 The submission from the National Association of Forest Industries (NAFI) described the forestry industry as generally less susceptible than other agricultural enterprises to climatic variation:

> At the landscape level, forestry can provide a valuable complementary land use to other forms of agriculture, which may be at greater risk from the effects of climate change. As a long term crop, trees are generally not as susceptible to seasonal and long term climatic variations as certain types of agriculture.

---

37 *Committee Hansard*, 30 June 2008, p. 86.

38 *Committee Hansard*, 30 June 2008, p. 53.

39 *Committee Hansard*, 30 June 2008, p. 40. Chapter 4 discusses the potential for sequestration of carbon in soil as a means of financing these input costs.

> Recent drought conditions throughout Australia have resulted in dramatic reductions in agricultural production, yet the level of impact on production forestry has been far less severe.[40]

3.47 The Victorian Department of Primary Industries detailed the benefits that forestry may have in improving the adaptive capacity of agricultural enterprises:

> Adaptive capacity can be enhanced through synergies between forestry and agricultural land uses. For example, shelterbelt tree planting can reduce heat stress for livestock and climatic exposure for pastures and crops, and tree canopies can provide a feed source for livestock during the summer months and drought conditions, usually as a last resort.[41]

3.48 NAFI's submission outlines other benefits of using plantations as a complement to agricultural industries:

> The strategic placement of plantations on farms can lower saline water tables to limit salt loading into watercourses, as well as to filter and absorb excess nutrients from other agricultural activities (i.e. dairying and cropping) prior to entering waterways. The deep rooted characteristics of plantations established in appropriate locations on the farming landscape, is a key tool in managing stream water quality.[42]

3.49 The committee notes that the National Association of Forest Industries' claims in relation to susceptibility to climate variation did not adequately acknowledge the water interception of plantations, the impacts of plantations on ground water or the water needs in plantation establishment as reasons to support their claim. The committee is concerned about the impact that forestry plantations will have on water run-off in catchment areas and the committee notes the evidence of Mr David de Jongh of NAFI, that in terms of the CSIRO's research on salinity impact and water uptake, the best accepted convention on the proportion of a catchment that should be planted under trees before it affects water run-off is 20 per cent.[43]

3.50 Committee members are also concerned about the potential competition between forestry and agriculture in the design of an emissions trading scheme. This issue is discussed in Chapter 4 of the report.

Other diversification options

3.51 The submission of Mr Tim Wiley and Mr Bob Wilson described research the Western Australian Department of Agriculture is undertaking into the potential of diversified farm enterprises in the north east wheat belt of Western Australia:

---

40 *Submission 6*, pp 1-2. See also: A3P, *Submission 9*, p. 3.

41 *Submission 27*, p. 15.

42 *Submission 6*, p. 3.

43 *Committee Hansard*, 30 June 2008, p. 110.

> Caroline Peek and Megan Abrahams from DAFWA in Geraldton have been modelling the economic consequences of climate change on a north east wheat belt farm…They find that cropping will not be commercially viable in the near future under the climate change predicted.
>
> …Abrahams et al also considered alternative enterprises that could keep farms profitable. Their modelling suggests that a grazing enterprise based on fattening and trading station cattle could be economically viable if the stocking rate and animal growth rates were high enough…
>
> Abrahams et. al.…also analysed future farming systems that included oil mallees, carbon trading and opportunistic cropping in wetter years as well as station cattle…All of these enterprises can contribute to improving farm profit. However cattle production is the main driver of profit.[44]

3.52 Another option for diversification could be the development of farming enterprises around alternative energy generation. This is discussed later in this chapter in the section on 'Alternative energy sources'.

Mitigating and offsetting greenhouse gas emissions

3.53 The mitigation and offsetting of greenhouse gas emissions also presents a number of opportunities and challenges for the Australian agricultural sector. This section of the report gives a brief background on the amounts and types of agricultural emissions and then goes on to discuss some of the options in relation to mitigating those emissions, as well as offsetting emissions from the agricultural sector and other sectors within the economy.

Greenhouse gas emissions from the agricultural sector

3.54 In 2006, Australia's net greenhouse gas emissions were 576.0 million tonnes of CO_2-equivalent (Mt CO_2-e). The agricultural sector was the second largest source of greenhouse gas emissions, contributing 15.6% of emissions. Land use, land-use change and forestry sectors contributed 6.9% to Australian's greenhouse gas emissions. Compared to other countries, the Australian agricultural and forestry sectors make a relative large contribution to total net greenhouse gas emissions.[45]

3.55 The Kyoto Protocol to the United Nations Framework Convention on Climate Change breaks agricultural emissions down into six sources: enteric fermentation in livestock; manure management; rice cultivation; agricultural soils; prescribed burning of savannas; and field burning of agricultural residues.

---

44 *Submission 41*, pp 10-11.

45 See Department of Climate Change, *Carbon Pollution Reduction Scheme Green Paper* (Green Paper), July 2008, p. 95, citing Department of Climate Change, *Australia's National Greenhouse Accounts*: *National Greenhouse Gas Inventory 2006*, June 2008. The energy sector was the largest source of greenhouse gases contributing 69.6% of emissions.

3.56 Agriculture is the dominant source of methane, primarily from livestock (enteric fermentation and manure management), and nitrous oxide, mainly from agricultural soils. In 2006, there was 69.8 million tonnes of carbon dioxide equivalent (Mt CO_2-e) of methane emissions from agricultural sources. These emissions accounted for 59.0% of Australia's net methane emissions. In 2006, there was 20.3 Mt CO_2-e of nitrous oxide emissions from agricultural sources accounting for 83.9% of Australia's net nitrous oxide emissions.[46]

3.57 The Green Paper outlines how agricultural emissions are highly variable in response to management strategies:

> For example, cattle breeds and feed types in tropical and subtropical regions differ from those in temperate regions, and have methane conversion rates that are significantly different. Nitrous oxide emissions from soils in major cereal-growing regions vary geographically and over time, according to different rainfall, soil types and fertiliser application rates.[47]

3.58 The committee was provided with evidence of the potential for the agricultural sector to mitigate its emissions, and also opportunities for offsetting emissions from agriculture and other sectors. These opportunities, and some associated challenges, are discussed below.

Mitigating agricultural emissions

3.59 The joint submission of the Department of Agriculture, Fisheries and Forestry (DAFF) and the Department of Climate Change (DCC) indicated that the Australian Government is funding research in the area of mitigation of agricultural emissions:

> Through the *Greenhouse Action in Regional Australia* (GARA) program, established in 2004, DCC has provided leadership and coordination for greenhouse action in agriculture and land management. About $25 million has been spent over five years to support development of methods and technologies for measuring greenhouse emissions from agriculture and, in partnership with industry, to identify and support implementation of cost-effective abatement strategies.
>
> The GARA program has facilitated strategic climate change research to build the capacity of the agricultural and land management sectors to manage greenhouse gas emissions and response to climate change. Research areas include livestock and emissions from soils, emissions from savannas and forests, and climate change responses in farming systems and natural resource management.[48]

---

46 Department of Climate Change, *Australia's National Greenhouse Accounts*: *National Greenhouse Gas Inventory 2006*, June 2008, p. 12.

47 Green Paper, p. 123.

48 *Submission 34*, p. 13.

3.60 In evidence to the committee, Ms Nicolette Boele of the Agricultural Alliance on Climate Change (AACC), referred to some preliminary results from studies showing over a 25 per cent reduction in methane output in sheep eating saltbush. The committee notes Ms Boele's comment that the work is yet to be peer reviewed.[49]

3.61 The submission of the Victorian Department of Primary Industries outlined the work of the 'Greenhouse in Agriculture' program, which is 'an ongoing program of research, development and extension aimed at delivering measurable abatement of methane and nitrous oxide from farming systems in Victoria, whilst maintaining profitable and viable production systems':

> This program has already made significant breakthroughs in developing more accurate benchmarks for agricultural emissions of methane and nitrous oxide. Mitigation opportunities for the dairy farm sector now being verified include selective cattle breeding, use of dietary supplements and extended lactation management.[50]

3.62 In a joint submission, the Cattle Council of Australia and Meat and Livestock Australia (MLA), were cautious as to the overall effect that research into the mitigation of agricultural emissions would have:

> MLA is supporting research into mitigation of emissions of methane from livestock and nitrous oxide and methane from animal waste, but the options are likely to take considerable time to operationalise, produce relatively small reductions, and be costly.[51]

3.63 The committee is also aware of the discussion in The Garnaut Climate Change Review about the potential for a reduction in agricultural emissions through shifting of meat production from sheep and cattle to kangaroo, which emit negligible amounts of methane through enteric fermentation.[52]

3.64 Voiceless provided the committee with a submission outlining the role that increasing global meat consumption plays in contributing to climate change:

> It has recently been observed that while coal is often seen as the major threat to the environment, it is actually cattle that will have the biggest impact on the climate during the next 20 years…
>
> The livestock sector has emerged as one of the most significant contributors to the more serious environmental problems, with farmed animals now producing more greenhouse gas emissions than the world's entire transport system.[53]

---

49 *Committee Hansard*, 1 July 2008, p. 18.

50 *Submission 27*, p. 26.

51 *Submission 36*, p. 5.

52 Professor Ross Garnaut, *The Garnaut Climate Change Review: Final Report*, 30 September 2008, p. 547-8. See also: Mr Ian Bowie, *Submission 2*, p. 4.

53 *Submission 11*, p. 5.

3.65 Voiceless' submission concluded that 'only a reduction in meat consumption and intensive livestock production can effectively address the issue of global warming and slow the pace of climate change'.[54]

3.66 While Voiceless makes valid points in relation to the impacts that livestock production and meat consumption has on increasing greenhouse gas emissions, calls to reduce meat consumption obviously concern those in the agricultural sector. MLA made the following submission on the impacts of decreased meat consumption:

> A shift away from meat-based diets towards vegetable-based diets will have important ramifications for the economic viability of livestock producers and processing industries. It will also have impacts on landscape health if more fragile lands are cropped rather than grazed, especially under irrigation. There is also good evidence that a decline in intake of the nutritional benefits of meat will have long-term implications for health.[55]

Soil Carbon Sequestration

3.67 In its consideration of evidence and submissions about perennial pasture and fodder systems, the committee was particularly interested in the potential of these systems to act as permanent carbon sinks through the sequestration of carbon in the soil. The committee received evidence from a number of witnesses who are very enthusiastic about the potential of agricultural soils to act as a carbon sink. However, the committee notes there appears to be little support in the scientific community.

3.68 Dr Mark Howden of the CSIRO, while noting that there was no 'single CSIRO view' of soil carbon sequestration, was cautious as to prospects of soil carbon sequestration:

> Soil carbon is essentially a function of how much carbon goes into the system, so it is really a function of the ecosystem production, and how much goes out of the system, which is a function of various breakdown rates, degradation rates – which can be caused by people using, say, windrowing or burning, or just part of natural processes. The balance between those is what is left in the system, and that is the soil carbon. It can go up or go down. We know with a great deal of certainty that certain conversions of agricultural land from one form to another have significant carbon implications in the soil. Within each land use, the flexibility to improve carbon content is often small, but sometimes it can be larger. There is a need to be cautious about the prospects for incorporating soil carbon into some systems, because that carbon can be quite labile, which means it can be easily lost, and there can be significant overestimates of how much carbon can be incorporated into agricultural systems as well.[56]

---

54 *Submission 11*, p. 6.

55 *Submission 36*, p. 5.

56 *Committee Hansard*, 30 June 2006, p. 19.

3.69 According to Dr Jones of ASCAS, soluble carbon entering soil from plant roots is rapidly humified if appropriate microbial associations are in place, and this humified carbon is not labile and is not easily lost.[57] Dr Jones went on to explain to the committee how conventional cropping inhibits the sequestration of carbon in soil:

> What happens in a conventional zero-till type cropping is you would have stubble that would break down into the soil and form what they call labile carbon, which is very readily decomposed, and within 12 to 18 months most of that goes back to the atmosphere as carbon dioxide. So it is a very rapid cycling of carbon, and the reason that that happens is that the microbes necessary for humification are not there because the chemicals used in zero till have knocked them out of the system. This is why we have experts across Australia telling us we cannot build soil carbon because they are looking at conventional zero-till systems where the microbes that you need to build the carbon simply are not there. They are actually quite correct that you cannot build carbon in those systems. But if we go to perennial based agriculture and change the soil biology and get the microbial associations, we can build carbon at rates faster than people will actually acknowledge is possible.[58]

3.70 In terms of how governments view the potential of this area, the joint submission of DAFF/DCC states that 'the management of soil carbon is one opportunity that requires further research'.[59] To this end, in March 2008 the Prime Minister announced that the Federal Government would be investigating soil carbon as part of the *Australia's Farming Future* initiative.[60] In contrast, the assessment in the Green Paper of the potential of sequestration of soil carbon in agricultural soils is more muted:

> There are likely to be important opportunities to increase the carbon stored in agricultural soils. However, scientific research conducted in Australia suggests that, while there are opportunities for increasing and retaining agricultural soil carbon, Australia does not have the same sequestration potential as other countries, and there is significant risk of loss of soil carbon in times of drought or changed management practices. Nevertheless,

---

57 *Committee Hansard*, 30 June 2008, p. 41.

58 *Committee Hansard*, 30 June 2008, p. 44.

59 *Submission 34*, p. 7. See also: Mr Jim Groves, General Manager, Climate and Resource Policy, Queensland Department of Primary Industries and Fisheries, *Committee Hansard*, 1 July 2008, p. 66.

60 The Hon. Kevin Rudd, Prime Minister of Australia, *Address to the ABARE Outlook 2008 Conference*, 4 March 2008, p. 5. Available at: http://www.abare.gov.au/interactive/Outlook08/files/day_1/PMrudd_opening.pdf, accessed 22 November 2008. See also: Dr Colin Grant, Executive Director of the Bureau of Rural Sciences (BRS) *Committee Hansard*, 1 July 2008, p. 90, who indicated that BRS, in conjunction with CSIRO were in the process of producing a report evaluating work being done across the world in terms of soil carbon and to identify the issues associated with soil carbon.

> Australia should continue to investigate opportunities for improving soil carbon retention…[61]

3.71 In their submission and in evidence to the committee Mr Wiley and Mr Wilson provided some preliminary data they have about the ability of agricultural soils to sequester carbon. Soil carbon sequestration by perennial pasture systems has been calculated to be 5-10 tonnes CO_2-equivalent/hectare/year (CO_2-eq/ha/yr), compared to sequestration of less than 1.5 tonnes CO_2-eq/ha/yr by annual systems.[62]

3.72 In evidence to the committee Mr Wiley acknowledged that he was 'not totally certain' that this data was correct:

> …we are right at the point at trying to collect good, vigorous, scientific data to find out whether we are really right although I myself have some uncertainty about that. Once we have that data, that will create a whole pile of challenges for the scientists to try to figure out how it is happening.[63]

3.73 Dr Jones also gave evidence to the committee that in some areas the sequestration of carbon by soils was 'far more' than could be sequestered in trees. Further, the perennial pastures had an advantage over trees as a carbon sink because it could be grown in 'marginal areas' where trees would not receive sufficient rainfall to grow.[64]

3.74 When questioned about the response from the scientific community about these findings, Mr Wiley noted that he has had discussions with a scientist at CSIRO who indicated a willingness to further investigate what is occurring with perennial pastures in Western Australia in terms of the amount of carbon being sequestered.[65] In contrast, Dr Jones told the committee she had been applying for funding in this area for at least 10 years:

> I have folders full of reject letters saying that it was an extremely well worded application, that it has possibility but the current science does not support it and it is not possible to actually increase carbon to the levels that we were documenting on farm. I would have to say that that has changed very quickly recently. In fact in the last week even, there have been huge changes. I think we have just finally got to the tipping point. We have 2,000 farmers involved in this. It is a huge grassroots revolution that the scientific

---

61 Green Paper, p. 121.

62 See *Submission 41*, p. 15; and Mr Wiley, *Committee Hansard*, 30 June 2008, p. 40. Information on the sequestration rates of perennial pastures compared with annual pastures was also presented to the subcommittee on its visit to the Binnu district of Western Australia. See also: Dr Jones, *Committee Hansard*, 30 June 2008, p. 41.

63 *Committee Hansard*, 30 June 2008, pp 40 and 42.

64 *Committee Hansard*, 30 June 2008, p. 43.

65 *Committee Hansard*, 30 June 2008, p. 42.

> establishment for some reason seems to be completely unaware of or, if they are aware of it, have totally discounted as irrelevant.[66]

3.75 Dr Michael Robinson of Land & Water Australia, and Chair of the Joint Strategy Team of the National Climate Change Research Strategy for Primary Industries (CCRSPI), told the committee that the CCRSPI process had identified approximately 26 research projects that are directly related to soil carbon, however, those projects are part of a broader suite of work around agricultural production and sustainability, and carbon accounting or nitrous oxide emissions.[67]

Alternative energy sources

3.76 The committee received some evidence as to the role that the agricultural sector could play in the production of alternate energy sources as a means of reducing emissions from other sectors of the economy. Much of the evidence considered by the committee related to the role of biofuels and the impacts that this would have on food production.

Biofuels

3.77 Submissions highlighted the potential for biofuels production in Australia. The Agricultural Alliance on Climate Change (AACC) referred the committee to research it had commissioned the CSIRO to undertake. The resulting report, *Rural Australia providing climate solutions*, made the following comments on the expected expansion of biofuel production in Australia:

> Biofuel supply is expected to exceed … 350ML by 2010, and significant further expansion of domestic biofuel production in the medium term would be possible with step changes in production technologies or specific policy action in addition to the introduction of emissions trading. Realising the benefits of increased production and use of biofuels will require all stakeholders to be involved in developing practical pathways for commercialising biofuels that are environmentally sustainable and do not disrupt food and fibre production, along with significantly increased research and development into prospective second generation biofuels that are relevant to Australia…[68]

3.78 This statement touches on the concerns raised in submissions about the expansion of biofuel production, specifically the delicate balance between production for food and fibre and production for biofuels. The Australian Landcare Council noted this challenge in its submission:

---

66 *Committee Hansard*, 30 June 2008, p. 47.

67 *Committee Hansard*, 30 June 2008, p. 59.

68 Agricultural Alliance on Climate Change, *Rural Australia providing climate solutions*, October 2007, p. 5. See also: Victorian Department of Primary Industries, *Submission 27*, p. 16.

> The role of biofuels in [greenhouse gas] strategies presents some challenges to policy makers. Dedicated agricultural production of biofuel feedstocks can compete with food production with resultant upward pressure on food prices, leading to social and economic impacts. Secondly, whole-of-lifecycle analyses often reveal little net emissions benefit from existing biofuel production systems.[69]

3.79 The Sydney Centre for International Law outlined concerns in relation to mitigation of climate change, and the impact that this might have on food production:

> Australia must be cautious not to aggravate other serious international problems through its mitigation measures. For example, the World Bank recently reported that global food prices rose by 83% in the past three years, in part due to demand for bio-fuels and the consequent conversion of food crops to energy crops, driving up basic food prices. The consequence is chronic food insecurity in some parts of the developing world, which both infringes the basic human right to food, and generates social and political instability and even violent conflict.[70]

3.80 In response to a question on notice, the CSIRO provided the following information about the expansion in global biofuel production:

> [Organisation for Economic Cooperation and Development-Food and Agriculture Organisation of the United Nations] estimates of world wheat and coarse grain (maize, sorghum, barley and oats) production for 2007 amount to 1,661 million tonnes. Of this 761 million tonnes was used for feed and industrial purposes, including an estimated 93 million tonnes for biofuels (dominated by maize in the USA). In other words, approximately 6% of wheat and coarse grain was used for biofuels in 2007. World production of rice amounted to 660 million tonnes in 2007 and no diversion of rice to biofuels is taking place – hence overall percentage of grain (wheat, rice and coarse grains) going to biofuels appears to be approximately 4% in 2007.
>
> In terms of rates of growth in grain demand, biofuels are an important driver. Wheat and coarse gain usage globally is estimated to have increased 80 million tonnes between 2005 and 2007. Over this time, biofuel use of grain increased by 47 million tonnes, amounting to approximately 60% of the increased global wheat and coarse grain consumption.[71]

3.81 The submission provided by A3P, the peak body for Australian plantation, plantation products and paper industries, and representatives from the National

---

69 *Submission 13*, p. 4. See also: Queensland Government, *Submission 30*, p. 7.

70 *Submission 39*, p. 5.

71 Answers to Questions on Notice, 23 July 2008.

Association for Forestry Industries highlighted the role that forests could play in biofuel production.[72]

3.82 A3P pointed out in its submission that using plantation products could avoid the 'perverse outcomes associated with other biofuel opportunities such as more intense harvesting or conversion of natural forests, reduced food production, or reduced fibre for timber and paper production.'[73]

3.83 However, the committee also received evidence from Dr Mark Howden of the CSIRO stating that there is a 'technological hurdle' to be overcome in relation to using wood products for biofuels, namely the lignocellulosic breakdown of wood products to produce ethanol or similar products. Dr Howden indicated that, to his knowledge, no research is currently being undertaken in Australia to overcome this 'technological hurdle'.[74] The committee is also aware that conversion of native forests is still practised in some parts of Australia and biofuel production may pose the same risks domestically as it does overseas.

3.84 The committee also notes the comments of Associate Professor Christopher Preston of the Cooperative Research Centre for Australian Weed Management, in relation to the 'weediness' potential of prospective biofuel crops.[75]

Other forms of alternative energy generation

3.85 The committee was disappointed that it received very little evidence or submissions about the potential for using agricultural land as a means of 'farming' alternative energy sources.

3.86 The AACC's paper, *Rural Australia providing climate change solutions*, states that '[r]enewable energy offers significant financial and other benefits to landholders and rural communities'. The report goes on to speculate on the value of renewable energy:

> Previous reports imply wind and bio-electricity could generate total annual revenues of $300-1000 million by 2020 with an ambitious emissions reduction target or other policy support for renewable energy. Estimates undertaken for this report suggest potential wind royalties of up to $150 million a year, or more.[76]

---

72 A3P, *Submission 9*, p. 5; and Mr Allan Hansard, Chief Executive Officer, National Association of Forest Industries, *Committee Hansard*, 30 June 2008, p. 102.

73 *Submission 9*, p. 5.

74 *Committee Hansard,* 30 June 2008, pp 5, 19-20.

75 *Committee Hansard*, 30 June 2008, p. 94. This issue was discussed in Chapter 2.

76 Agricultural Alliance on Climate Change, *Rural Australia providing climate change solutions*, October 2007, p. 4.

3.87 The committee questioned Dr Mark Howden of the CSIRO as to the whether in its research the CSIRO is looking at wind and solar thermal energy options as a feasible farming option. Dr Howden indicated that he had spoken to farmers about this issue and that some were 'thinking constructively along those lines'.[77]

3.88 The joint submission from the Department of Agriculture, Fisheries and Forestry and the Department of Climate Change provided information on the *Methane to Markets Program*, which 'seeks to lower agricultural greenhouse gas emissions by capturing and using methane for energy generation':

> The program will adapt for Australian conditions technology already in use in intensive animal production in a number of other countries, including he United States, the United Kingdom and Canada. The captured methane generated from the waste can be used for industrial heating and drying or, alternatively, for electricity generation to supply power grids.[78]

Committee view

3.89 The committee was pleased to hear about the many potential opportunities that climate change may present to the agricultural sector, particularly in relation to issues such as perennial pastures and soil carbon sequestration. However, the committee is also concerned about the many challenges presented to the Australian agricultural sector by climate change, not least in terms of competition for water resources and reduced water availability.

3.90 The committee is very concerned about what it perceives to be a disconnect between the Australian agricultural sector and those in the scientific area. The committee noted this disconnect in its Interim Report in relation to the communication of climate projections. The committee heard evidence about the 'very strong relationship' that farmers have with the land, and its natural cycles.[79] For this reason, the committee is disappointed that, at times, it appears that the scientific community and the Government take a dismissive view of adaptation and mitigation possibilities which have strong support in the agricultural sector. The committee urges those researching and investigating climate change adaptation and mitigation opportunities and risks to fully engage with those in the agricultural community.

Recommendation 1

3.91 The Government should significantly increase the research effort in relation to the potential of soil carbon as a climate mitigation measure, as a

77 *Committee Hansard*, 30 June 2008, p. 5.

78 *Submission 34*, p. 15.

79 Ms Nicolette Boele, Director, Strategic Projects, Agricultural Alliance on Climate Change, *Committee Hansard*, 1 July 2008, p. 24. See also: Mr Ben Fargher, Chief Executive Officer, NFF, *Committee Hansard*, 1 July 2008, p. 26.

means of reducing the capital input costs to agriculture as a means of increasing resilience in agricultural systems.