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water in drylands
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Carbon in Agriculture

A preliminary study of Wimmera farmers' attitudes and perceptions
of greenhouse gas reduction on-farm

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Forward

The Water In Drylands Collaborative Research Program (WIDCORP) is a group of peak organisations from the Wimmera Mallee and University of Ballarat. The program partners work collaboratively to:

- advance understanding of the value of water and its uses;
- identify emerging opportunities for Wimmera Mallee dryland communities experiencing climatic variability and major water infrastructure change; and
- provide stakeholders with knowledge to foster the regions capacity to adapt to change in order to achieve economic and social growth and environmental sustainability.

This report is a preliminary investigation of the level of knowledge and the perspectives of Wimmera farmers towards minimising their carbon footprint on-farm. The study examines farmers' current attitudes and aspirations along with their expectations of future benefits of becoming carbon neutral on-farm. It also looks at potential barriers that discourage growers to become CO₂ neutral on-farm. The research aims to provide a preliminary indication of the key drivers for farmers to reduce greenhouse gas emissions. This study has been undertaken as part of the Department of Primary Industries (DPI) graduate program to provide research training and some base-line information to assist DPI in developing focussed extension activities to meet the future needs of farmers in relation to carbon management on-farm.



Dr Pam McRae-Williams
RESEARCH DIRECTOR
WIDCORP

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Contents

| | |
|---|----|
| List of Tables | 7 |
| List of Figures | 8 |
| 1. Background..... | 9 |
| 1.1 Introduction..... | 9 |
| 1.2 The Wimmera Region | 10 |
| 1.3 Purpose | 11 |
| 1.4 Scope of Project | 11 |
| 2. Study Objectives | 12 |
| 2.1 Study Context..... | 12 |
| 2.2 Aims and Outcomes | 14 |
| 3. Literature Review | 15 |
| 3.1. Introduction..... | 15 |
| 3.2. Climate Change..... | 16 |
| 3.3 Response to climate change | 17 |
| 3.3.1 Australian Government Response | 18 |
| 3.3.2 Sector emissions | 19 |
| 4. Agricultural response to climate change..... | 20 |
| 4.1 Underlying factors influencing farmer’s perceptions | 20 |
| 4.2 Farmer adaptation response..... | 22 |
| 4.3 Future adaptation opportunities to contribute to mitigation of GHG on farm | 23 |
| 4.3.1 Short-term adjustments..... | 23 |
| 4.3.2 Long-term adjustments | 23 |
| 5. Drivers of adoption. | 24 |
| 6. Barriers to adoption | 25 |
| 6.1 Complexity | 25 |
| 6.2 Congruence | 25 |
| 6.3 Loss of flexibility..... | 26 |
| 6.4 Economics | 26 |
| 6.5 Implementation cost..... | 27 |
| 6.6 Risk and Uncertainty..... | 27 |
| 6.7 Environmental perception | 28 |
| 6.8 Conflicting information | 28 |
| 7. Summary | 28 |
| 4. Methods | 30 |
| 4.1 Overview of the study methodology | 30 |
| 4.2 Steering group..... | 30 |
| 4.3 Literature Review | 31 |
| 4.4 Survey Design Process | 31 |
| 4.4.1 Ethical considerations | 31 |
| 4.4.2 Survey distribution | 31 |
| 4.4.3. Survey Development and Delivery..... | 32 |
| 4.4.4 Data analysis | 33 |
| 5. Results..... | 34 |

| | |
|---|----|
| 5.1 Geographical location of workshops..... | 34 |
| 5.2 Demographic Questions | 35 |
| 5.3 Farmers Knowledge | 38 |
| 5.4 Farmers attitudes and perceptions | 42 |
| 5.5. On-farm carbon | 43 |
| 5.6. Changes in Attitudes | 50 |
| 6. Summary and Discussion | 62 |
| 6.1 Farmers knowledge of greenhouse gas and understanding of CO ₂ emissions | 62 |
| 6.1.1 Wimmera farmer profile | 62 |
| 6.1.2 Perceptions of climate change and greenhouse gases | 62 |
| 6.1.3 Farmer knowledge of greenhouse gases..... | 63 |
| 6.1.4 Emissions profiles for industrial sectors and agriculture | 63 |
| 6.1.5 Food vs. Fuel - 'The need to produce food for humans and not food not fuel'. | 65 |
| 6.2 Current attitudes and expectations of farmers towards their role in the carbon market. | 65 |
| 6.2.1 Agriculture and GHG emissions..... | 65 |
| 6.3 Potential drivers and barriers that influence farmers' adoption..... | 66 |
| 6.3.1 Changing farming practice | 66 |
| 6.3.2 Motivation to reduce carbon emissions on-farm | 67 |
| 6.3.3 Drivers for adaptation to new farm practices..... | 67 |
| 6.4 Knowledge and perception changes through information delivery | 68 |
| 6.5 What information and issues will need to be addressed in the future research and initiatives..... | 69 |
| 7. Conclusion & Research Learnings..... | 70 |
| 7.1 Conclusions..... | 70 |
| 7.2 Research Opportunities & Learnings..... | 71 |
| 7.2.1 Data Collection | 71 |
| 7.2.2 Follow up research | 71 |
| 7.3 Research Reflections | 72 |
| 8. References | 73 |
| 9. Appendix..... | 76 |
| 9.1 Appendix 1 - CARBON IN AGRICULTURE SURVERY - PART A.... | 76 |
| 9.2 Appendix 2 - CARBON IN AGRICULTURE SURVERY - PART B.... | 83 |
| 9.3 Appendix 3 - ETHICS APPLICATION APPROVAL..... | 85 |

List of Tables

| | |
|---|----|
| Table 1 - Short term Objectives and Outcomes | 14 |
| Table 2. TopCrop Workshops | 32 |
| Table 3. Age distribution | 35 |
| Table 4. Farm size | 36 |
| Table 5. Land leased | 37 |
| Table 6. Farming operation | 38 |
| Table 7. Global Warming Potentials of greenhouse gases | 39 |
| Table 8. Ranking of greenhouse gases | 39 |
| Table 9. Ranking of industry sector greenhouse gas emissions | 41 |
| Table 10. Sources of carbon emission..... | 42 |
| Table 11. On-farm carbon balance | 45 |
| Table 12. On-farm practice change and carbon balance. | 48 |
| Table 13. Farmers perceptions of a Carbon Pollution Reduction Scheme..... | 49 |
| Table 14. Environmental accounting on farm..... | 50 |
| Table 15. Activities that farmers believe will help improve knowledge. | 61 |

List of Figures

| | |
|--|----|
| Figure 1. Map of Wimmera Region, Victoria | 10 |
| Figure 2. Policy response to Climate Change | 18 |
| Figure 3. Australia’s greenhouse gas emissions by sector | 19 |
| Figure 4. Greenhouse Gas Emissions from Australian Agriculture | 19 |
| Figure 5. The study approach; non-probability sampling design..... | 30 |
| Figure 6. Map of Topcrop groups in Wimmera..... | 34 |
| Figure 7. Time farming..... | 35 |
| Figure 8. Farm ownership | 36 |
| Figure 9. Living on farm | 37 |
| Figure 10. Ranking per capita greenhouse gas emissions | 40 |
| Figure 11. Concern regarding climate change | 42 |
| Figure 12. Importance of reducing global greenhouse gas emission..... | 43 |
| Figure 13. Farm carbon management..... | 44 |
| Figure 14. Importance of reducing carbon emissions on-farm. | 44 |
| Figure 15. On-farm carbon assessment..... | 45 |
| Figure 16. Use of carbon assessment programs | 46 |
| Figure 17. Carbon certification in Australia. | 46 |
| Figure 18. Farmers knowledge of carbon management..... | 47 |
| Figure 19. Carbon management on farm | 49 |
| Figure 20. Farmers attitude change to climate change concerns | 51 |
| Figure 21. Change in participant’s response..... | 51 |
| Figure 22. Change of farmers perception of importance of reducing GHG emissions..... | 52 |
| Figure 23. Level of participants response in concern of reducing GHG emissions..... | 53 |
| Figure 24. Farmers attitude change in the role of farm in carbon management | 53 |
| Figure 25. Farmers perceptions of reducing carbon emissions on farm | 54 |
| Figure 26. Participants response to reducing carbon emissions on-farm..... | 55 |
| Figure 27. Farmers attitude to farms carbon balance | 55 |
| Figure 28. Farmers reassessment of on-farm carbon balance | 56 |
| Figure 29. Comparison of participant’s response to level of knowledge relating to carbon management. | 57 |
| Figure 30. Participants change in response to knowledge relating to carbon management..... | 58 |
| Figure 31. Participants change in response to getting involved in carbon management on farm..... | 58 |
| Figure 32. Participants change in change in response. | 59 |
| Figure 33. Participant’s timeframe for being involved in carbon management on farm in the future..... | 59 |
| Figure 34. What areas farmers believe they will get involved in the future. ... | 60 |

1. Background

1.1 Introduction

The implementation of a Carbon Pollution Reduction Scheme (CPRS) within Australia by 2010 will present a number of changes and opportunities for Australian farmers and the wider agricultural sector. Australia's national greenhouse gas accounts from 2006 placed agriculture (90.1 Mt CO₂e)¹ as the second largest emitter of greenhouse gas to that of stationary energy (400.9 CO₂e) across all sectors (NGGI, 2006); therefore it may be expected to play a major role in emission reduction in the future to meet Kyoto greenhouse gas reduction targets of a total cut in greenhouse-gas emissions of at least 5 per cent from 1990 levels in the commitment period 2008-2012.²

Conversely, agriculture is also regarded as having the potential for carbon storage and being a voluntary carbon offset provider in greenhouse abatement and may be expected to do this for Australia to comply with the Kyoto protocol. This situation raises many questions about how carbon will be accounted for on-farm and what farmers can do to become 'carbon neutral'³ or increase their potential carbon stores on-farm.

If farmers are to engage in CPRS it will be important to understand their attitudes and aspirations about how carbon may play a role in agricultural systems and farming practices; and determine how their current farming practice may affect the processes of change in relation to the uptake of new opportunities arising from carbon trading or potential carbon marketing. It is expected that increased farmer knowledge will assist farmers in determining the potential implications of on-farm carbon reduction and potential opportunities.

Current consumer trends suggest the use of environmental marketing (for example carbon miles and carbon labelling (Saunders *et al* 2006)) is developing interest globally and is becoming a market requirement (non-tariff barrier) as retailers look to improve business sustainability regardless of consumer desire. Australia has the potential to further promote its 'clean green' image by marketing carbon neutral products to the domestic or export market. This may be of value to farmers wanting to obtain a premium for production whilst improving on-farm sustainability and making contributions to reducing the impact of climate change.

This preliminary study pilots an approach designed to understand the information needs and perceptions of farmers about greenhouse gas emissions, particularly Carbon Dioxide (CO₂) on their farms. It is set in the Wimmera region of Victoria where the expected increased water reliability resulting from the construction of the Wimmera Mallee pipeline may provide new opportunities for development of more intensified agricultural (livestock) industries. The carbon implications of such changes

1 Carbon dioxide equivalent, CO₂-e, provides the basis for comparing the warming effect of different greenhouse gases.

2 Carbon Pollution Reduction Report (2008) Retrieved: 1st August 2008. Available at: www.climatechange.com.au

³ 'Carbon neutral' refers to voluntary mechanism where an activity, event, household, business or organization is responsible for no net emissions of greenhouse gases and can therefore be declared carbon neutral in that specific area. Carbon neutrality can be achieved by reducing emissions as far as possible (e.g. energy efficiency, purchasing renewable energy) and then purchasing offsets for any residual emissions in order to achieve zero net emissions. (2008) Retrieved: 11th November 2008. Available at: <http://www.epa.vic.gov.au/climate-change/glossary.asp>

will be of interest to farmers within this region. This study aims to provide some preliminary information to assist farmers and farm extension personnel to better understand the implications of carbon management as part of a sustainable farming system, and the potential of farmers to engage in a carbon economy.

1.2 The Wimmera Region

The Wimmera region covers an extensive area of western Victoria, some 30,000 square kilometres - representing about 13% of Victoria's total area. It extends from the South Australian border to Stawell in the east and the Mallee region in the north, bordered by Rainbow and Birchip. This region is outlined in Figure 1. Agriculture is the principle activity and primary source of income in the region and is heavily reliant on broad-acre cropping. Agriculture in the Wimmera is highly export focussed with over 60% of all crop products exported⁴.

There are approximately 2,700 farm establishments in the Wimmera. Average farm size is in the order of 880 ha in the Wimmera. Average annual rainfall in the region is approximately 450 mm but varies to approximately 350 mm in the northern extremities to 550 mm in the south.

The region is also home to some of the state's most unique national and state parks such as the Grampians and Little Desert National Parks.

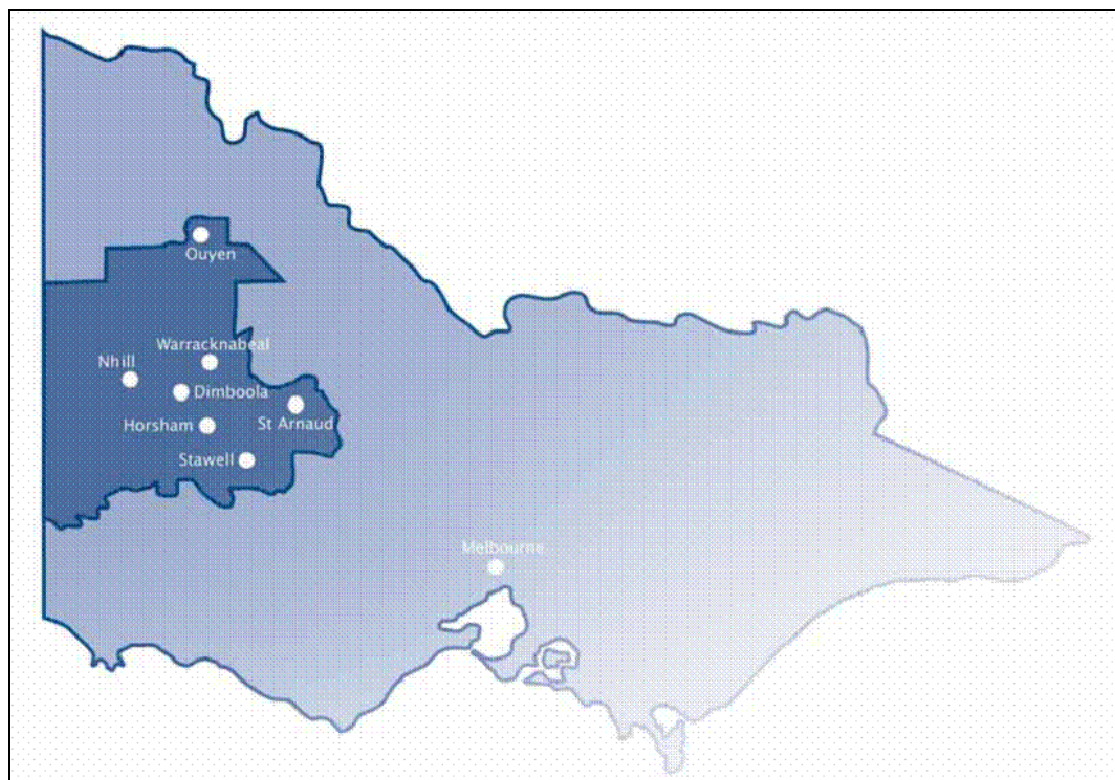


Figure 1. Map of Wimmera Region, Victoria

⁴ Sourced from DPI Victoria Website Retrieved: 22nd October 2008. Available: www.dpi.vic.gov.au/Wimmera.pdf

1.3 Purpose

The study investigates the perceptions and current knowledge that Wimmera landholder's have towards carbon emissions on their farms and the priority they place on reducing their carbon footprint on-farm. This report describes the results of this preliminary study indicating current farmer attitudes and knowledge together with their expectations of the future benefits and implications of an Emission Trading Scheme (ETS) commencing in Australia.

This project is a collaboration between the Department of Primary Industries (DPI) and Water in Drylands Collaborative Research Program (WIDCORP). It is part of the DPI Graduate program where graduates are required to undertake particular projects to increase their skill-set in certain areas.

Areas of interest include increasing research capacity, particularly in the area of social research, and to begin to build an understanding of the role of carbon in agriculture through engaging with farmers in the Wimmera region.

The project was undertaken by Michelle Nolan with the support and guidance of Dr Imogen Schwarz, Dr Pam McRae-Williams (WIDCORP) and Danielle Park (DPI).

1.4 Scope of Project

This preliminary study pilots an extension approach which aims to gain a better understanding of how farmers in the Wimmera understand and are managing on-farm greenhouse gases. The study included a literature review of the current context of carbon and agriculture and landholders capacity to adapt to environmental changes; a survey to capture farmer knowledge and perceptions; and information sessions with four TopCrop groups⁵ from the Wimmera region.

This study will begin to build base-line knowledge about farmers and their perceived role in carbon management. This will assist DPI in developing focussed extension activities to help farmers to better understand the implications of a CPRS on current and new farming practices, and innovations on their future emissions trading options.

⁵ TopCrop groups are traditionally farmer focused information networks for cereal, canola and grain legume growers but more recently also are made up of a mix of farmers, growers, contractors, agribusiness and invited experts. They are used to address local (and regional) issues through regular group meetings.

2. Study Objectives

2.1 Study Context

Agricultural business and their closely related sectors generate \$103 billion per year in production – underpinning 12% of the GDP (Australian Farm Institute, 2005). In February 2008, 294,440 people were directly employed in the Australian farm sector – accounting for around 3% of the national workforce (ABS, 2008).

Australian farmers produce 93% of Australia's domestic food supply (DAFF, 2007) and in terms of export earnings for Australia, each of the top eight commodities (cereal for grain, cattle & calves, whole milk, wool, sugar, cotton, sheep & lamb and grapes) make a substantial contribution to the national economy – accounting for over \$20 billion of the total \$27.6 billion value of agricultural exports (ABS 2006/2007)

The importance of the agricultural industry within the economy is significant, however in recent times it has been facing increasing stresses from drought, environmental and economic changes. The ability of farmers to adapt, develop new technology and improve farming practice has become increasingly important through this period in order to maintain income and domestic/export food supply.

Scientific research into carbon management on-farm is largely focused on technical approaches through the development of carbon accounting tools and methods of measuring and verifying carbon and greenhouse gases. Research is being completed by research groups such as The Australian Commonwealth Scientific and Research Organisation (CSIRO), Grains Research & Development Corporation (GRDC, Victorian Climate Change Adaptation Program (VCCAP) and The Department of Primary Industries to evaluate whole farm greenhouse gas emissions for each sector such as cropping, dairy and sheep. Current research includes the measurement of methane emissions from livestock (Lassy, 2007) and how dietary supplements could be used to mitigate methane emissions from ruminant animals (Beauchemin *et al* 2008), also the measurement and potential for carbon sequestration in crops such as wheat and in the soil (Kingwill, 2006). There is however, little baseline research conducted about farmers' perceptions and understanding of how greenhouse gases impact on agriculture and their businesses. As carbon accounting tools are developed, important questions emerge. Do farmers feel the need to change their practices in order to adapt to better management of carbon on-farm? Do farmers perceive there will be benefits that will influence them to adopt these farming practises? This report describes the results of this preliminary study indicating current farmer attitudes and knowledge together with their expectations of the future benefits and implications of an Emission Trading Scheme (ETS) commencing in Australia.

The limited research in this area may be due to the relatively short time-frame in which the conversation about carbon reduction mechanisms has occurred within Australia. At this stage agriculture is not being included in Australia's ETS until accounting and verification mechanisms are developed. There is recognised difficulty in measuring each of the 130,000 individual farm enterprises in Australia (ABS 2007). However, many simple and efficient changes can be made to reduce greenhouse gas emissions and the governments latest CPRS report (CPRS, 2008) has recommended that by 2013 agriculture may be re-assessed for its inclusion in the

scheme to help contribute to GHG mitigation and deliver Australia's commitment to projected reduction targets.

Any national response to greenhouse in agriculture needs to incorporate economic, environmental, and social considerations. A number of recent initiatives at the Commonwealth, State, and Industry levels have highlighted the need for greater coordinated action at the national level. Some of these initiatives are the establishment of the Greenhouse and Agriculture Taskforce, progress of the Standing Committee on Agriculture and Resource Management work program on greenhouse, agricultural components of National and State Greenhouse Strategies, the Greenhouse Challenge program, the National Greenhouse Gas Inventory, the National Carbon Accounting System, the CRC for Greenhouse Accounting, and the Greenhouse Gas Abatement Program⁶.

If farmers are required to play a role in carbon reduction in the future, it is important that they have an understanding of why they need to reduce carbon on-farm and what policies are being developed that will include agriculture in achieving carbon reduction targets. This study will provide a preliminary indication of Wimmera farmers' perceptions of carbon in agriculture and will form a basis for further research in this area.

⁶Developing a Strategic Framework for Greenhouse and Agriculture. (2002). Retrieved: 13 August. Available at: <http://www.climatechange.gov.au>

2.2 Aims and Outcomes

The primary aim of this project is to generate baseline data to gain an understanding of the perceptions and current knowledge held by Wimmera landholders about carbon emissions on their farms and the priority they place on reducing their carbon emissions. The study objectives and outcomes are highlighted in Table 1.

Table 1 - Short term Objectives and Outcomes

| Objective | Outcome |
|---|---|
| 1. Determine farmers' level of knowledge about greenhouse gas and understanding of GHG emissions in agriculture and on-farm | <ul style="list-style-type: none"> a) Farmer profiles b) Farmer perceptions of climate change and greenhouse gases c) Farmer knowledge of greenhouse gases d) Farmer knowledge of emission profile by sector e) Identify issues of concern |
| 2. Determine current attitudes and expectations of farmers towards their role in the carbon market in the future | <ul style="list-style-type: none"> a) Farmer perceptions of agriculture in the carbon market b) Farmer perceptions of their role in the carbon market |
| 3. Identify drivers and barriers that influence farmers' ability to change their practices in order to adapt to better GHG management on-farm | <ul style="list-style-type: none"> a) Extent and types of practice change b) Motivations to reduce farm carbon emissions c) Drivers for adaptation to new farm practices |
| 5. Investigate if farmers' knowledge and perceptions change through information delivery. | <ul style="list-style-type: none"> a) Assess effectiveness of information delivery b) Identify relationship between knowledge and farmers perceptions. |
| 6. Identify information needs and issues to be addressed to assist farmers to become more engaged in farm carbon management. | <ul style="list-style-type: none"> a) A literature review to assess current research and identify research gaps b) A report of the results of this preliminary study indicating current farmer attitudes and knowledge together with their expectations of the future benefits and implications of ETS commencing in Australia. c) Highlight lessons learnt from this study and research opportunities for further studies |

3. Literature Review

3.1. Introduction

There is now firm evidence that the global climate has changed over the past century and this will continue throughout the 21st century in response to continued increase in global greenhouse gas emissions (IPCC, 2007). Human activities are recognised to be the main contributor increasing global greenhouse gases such as carbon dioxide (CO₂), methane (CH₄) and nitrous oxide (N₂O), and these GHG affect the radiative balance of the earth, keeping it warmer (Howden *et al* 2008).

Agriculture is extremely vulnerable to climate variability; reductions in rainfall, extreme weather conditions, floods and drought will have a major impact on productivity (Crimp *et al* 2008). Rural landholders are developing adaptation strategies in response to climate variability to reduce risk to their farm enterprise into the future.

Improvements in water use efficiencies, farming practices and appropriate land use changes, increased provision of information such as use of seasonal forecasts for farmers, improved crop cultivars and improved bio-security services are important strategies developed to help farmers deal with this variability (Kingwell, 2006). In addition to the changes in farming practice, current abatement strategies of climate change have potential longer term impacts on agriculture. These strategies include; mitigation of greenhouse gases by the reduction of emissions by industries, increased capacity and knowledge to store carbon and the development and use of alternate energy sources such as solar and wind which are being developed to help reduce the reliance on fossil fuels and reduce the impact of climate change in Australia (IPCC, 2007).

The role of agriculture in such mitigation mechanisms has not yet been determined; to what extent agriculture will be expected to play a role in abatement of greenhouse gas emissions⁷. But due to the significant contribution of greenhouse emissions from agriculture and the ability to potentially store carbon within plants, animals and soils it is becoming an increasingly important aspect of carbon reduction strategies and policy. While current policy in Australia relating to an Emissions Trading Scheme is delaying the inclusion of agriculture, it has been shown that its contribution can be significant (Garunet Report, 2008; Australian Farm Institute, 2008; Greenpaper, 2008).

The ability of farmers to deal with these expectations is unclear. Most dryland farmers in southern Australia are currently adapting farming practises to cope with reduced water availability and to conserve soil moisture for crops. With

⁷ Australian Government (2007) Agriculture, forestry and emissions trading: how do we participate?. Retrieved: 2nd October 2008. Available: <http://www.ruralrdc.com.au>

financial stress resulting from prolonged drought, the prospect of also dealing with on-farm greenhouse gas (GHG) emissions may seem too much to manage with for some farmers; others may be interested in the potential opportunities that may result.

For centuries the ability of farmers to adapt and adopt practice changes have been occurring (Vanclay, 2004). Whilst the need to change and improve practices to become more sustainable is ongoing, what determines farmers need to change? What is the driver to want to make changes on farm? Are they driven by lifestyle, financial benefits, environmental benefits or is it events that are out of their control that force change such as seasonal conditions or disease?

There is a large amount of research outlining Australian farmers' adaptation to climate change (Kingwell, 2006; Howden & Soussana, 2007; Sposito, 2006; Sietchiping, 2006; Kelly, 2000), and research into technology and accounting tools in the context of facilitating climate change responses in extension activities (Vanclay, 2004; Black, 2000; Fliert, 2003). However limited research has been conducted on understanding rural landholder's attitude towards farmers contributing to the abatement of greenhouse gas emissions on-farm, the ability for rural landholders to adapt to a carbon economy and how they believe this will affect their farming business.

This review of literature presents the current context of climate change and abatement of GHG research and how agriculture may be expected to play a role. It will examine the literature available on understanding adoption practices by rural landholders and what drives or prevents on-farm adoption. It will look at current research into carbon reduction in agriculture, and if any research has identified the drivers and barriers for landholders to reduce carbon emissions on-farm.

3.2. Climate Change

A majority of world scientists believe that human-induced climate change is occurring and that the increasingly high levels of GHG emissions are the main factor that has been contributing to climate change in Australia since the 1950's (Pittock, 2003). In its Fourth Assessment Report released in 2007, the Intergovernmental Panel on Climate Change (IPCC) stated that "most of the observed increase in globally averaged temperatures since the mid-20th century is very likely due to the observed increase in human produced greenhouse gas concentrations" (2007 p.36). Human activities, including the burning of fossil fuels, land clearing and the development of more intensive agricultural systems have led to an increase in the concentration of GHG in the earth's atmosphere (Sposito, 2006). This resulting in an increase in the amount of heat trapped by the atmosphere leading to a change in the earth's climate known as the enhanced greenhouse effect (Sposito, 2006).

The Australian Commonwealth Scientific and Research Organisation (CSIRO) current climate projection for Australia indicates that due to the increasing levels of GHG emission, our continent may warm at a slightly faster rate than the global average of 0.4 - 2.0°C above average by 2030 and 1 - 6°C by 2070 (Goldie *et al*, 2003).

Climate change is predicted to have significant impacts on human and natural systems. These impacts may include: coastal flooding; more heat waves, storms and droughts; less frost, snow and ice; more people at risk from food and water shortages; reduced habitat for many plants and animal species; and more people exposed to infectious diseases⁸ (Australian Government 2005).

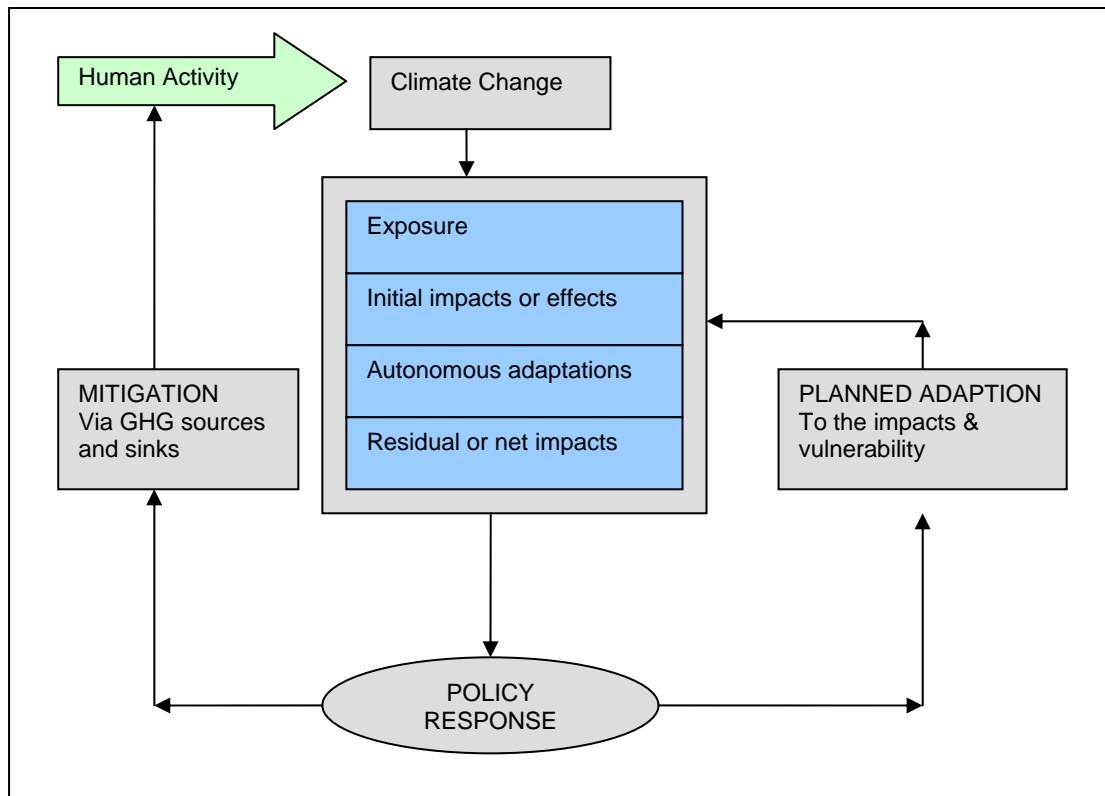
Agriculture is an industry that will be particularly exposed to the risk of adverse outcomes associated with climate change. Climate change policies such as an ETS will have both direct and indirect consequences for agriculture in Australia⁹ (Australian Government 2007).

3.3 Response to climate change

The response to climate change will be varied depending for example on the type of industry, economic and social circumstances. From a systems perspective, these changes may result in 'autonomous' or 'planned' adaptations (Sopsito, 2006; Guerin, 1994; Hertzler 2007; Pannell 2006; Vanclay 2004). Sopsito (2006) suggests that autonomous adaptation will shape the residual, or net impacts of climate change. Policy responses to impacts already exist and can take the form of 'planned adaptations' to reduce the adverse effects of climate change or enhance beneficial ones. Responses can also take the form of actions to mitigate climate change through GHG emissions reduction and enhancement of climate sinks (Sposito, 2006). This can be seen in Figure 2.

⁸ Australian Government (2005) 'Climate Change Risk and Vulnerability Promoting an efficient adaptation response in Australia. Final Report, March 2005
Published by the Australian Greenhouse Office, in the Department of the Environment and Heritage. ISBN: 1 920840 94 Retrieved: 11th November 2008, Available at www.greenhouse.gov.au

⁹ Australian Government (2007) Agriculture, forestry and emissions trading: how do we participate?. Retrieved: 2nd October 2008. Available: <http://www.ruralrdc.com.au>



Source: Sposito (2006) *A strategic approach to climate change and impacts and adaptation*.

Figure 2. Policy response to Climate Change

3.3.1 Australian Government Response

The Australian government's commitment to reducing the effect of climate change came into effect in March 2008 when it ratified the Kyoto Protocol to the United Nations Framework Convention on Climate Change (UNFCCC). In July 2008, the federal government issued a Green Paper for a national Carbon Pollution Reduction Scheme, the central component of which is a broad based national emissions trading scheme. Following consultations on the Green Paper, a White Paper describing the final scheme design and draft legislation will be issued by the end of 2008. It is planned that the required legislation will be passed during 2009 in time for the scheme to commence in 2010¹⁰.

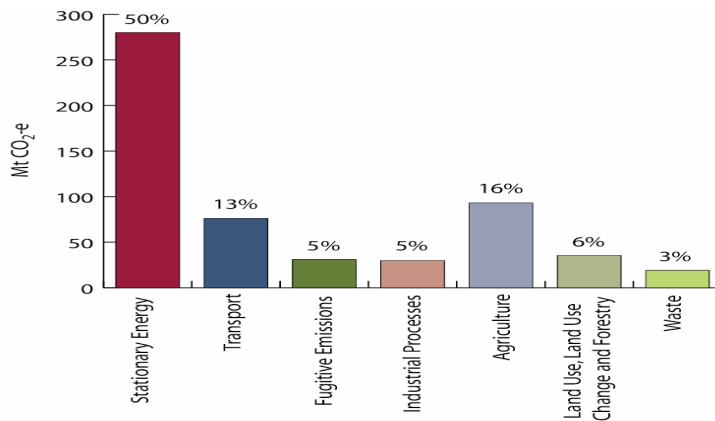
The Australian government plans to meet its Kyoto Protocol obligations by; setting a target to reduce emissions by 60 per cent on 2000 levels by 2050, establishing a national emissions trading scheme by 2010, and setting a 20 per cent target for renewable energy by 2020 to expand the use of renewable energy sources such as solar and wind¹¹ (Australian Government, 2008).

¹⁰ Asia Pacific Emissions Trading Forum, Retrieved: 22nd October 2008 Available at: <http://www.aetf.net.au>

¹¹ Australian Government (2008) Published by the Department of Climate Change' Carbon Pollution Reduction Scheme July 2008. Retrieved: 2nd August 2008. Available from: www.climatechange.gov.au

3.3.2 Sector emissions

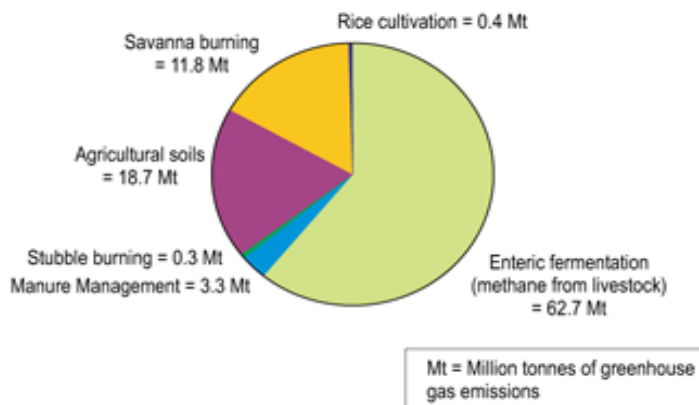
The National Greenhouse Gas inventory (2006) identified Australia's net greenhouse gas emissions across all sectors totalled 576.0 million tonnes of carbon dioxide equivalent (Mt CO₂-eq) in 2006 under the accounting provisions applying to Australia's 108% Kyoto emissions target. The inventory showed agriculture as being responsible for 16 per cent of Australia's greenhouse gas emissions or 87.9 Million tonnes of carbon dioxide equivalent (Mt CO₂-eq)¹² (Australian Government, 2006). This places agriculture as the second largest emitter of greenhouse gases behind stationary energy (Figure 3).



Source: National Greenhouse Gas Inventory 2006.

Figure 3. Australia's greenhouse gas emissions by sector

As shown in Figure 4, the sources of greenhouse gas emissions in the agricultural sector include; enteric fermentation in livestock (the largest contributor), manure management, agricultural soils, rice cultivation and burning of agricultural residues and savanna burning.



Source: National Greenhouse Gas Inventory 2006.

Figure 4. Greenhouse Gas Emissions from Australian Agriculture

¹² National Greenhouse Gas Inventory (2006) Accessed: 2nd July 2008. Available at: <http://www.climatechange.gov.au>.

Issues concerning the ability to accurately measure and account for carbon storage and emissions have prevented agriculture from being included in the initial phase of an Emission Trading Scheme (ETS) (Garnaut, 2008).

Conversely, the energy sector is required to and is responsible for reporting all of their greenhouse gas emissions. This apparent discrepancy is reportedly due to the need for more reliable and cost-effective ways to measure, and or estimate, net carbon emissions for the agricultural sector together with the need for the development of rules to address how non-anthropogenic emissions such as those caused by drought and fire will be managed¹³.

Increasing investment in Research and Development in agriculture to resolve these issues is occurring and the government plans to re-assess if agriculture will be required to help meet GHG emission reduction targets in 2013¹⁴.

4. Agricultural response to climate change

Historically, Australian agriculture has adjusted and adapted to climate change. These changes have predominantly occurred through productivity improvements from technology changes to farm management practices and more market-orientated domestic policy reforms (ABARE, 2007).

4.1 Underlying factors influencing farmer's perceptions

The survival of agriculture in Australia is largely dependent on the survival of rural communities (Vanclay, 2004). Vanclay and other social researchers have identified a number of social principles which are important in the understanding of farmers and how they regard farming.

¹³ Gaurnet Climate Change Review (2008) Accessed: 2nd October 2008. Available at: <http://www.garnautreview.org.au>

¹⁴ Australian Government (2008) Published by the Department of Climate Change' Carbon Pollution Reduction Scheme July 2008. Accessed: 2nd August. Available from: www.climatechange.gov.au

Some of these important principles are described below and should be noted and incorporated in planning and facilitation of farmers into carbon management on farm;

Social Principles – How Farmers Regard Farming.

- Farming is a socio-culture practice rather than a technical activity; it is a way of life and a way of making a living (Vanclay, 2004).
- Farming communities are not homogenous (not all the same). They can be rich, poor; big, small; old and young; innovators, laggards. Instead of classing farmers in demographic or structural variables it may be more appropriate to group farmers into styles of farming (Vanclay *et al* 1998; Howden 1998).
- Adoption takes place in a social context, with farmers discussing ideas with other farmers. Adoption is a deliberate decision by an individual farmer (Vanclay, 2004).
- Profit is not the main driver for farmers. Farmers seek to make a reasonable income for a reasonable amount of work taking a reasonable amount of risk, with each farmer defining what is reasonable for them (Vanclay, 2004)
- The promotion of adoption of new technology requires more than emotion, “it’s hard to be green when you’re in the red” (Vanclay, 2004)
- A strong desire to hand down the farm to the next generation in a better condition than they themselves received it (Curtis, 2002)
- Farmers attitudes are not antagonistic, they do not believe they are doing the land damage, they have different views of what environmental management means, and have concerns with farm practices that are promoted as sustainable or profitable (Vanclay, 2004).
- All individuals and groups create knowledge about their own experience of the work. Information provided to farmers via extension activities is evaluated against other information, knowledge and experience in decision making (Fliert, 2003).
- In terms of GHG reduction, farmers may be asked to make a significant personal contribution to GHG reduction and may need to know that this contribution is appreciated and valued by the broader community (Vanclay 2004; Howden 1998).

As indicated from the research, there are complex social norms that influence how and why farmers farm and these are likely to have some influences on the way farmers will respond and adapt to changes brought about by climate change and the introduction of ETS or other carbon management systems.

4.2 Farmer adaptation response

Farmer's capacity to adapt to environmental and market changes continues to evolve. According to Vanclay & Lawrence (1995), adaptation is seen to depend on a range of personal, cultural and economic factors and also characteristics of the innovation itself. Adaptive capacity may also be influenced by a person's level of education and training, diversity of on and off-farm income sources, and levels of income (Nelson *et al* 2005; Brooks & Adger, 2005).

A number of studies have been undertaken to explore landholders and rural community's ability to adapt to climate change. Many of these studies on adaptation of farming systems to climate change conclude that there is a need to consider all the agronomic (practice and economic) decisions made at the farm level as part of the adaptive process (Kaiser *et al.* 1993).

Pannell *et al* (2006) looked at adaptation of farmers and found that perceived goals, can vary between landholders and these goals will differ between individuals depending on circumstance and personal preference. They reported that, if the landholder does not perceive that their goals are likely to be met, adoption will certainly not follow (Pannell *et al* 2006). They found that adoption is based on 3 broad sets of issues; the process of learning and experience, the characterisation and circumstance of the landholder within their social environment, and the characterisation of the practice.

Sietchiping (2006) attempted to develop an index of adaptive capacity to climate change in North Western Victoria. He defined 'adaptive capacity' as the ability of a system to adjust to climate-induced changes (including climate variability), by accommodating the associated risks or taking advantage of any opportunities. It includes the ability to implement planned adaptation measures but excludes mitigation strategies. Sietchiping (2006) found the ability of a social system to adapt depends on; social capital, population sustainability, family status, education and knowledge of the inhabitants. This is supported by other current literature on farmer's ability to adapt to climate change (Curtis & Byron, 2002; Adger, 2003).

Howden *et al* (2003) also reviewed the adaptive capacity of the Australian agricultural sector to climate change. They concluded that the most potential adoption options for agriculture was through extension or enhancement of existing activities for managing current climate variability, and that there is a large range of farm-level options for adapting to climate change.

4.3 Future adaptation opportunities to contribute to mitigation of GHG on farm

Bindi & Howden (2004) argue that adaptations can be made to counter negative impacts or to take advantage of positive ones and are applicable at different temporal and spatial scales; for example, short term adjustments and long term adaptations, farm-level adaptations or those at the regional or national policy level, these concepts are discussed below.

4.3.1 Short-term adjustments

Short term adjustments are efforts to optimise productivity without major system changes and are 'autonomous' in that no other sectors are needed in their development and implementation (Marco & Howden 2004). Such short term adjustments could include: changing cultivar and planting dates (Puckridge, 1971), or changing inputs such as nitrogen fertilisers (Munch & Beese 2001) and improving moisture conservation practices (Tullberg *et al* 2001).

The Department of Climate Change (2008) provides other examples of short-term adjustment opportunities for farmers to reduce carbon emissions from the farm; the application of nitrogen fertilisers only at times and quantities that are useful for plant growth and the reduction in reliance of fertilisers which are energy-intensive in their manufacture and application. The alternative use of recognised animal wastes as fertiliser to substitute commercial nutrient source may become more applicable for many farmers and while they also have some impact on GHG, data is limited on any direct comparison when one takes into account energy in manufacturing and levels of volatilisation of GHG's.

4.3.2 Long-term adjustments

Long-term adjustments refer to major structural changes to overcome adversity caused by climate change. They can include; changes in land use, reduction of livestock numbers and nutritional management, introduction of more resistant crop varieties, substitution of crops, irrigation changes, and changes at the farming systems level (Marco & Howden 2004).

Howden *et al* (2003) identified some key adaptive changes that could be made on farm such as;

- Further develop risk amelioration approaches (e.g. zero tillage and other minimum disturbance techniques, retaining residue, extending fallows, row spacing, planting density, staggering planting times, controlled traffic, erosion control infrastructure).
- More opportunistic cropping – more effectively taking into account environmental condition (e.g. soil moisture), climate (e.g. seasonal climate forecasting) and market.
- Expand routine record keeping of weather, production, degradation, pests and diseases, weed invasion.
- Tools/training to access/interpret climate data and analyse alternative management options.
- Learning from farmers in currently more marginal areas or early adopters.
- Selection of varieties with appropriate thermal time and vernalisation requirements, heat shock resistance, drought tolerance (e.g. 'Staygreen' varieties), high protein levels, resistance to new pests and diseases and perhaps that set flowers in hot/windy conditions.
- Improve seasonal and other climate forecasting and also develop early warning systems of the likelihood of very hot days and high erosion potential.

5. Drivers of adoption.

Howden *et al* (2003) found that there are a range of adaptive options for farmers. They also found that the adoption of these new practices will require;

- 1) Confidence that climate changes several years or decades into the future can be effectively predicted against a naturally high year-to-year variability in rainfall that characterises these systems
- 2) The motivation to change to avoid risks or to use opportunities
- 3) Development of new technologies and demonstration of their benefits
- 4) Protection against establishment failure of new practices during less favourable climate periods; and
- 5) Alteration of transport and market infrastructure to support altered production (McKeon *et al* 1993)

Howden *et al* (2003) believed that adaptation strategies that incorporate the above considerations are more likely to be of value and be implemented. This

is because they could be more readily incorporated into existing on-farm management strategies.

6. Barriers to adoption

Sometimes the opportunity to adopt new technologies might be limited by infrastructure constraints such as access to inputs and to markets (Vanclay & Lawrence 1995). Vanclay and Lawrence (1995) cite a number of constructs in their work on innovation and socio-ecological concerns in natural resource management which may also influence the ability of farmers to adapt their farming practice to climate change and for policy makers to provide the structures to enable this to occur. These include; complexity, congruence, lack of flexibility, economics, implementation costs, environmental perception, conflicting information, risk and uncertainty.

6.1 Complexity

Complexity can refer to something with many parts in intricate arrangement. There are many times of complexity including technical, financial and market (McGregor 2007). Complex innovations may increase risk, and farmers may require better skills and specialised knowledge of other external processes or factors (Vanclay & Lawrence, 1995). Complexity may increase the intensity of effort required for ongoing management, and the risk of the innovation failing in any given year, it can also reduce the relative advantage of the innovation (Pannell *et al* 2006).

Soil carbon is a good example of on-farm complexity. Soil carbon can be characterised by spatial, seasonal and annual variations and sampling can be costly (Garnaut Review, 2008). Estimation of emissions and removal by soils is difficult and models can give varying results. Currently more reliable and cost-effective ways to measure or estimate net emissions are needed in the farming sector and are being established.

With around 130 000 agricultural establishments in Australia (ABS, 2007), each with diverse emission profiles, regulation of these businesses will be complex and require management systems to deal with regulation and verification.

6.2 Congruence

Congruence refers to situations where innovation is less compatible with farming practices or personal objectives. Congruence may depend on level of complexity of innovation, and rationalising decisions with farm business and personal goals (Vanclay & Lawrence, 1995).

Farmers may consider themselves wedded to a particular production output (livestock, broad-acre, forestry) or a production method (organic, zero-till, and conventional) because they identify with it personally. This can reduce the relative advantage of alternatives (Pannell *et al* 2006).

Furthermore some farmers are older and do not have children to pass the farm on (Barr, 2005). These farmers may be more focused on selling their land, (Curtis & Bryon, 2002) and less likely motivated to change.

6.3 Loss of flexibility

Loss of flexibility is defined to be where an innovation reduces or restricts flexibility; farmers are less likely to adopt the innovation (Vanclay & Lawrence, 1995). Many farming practices are run flexible to climatic conditions. If farmers are to increase commitments to long-term costly mitigation investments, the loss of flexibility could become problematic.

Some farmers are currently investing in zero-till farming practice and machinery in the broad-acre sector. This system is designed to increase soil carbon and soil moisture, however, implementation of this system is not inclusive of livestock, which can provide an income to many farmers if crops have failed. Many farmers have reduced the practice of burning stubble (crop residue) and this contributes to a reduction in GHG emissions, however under certain seasonal conditions stubble burning may be necessary. If carbon management strategies prohibit the farming practices of tactical burning, the ability of the farmer to be flexible to seasonal conditions may be limited.

Loss of flexibility is a major issue in farming systems, especially in relation to seasonal variability. If farmers tie up productive land in farm forestry schemes to help offset industry emissions then this land will not be available for food production in years when that use of land may be more suitable for this use (Tonts *et al* 2001).

6.4 Economics

The link between economic benefit and innovation is unclear, but it may be determined that if the innovation is not economical then adoption is unlikely to occur (Vanclay & Lawrence, 1995).

Schwarz & McRae-Williams (2007) identified farmer perspectives and aspirations in relation to the development of Wimmera Mallee Pipeline. Their research indicated that for some farmers, the decision to adopt innovations are based on whether their current economic situation will warrant it. This is further reflected by Vanclay & Lawrence (1995), “the more likely an innovation will provide concrete economic benefits, the greater the likely rate of adoption” (p. 102).

6.5 Implementation cost

This refers to the capital outlay associated with implementing the innovation. Where farmers are resource-limited, they may not have the opportunity to adopt to innovation or new technology (Vanclay & Lawrence, 1995).

The agriculture industry currently appears to lack cost effective GHG mitigation options. For example, methane abatement options such as ruminant nutritional supplements are costly and may increase labour requirements (Garnaut Review, 2008). Land conservation practices are often characterised by high up-front costs and benefits are not realised until some time in the future (eg. establishment of native vegetation corridors). It is therefore often large upfront costs plus accumulated interest that may reduce the attractiveness of a change in farming practice (Pannell *et al* 2006) such as reducing GHG emissions, especially when these reduction can not be seen by farmers but are assumed to be made by scientific modelling.

6.6 Risk and Uncertainty

Research suggests that the more risk and uncertainty about innovation, the greater the influence on the farmers' decision to adopt or reject the innovation (Vanclay & Lawrence, 1995). Within the broader context of climate change, GHG emissions and water shortages; risk and uncertainty are high.

The relative advantage for example of using a new crop would be reduced if it were perceived to be more subject to price variability, to establishment failure, to yield or production loss due to drought, weeds, and pests than the current variety grown. If a new, higher yielding wheat variety is readily adopted by existing wheat farmers because it is compatible with current farming practice such as machinery, rotations, herbicide and pesticide use, it would be beneficial and in turn more reliably adopted. However this might not be the same if a new type of tree crop is considered as it is unlikely to be compatible with existing farming practice, and the cost of making the transition to new this farming practice would reduce its relative advantage (Pannell *et al* 2006).

The wide range of different soil types across Australia may result in a higher relative advantage to practice change on some farms than others. For example, while annual crop biomass is a store of carbon during plant growth, most Australian dryland annual cropping systems cannot be viewed as a long-term store for carbon as very little carbon is stored after the crop has decomposed or been harvested and the ability for farmers to increase their soil carbon is limited¹⁵. This is contrary to some American & European soils, for example, where stubble retention & direct drilling produces increases in soil carbon and creates a long-term store of carbon (BCG Manual, 2004).

¹⁵ National Carbon Accounting System Technical Report (2005) Retrieved: 2nd July 2008. Available at: <http://www.greenhouse.gov.au/ncas>

6.7 Environmental perception

Public and media representation of risk, such as land degradation or climate variation, are often sensationalised and depict the worst-case scenario or best-case scenario. A possible reason for non-adoption by some is when the media images conflict with a farmer's own experience or knowledge of problems (Vanclay & Lawrence, 1995).

For farmers with a focus on profit, the farm-level economics of a proposed conservation or environmental practice will be important. Conservation practices that are not profitable on a farm level will tend to be adopted only by farmers with stronger conservation goals. The lower the perceived profitability, the stronger the conservational or environmental goals need to be for adoption to occur (Pannell *et al* 2006).

6.8 Conflicting information

Farmers' assessment of uncertainty about an innovation has some influence in the individual farmer's decision to adopt or reject the innovation (Schwarz & McRae-Williams 2006). This can also be seen as the extent to which the farmer finds the new technology complex and difficult to comprehend. How readily observable the outcomes of an adoption are; its financial cost; the farmers cost; the farmers beliefs and opinion towards the technology; the farmers level of motivation; the farmers perception of the relevance of the new technology; and the farmers' attitude towards the risk and change are all important indicators of the propensity for adoption of new or innovative practices (Guerin, 1994).

While the impact of climate change is uncertain and the diverse and conflicting views remain about the science and the causes, it is clear that this will effect innovation and adoption new practices that will reduce emissions or capture and store carbon on-farm.

7. Summary

Due to increasing industrialisation of developing countries the world nations need to accept and construct ways to measure and reduce global greenhouse emissions, if not to reduce the impacts of climate change but to just become less wasteful of our natural resources. The literature suggests that it is important that we address this not just at an industry or enterprise level but at an individual level, to achieve reductions in human dependence and demand of fossil fuel based energy.

The combination of record heat and widespread drought during the past five to ten years over large parts of southern and eastern Australia is without

historical precedent and is, at least partly, a result of climate change¹⁶. Whilst the literature conveys information about the possible impact of climate change on agriculture and agriculture's contribution to climate change, as well as the drivers and barriers for farmers to adopt new innovations, there is little depth of information understanding farmers' perceptions and likely uptake of adaptation mechanisms that will occur on-farm.

The literature clearly identifies that there are many socio-cultural factors and structural and demographic characteristics which influence a farmer's decision to adapt to new technologies and new farming practises. It seems from this literature that adaptation, social factors and scale of adjustment are linked and that building upon existing knowledge and management may be effective in facilitating the adaptation of agriculture to climate change, GHG emission abatement and carbon management.

This study seeks to draw out the farmer's current perceptions and attitudes towards the carbon management on-farm, to gain their insights and current levels of knowledge and explore if farmers are currently using any tools or changed current farming practise contributing to GHG abatement. This preliminary investigation will provide input toward the development of activities and strategies to assist farmers to adapt to farming practices more conducive to the emerging shift in agriculture that will be driven by climate change and the introduction of an emission trading scheme.

¹⁶ Australian Government BOM (2008) October Drought Statement, Retrieved: 1st October 2008. Available from: <http://www.bom.gov.au>

4. Methods

4.1 Overview of the study methodology

This section outlines the methodological approach to this study. Figure 5 represents the study approach.

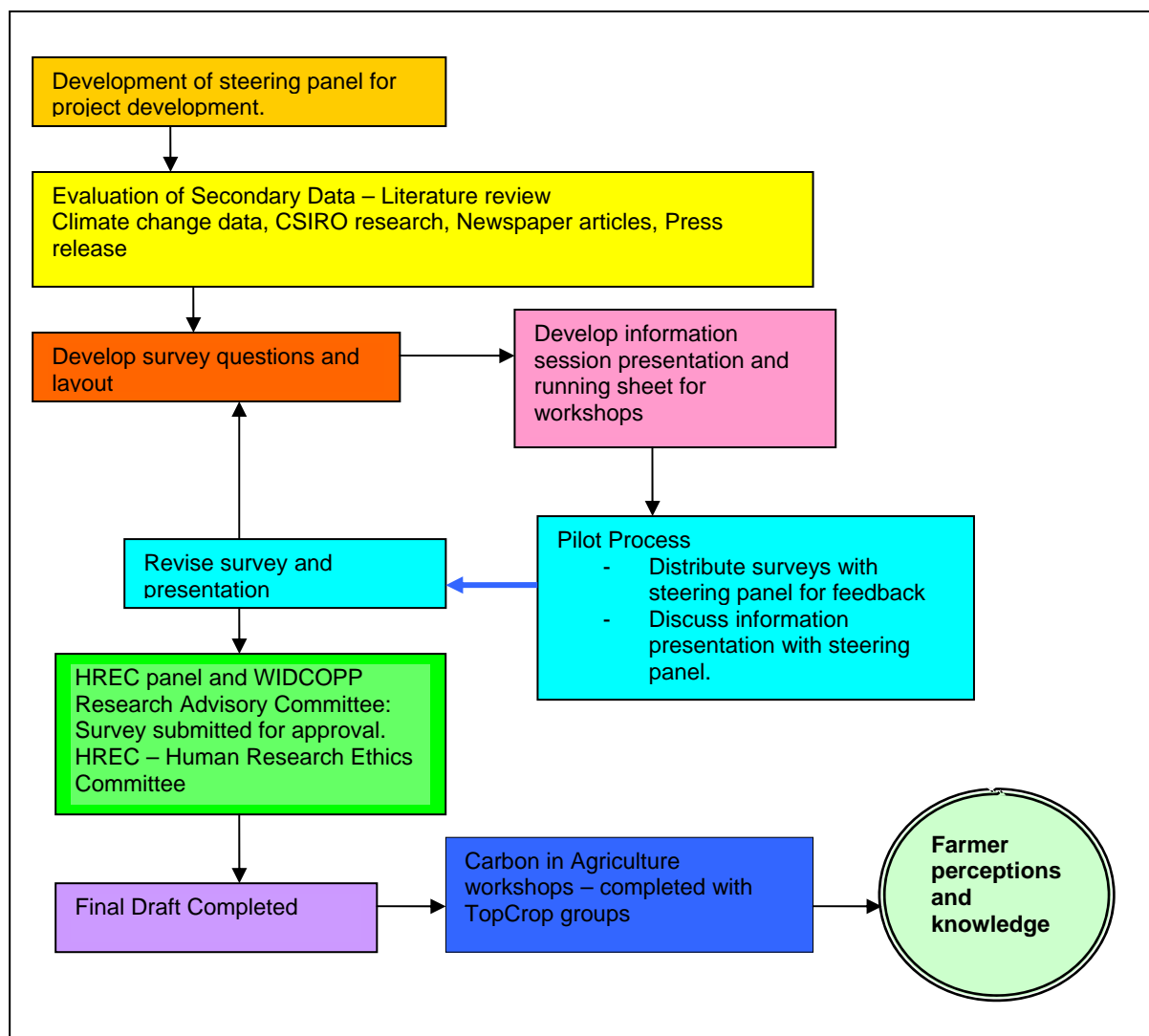


Figure 5. The study approach; non-probability sampling design

4.2 Steering group

A steering group was established for this project. It included representatives from the Department of Primary Industries and WIDCORP. The purpose of the panel was to develop and test the survey design and the 'Carbon in Agriculture' presentation to be delivered to farmers. The steering group also ensured that ethics approval was gained through the University of Ballarat for the conduct of the survey.

An initial workshop with several members of the steering group and agricultural consultants tested the survey and provided feedback prior to the implementation of the survey to the final farmer workshop groups. The steering panel provided feedback for the 'Carbon in Agriculture' presentation and also provided feedback and advice during the workshops to make improvements to the workshop content.

4.3 Literature Review

A desk-based review of the literature was conducted principally to identify published evidence of the current status of agriculture with regard to its current role in carbon management on-farm within Australia. In addition, the review sought literature on how and why farmers adapt their farming practices to address issues such as climate change and to identify current research and research gaps in the area of carbon management on-farm.

The literature search was conducted on 'keywords' to explore topics in most Australian University library catalogues and agriculture and environmental databases. Keywords used were 'carbon', 'carbon in agriculture', 'greenhouse gas emissions', 'emission trading scheme', 'farmer adaptation', 'environmental accounting'. Specific databases searched were Emerald/Full Text, Google Scholar, CSIRO, Australian Farm Institute and contents of the *Australian Journal of Experimental Agriculture* and *The Journal of Agricultural Education and Extension*. A general search was also conducted using 'Google' search engine.

4.4 Survey Design Process

4.4.1 Ethical considerations

Ethics approval was granted on the 17th July 2008 from the University of Ballarat Human Research Ethics Committee. The workshops and survey were generally well received by the farmer groups, however on occasion they did evoke some discussion regarding the information delivered. All the data from the surveys has been de-identified and aggregated to ensure anonymity of participants and code names were used in place of real names. Ethical procedures were followed in responding to participant concerns.

4.4.2 Survey distribution

A purposive sampling method was used for the design of this research project. This method was chosen for the following reasons; the cases can be selected for particular groups (landholders); it is useful for selecting members of a population that are difficult to sample by other methods; and to identify particular cases which can be used for further research. This study sought to identify farmer's attitudes and perceptions, and the TopCrop groups were considered by the steering group to be the most appropriate contact to invite a representative sample of farmers from across the Wimmera region to participate in the workshops and survey. Recruiting farmers to participate in social research is difficult (Aslin, 2006).

It is not the expectation of this study that results of the workshops and survey can be generalised to the wider population, however the research will give an indication of the current issues and thinking of farmers in the Wimmera region, and provide a base to develop future activities and further research.

TopCrop groups are traditionally farmer focused information networks for cereal, canola and grain legume growers but more recently are also made up of mixed farmers, growers, contractors, agribusiness and invited experts. They are used to address local (and regional) issues through regular group meetings and paddock walks. The Wimmera region has seventeen TopCrop groups and four of these groups participated in the workshops. Three other groups were targeted to be involved in the workshops but these group meetings were cancelled during the designated research period.

A mail-out promotional letter was sent to each of the groups prior to the commencement date of the workshop to promote participation in the research project. As shown in the Table 2 below, the TopCrop groups involved in the research had a good representation of members at each of the meetings. The numbers of attendees at each workshop varied and a number (11) of attendees elected not to participate in the survey.

Table 2. TopCrop Workshops

| Topcrop Group | Date | Number of meeting attendees | Number of participants |
|---------------------|----------|-----------------------------|------------------------|
| Nhill South /Winiam | 21/08/08 | 16 | 15 |
| Lubeck | 14/08/08 | 10 | 10 |
| Horsham East | 28/08/08 | 17 | 8 |
| Brim | 29/08/08 | 15 | 14 |
| Total | | 58 | 47 |

Given the timeframes, the target was to survey 60 Topcrop farmers from approximately four to six of the groups within the region. The groups that were surveyed were Brim, Horsham East, Winiam/Nhill and Lubeck and a total of 47 farmers participated in the carbon workshops. It was decided due to time limitations to not pursue further groups for this preliminary study.

4.4.3. Survey Development and Delivery

Baseline data for this study was collected using a survey approach during a farmers' workshop. Each of the workshops with TopCrop groups began with a brief outline of the study including participant requirements (covering plain language statement and consent form) and distribution of the survey (survey questions are provided in Appendix 9.2). Those farmers who agreed to participate were then asked to complete the first section of the survey. After the completion of Section A, the 'Carbon in Agriculture' presentation was delivered by a Climate Change Officer from the DPI to the entire TopCrop group. The presentation was followed by group discussion. The final part of the survey (Section B) was then completed by participants. The objective of Section B was to determine if farmers' perceptions and knowledge had changed as a result of the delivery of information and discussion.

Field observations were noted during the discussions with farmers during and proceeding the information session. The baseline data gathered could be used to inform a larger longitudinal study to understand and track changes in response to the future implications of farm carbon management and an ETS on the agricultural sector within the Wimmera region. The research could also be widened to state level and across other agricultural sectors such as horticulture, dairy, and intensive livestock industries.

4.4.4 Data analysis

Quantitative data was analysed using the computer software package SPSS to generate descriptive statistics and charts for interpretation of the results. Qualitative data in the form of field observations was used to inform the general discussion in the report and to assist with translation of quantitative data.

5.2 Demographic Questions

▪ Age

The majority of respondents were in the 35 to 44 age group (44.7%) with an even representation of both the under 35 and over 55 year old age category (27.7%) (Table 3).

Table 3. Age distribution

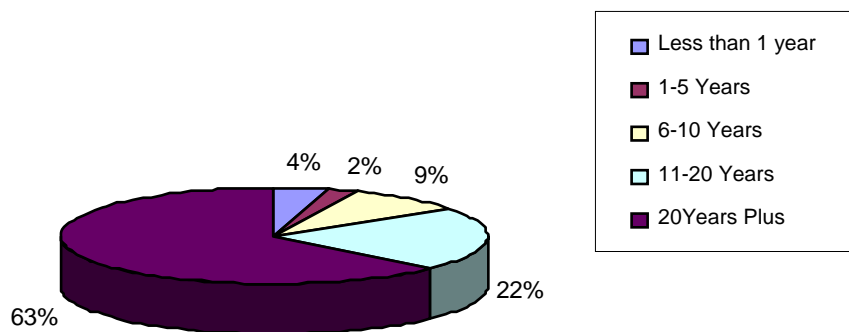
| Age Group | Frequency (n= 47) | Percentage % |
|--------------|----------------------|-----------------|
| Under 35 | 13 | 27.7 |
| 35-55 | 21 | 44.7 |
| 55 Plus | 13 | 27.7 |
| Total | 47 | 100.0 |

Q. Please indicate your age group?

▪ Length of time farming

The majority of respondents have been farming for 20+ years (63%) within the Wimmera region with only a small group (6.5%) farming for less than five years in the region (Figure 7).

Figure 7. Time farming



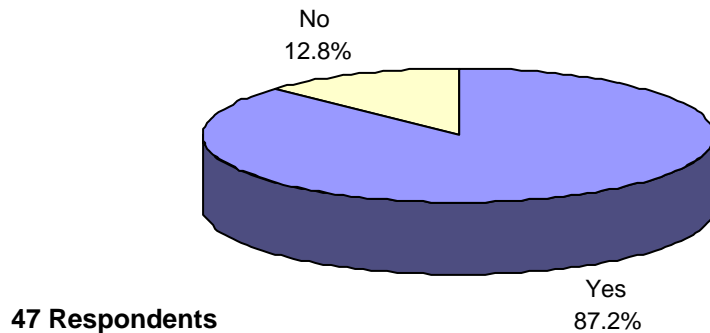
46 Respondents

Q. How long have you been farming within the Wimmera region?

- **Farm Ownership**

Most of the respondents (87.2%) owned farmland in the Wimmera. Of the six respondents that answered no, only one leased land in the region (Figure 8).

Figure 8. Farm ownership



Q. Do you own farm land in the Wimmera Mallee?

- **Farming land owned**

The average number of hectares of farmland owned by respondents was 933 ha with a median of 809 hectares of land owned in the region, the top response was 1214 or more hectares of farm land owned in the Wimmera Mallee as shown in the Table 4.

Table 4. Farm size

| Acres | Frequency (n= 39) | Percentage % |
|---------------|----------------------|-----------------|
| Less than 499 | 3 | 7.8 |
| 500 to 999 | 3 | 7.8 |
| 1000 to 1499 | 8 | 20.25 |
| 1500 to 1999 | 3 | 7.8 |
| 2000 to 2499 | 8 | 20.25 |
| 3000 and over | 14 | 36.1 |
| Total | 39 | 100.00 |

Q. How many acres do you own in the Wimmera Mallee?

- **Farming land leased**

Of the respondents, 50 % (21 respondents) lease some land in the Wimmera Mallee. An average area of land leased was 572 hectares, with a median of 404 hectares (Table 5).

Table 5. Land leased

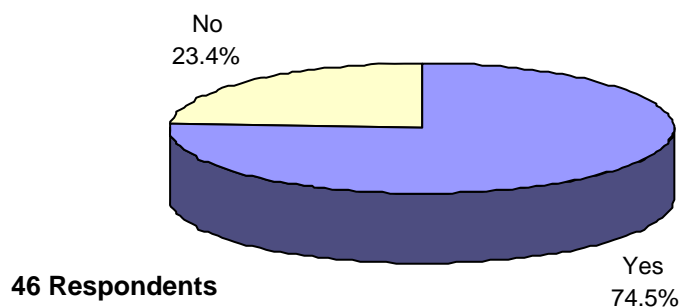
| Acres | Frequency (n= 21) | Percentage (%) |
|---------------|----------------------|-------------------|
| Less than 499 | 7 | 14.8 |
| 500 - 999 | 3 | 6.3 |
| 1000 – 1499 | 3 | 14.3 |
| 1500 – 1999 | 0 | 0 |
| 2000 – 2499 | 5 | 10.6 |
| 3000 and over | 3 | 6.4 |
| Total | 21 | 52.4 |

Q. Do you lease land in the Wimmera Mallee from another person to farm yourself if so how much?

- **Living on-farm**

Of the 46 people that responded 35 (74.5%) lived on-farm, and 11 (23.4%) did not live on the farm (Figure 9).

Figure 9. Living on farm



Q. Do you live on-farm?

- **Farming Operation**

Almost all the respondents participated in broad-acre farming; this category was broken up into cereal grain production (95.7%), pasture hay (72.3%), oilseed (57.4%) and pulse production (38%) (Table 6). Of these respondents, only seven participated in cropping without any livestock.

Of the sheep producers, 30 people produced sheep for wool and meat, seven just produced sheep for meat, and one produced sheep just for wool, and they all produced some type of crop (mixed enterprise). 12.8% participated in intensive livestock production, 6.4% had some farm forestry production and 10.6% of respondents answered 'Other'. These activities included contract hay production, production of alpacas, angora goats, irrigated vegetables and seed, and both a beef and a sheep feedlot.

Table 6. Farming operation

| Farming production | Frequency (n = 235) | Percentage (%) |
|--------------------------------|------------------------|-------------------|
| Broad acre - | 137 | 319.1 |
| <i>Cereal Grain Production</i> | 34 | 95.7 |
| <i>Pasture Hay</i> | 38 | 72.3 |
| <i>Pulse Production</i> | 38 | 80.9 |
| <i>Oilseed</i> | 27 | 57.4 |
| Intensive Livestock | 6 | 12.8 |
| Dairy | 0 | 0 |
| Horticulture | 1 | 2.1 |
| Farm forestry | 3 | 6.4 |
| Sheep – | 68 | 114.7 |
| <i>Meat</i> | 37 | 78.7 |
| <i>Wool</i> | 31 | 66 |
| Beef Cattle | 8 | 17 |
| Other | 5 | 10.6 |

Q. Which of the following does your farm participate or operate in...

5.3 Farmers Knowledge

- **Greenhouse Gases**

Apart from water vapour, the Victorian greenhouse gas inventory reports that the six main greenhouse gases are carbon dioxide (CO₂), methane (CH₄), nitrous oxide (N₂O) and synthetic greenhouse gases; hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) (eg. CF₄, C₂F₆, C₃F₈) and sulphur hexafluoride (SF₆)¹⁷.

¹⁷ National Greenhouse Gas Inventory (2006) Accessed: 2nd July 2008. Available at: <http://www.climatechange.gov.au>.

The impact of each greenhouse gas varies in terms of its effectiveness in trapping solar radiation and, consequently, its contribution to global warming. The extent of this variation is indicated by the Global Warming Potential (GWP) of each gas relative to CO₂ as described in the table below. Carbon dioxide is the most significant greenhouse gas followed by methane, nitrous oxide, perfluorocarbons and so on (Table 7).

Table 7. Global Warming Potentials of greenhouse gases

| Gas | Global Warming Potential (GWP) |
|-------------------------------|--------------------------------|
| Carbon dioxide | 1 |
| Methane | 21 |
| Nitrous oxide | 310 |
| CF ₄ | 6,500 |
| C ₂ F ₆ | 9,200 |
| HFC-23 | 11,700 |
| SF ₆ | 23,900 |

Source: Intergovernmental Panel on Climate Change Second Assessment Report: the science of climate change¹⁸

Of the 47 participants twenty ranked the three greenhouse gases they believe contribute most to concentrations of GHG in the atmosphere. Rankings by participants of the top three gases are shaded in grey. 55% of the respondents believe that carbon dioxide was most abundant followed by carbon monoxide (36.8%), then methane (25%) (Table 8).

Table 8. Ranking of greenhouse gases

| Greenhouse Gas (GHG) | Ranking – 1 | Ranking – 2 | Ranking – 3 |
|----------------------|-------------|-------------|-------------|
| | % | | |
| Carbon Dioxide | 55.0 | 15.8 | 20.0 |
| Carbon Monoxide | 20.0 | 36.8 | 15.0 |
| Methane | 15 | 31.6 | 25 |
| Nitrous Oxide | 5 | 10.5 | 20 |
| Other GHG | 5 | 5.3 | 20 |

Q. The list below displays seven major greenhouse gases that are released into the atmosphere. Please circle and rank the three greenhouse gases that you believe contribute most to greenhouse gas concentrations in the atmosphere.

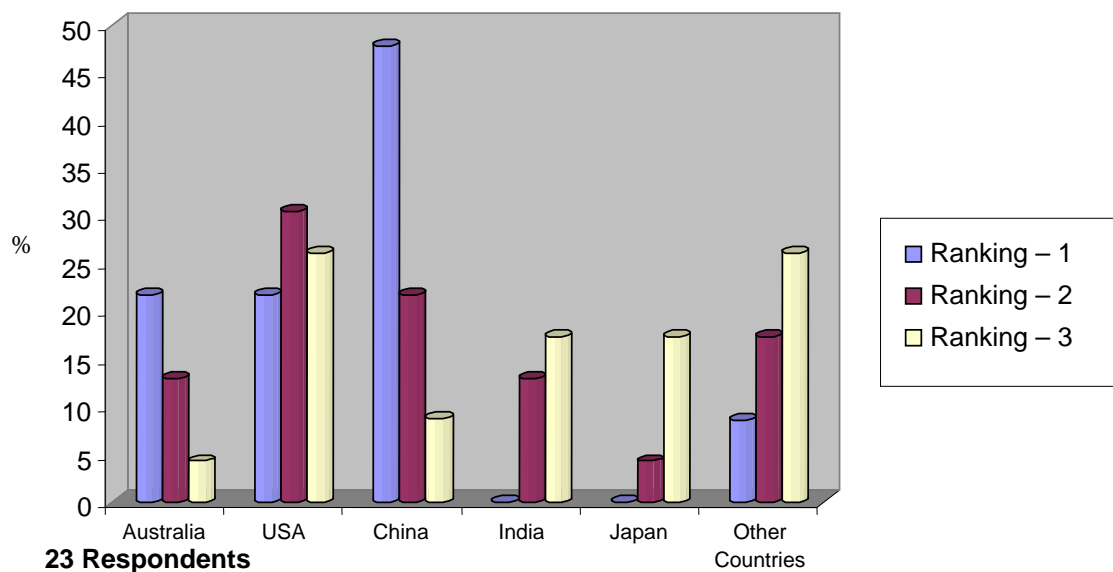
¹⁸EPA (2008) Global Warming Potentials. Retrieved: 11th November 2008. Available at: <http://www.epa.vic.gov.au/climate-change/glossary.asp>

- **Greenhouse gas emissions per capita**

The United Nations Environment Programme (UNEP) reports the contributions of different countries to global greenhouse gas emissions and presented in per capita emissions. They report that the United States, Saudi Arabia, Australia and Canada are the largest contributors per capita of greenhouse gas emissions globally. 'Per capita emissions' are used as an indicator of the difference of emissions per country based on income to low income nations on CO₂ output (Refer to Appendix for per capita emissions graph).

Of the total respondents, 11 (47.8%) participants ranked China to be the country that is emitting the most greenhouse gas emissions per capita, this was followed by the USA, ranked second (30.4%) and China third (26.1%) (Figure 10).

Figure 10. Ranking per capita greenhouse gas emissions



Q. Many countries contribute to varying amounts of greenhouse gas emissions. From the list of countries please circle and rank the three countries you believe contribute most to greenhouse gas emissions per capita?

- **Greenhouse Gas Emissions Per Sector**

The National Greenhouse Gas Inventory (2006), reported that Australia's net greenhouse gas emissions using the Kyoto accounting provisions is 576.0 million tonnes (Mt) CO₂-equivalent (CO₂-e). The largest contributor to greenhouse gas emissions on Australia's inventory is the energy sector comprising 69.6% (400.9 Mt CO₂-e) of emissions, followed by agriculture (15.6%).

Table 9 shows where respondents placed each industry sector in relation to the amount of emissions each sector is responsible for ('% of CO₂ emissions'), in comparison to that reported by the National Greenhouse Gas Inventory (represented by the shaded boxes).

Fifty four percent of respondents chose the correct percentage representation of carbon emissions from the electricity, gas and water sector which accounts for 35% of the total carbon emissions from industry. No respondent chose the representation

of 24% being related to agriculture. Farmer respondents all positioned Agriculture in the lower emission sectors of Manufacturing (12%), Mining (9%) and Residential (9%).

Table 9. Ranking of industry sector greenhouse gas emissions

| CO2 emissions (%) | Top Three Responses | | | Chosen in actual top three |
|-------------------|----------------------------------|--------------------------------|----------------------------------|------------------------------|
| | 1 st | 2 nd | 3 rd | |
| 35 (*) | Electricity, gas & water (54%) * | Manufacturing (20%) | Services & transport (14.6%) | ✓ |
| 24 (*) | Services & transport (27%) | Manufacturing (25%) | Electricity, gas & water (16.7%) | ✗ (Ag, forest and fishery) * |
| 12 (*) | Services & transport (27.1%) | Ag, forestry and fishery (25%) | Mining (14.6%) | ✗ (Manufacturing) * |
| 10 (*) | Residential (22.9%) | Manufacturing (22.9%) | Mining (16.7%) | ✗ (Services & transport) * |
| 9 (*) | Residential (39%) | Mining (20.8%) * | Ag, forestry and fishery (18.8) | ✓ |
| 9 (*) | Ag, forestry and fishery (31%) | Mining (24%) | Residential (17.8%) * | ✓ |

Q. According to the National greenhouse gas inventory (NGGI, 2006) the contribution of emissions have been grouped into sectors. These sectors represent the main human induced activities that contribute to the release of carbon into and from the environment. Place the letter that you believe best matches the percentage of carbon emissions from each sector.

▪ Emissions by the Agricultural Sector

Australian agriculture was responsible for 16.5% of Australia's greenhouse gas emissions in 2004 (AUS GOV 2007) or 87.9 million tonnes of carbon dioxide equivalent (Mt CO₂-eq) (NGGI 2007). This makes agriculture the second largest emitter to that of stationary energy. The key sources of emissions in the agricultural sector include enteric fermentation in livestock (65%), agricultural soils (18%), manure management (4%), and burning of savannas (12%) and agricultural crop residues (1%).

Table 10, shows the percentage of respondents that chose each of the represented agricultural emissions. The answers for each sector are highlighted in the table.

Only a small proportion of the respondents (9.3%) believed that 65% of carbon emissions are due to livestock enteric fermentation (ruminant digestion). On the contrary, 30.2% believed that a high proportion of emissions (65%) from agriculture are attributed to the burning of crop residues, which in reality only accounts for 1% of emissions (Table 10).

Table 10. Sources of carbon emission

| CO2 emissions (%) | Ag Soils (%) | Manure Management (%) | Burning of savannas (%) | Burning of Crops (%) | Ruminant Digestion (%) | Total (%) |
|-------------------|--------------|-----------------------|-------------------------|----------------------|------------------------|-----------|
| 65 (*) | 18.6 | 18.6 | 23.3 | 30.2 | 9.3 * | 100 |
| 18 (*) | 14 * | 0 | 14 | 23.3 | 48.8 | 100 |
| 12 (*) | 18.2 | 31.8 | 31.8 * | 13.6 | 4.5 | 100 |
| 4 (*) | 41.9 | 18.6 * | 9.3 | 18.6 | 11.6 | 100 |
| 1 (*)_ | 7.0 | 25.6 | 25.6 | 16.3 * | 25.6 | 100 |

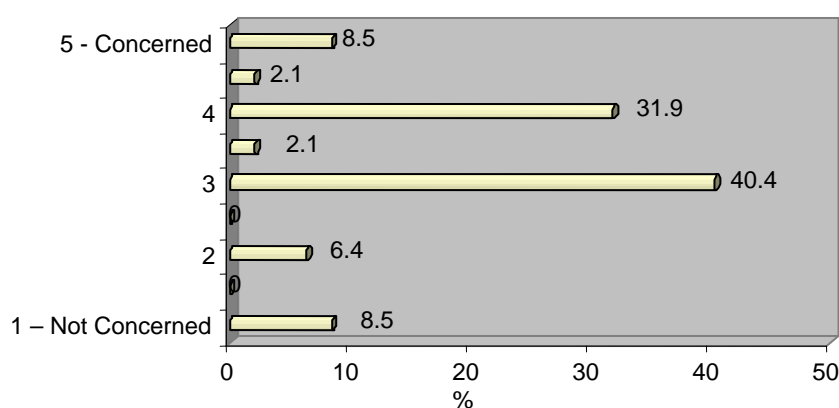
Q. In agriculture the level of greenhouse gas emissions can be broken up into major contributors. Place the letter that you believe best matches the percentage of carbon emissions from agriculture.

5.4 Farmers attitudes and perceptions

- **Concern regarding climate change**

Participants were asked to rank how ‘concerned they are about climate change’ on a scale of 1 to 5, 1 being ‘not concerned’ to 5 being ‘concerned’. The majority of respondents were neutral in their concerns about climate change and only four of the 47 respondents were ranked as being concerned about climate change. However a proportion of respondents (31.9%) ranked climate change as 4, between neutral and concerned (Figure 11).

Figure 11. Concern regarding climate change



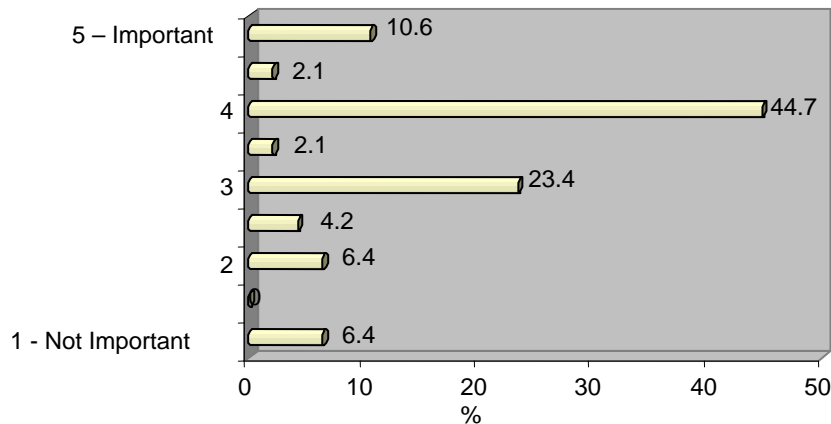
47 Respondents

Q. How concerned are you about climate change?

- **Importance of reducing global GHG emissions**

Of the total 47 respondents, over half (82%) believe in the importance of reducing global greenhouse gas emissions to address climate change, whilst 17% of respondents did not think that global greenhouse gas reduction was important (Figure 12).

Figure 12. Importance of reducing global greenhouse gas emission



47 Respondents

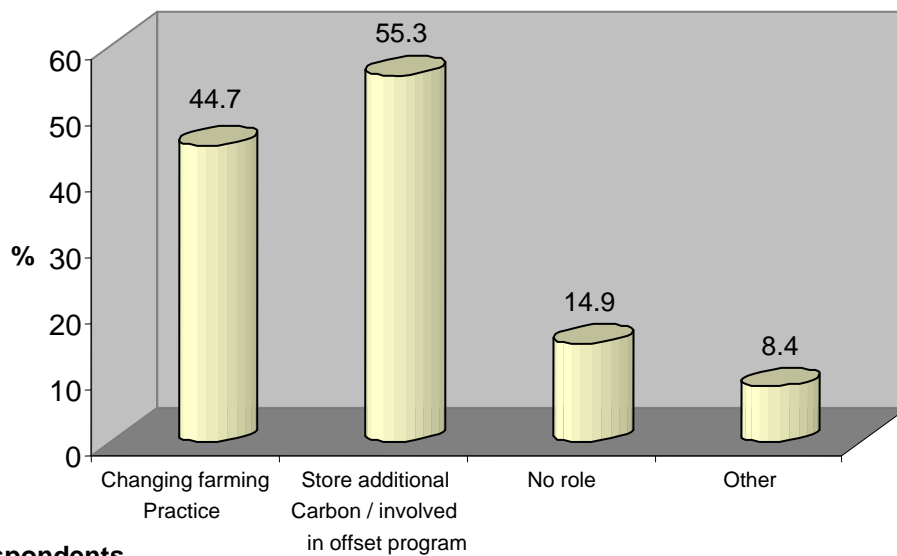
Q. How do you rate the level of importance in reducing global greenhouse gas (GHG) emissions to address climate change?

5.5. On-farm carbon

- **Farms role in carbon management**

A multiple choice answer was provided for respondents to best describe the role they could play in on-farm carbon management. 14.9% of people believed they did not have a role to play in carbon management on-farm, whilst most felt they had some role in carbon management – either the farm could reduce emissions by changing farming practice (44.7%), or store additional carbon (55.3%). Four participants who selected ‘other’ suggested that they could plant more trees or vegetated lanes, or ‘use bio-fuels’ to help play a role in carbon management (Figure 13).

Figure 13. Farm carbon management



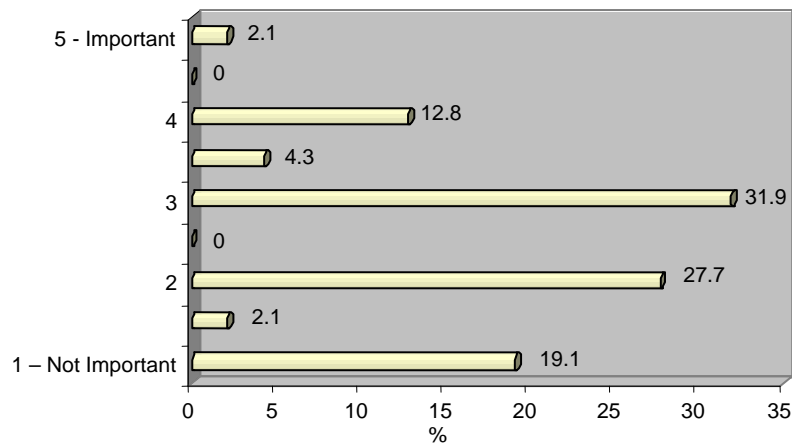
58 Respondents

Q. From the list which best describes how your farm could play a role in carbon management?

▪ **Importance of reducing carbon emissions on-farm**

A large proportion of respondents (48%) felt that it is not important to reduce carbon emissions on-farm. 19.2% of respondents felt that carbon reduction on-farm was important, and 31.9% were neutral (Figure 14).

Figure 14. Importance of reducing carbon emissions on-farm.



47 Respondents

Q. How do you rate the level of importance in reducing carbon emission on your farm?

- **On-farm Carbon Balance**

The 47 respondents were asked to rate their farms carbon balance on a scale from 1 to 5, with 1 being 'carbon emitter', and 5 being 'carbon store'. As shown in the table below, 44.7% of respondents believe they are carbon neutral in relation to their carbon balance on-farm (shaded grey), and few believed they are potentially carbon emitters.

Table 11. On-farm carbon balance

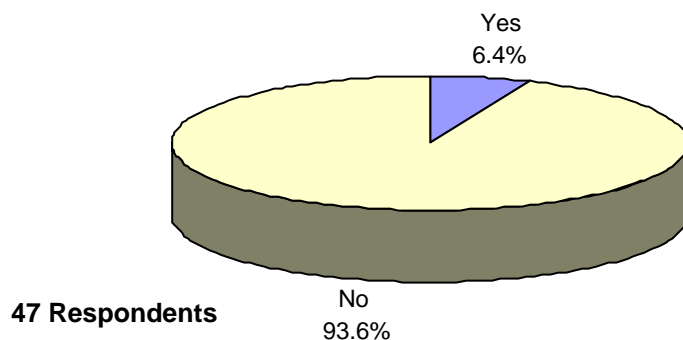
| Carbon Balance | Frequency (n= 47) | Percentage % |
|--------------------|----------------------|-----------------|
| 1 – Carbon Emitter | 0 | 0 |
| 1.5 | 0 | 0 |
| 2 | 9 | 19.1 |
| 2.5 | 4 | 8.5 |
| 3 – Carbon Neutral | 21 | 44.7 |
| 3.5 | 3 | 6.4 |
| 4 | 7 | 14.9 |
| 4.5 | 0 | 0 |
| 5 – Carbon Store | 3 | 6.4 |
| Total | 47 | 100.0 |

Q. Which do you believe best describes your farm in relation to carbon balance?

- **On-farm carbon assessment**

94% of respondents had not obtained a carbon assessment of their farm. If the respondent answered 'no' they were asked if they would be interested in obtaining a carbon assessment on-farm; 65% answered 'yes' and 35% answered they would not be interested in obtaining an assessment of their farms carbon footprint (Figure 15).

Figure 15. On-farm carbon assessment

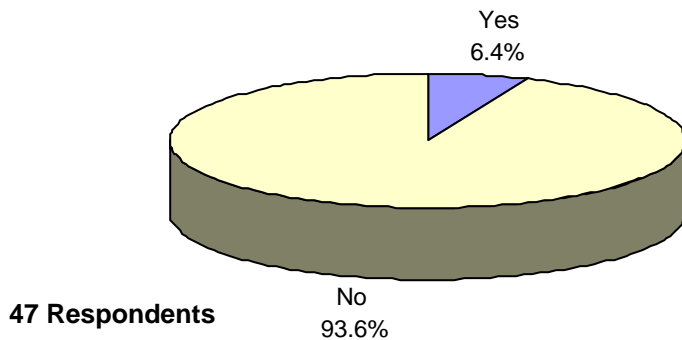


Q. Have you obtained an assessment of your farms carbon footprint?

- **Carbon assessment programs**

The majority of respondents (93.6%) answered 'no' to being aware of carbon assessment programs that could be used to measure carbon emissions on-farm (Figure 16). Only 6.4% of respondents are aware of carbon assessment programs such as Landcare Carbon Smart.

Figure 16. Use of carbon assessment programs

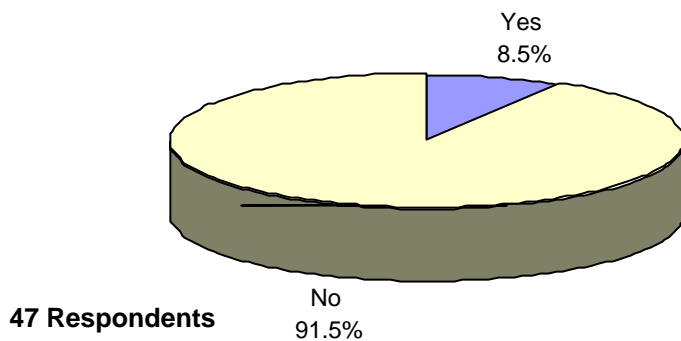


Q. Are you aware of carbon assessments programs used to measure carbon emissions on-farm?

- **Carbon certification in Australia**

There was an overwhelming majority (91.5%) of respondents that are not aware of any carbon certification systems in Australia. Of the four respondents aware of these systems, two responded with Greening Australia and Kyoto (Figure 17).

Figure 17. Carbon certification in Australia.

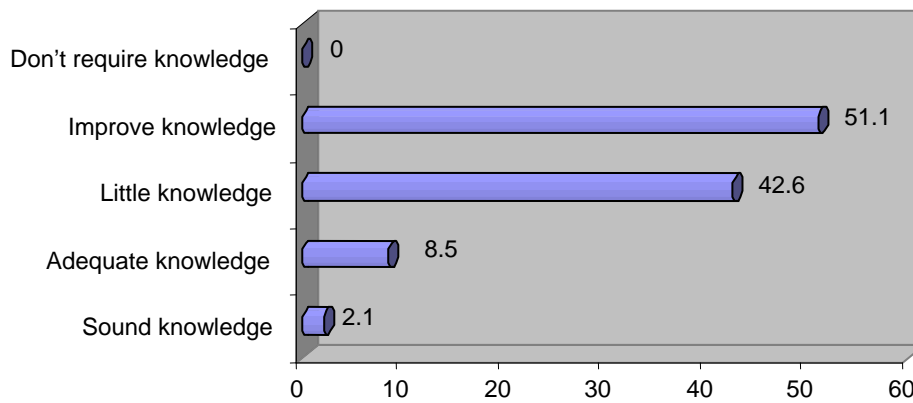


Q. Are you aware of any carbon certification system in Australia?

- **Farmers Knowledge relating to carbon management on-farm.**

Most respondents felt that they had little knowledge (42.6%) or would like to improve their knowledge relating to carbon management (51.1%). Only one respondent felt that they had sound knowledge in the area of carbon management. No one believed they did not require any knowledge in this area. Some people answered more than one answer for this question (Figure 18).

Figure 18. Farmers knowledge of carbon management.



47 Respondents

Q. Which statement best describes your level of knowledge relating to carbon management on-farm?

▪ **On-farm Practice Change**

All respondents had made some form of on-farm practice changes over the past three years. As shown in the Table 12, the five most popular farm practice changes are shaded in grey.

The majority of farmers (85.7%) had reduced stubble burning practice on-farm over the past three years and of those 40 respondents, 29 believed that this would decrease their carbon emissions on-farm and five believed it increased (this may have been from question interpretation) or did not change the balance of carbon on-farm which can be seen in the table below.

Twenty three (48.9%) of the respondents had made reductions in the use of Nitrogen fertiliser, and of these 14 respondents believed this had increased their carbon emissions on-farm.

Thirty one (66%) respondents had planted trees on-farm and 20 of those believed this would reduce their carbon emissions. Five people believed that this would increase their carbon emissions on-farm.

14.9% had moved into controlled traffic farming for cropping over the last three years, four of the respondents had started using GM crops, and one farmer used nitrogen inhibitors in cropping.

Table 12. On-farm practice change and carbon balance.

| Practice Change | Frequency n = 47 | % | Carbon Balance On-Farm | | |
|--|---------------------|------|------------------------|------------|------------|
| | | | Increased | Decreased | No Change |
| Controlled Traffic | 7 | 14.9 | | 7 (100%) | |
| Variable Rate Technology | 4 | 8.5 | | 3 (100%) | |
| Altered Crop Rotations | 24 | 51.1 | 3 (15%) | 12 (60%) | 5 (25%) |
| Reduced Livestock Numbers | 15 | 31.9 | | 12(100%) | |
| Increased Stock Numbers | 10 | 21.3 | 5 (55.6%) | 3 (33.3%) | 1 (11.1%) |
| Included Intensive Animal Production | 3 | 6.4 | 2 (66.7%) | | 1 (33.3%) |
| Reduced Intensive Animal Production | 0 | 0 | | | |
| Reduced Stubble Burning | 40 | 85.1 | 3 (8.8%) | 29(85.3%) | 2 (5.9%) |
| Using New Crop Varieties | 25 | 53.2 | 2 (4.3%) | 6 (12.8%) | 12 (25.5%) |
| Use of dietary supplements for livestock | 2 | 4.3 | 1(50%) | 1(50%) | |
| Using GM crops | 4 | 8.5 | 1 (50%) | 1 (50%) | 1 (50%) |
| Reduced application of nitrogen | 23 | 48.9 | 14 (87.5%) | | 2 (12.5%) |
| Use of nitrogen inhibitors | 1 | 2.1 | 1 (100%) | | |
| Planted trees on-farm | 31 | 66 | 5 (18.5%) | 20 (74.6%) | 2 (7.4%) |
| Total | 189 | | | | |

Q. Have you made any of the following farming practice changes in the past three years, and if so how do you think this will effect your carbon balance on-farm?

▪ **Implications of Carbon Pollution Reduction Scheme to farms**

The Federal Government’s Carbon Pollution Reduction Scheme (CPRS) will place a limit, or cap, on the amount of carbon pollution industry can emit by 2010. It will require affected businesses and industry to buy a ‘pollution permit’ for each tonne of carbon they contribute to the atmosphere.

The respondents were asked to provide their views about how a carbon pollution reduction scheme within Australia would affect their farming business. The majority of respondents believe there will be an increase in fuel, electricity, food and fertiliser prices due to an emissions trading scheme. Twelve farmers believed that potential opportunities would increase, and eight believed that no new opportunities would

arise; some farmers also believed that potential trade barriers would increase due to an emission trading scheme (Table 13).

Table 13. Farmers perceptions of a Carbon Pollution Reduction Scheme

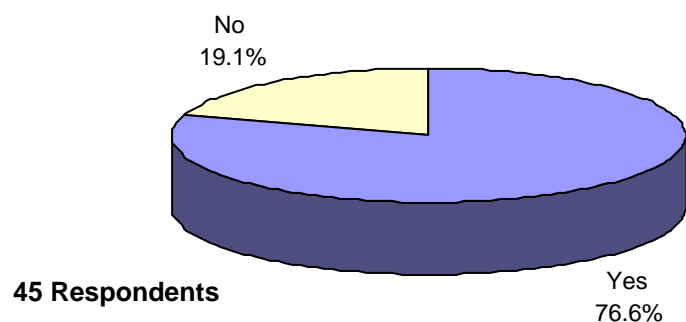
| | No change | Increase | Decrease | Unsure | Total (n =response) |
|--------------------------|-----------|----------|----------|--------|---------------------|
| Cost of Fuel | 6 | 41 | 0 | 2 | 46 |
| Cost of Electricity | 2 | 43 | 0 | 1 | 46 |
| Cost of Food | 2 | 42 | 0 | 2 | 46 |
| Cost of Fertiliser | 2 | 44 | 0 | 0 | 46 |
| Commodity Prices | 10 | 16 | 8 | 11 | 45 |
| New Opportunities | 8 | 12 | 8 | 16 | 44 |
| Potential Trade Barriers | 7 | 14 | 5 | 19 | 45 |
| Other | 0 | 0 | 0 | 0 | 0 |

Q. When the Australian Government introduces a carbon pollution reduction scheme (emission trading scheme) how do you believe your farm will be affected by this? Please tick no change, increase, decrease for each item you believe will change.

▪ **Carbon management on-farm**

76.6 % (36) of respondents felt that they would get more involved in carbon management in the future and 19.1% (9) believed they would not (Figure 19)

Figure19. Carbon management on farm



Q. Do you think you will get more involved in carbon management on-farm?

- ***Environmental Accounting on-farm***

None of the respondents were currently undertaking any form of environmental accounting on-farm (Table 14)

Table 14. Environmental accounting on farm

| Response | Frequency (n=47) | Percentage (%) |
|-----------------|-----------------------------|---------------------------|
| Yes | 0 | 0 |
| No | 46 | 100 |
| Total | 46 | 100.0 |

Q. Do you currently undertake any form of environmental accounting on-farm?

5.6. Changes in Attitudes

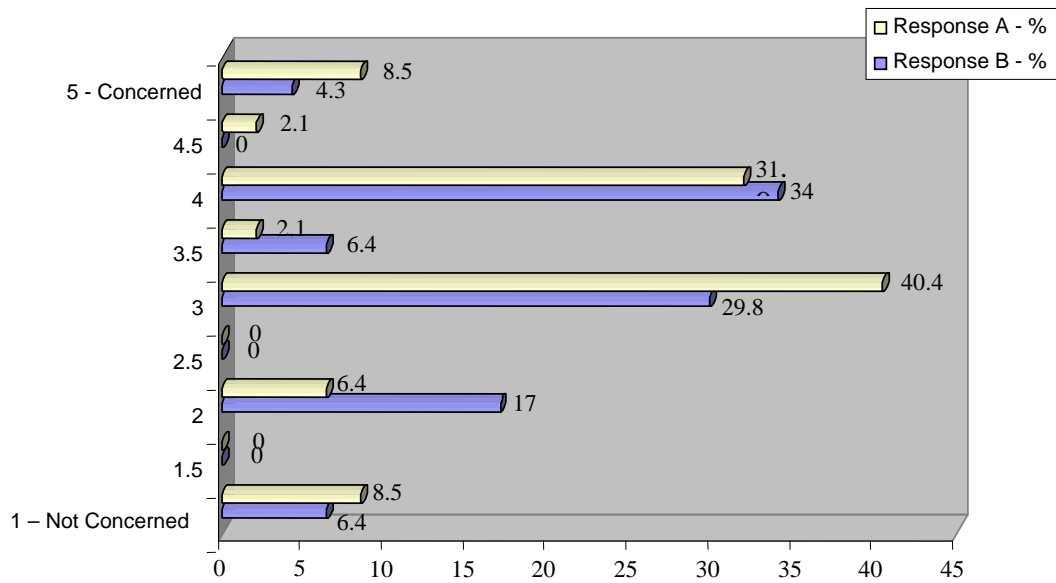
This section reports on Section B of the survey. This section was distributed after additional information was provided to participants through a Carbon in Agriculture presentation

- ***Attitude change of concern about climate change***

After the information session the participants were again asked, ‘How concerned are you about climate change?’ Figure 20 below shows the participants responses to this question before (Response A) and after (Response B) the information sessions.

During the initial section of the survey, prior to the information session, many of the respondents were neutral towards their concern for climate change. In addition, a large proportion (42.2%) of the respondents was also on the concerned side of the scale (3.5 to 5). The percentage of respondents initially who are not concerned or are slightly unconcerned was only 14.9%.

Figure 20. Farmers' attitude change to climate change concerns

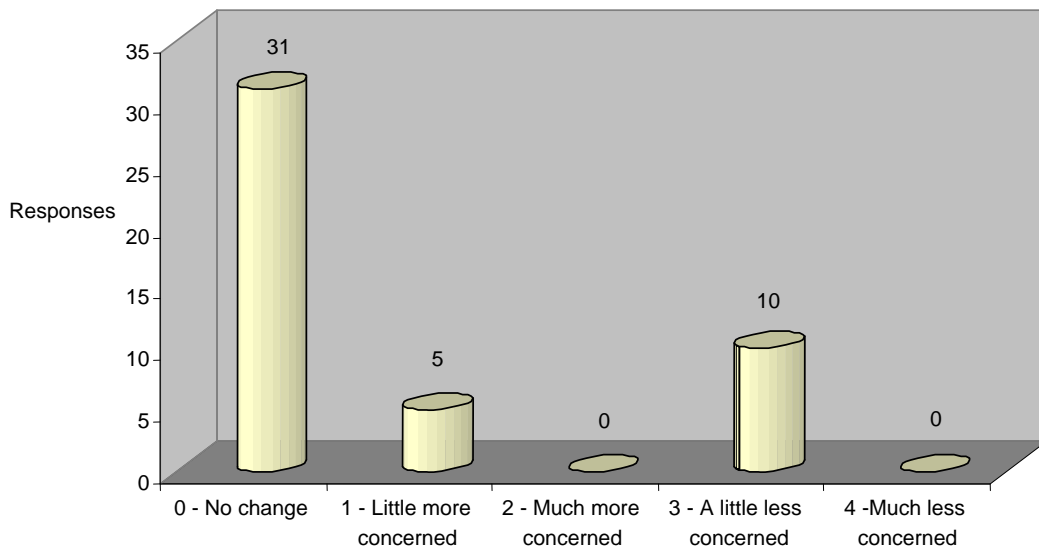


46 Respondents

Q. How concerned are you about climate change?

Figure 21 below shows the change in participants' responses, after completion of the information session.¹⁹ Of the 46 respondents, 31 people did not change their response from the initial question, 10 respondents were a little less concerned about climate change, and five respondents were a little more concerned about climate change.

Figure 21. Change in participant's response

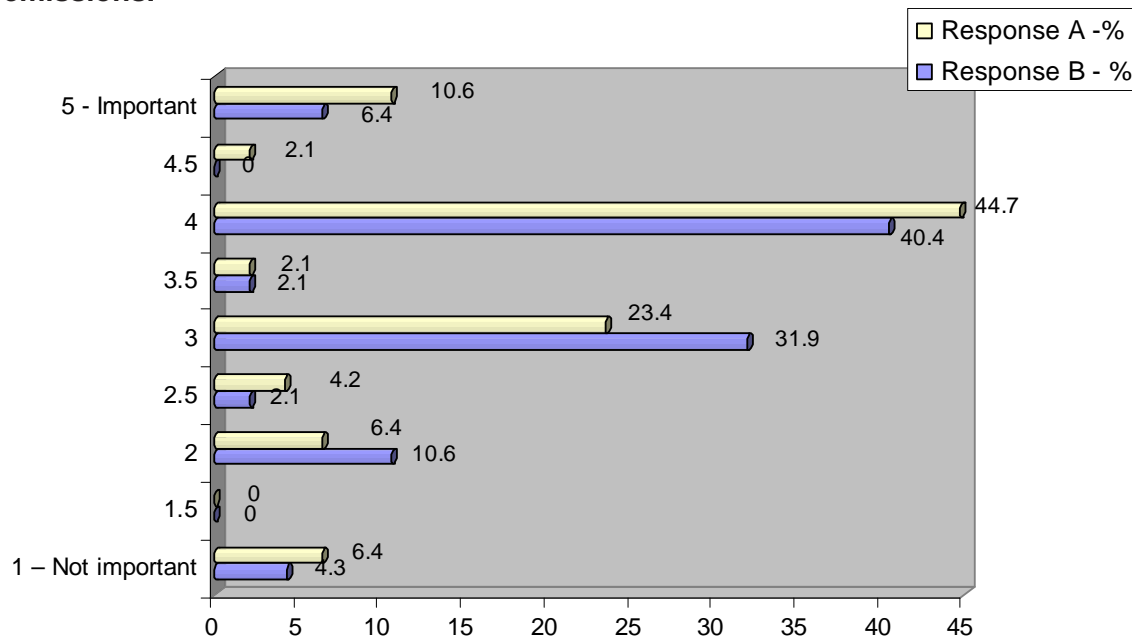


¹⁹ The analysis required the linking up of each participant's responses for Section A and B of the survey, and then rating the change on a scale from 0 to 4, with 0 being 'no change', 1 being 'little more concerned' and 4 being 'much less concerned'. This enabled us to track the actual changes of each participant views.

- **Attitude change of importance in reducing GHG emissions**

After the information session the participants were again asked, ‘How do you rate the level of importance in reducing global GHG emissions to address climate change?’ the answers can be seen in the following Figure 22. Many of the respondents, both pre (44.7%) and post information (40.4%) delivery rated their response as slightly important (4). Another large group of respondents are neutral towards the importance of reducing greenhouse gas emission to mitigate climate change (31.9% pre and 23.4% post-workshop delivery).

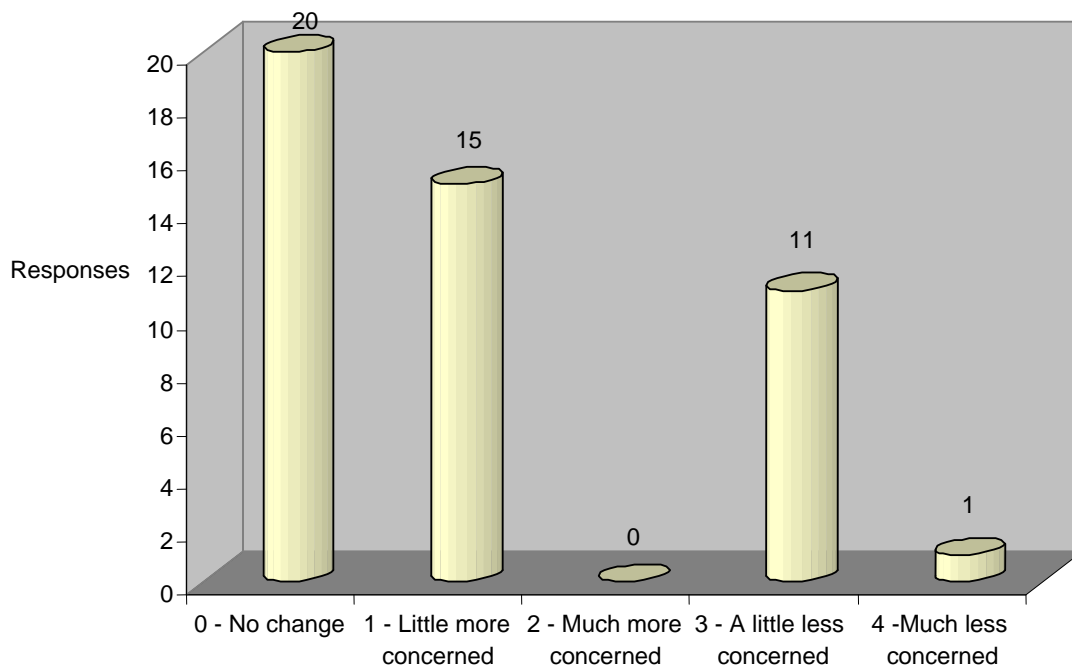
Figure 22. Change of farmers’ perception of importance of reducing GHG emissions.



Q. How do you rate the level of importance in reducing global greenhouse gas (GHG) emission to address climate change?

The following Figure 23 shows the level of change in participants’ responses after participating in the information session. Of the 47 participants, 20 did not change their response, 15 were a little more concerned, and 12 were less concerned about reducing greenhouse gases to address climate change.

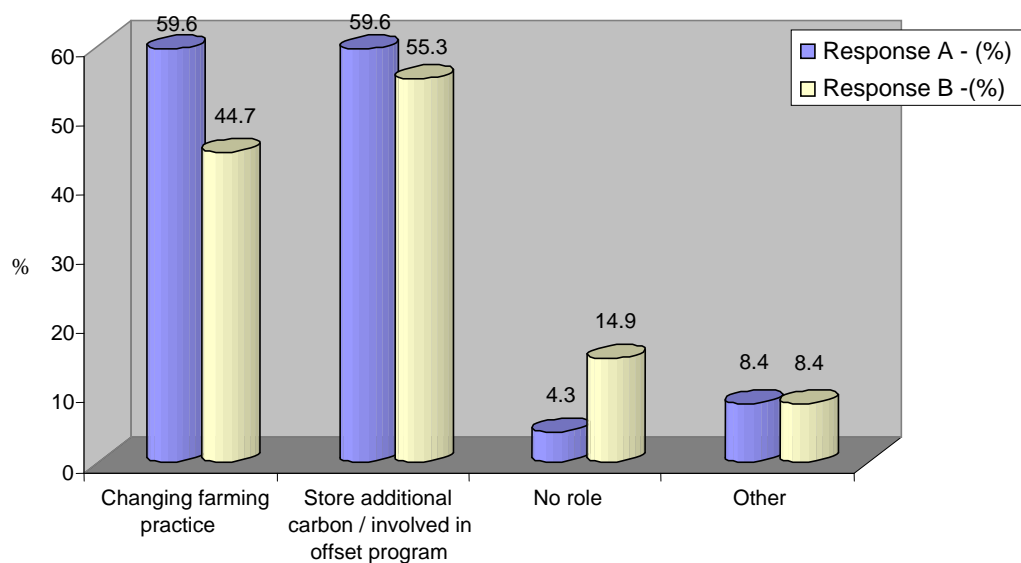
Figure 23. Level of participants response in concern of reducing GHG emissions



▪ **Attitude change of farms role in carbon management**

After the information session the respondents' perceptions as to whether they felt they had a role in carbon management on-farm were less optimistic than the initial round. 14.9% of respondents that answered 'Change farming practice,' did not answer it for Response B, and they felt they had no role. After the information session, the number of respondents that believed they 'Could not play a role in carbon management' increased by 10.6% (Figure 24)

Figure 24. Farmers attitude change in the role of farm in carbon management



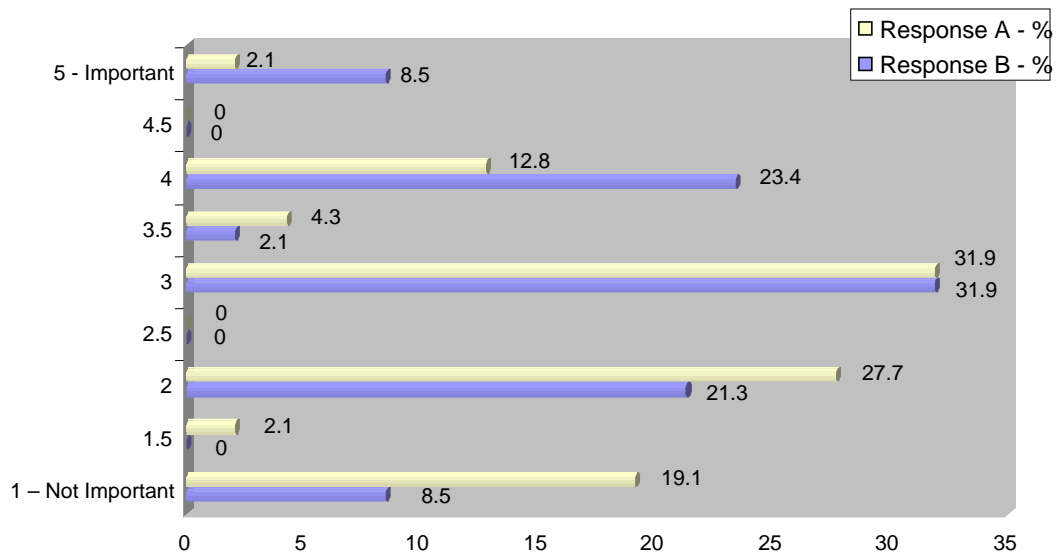
47 Respondents

Q. From the list below please tick the box(s) that best describes your farm could play a role in carbon management?

- **Attitude change of importance in reducing carbon emissions on-farm**

After the information session the respondents' perceptions as to how important it is to reduce carbon emissions on-farm did increase to a little more important than in Response A, as can be seen in the figure below. Many of the respondents (31.9%) rated their response as neutral (3) both pre and post information session. The number of respondents that rated reducing on-farm carbon emissions as important (4-5) increased after the information session (Figure 25).

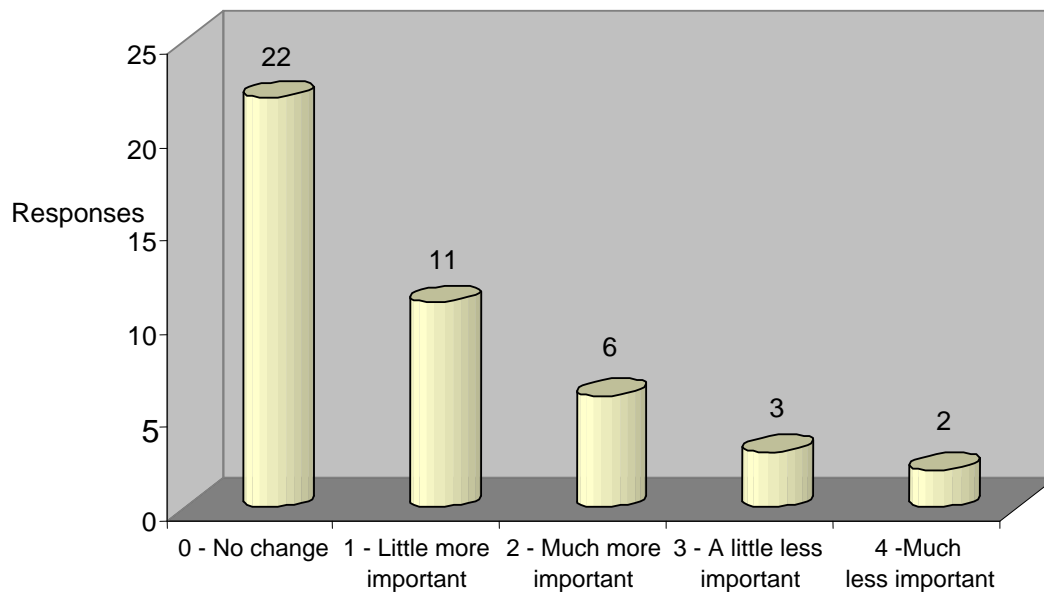
Figure 25. Farmers perceptions of reducing carbon emissions on farm



Q. How do you rate the level of importance in reducing carbon emissions on your farm?

It can be seen in Figure 26 below that of the 44 respondents, 22 of these did not change their response from the first part of the survey. Eleven of the respondents felt that it was a little more important than initially thought, to reduce carbon emissions on-farm, and two believed it was much less important than their initial response.

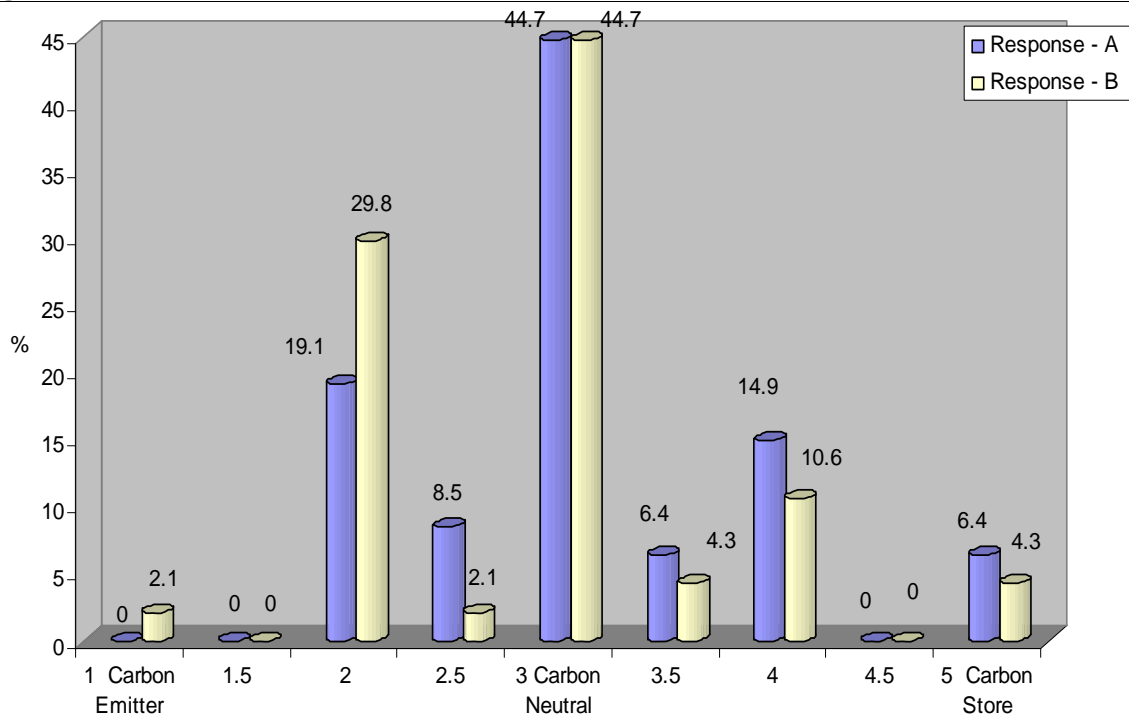
Figure 26. Participants response to reducing carbon emissions on-farm.



▪ **Attitude change to farms carbon balance**

After the information session the participants were again asked 'Which do you believe best describes your farm in relation to carbon balance?' The figure below shows the participants responses for before and after the information sessions. There is no change in response of farmers that believe they are carbon neutral on-farm. However there is a shift from farmers that believed they stored carbon to being carbon emitters.

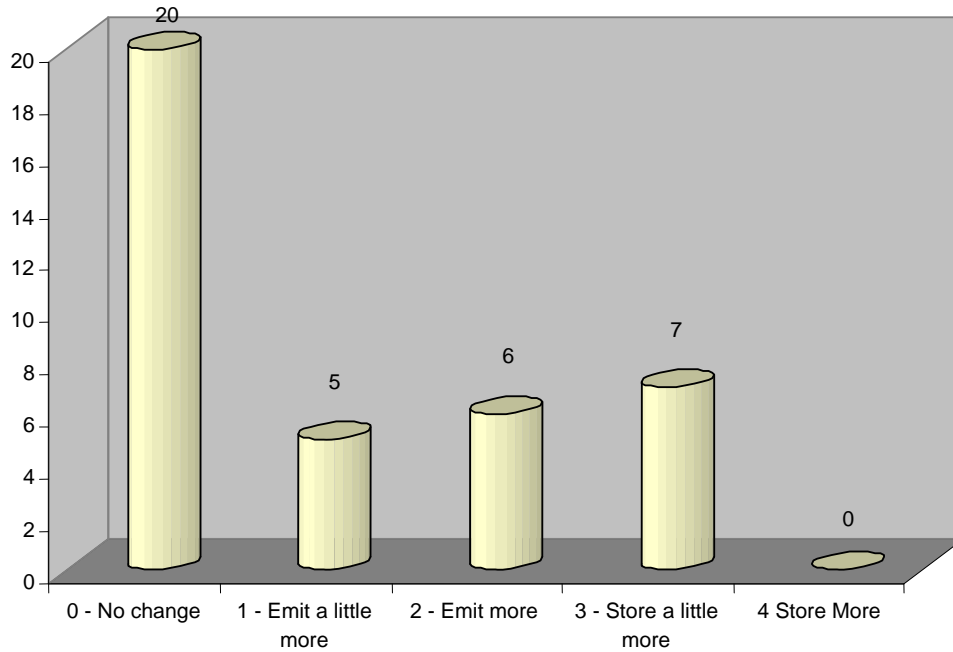
Figure 27. Farmers attitude to farms carbon balance



Q. Which do you believe best describes your farm in relation to carbon balance?

Figure 28 below shows whether farmers reassessed their position on the carbon balance scale after participating in the carbon information session. Of the 47 respondents, 20 did not change their response, 7 believed that they potentially stored more and 11 believed they may have emitted a little more (5) to more (6) carbon on their farm, than before the information session.

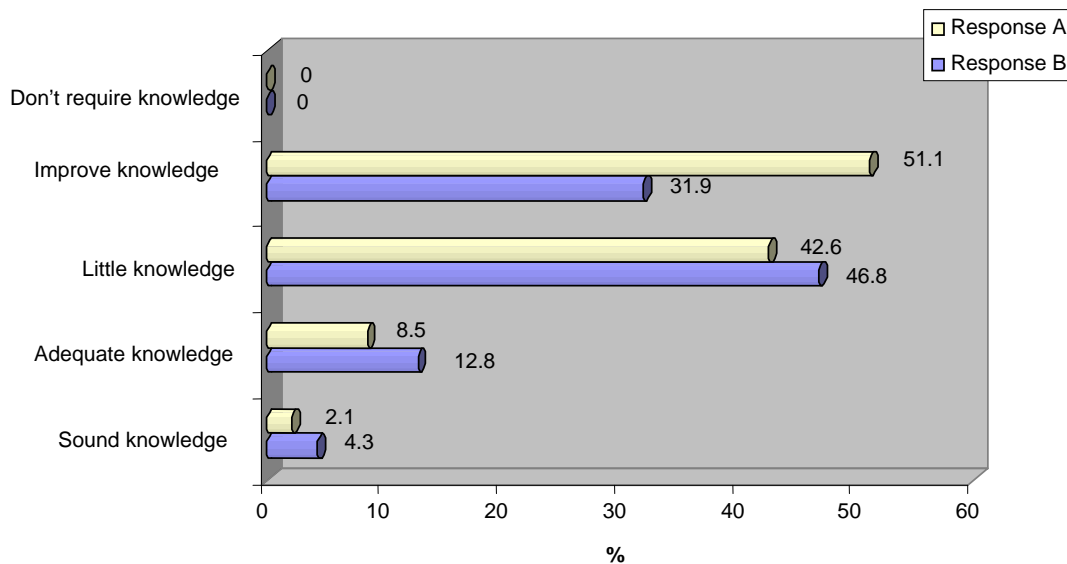
Figure 28. Farmers reassessment of on-farm carbon balance



- **Attitude change to farmer's knowledge of carbon management on-farm**

After the information session the participants were asked again how they rated their level of knowledge of carbon management on-farm. The figure below shows the participants' responses for before and after the information sessions. It can be seen that the majority of participants believed they had little knowledge or would like to improve their knowledge in this area.

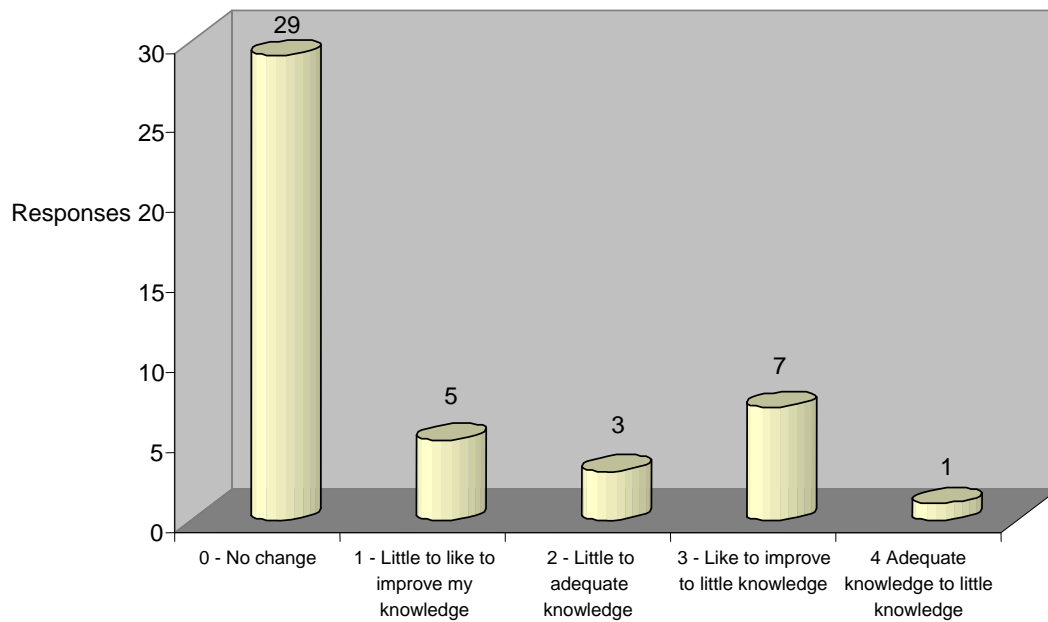
Figure 29. Comparison of participant's response to level of knowledge relating to carbon management.



Q. As a result of the information session which statement best describes your level of knowledge now relating to carbon management on your farm?

After the information session 31.9% respondents believed that they did not need to improve their knowledge compared to 51.1% prior the session and an increase of 4.3% believed they had adequate knowledge after the information session. Only 4.3% of the participants felt they had sound knowledge after the information session. None of the respondents felt they did not require any knowledge, even after the carbon presentation.

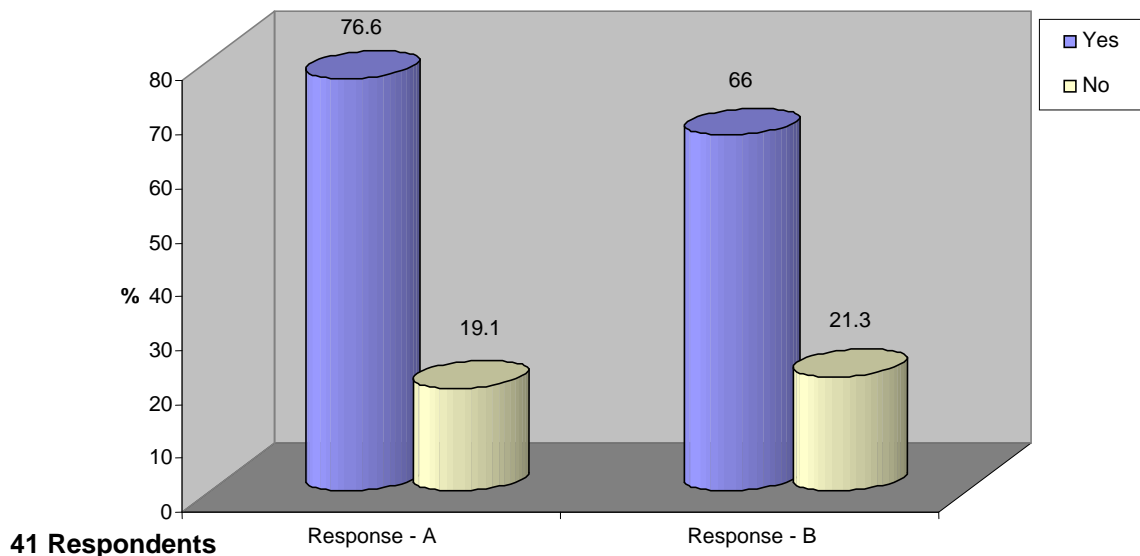
Figure 30. Participants change in response to knowledge relating to carbon management.



▪ ***Involvement in carbon management on-farm***

Participants were asked after the information session if they thought they would get more involved in carbon management on-farm in the future. Of the 41 people that responded, 31 believed they will get more involved in carbon management on-farm in the future, and only 10 believed they will not.

Figure 31. Participants change in response to getting involved in carbon management on farm.

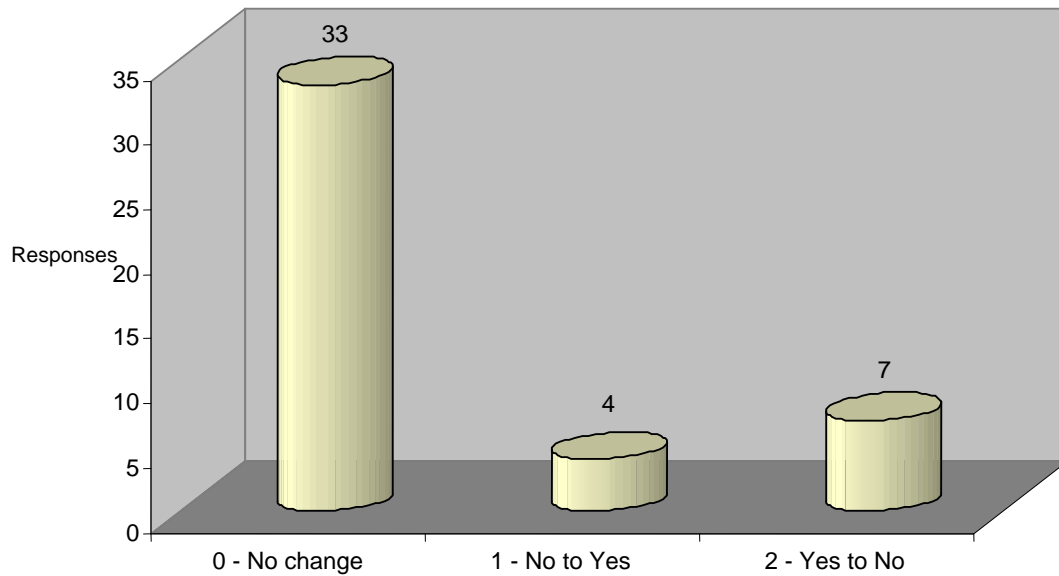


Q. Do you think you will get move involved in carbon management on-farm?

It can be seen in the following Figure 32 that 33 of the respondents surveyed did not change their initial response after the information session. Four respondents that answered 'no' in Section A changed their response to 'yes' after the information

session and 7 respondents changed their response from 'yes' to 'no' after the information session.

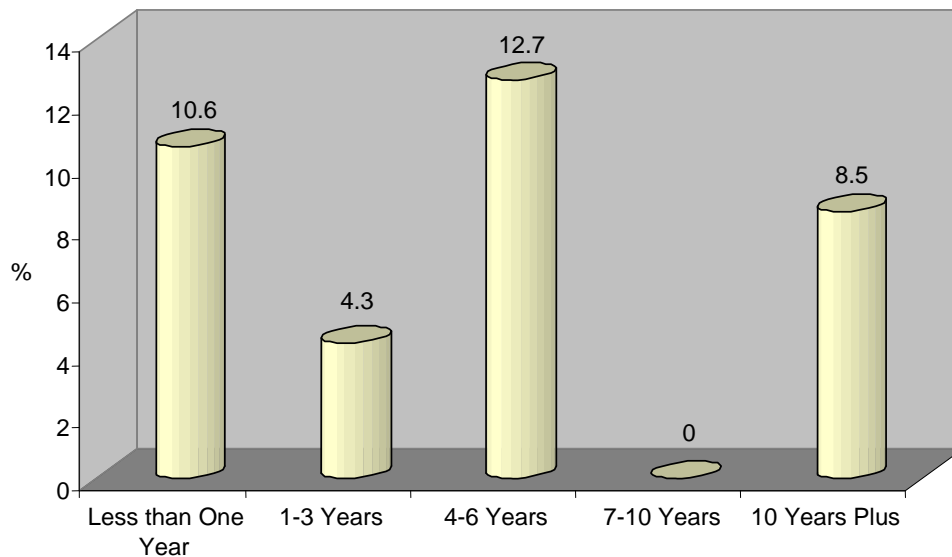
Figure 32. Participants change in change in response.



▪ **Timeframe for getting involved**

12.7% of respondents believed they would get involved in carbon management on-farm within the next four to six years. 10.6% believed involvement would occur in less than a year, and 8.5% believed they would get involved in ten years or more (Figure 33).

Figure 33. Participant's timeframe for being involved in carbon management on farm in the future.



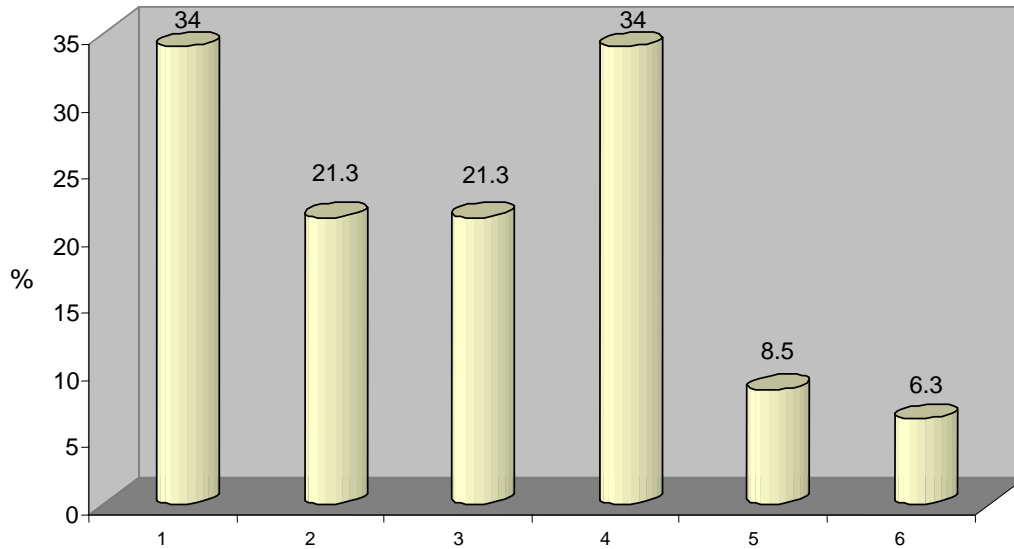
29 Respondents

Q. What time frame do you see yourself getting involved in this area?

▪ **Areas of Involvement in Carbon Management**

Sixteen (34%) of the respondents believed they would get involved in carbon sequestration or potential business opportunities (34%) that may evolve from carbon management in the future. Ten (21.3%) of the respondents believed they would be involved in becoming an offset provider or undertaking life cycle analysis on-farm, four (8.5%) in policy and three (6.3%) believed they would get involved in other areas of carbon management.

Figure 34. What areas farmers believe they will get involved in the future.



Q. In which area do you believe you will be more involved in?

- | |
|-------------------------------------|
| 1. Carbon Sequestration |
| 2. Offset provider |
| 3. Life cycle analysis |
| 4. Potential business opportunities |
| 5. Policy |
| 6. Other |

- **Activities that will benefit farmers in improving knowledge**

The participants were asked what kind of activities they felt would benefit them in developing a greater understanding of carbon in agriculture. 47 of the participants felt that newsletter updates (42.6%) or information sessions (57.4%), would help them to gain a greater understanding of carbon and keep them up to date. Others were interested in policy updates or a forum site that farmers could have access to for updated information (Table 15).

Table 15. Activities that farmers believe will help improve knowledge.

| Response | Frequency (N) n = 79 | Percentage (%) |
|---|-------------------------|----------------|
| Newsletter Updates | 20 | 42.6 |
| Information Sessions | 27 | 57.4 |
| Policy Updates | 10 | 21.3 |
| Carbon accounting and knowledge on-farm | 11 | 23.4 |
| Carbon forum site for farmers | 11 | 23.4 |
| Other | 0 | 0 |
| Total | 79 | 168.1 |

Q. What other activities do you feel would benefit you in gaining a greater understanding of the role of carbon in agriculture?

6. Summary and Discussion

6.1 Farmers knowledge of greenhouse gas and understanding of CO₂ emissions

6.1.1 Wimmera farmer profile

The majority of farmers represented in the survey are in the 35 to 44 year old age group and have been farming in the Wimmera region for 20+ years (63%). Most farmers surveyed owned land (87.2%) and or leased some land (50%), participated in broad-acre farming or had a mixed enterprise consisting of sheep for wool (66%) or meat (78.7%) and also produced crops. A few farmers participated in intensive animal industries (12.8%) and horticulture (2.1%).

6.1.2 Perceptions of climate change and greenhouse gases

There were varied reactions from farmers in the workshop discussion and survey response about climate change and their knowledge of greenhouse gases.

From the workshop discussion some farmers appear sceptical of the science of climate change. They may be of the belief that natural cycles in climate variation have been present for a number centuries in which their past generations have lived through. Other farmers may accept that climate variation is producing increased climate variability such as a lack of seasonal rainfall events and are becoming interested in scientific climatic projections. The farmers surveyed in this study were mostly neutral in their concern yet more were moderately concerned than not at all. It is important to note that the science of climate change was not covered in this workshop it was only described to place greenhouse reduction mechanisms in context for the study.

Most farmers that participated in the survey were neutral or had some belief that it is important to reduce greenhouse gas emissions to address climate change. From the discussion, the main issues with greenhouse gas reduction is that the agricultural sector would not contribute substantially to climate reduction on a global scale especially in GHG reduction, but the potential storage of carbon in soils, vegetation and trees is substantial and should be included in carbon management or carbon trading schemes.

Another issue that developed from the discussion was the lack of belief in scientific validation of actual emission profiles and responsible GHG. As greenhouse gases are not a 'tangible' commodity farmers appear to have some difficulty in understanding how to manage something they can not see or have issues with any contributions made to GHG reduction will purely be based on scientific modelling. This could also be explained by a large proportion of farmers being sceptical of climatic science which in turn may affect their level of assurance with GHG modelling.

Farmers are not identifying interest in potential cost benefits of reducing reliance of highly intensive farm inputs, these productivity gains may be focused on in the future as on-farm input costs for fuel, electricity and fertilisers etc become more expensive.

The following comments regarding climate change and greenhouse gas emissions reflect opinions of some of those who participated in the workshops.

“But it’s not getting any warmer its getting colder...we have had more incidents of frost this year”.

“What are we meant to go around and capture this carbon in wheelie bins and take it somewhere?”

“It’s not such a bad thing if carbon levels increase for us... [Broad-acre farmer]”

6.1.3 Farmer knowledge of greenhouse gases

This study looked at farmers’ basic knowledge and understanding of greenhouse gas emissions and their sources.

Most participants (55%) believed that carbon dioxide is the major contributor of greenhouse gas concentrations in the atmosphere but few participants believed that methane and nitrous oxide were also large contributors. Of the respondents 20% believed that carbon monoxide (CO) was the second major contributor of greenhouse gas. This lower rating greenhouse gas is produced from motor vehicle exhaust and some industrial activities, such as making steel and also naturally from volcanoes and bushfires.

From the workshop discussion many participants had not heard of some of the greenhouse gases discussed. It could be explained that the major focus of media is on the concept of ‘carbon’ rather than on other aspects of climate change, which would explain most people’s understanding of carbon being the biggest contributor to increases in GHG concentrations.

6.1.4 Emissions profiles for industrial sectors and agriculture

Most farmers surveyed had limited knowledge of the break down of emissions from each industry sector or from agriculture. Most respondents believed that the emission from agriculture were responsible for less than 8% of total greenhouse gas concentrations, 30.2% of respondents felt that the majority of emissions from agriculture were from burning of crop residues, which in reality is only 1% of the contribution from agriculture.

A number of respondents did not feel that ruminant digestion was a major contributor of greenhouse gas emissions; this may indicate that farmers had little knowledge of what the major greenhouses gases were (apart from carbon dioxide), and where greenhouse gases come from, especially in their farming systems.

In the workshop, the presentation described Australia’s position of contributing to greenhouse gas emissions on a per capita basis being fourth to that of USA and Canada and India. From the data most of the respondents felt that China (47.8%) and the USA (30.4%) were the biggest contributors to greenhouse gas emissions.

The response to this question may have been interpreted as emissions based on whole country emission profile, not on a per capita basis. This could indicate that many of the farmers did not understand what 'per capita' emissions are or that they believed that China and the USA were the most responsible for per capita emissions.

The per capita use of measuring carbon emissions takes into consideration population growth and gross domestic product (GDP) of a country. Australia is considered to be a high emitter on a per capita basis as we have higher rates of consumption and more energy-intensive lifestyles, although other factors such as trade, population density, and geography also influence a country's per capita emissions.

At each workshop, when the discussion turned to representing Australia's ranking of emissions on a per capita basis it created a lot of discussion with the farmer groups. In reflection, many of the farmers had a strong reaction towards Australia being one of the top four greenhouse emitting countries. The discussion focused towards countries such as China and the USA was apparent and can be seen in the following comments from farmers that participated in the workshops.

"Why would you not measure the emissions as per country especially when china has so many people?"

"Why should we do anything when other countries will just do exactly what they want?"

"Why would countries like China not have higher emission than Australia, they are the ones that are producing all the pollution?"

"What about China who is responsible for the emissions when they import/export everything? Are we responsible for those emissions as well?"

"Australia is very dependent on fossil fuels, we should be investing in alternative energy sources"

"What are all the people in the city's doing, why should we make changes if they aren't?"

Some participants also focused on what people in the 'city' are doing about their emissions, and felt that people living in large cities are not contributing to greenhouse gas reduction, so why are people living in rural areas responsible. There seemed to be a division in where farmers placed themselves against people from major cities - a 'rural-urban divide'. This may indicate that farmers feel under pressure and that there is a division of priorities and that people living in a city could be contributing more to greenhouse gas reduction on an individual level. Some farmers felt that their urban counterparts are not participating in helping reduce their reliance on water and energy, and still want food at the end of the day at a reasonable price, so why should farmers be required to participate in emission reduction.

The potential implications of consumer purchasing decisions based on carbon miles and environmental market requirements were not raised by farmers in the sessions. Yet this is important to discuss. Consumer choice is shifting and animal welfare groups are becoming well established with large structured networks globally. These groups have been putting pressure and creating a number of changes to agricultural

sectors. This can be seen particularly in Australian wool production; the contentious issue of mulesing merino sheep is an example of the influence such groups can have on such industries. These influences will only increase pressure on the agricultural sector to improve and contribute to environmental goals for the future. The UK is a great example of this shift in consumer choice and market requirements. The potential for Australia's need to comply and adjust to these market requirements maybe essential for the development of Australia's export trade. It would be naive for agriculture groups to not be aware and keep up to date with consumer trends and potential implications these issues will raise, also the potential threats of these issues could become in the form of potential trade barriers for Australia due to its perceive image.

6.1.5 Food vs. Fuel - 'The need to produce food for humans and not food not fuel'.

A number of the participants voiced their views about their obligation as broad-acre farmers to be producing crops for food and not for fuel. Participants felt some alternative methods to help reduce carbon emissions on-farm could be developed such as investment into production and development of clean fuels, solar or wind power. A number of participants felt that with current food shortages issues of feeding the world are more important than that of reducing GHG and the production of bio-fuels (see comments below).

"If they tax agriculture on carbon, who's going to be producing all the food for the world what about the world food shortage"

"We need to put more interest into food production not into carbon when it is going to make such little difference if we reduce our emissions anyway"

"What about all the city people what are they doing to reduce their carbon why should we be responsible we are the ones feeding them"

From the discussion it appeared that several farmers believed that the introduction of an emission trading scheme would have no short term benefits for farmers; they will be faced with increasing costs of farming inputs, electricity and fuel; that few new opportunities would exist in the future; and that it will only make it more difficult for farmers to make a profit off the land, particularly whilst dealing with drought and financial hardship.

6.2 Current attitudes and expectations of farmers towards their role in the carbon market.

6.2.1 Agriculture and GHG emissions

The majority of farmers that participated in the survey and workshops were broad-acre farmers. From the data, many of these farmers perceived that a large percentage of GHG were emitted from practices such as stubble burning, use of fertilisers or from soils. They did not recognise that the majority of GHG emissions were from ruminant digestion from livestock. The majority of farmers surveyed did believe that given the amount of land they occupy and the types of crops they

produce, they are potentially able to store carbon (6.45%) or be carbon neutral (44.7%). Only one person perceived themselves as a carbon emitter (2.5%).

After the 'Carbon in Agriculture' presentation which included the break down of GHG emissions within agriculture many of the farmers voiced that they don't have large numbers of livestock (cattle) hence see the need for them to reduce GHG priorities is much lower, unlike in the dairy industry. Rather they believed that they have a much larger potential to store carbon in the soil and therefore claim carbon credits.

The following comments regarding on-farm carbon storage and emissions reflect opinions of those that participated in the workshops.

"Most gas emissions are from livestock so it doesn't really worry us why do we have to change, especially when we store heaps of carbon in soil and crops"

"Look at the average cropping farmer they would be storing more carbon than they are producing"

"What about storage of carbon in crops and in soil"

The question of on-farm storage of carbon was raised numerous times in the workshops. Farmers were generally unaware of how carbon could actually be stored on-farm and where emissions were produced on-farm. They were interested in finding out information about carbon accounting tools on-farm and carbon research available. There was general scepticism about the science of climate change and the contribution agriculture makes to greenhouse gases in the atmosphere.

6.3 Potential drivers and barriers that influence farmers' adoption

6.3.1 Changing farming practice

The survey indicated that all participants (47) had made some 'on-farm' practice change over the past three years. Whether that was moving to no-till, controlled traffic farming, increased livestock numbers, reduced stubble burning or reducing the amount of nitrogen fertiliser being used, some on-farm change had been made. These changes can be explained by drivers identified by Vanclay & Lawrence (1995) and could include increases in efficiency, technology, lack of water, production improvements, social benefits, environmental benefits, cost or income but they motivated the farmer to change practice for a foreseeable reason.

Many of the farmers that participated in the discussion were concerned that these on-farm changes, such as planting more trees (66% of respondents had done this in last three years), would not be accounted for as carbon credits in an ETS in the future, due to the carbon accounting policy. They recognise that they have been making numerous on-farm changes to increase sustainability and biodiversity but are unhappy that these changes are not being recognised as having stored carbon and the potential to claim them in future carbon trading schemes is limited and uncertain.

The following comments regarding on-farm practice change reflect opinions of those that participated in the workshops

"I have planted heaps of trees on my property over the years, why won't they be counted as carbon stores; but they are still storing carbon no matter when they were planted"

"Most of us don't really burn stubble now but it depends on the season, we may need to do that in the future what will happen then?"

"Has it been taken into consideration of the past three years of improvements? We have been making on-farm practice change improvements such as trees, blue gums or zero till"

"So if my trees are not counted because they are too old, am I meant to chop them down and replant them just to get carbon storage credit?"

6.3.2 Motivation to reduce carbon emissions on-farm

Of the farmers surveyed the majority (48%) felt that it was not important to reduce carbon emissions on-farm or were indifferent (31.9%) about the importance of reducing carbon emissions on-farm. Many of them (44.7%) believed that they were carbon neutral on-farm. Many of the farmers surveyed had not done any initial on-farm carbon accounting or had little knowledge of certification or carbon assessment tools they could use. Only one respondent was aware of the Landcare Carbon Smart program.

The following comments regarding being carbon neutral-on-farm reflect opinions of those that participated in the workshops.

"I have planted trees on my property / or have trees on my property how can I test if I am carbon neutral"

"I believe I am nearly carbon neutral"

"I have trees and am not sure when I planted them can I use them to claim carbon credits"

"Will I have all of my trees marked off as being carbon stores?"

"If I have to determine when I planted trees to claim carbon credits it's just making more paper work for us"

6.3.3 Drivers for adaptation to new farm practices

The biggest driver of adoption of new or different farming practice is that farmers perceive that the change will have, for example, social, economic or environmental benefits (Vanclay & Lawrence 1995). Extrapolating from this, if farmers don't perceive that reduction of greenhouse gases will benefit them in any way, it is unlikely this will influence them making any on-farm changes or be interested in taking up new farming technology that will improve their carbon management.

After the Carbon in Agriculture presentation, most participants (66%) believed that they would get involved in carbon management on-farm in the future. Of these 12.7% believe they will get involved in the next 4 to 6 years, 10.6% in less than 1

year, and 8.5% believe they will get involved in the next 10 or more years. It is unclear if the participants felt that they would be forced to get involved or if they would participate on a voluntarily basis in carbon management on-farm.

The following comments regarding on-farm carbon management reflect the opinions of those that participated in the workshops

"It will just be extra paper work that we will have to do and we have got better stuff to be doing"

"I have financial issues that are much bigger issue than this at the moment"

"You are just going to make carbon management/policy one more piece of paper work to do like BAS its just more work for us to do at the end of the day"

"I am just trying to get through this year with my bank on my back let alone think about reducing my carbon emissions by 2013"

Many farmers believed that carbon management will become an issue that they will be forced to comply with in the future rather than voluntarily enter into. Many believed that they will be taxed for their emissions on-farm and will not be faced with any perceived benefits for the contributions they will be able to make. Financial issues seemed to be the cause of the considerable stress that many of the farmers are facing currently and that the need to participate in carbon reduction seemed to be another stress factor that many are concerned about.

6.4 Knowledge and perception changes through information delivery

The 'Carbon in Agriculture' presentation was used in the research design to determine if information delivery would change farmers' perceptions or knowledge of the topic. It was designed to entice discussion within the groups on a range of topics such as policy, on-farm issues, marketing and potential opportunities to get a range of different views about carbon reduction and what this really means to farmers and their enterprise.

The participants were asked pre and post information session questions relating to their perceptions. After the information sessions, many of the farmers did not change their initial response to most questions in the survey.

Some participants felt they were more concerned about the need to reduce global greenhouse gas emissions to address climate change. 11 participants felt that after the information session they believed carbon reduction on-farm was a little more important. However when asked what role they could play in carbon reduction, such as change farming practice or become a carbon offset provider, 10.6% of participants changed their initial response after the information session, and they felt they had 'no role in carbon reduction on-farm'.

In summary, many farmers' perceptions did change, whether it increased their awareness or provided them with some information, and this did influence their perception of their role in carbon management. It is notable however that their

remained considerable uncertainty as to how they may of them would get involved and what it would take for them to benefit from such involvement.

6.5 What information and issues will need to be addressed in the future research and initiatives

The participants were asked in the survey to identify what kind of activities would benefit them in developing a greater understanding of carbon in agriculture. This question was asked to determine what farmers felt would best meet their learning needs. The majority of farmers felt that information sessions relevant to the target audience and a newsletter update would be the most effective methods of delivery of information to help farmers to improve their knowledge.

The study identified a number of considerations for future research of this type. These include;

- Improving the level of participation in the survey and workshop discussion, this may be with a more interactive methodology.
- The carbon in agriculture information may need to be more sensitive to the specific situation of farmers and a more structured plan for discussion groups to keep them more focused and to feel their concerns and questions are being addressed.
- Have strategies in place to deal with the sensitivities of this topic, particularly as some farmers are under considerable stress.
- Farmers had varying levels of knowledge and scepticism of the science hence more authoritative information may have been useful
- Strategies to overcome negativity in participating in the workshops and not completing the surveys.
- Other methods of surveying to address literacy difficulties that participants may have.

A more interactive survey design may have assisted farmers in becoming more involved and achieving learning objectives. Many of the farmers did not respond to the open ended questions asked, hence discussion could have been more focused in drawing upon farmers opinions and knowledge in certain areas to gather more qualitative data.

A focus group with a number of farmers to inform the development of the survey could have been beneficial in determining the key issues and complexities of carbon in agriculture in general and on-farm carbon management in particular.

7. Conclusion & Research Learnings

The study has compiled some primary and secondary data from a range of sources to gain an understanding of Wimmera farmers' current perceptions and future thoughts about emission reduction on-farm. The study has provided an initial picture of farmers' current attitudes and perceptions which can be built upon with further robust research about the role of farmers in carbon reduction and management.

However, there are a number of limitations associated with the method. Only general trends in the data can be highlighted and lessons learnt rather than recommendations for policy and practice. This section summarises the conclusions of the study and discusses limitations and future research opportunities.

7.1 Conclusions

The findings summarised in this report are not intended to be generalised to the wider farming population but are reflective trends that were found in the data. This preliminary research however, provides a guide to broad-acre farmers' perceptions in the Wimmera and provides a base for further longitudinal research in this area.

The main findings of this preliminary study of Wimmera farmers' attitudes and perceptions of carbon reduction on-farm are:

- Most farmers believe it is important to reduce carbon emissions to address climate change but do not believe they are responsible on-farm for the reduction of greenhouse gases.
- The majority of broad-acre farmers believe that they are carbon stores and not carbon emitters
- The majority believe they will be involved in carbon management on-farm in the future and most of these farmers see themselves being involved over the next four to six years.
- Participation by farmers in future research also needs to be carefully planned to make sure that farmers' perceptions and knowledge can be determined and that they feel they are able to benefit from participation in research.

A study by the Bureau of Rural Science 'Which farmers participate when?' (Aslin *et al* 2006), found that there were marked variations between different industry groups within agriculture in terms of industry participation. Participation appeared to be lowest in traditional broad-acre and livestock industries, and highest in specialised and intensive industry groups like grape and cotton. This may, of course, relate to factors like the inherent nature of these industries and their members, and how these activities are targeted, marketed and delivered.

They reported that current farmers had a strong preference for informal capacity building activities, particularly workshops or short courses, demonstration sites or field days, and to a lesser extent conferences. Cost factors and time spent away from the farm may have been a major influence on these preferences as well as farmers typical learning styles. These factors should be noted in future research, the increased lack of knowledge gained from a number of information sessions run for farmers are becoming apparent. Sessions need to be relevant and targeted to specific groups.

7.2 Research Opportunities & Learnings

A number of research opportunities and lessons have been learnt from the completion of this study. These lessons fall into the method of data collection, follow up research and research opportunities.

7.2.1 Data Collection

A number of lessons could be identified in the data collection process.

- Farmer groups were interested in the topic and attending workshops but were not that interested in participating in the survey or found the survey process difficult.
- The method of delivery may not have been targeted to farmers and their encompassed learning styles. Many farmers did not provide open feedback in the survey and this may be improved with more participatory and interactive surveying methods with farmer groups.
- The nature of the topic was sensitive to many of the participants and this information may need to be delivered in different ways.
- Building rapport with farmers in a face to face context is essential for effective communication.
- Farmers may have felt reluctant to share their opinions in an open forum with peers.

7.2.2 Follow up research

In future research the following lessons from this study may assist in the development of robust investigation into farmer's perceptions in this area.

- Longitudinal and action research of all agricultural sectors is required to assess the development of farmer attitudes and aspirations over longer periods of time and in different farming based industries.
- In-depth case studies of particular farmers would be beneficial in determining an enhanced understanding of farmer perceptions and gain more qualitative data.
- The need for further longitudinal study of farmer perspectives are as important as research and development of technology as there must be a perceived need by farmers to uptake these technologies and farming system changes.

7.3 Research Reflections

The importance of research and developing an understanding of farmers' attitudes and expectations will be fundamental in the development of successful extension activities to assist farmers in potential carbon management requirements. These activities will benefit farmers in gaining knowledge and information to facilitate them into a carbon economy and carbon management on-farm.

The need to understand the 'human component' in agricultural production systems is important and will complement the research focussing on technology tools. This 'human' component of farming systems can be characterised by the abilities and behaviours farmers display, including knowledge and skills they possess, decision-making processes they apply, and individual and collective actions they take (Fliert, 2003). This component has implications for extension activities as the methodology used should be orientated towards the learner (farmer) and their needs or learning styles, the activities should be participatory, experience based and adaptable.

The need for farmers to perceive that benefits of reduction of greenhouse gas emissions on-farm not only include potential environmental benefits but also operational efficiencies is important for farmer adoption. Farmers deserve more credit for the beneficial changes that they have made to on-farm operational improvements and sustainable farming practises that they have adopted from year to year. It may also be unfair to expect them to adapt to more stringent carbon management if they have little knowledge or are not provided with the benefits of doing so.

The impacts of climate change and potential GHG requirements will not only affect many farming business, but people lifestyles as well. For many they do not leave their place of work at the end of the day, they live and work on the land. This maybe an issue that is leaving farmers exposed or vulnerable to such unknown changes. The farm is their home and future changes or business implications may have more detrimental effects than that for industry.

The need to understand the best methods to help extend knowledge of policies being developed in cities back to farming groups is of tremendous importance and is deserved. By increasing knowledge and information delivery to farmers, they will be able to make more informed decisions and potentially feel confident that potential opportunities exist rather than intimidation of threats from GHG management and ETS regulation in the future.

Roling and Wagemakers (1998) note the following five interlocking dimensions of transformation to sustainable farming: (i) agricultural practices; (ii) learning those practices; (iii) facilitating that learning; (iv) institutional frameworks that support such a facilitation; and (v) conducive policy frameworks. These same sustainability principles can be used in facilitating farmers into making much needed contributions in greenhouse gas reduction, improving their ability to store carbon on-farm, and to help secure the future of farmers living and working on the land for generations to come.

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9. Appendix

9.1 Appendix 1 - CARBON IN AGRICULTURE SURVEY - PART A

CARBON IN AGRICULTURE RESEARCH PROJECT

QUESTIONNAIRE

SECTION 1 - PRE-INFORMATION SESSION

Question 1

How concerned are you about climate change?

Please rate by placing a mark on the scale below



Question 2

How do you rate the importance of reducing global greenhouse gas (GHG) emissions to address climate change?

Please rate by placing a mark on the scale below



Question 3

The list below displays seven major greenhouse gases that are released into the atmosphere.

Please circle and rank the three greenhouse gases that you believe contribute most to greenhouse gas concentrations in the atmosphere.

Carbon dioxide
Methane
Nitrous oxide
Carbon monoxide
Hydrofluorocarbons
Sulfur hexafluoride
Perfluorocarbons

Question 4

Many countries contribute to varying amounts of greenhouse gas emissions.

From the list of countries below please circle and rank the three countries you believe contribute most to greenhouse gas emissions per capita?

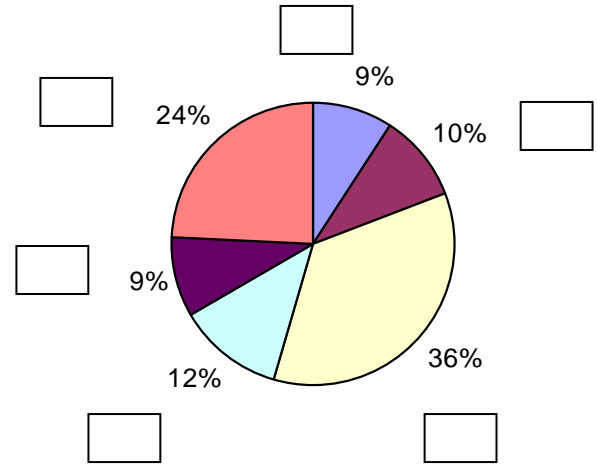
United Kingdom
Australia
China
India
Germany
New Zealand
Japan
Canada
United States of America
United Arab Emirates
Russia

Question 5

According to the National Greenhouse Gas Inventory (NGGI 2007) the contribution of emissions have been grouped into sectors. These sectors represent the main human activities that contribute to the release or capture of carbon into or from the atmosphere.

Place the letter that you believe best matches the percentage of carbon emissions from each sector.

- A. Electricity, gas and water
- B. Services & transport
- C. Residential
- D. Agriculture, forestry and fishery
- E. Manufacturing
- F. Mining



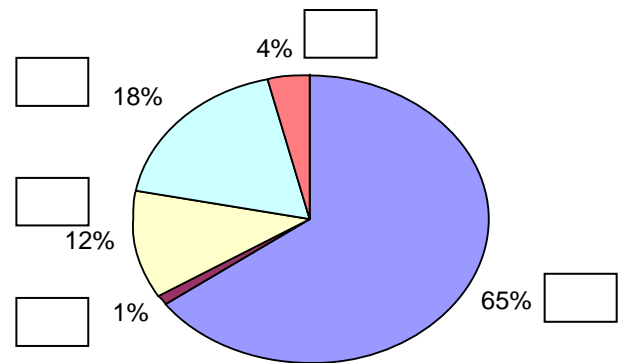
Question 6

In agriculture the level of greenhouse gas emission can be broken up into major contributors.

Place the letter that you believe best matches the percentage of carbon emissions from agriculture.

Appointment of emissions within agriculture

- A. Ruminant digestion (burping)
- B. Agricultural Soils
- C. Manure management
- D. Prescribed burning of savannas
- E. Burning of residues – crop/sugar



SECTION 2 – YOUR FARM

Question 7

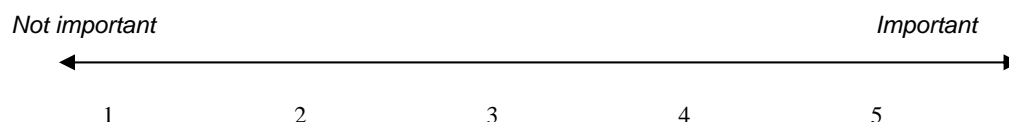
From the list below please tick the box(s) that best describes how your farm could play a role in carbon management.

- My farm could reduce emissions by changing farm practise.
- My farm could store additional carbon on farm or be involved in an _____ offset program.
- No role
- Other (please specify)_____

Question 8

How do you rate the level of importance in reducing carbon emissions on your farm?

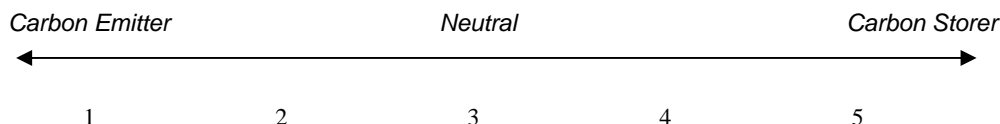
Please rate by placing a mark on the scale below



Question 9

Which do you believe best describes your farm in relation to carbon balance?

Please rate by placing a mark on the scale below



Question 10

Have you obtained an assessment of your farms carbon footprint?

- Yes
- No – Would you be interested
- Yes
- No

Question 11

Are you aware of any assessment programs used to measure carbon emissions on farm?

- Yes. If so what programs are you familiar with _____
- No

Question 12

Are you aware of any carbon certification system in Australia?

- Yes. If so what system are you familiar with _____
- No

Question 13

Which statement best describes your level of knowledge relating to carbon management on your farm?

- I have a sound knowledge in this area
- I have adequate knowledge
- I have little knowledge in this area
- I would like to improve my knowledge
- I do not believe I require any knowledge in this area

Question 14

Over a number of years it has been shown that farmers have the ability to improve farm practices and utilise technology to help them adapt and enhance their ability to manage climatic variability and productivity challenges in agriculture.

A. Please read the list below and tick the box if you have made any of the mentioned changes to your farming practice over the past three years

B. Now list how you believe those changes would influence your carbon balance on farm

Please mark if you believe carbon emissions on farm:

- Increased carbon emissions* ↑
- Decreased carbon emissions* ↓
- No change in carbon emission.* -

| Farm Practice | A. Changed (tick) | B. Carbon balance on farm |
|--|--------------------------|----------------------------------|
| Using Control Traffic | <input type="checkbox"/> | _____ |
| Variable rate technology | <input type="checkbox"/> | _____ |
| Altered crop rotations | <input type="checkbox"/> | _____ |
| Reduced livestock numbers | <input type="checkbox"/> | _____ |
| Increased livestock numbers | <input type="checkbox"/> | _____ |
| Included intensive animal production | <input type="checkbox"/> | _____ |
| Reduces intensive animal production | <input type="checkbox"/> | _____ |
| Reduced stubble burning | <input type="checkbox"/> | _____ |
| Using new crop varieties | <input type="checkbox"/> | _____ |
| Use of dietary supplements for livestock | <input type="checkbox"/> | _____ |
| Using GM crops | <input type="checkbox"/> | _____ |
| Reduced application of nitrogen fertiliser | <input type="checkbox"/> | _____ |
| Use of nitrogen inhibitors | <input type="checkbox"/> | _____ |
| Planted trees on farm | <input type="checkbox"/> | _____ |
| Other please specify _____ | <input type="checkbox"/> | _____ |

Question 15

When the Australian Government introduces a Carbon Pollution Reduction Scheme (emissions trading scheme) how do you believe your farm will be affected by this change?

Please tick the no change, increase or decrease box for each item you believe will change in cost.

| | No change | Increase | Decrease | Unsure |
|-------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| Fuel prices | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Electricity costs | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Food | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Fertiliser | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Commodity Prices | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| New opportunities | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Trade Barriers | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Other _____ | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

Question 16

In the future do you think you will get more involved in carbon management on your farm?

- Yes
- No

Question 17

Do you currently undertake any form of environmental accounting on farm?

- Yes, if so what _____
- No

SECTION 3 - DEMOGRAPHIC QUESTIONS

- Please indicate your age group?**
 - Under 25
 - 25 – 34
 - 35 – 44
 - 45 – 54
 - 55 – 64
 - 65 and above
- Do you own farmland in the Wimmera Mallee Region?**
 - Yes – if so how many hectares do you own? _____
 - No
- Do you lease land in the Wimmera Mallee from another person to farm yourself?**
 - Yes – if yes, how many acres _____
 - No
- Which of the following does your farm participate in or operate... (Read list)**
[Multi-select]
 - pasture and hay production
 - cereal grain production
 - oilseed production
 - pulse production

- intensive livestock (specify)
- dairy production
- horticulture / glass house operation
- farm forestry
- sheep for wool
- sheep for meat
- beef cattle
- any other activities: (specify)

5. How long have you been farming in the Wimmera Mallee region?

- Less than 1 year
- 1 - 5 years
- 6 - 10 years
- 11 - 20 years
- 20 years or longer

6. Do you live on farm?

- Yes
- No

THIS PAGE WILL BE REMOVED FROM THE SURVEY AFTER THE QUESTIONNAIRE IS COMPLETED TO MAINTAIN CONFIDENTIALITY.

7. Would you be interested in completing further research in this area?

- Yes (*please provide contact details below*)
- No

8. Would you like to receive a summary of the results of this study?

- Yes (*please provide contact details below*)
- No

Contact details

Name: _____

Phone number: _____

Address: _____

Or

Email: _____

9.2 Appendix 2 - CARBON IN AGRICULTURE SURVEY - PART B

CARBON IN AGRICULTURE RESEARCH PROJECT

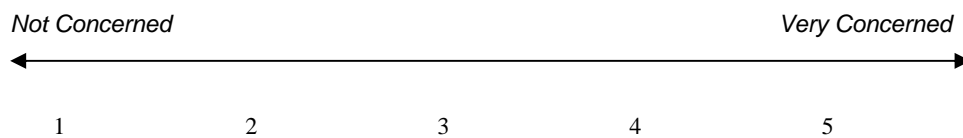
QUESTIONNAIRE

SECTION 2 - POST-INFORMATION SESSION

Question 1

How concerned are you about climate change?

Please rate by placing a mark on the scale below



Question 2

How do you rate the importance of reducing global greenhouse gas (GHG) emissions to address climate change?

Please rate by placing a mark on the scale below



Question 3

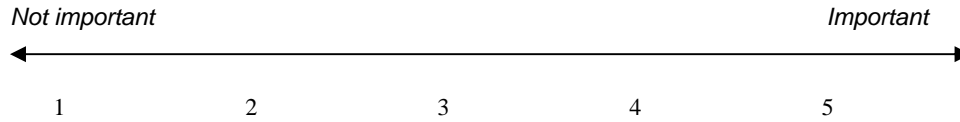
From the list below please tick the box(s) that best describes how your farm could play a role in carbon management.

- My farm could reduce emissions by changing farm practise.
- My farm could store additional carbon on farm or be involved in an offset program.
- No role
- Other (please specify) _____

Question 4

How do you rate the level of importance in reducing carbon emissions on your farm?

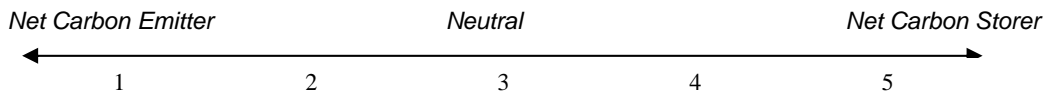
Please rate by placing a mark on the scale below



Question 5

Which do you believe best describes your farm in relation to carbon balance?

Please rate by placing a mark on the scale below



Question 6

As a result of the information session which statement best describes your level of knowledge now relating to carbon management on your farm?

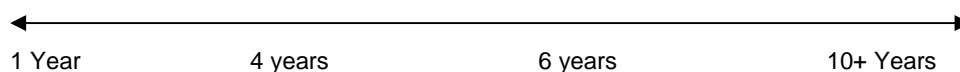
- I have a sound knowledge in this area
- I have adequate knowledge
- I have little knowledge in this area
- I would like to improve my knowledge
- I do not believe I require any knowledge in this area

Question 7

A. In the future do you think you will get more involved in carbon management on your farm?

- Yes*
- No

** If you answered yes to the above questions please mark on the scale the time frame you see yourself getting involved in this area.*



B. In which areas do you believe you will be involved in?

- Carbon sequestration on farm
- Carbon marketing
- Offset provider
- Life cycle analysis of farm
- Potential business opportunities
- Policy implementation
- Other (please specify)_____

Question 8

What other activities do you feel would benefit you in gaining a greater understanding of role of carbon in agriculture.

- Newsletter update
- Information sessions
- Policy updates
- Carbon accounting skills and knowledge transfer
- Carbon forum update site for farmers
- Other (please specify)_____

9.3 Appendix 3 - ETHICS APPLICATION APPROVAL

| |
|---|
| HUMAN RESEARCH ETHICS <u>APPROVAL</u> FORM |
|---|

| | |
|---|------------------|
| Principal Researcher/Supervisor: | P McRae-Williams |
| Associate/Student Researcher/s: | I Schwarz |
| School: | Business |

Ethics approval has been granted for the following project:

| | |
|------------------------|---|
| Project Number: | B08-094 |
| Project Title: | Identifying attitudes and perceptions of Wimmera Mallee farmers towards reduction of carbon emissions on farm |
| For the period: | 17/7/2008 to 30/11/2008 |

Please quote the Project No. in all correspondence regarding this application.

REPORTS TO HREC:

A final report for this project must be submitted to the Ethics Officer on:

30 December 2008

www.ballarat.edu.au/ard/ubresearch/hdrs/ethics/humanethics/docs/final_report.doc



Ethics Officer
17 July 2008

If any changes are to be made to this project, a 'Request for Amendments' form must be completed and forwarded to the Ethics Officer for approval.