Australian Vegetable Industry Carbon Footprint Tool - stage 2 (national development and adoption of the tool)

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South Australia Research & Development Institute (SARDI)

Project Number: VG09187

VG09187

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VEGETABLE CARBON CALCULATOR

Final Report

VG09187 Australian Vegetable Industry Carbon Footprint Tool: Stage 2
(National Development and Adoption of the Tool)

Date Completed: 23rd December, 2010
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South Australian Research and Development Institute

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Woolworths the fresh food people

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Statement of purpose of report:

This report details the research and extension undertaken in Project VG09187, the Australian Vegetable Industry Carbon Footprint Tool – Stage 2 (national development and adoption of the tool). The report includes the main findings, industry implications and recommendations to industry along with suggested areas of future research and development.

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Woolworths Limited

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Contents

1. Acknowledgments

This project was greatly assisted by a number of vegetable growers and industry advisors who have provided valuable feedback and information on farming practices. In particular, the project team would like to acknowledge the assistance of:

- Allison Clark, Houston's Farm;
- Andrew Tedesco, Tedesco Farms;
- Jason Huggins, Department of Primary Industries, QLD;
- Maureen Dobra, Loose Leaf lettuce Company;
- Peter Deuter, Department of Primary Industries, QLD; and
- Marcus Brandsema, J & A Brandsema

The project team acknowledge the generous support of Woolworths Australia Limited who have contributed financially towards helping vegetable growers understand and manage their greenhouse gas emissions. Landcare Australia were have also been involved in supporting this project.

The success of this project is in part due to the initial work on carbon footprinting in the vegetable industry which was initiated by Houston's Farm and completed with assistance from Pitt & Sherry.

The project team would also like to acknowledge the assistance of Alison Turnbull and Peter Melville from Horticulture Australia Limited.

2. Preface

This report is intended to outline the processes and methods used to develop the Vegetable Carbon Calculator and the associated website. The report itself does not address either the technical issues associated with developing a carbon calculator or the methods used. Readers interested in the technical elements of this project should see the Vegetable Carbon Calculator Protocol which is appended to this report together with the Carbon Calculator Manual and the Understanding Carbon Manual.

3. Media Summary

Australian vegetable growers can now calculate their farms' carbon footprint thanks to the development of the Vegetable Carbon Calculator. This online calculator has been designed specifically for the vegetable industry and was developed in conjunction with growers from across the country. To take a look at it visit: www.vegiecarbontool.com.au.

There are around 6,350 vegetable farms in Australia, contributing around six per cent of the gross value of agricultural production. Vegetable production is an important part of Australia's regional economy and provides significant direct and indirect employment. Agriculture is thought to be responsible for up to 16% of Australia's greenhouse gas emissions. Preliminary estimates suggest that horticulture contributes only about 1% of these agricultural emissions. Vegetables are a low carbon food source, but to gain a commercial advantage from this, farmers and vegetable industry participants must understand the principles and background behind carbon accounting.

Environmental awareness is rapidly spreading. Households are embracing practices such as recycling and reducing water use. Retailers are testing schemes which reduce packaging and lower greenhouse emissions and the Australian government may pursue the management of carbon emissions through a pricing mechanism in the future. It is with this background that the Australian vegetable industry commissioned the development of an industry specific greenhouse gas accounting tool.

The Vegetable Carbon Calculator provides a simple mechanism for farmers to enter their production inputs, such as fuel, electricity and fertiliser consumption and receive information about what aspects of their farming practices are contributing most significantly to their carbon footprint.

The calculator is also able to help farmers understand if their carbon footprint is similar or different to other farmers, by benchmarking their emissions against others.

This project (VG09187) was funded by Horticulture Australia Limited (HAL) using the vegetable levy and matching funds from the Federal Government. A voluntary contribution of funding from Woolworths, supplied by Landcare Australia, was made available as a precursor to this project (VG09187) with matching funds supplied by the Federal Government. The resources created from this project, including a video presentation, are available on The Vegetable Carbon Calculator website (www.vegiecarbontool.com.au).

4. Technical Summary

There are around 6,350 vegetable farms in Australia, contributing around six per cent of the gross value of agricultural production. Vegetable production is an important part of Australia's regional economy and provides employment and revenue opportunities across the supply chain. Agriculture is thought to be responsible for up to 16% of Australia's greenhouse gas emissions. Preliminary estimates suggest that Horticulture contributes only about 1% of these agricultural emissions. Vegetables are a low carbon food source, but to gain a commercial advantage from this, farmers and vegetable industry participants must understand the principles and background behind carbon accounting.

Environmental awareness is rapidly spreading. Households are embracing practices such as recycling and reducing water use. Retailers are testing schemes which reduce packaging and lower greenhouse emissions and the Australian government may pursue the management of carbon emissions through a pricing mechanism in the future. It is with this background that the Australian vegetable industry commissioned the development of an industry specific greenhouse gas accounting tool.

The Vegetable Carbon Calculator has builds on work completed by Houston's Farm in 2009 and provides a simple mechanism for every vegetable farmer to calculate their farm's greenhouse gas emissions. Although Houston's Farm used life cycle assessment methodologies in their approach to greenhouse gas accounting, this was not thought appropriate for the industry as a whole.

The Vegetable Carbon Calculator accounts for on-farm Scope 1 emissions as well as Scope 2 emissions associated with the electricity used on-farm. Calculation methodology is based predominantly on guidelines published by the Australian Government's Department of Climate Change and Energy Efficiency and by the Intergovernmental Panel for Climate Change.

This project has involved the development of a web site, which contains the calculator and all associated training material. The Vegetable Carbon Calculator provides a simple mechanism for farmers to enter their production inputs, such as fuel, electricity and fertiliser consumption and receive information about what aspects of their farming practices are contributing most significantly to their carbon footprint. In some instances user input cells are prefilled with default values to ensure growers can complete their footprint with minimal effort.

The Calculator is also able to help farmers understand if their carbon footprint is similar or different to other farmers, by benchmarking their emissions against others. Five different crop categories are used for the benchmarking process: Leafy, Cucurbit, Brassica, Root and Other. The benchmarking uses a ranking system to illustrate to growers where there produce fits on a fan diagram.

This project (VG09187) was funded by Horticulture Australia Limited (HAL) using the vegetable levy and matching funds from the Federal Government. A voluntary contribution of funding from Woolworths, supplied by Landcare Australia, was made available as a precursor to this project (VG09187) with matching funds supplied by the Federal Government. The resources created from this project, including a video presentation, are available on The Vegetable Carbon Calculator website (www.vegiecarbontool.com.au).

5. Introduction

Environmental awareness is rapidly spreading. Households are embracing practices such as recycling and reducing water use. Retailers are testing schemes which reduce packaging and lower greenhouse emissions and the Australian government will likely try to manage carbon emissions through a pricing mechanism at some point in the near future. It is with this background that the Australian vegetable industry commissioned the development of an industry specific greenhouse gas accounting tool.

The key objective associated with this project is to promote the awareness of carbon footprinting among the vegetable industry and to provide the framework which allows farmers to begin the process of reducing their environmental impact. This key objective was achieved through the development of the Vegetable Carbon Calculator together with industry wide training on carbon accounting practices.

There are around 6,350 vegetable farms in Australia, contributing around six per cent of the gross value of agricultural production. Vegetable production is an important part of Australia's regional economy and provides both direct and indirect employment. Agriculture is thought to be responsible for up to 16% of Australia's Greenhouse gas emissions. Preliminary estimates suggest that horticulture contributes to only about 1% of these agricultural emissions. Vegetables are a low carbon food source, but to gain a commercial advantage from this, farmers and vegetable industry participants must understand the principles and background behind carbon accounting.

This project was initially started (Stage 1) by Houston's Farms, Hobart, Tasmania. Stage 2 of this project expanded upon that work to develop an approach that was suitable for the entire Australian vegetable industry. The Vegetable Carbon calculator focuses upon the "on-farm" footprint rather than the supply chain.

5.1.Project Approach

This project was completed using the following stages:

- Formulation and meeting of a Project Reference/Steering Group
- Development of Version 1.0 of the Vegetable Carbon Calculator through consultation with growers
- Testing of Version 1.0 with a selected Early Adoption Group of vegetable growers from around Australia.
- Development of Version 2.0 incorporating feedback and requests from the Early Adoption Group.
- Industry training and promotion of the Vegetable Carbon Calculator.

5.2.Project Reference Group

The Project Reference Group was chosen to help steer this project towards objectives that maximise the benefit for the industry as a whole. Members were chosen for their understanding of both carbon accounting and the vegetable industry.

The Project Reference Group included:

- Allison Clarke, Houston's Farm;
- Alison Turnbull, Horticulture Australia Limited (later replaced by Peter Melville, Horticulture Australia Limited);
- Darren Oemcke, Provisor (later replaced by Dr Kathy Opel Keller, South Australian Research and Development Institute);
- Jason Huggins, Department of Primary Industries, QLD; and
- Peter Deuter, Department of Employment, Economic Development and Innovation (DEEDI), Primary Industries and Fisheries, QLD.

6. The Need for a Vegetable Carbon Calculator

Over the last decade, there has been a change in perception associated with environmental management. Environmental issues and policy are now mainstream topics. Environmental concern is seen in all areas of society and it is therefore important that the horticultural industry is prepared to respond to this sociological change.

But what is a carbon footprint? Andrew J East, of Growcom, who was commissioned by HAL to write the discussion paper "*What is a Carbon Footprint*," describes a carbon footprint as "a direct measure of greenhouse gas emissions, expressed in tonnes of carbon dioxide equivalents (CO_2e), caused by a defined activity. At a minimum this measurement includes direct emissions resulting from activities within the control or ownership of the emitter and indirect emissions resulting from the use of purchased electricity." (1)

Although East is able to generate a relatively robust definition of a carbon footprint there is still a lack of scientific consensus on what should be included in a carbon footprint (1). For this reason the industry specific calculators must clearly set out their approach and design philosophy.

Understanding and measuring greenhouse gas emissions is important for the vegetable industry. The Vegetable Carbon Calculator will help Australian vegetable growers in the following areas:

- Compliance;
- Retail Pressure,
- Export Opportunities;
- Carbon Opportunities; and
- Relevance.

6.1. Compliance

In the future carbon accounting may become mandatory. It is therefore necessary for growers to begin the process of understanding carbon accounting.

Agriculture contributes 16% of Australia's greenhouse gas emissions; mostly from the livestock industry. Horticulture is thought to be responsible for only 1% of the total emissions associated with the agricultural sector, predominantly due to the low amount of land used for horticultural production. Although a small contributor of greenhouse gases at the national level, and low in comparison to some other food types, vegetables utilise intensive farming practices and there are likely to be opportunities to reduce emissions on a production basis (2). Although excluded temporarily from the governments failed Carbon Pollution Reduction Scheme, as agriculture is responsible for 16% of Australia's greenhouse gas emissions it is unlikely to be permanently excluded from future carbon pricing schemes.

For agriculture, much work will need to done to ensure that the industry adapts to a changing climate. For vegetable producers this may include learning how to manage increased seasonal variation and extreme weather events. This work in adaptation is critical, to ensure that the industry remains sustainable in the longer term. In the shorter term, it is important for vegetable farmers to

begin quantifying their carbon footprint. This will empower the industry and build confidence among growers as the transition into a carbon economy occurs.

6.2. Retail Pressure

Retailers are increasingly applying pressure to their suppliers to provide them with environmentally responsible products. For the vegetable industry this pressure is currently not being actively applied, but it is thought that in the future retailers may request information about the carbon footprint of their vegetable suppliers.

The stance of most retailers in Australia is that carbon footprint information is currently not something they require from their growers, but they would like the vegetable industry to be prepared for such a request.

Internationally some retailers are beginning to use carbon footprint information to differentiate their products. This is particularly evident in Europe with companies such as Tesco in the UK and Casino in France providing carbon information on the labels of some of their products.

If the Australian vegetable industry wishes to retain domestic market share, and should it wish to raise its export levels then it needs to be prepared for some form of carbon labelling (2). While carbon labelling is a complex process, understanding the carbon footprint of a farm is a much simpler task and will provide good background should growers wish to be involved in carbon labelling projects in the future.

6.3. Export Opportunities

Many countries are further progressed in their carbon management systems than Australia, with emission trading schemes and labelling initiatives. There is the possibility that they may use carbon as a market access barrier. Although not considered an immediate threat, failure to measure carbon emissions and begin the reduction process may reduce the opportunities available for growers to sell their produce in export markets.

6.4. Carbon Opportunities

Carbon footprinting is often thought to impose a cost on those wishing to participate. However, there may be opportunities in the near future for farmers to be paid an incentive to reduce their emissions (3). There may also be opportunities associated with the Carbon Farming Initiative, which could enable farmers to cash in or certain emission reduction activities. It is therefore important that farmers begin the process of understanding their carbon footprint so that they can capitalise on any future reduction campaigns.

The opportunities currently being discussed include the modification of soil carbon content. Although a possible mechanism for carbon reduction, there is a lack of clear scientific understanding on soil carbon and how this interacts with greenhouse mitigation strategies. For this reason the Vegetable Carbon Calculator currently does not include soil carbon.

6.5.Relevance

Carbon accounting practices are newly developed and often complex. In order to assist industry members many industries have developed simple calculators which estimate the carbon emissions of businesses or organisations that participate in their sector. These calculators simplify the process of carbon accounting.

Prior to the development of the Vegetable Carbon Calculator there was no single mechanism or calculator designed specifically for the Australian vegetable industry. Four existing tools were reviewed as part of a preliminary study as to whether they could be used by the vegetable industry, however individually they were not thought to be readily applicable (3).

The Vegetable Carbon Calculator was designed so as to be appropriate for the Australian vegetable growers and uses language and examples which can be understood by the industry.

7. Method- Developing www.vegiecarbontool.com.au

This section outlines the processes used to develop the Vegetable Carbon Calculator. Specific calculation methodology is described in the Vegetable Carbon Calculator Protocol, which is included as an Appendix to this report. The Vegetable Carbon Calculator Manual, which includes instructions on how to use the Vegetable Carbon Calculator, is also included as an Appendix to this report.

7.1. Calculator Scope

The scope of the final accounting tool was defined through two methods:

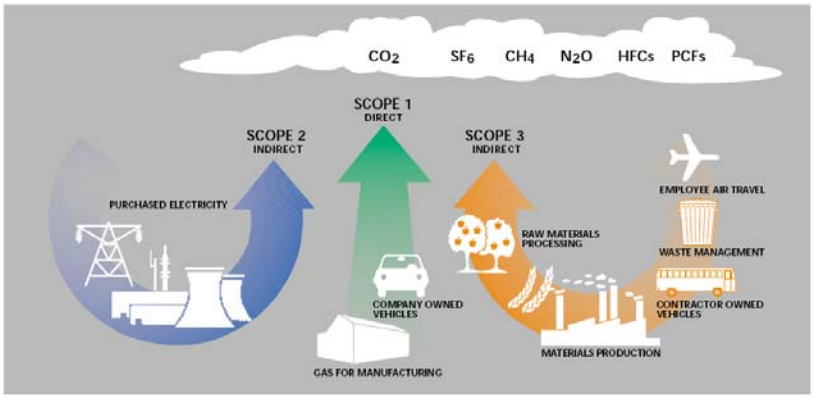
- Interaction with the Project Reference Group; and from
- Discussions with the Early Adoption Group.

The Project Reference Group first met at HAL's Sydney office on the 19th of October 2009 to discuss the scope of the calculator.

The following criteria were defined by the Project Reference Group:

- The calculator must educate and teach users about carbon footprinting.
- The calculator should be focused on the farm only and not consider the wider supply chain.
- The calculator must account for all Scope 1 and 2[1] emissions associated with vegetable farming.
- The calculator must work for both glasshouse and outdoor vegetable production.
- The tool must work with mixed enterprise vegetable production.
- The tool should try to develop a comparison method.
- The calculator should use Australian carbon accounting methodologies or IPCC methodologies if appropriate.
- Soil carbon and associated emissions are to be excluded.
- Animals are to be excluded from the tool.

[1] The World Resources Institute in their Greenhouse Gas Protocol have defined greenhouse gas emissions according to three different Scopes. These different Scopes are illustrated below.



Source: The Greenhouse Gas Protocol, World Resources Institute, http://www.ghgprotocol.org/

During the early adoption road testing a number of additional criteria were defined by vegetable growers. These included:

- The tool must be simple; ideally it would take only 1-2 hours to complete.
- Provide information on how the data are used and confidentiality requirements.
- Include a year-by-year function, so that results can be compared year to year.

7.2. Development of Version 1

Following the Project Reference Group meeting, Version 1.0 of the Vegetable Carbon Calculator was developed. This included a prototype calculator, a carbon accounting protocol and user guide.

Version 1.0 of all of the material was then demonstrated in webinar format with members of the Project Reference Group. A number of small changes were made and then Version 1.0 of the Calculator, Protocol and User Guide were then demonstrated to the Early Adoption Group.

7.3. Trials and testing with the Early Adoption Group

The Vegetable Carbon Calculator was thoroughly tested with the Early Adoption Group. This testing stage was used to check the functionality of the tool and if it met grower requirements.

The Early Adoption Group consisted of:

Participant	Crop or industry role	State
Alison Turnbull*, HAL	Industry advisory	New South Wales
John Mundy	Cauliflower	South Australia
Allison Clark*, Houston's Farm	Salad crops	Tasmania
Melina Parker, Milton Farm	Mixed production	Tasmania
Marcus Brandsema	Glass house grown tomatoes	Tasmania
Alan Wilson	Mixed production	Tasmania
Linton Brindlecombe	Beetroot	Queensland
Peter Deuter*	Industry advisory	Queensland
Jason Huggins*	Mixed production	Queensland

Lisa Crooks, Riverview Herbs	Parsley, radish	Queensland
David Putland, Growcom	Industry partner/consultant	Queensland
Maureen Dobra, Loose Leaf Lettuce Company	Lettuce, spinach, rocket	Western Australia
Damian Rigali, Gourmet Farm Produce	Lettuce	Western Australia
Andrew Tedesco	Asian greens, lettuce, cabbage	Western Australia

* Part of the Project Management Group

As can be seen from the list above a good representation of states, farm sizes and crop types were included in the Early Adoption phase of this project.

The many positive comments from the Early Adoption Group included:

- Calculator worked well in all locations;
- Calculator access via the web was excellent and meant results could be considered from any location with internet access;
- Simple to use, with many users commenting that it was a lot easier to use than they expected;
- Graphical output of results was helpful and clear;
- Comparison of crops with other members of the industry provided context and was well received.

There were a number of requests made by the Early Adoption Group. These requests included:

- Add a page on data confidentiality detailing the confidentiality of data;
- Add additional details to the survey questions – currently the questions are too vague;
- Add a year-by-year function to the tool, so that results can be compared year on year;
- Create an easier system for growers to include their fertiliser use. Many growers use more than one type of fertiliser and current layout of the tool does not support this;
- Add a mechanism to export the results into an excel format;
- Change the way in which fuel, electricity and fertiliser are allocated to individual crops. The current mechanism is too difficult for growers. A tabular format may be simpler to use; and
- Provide a mechanism to close the loop on the project by suggesting web links for further information, ways to reduce your emissions and other sites of interest.

7.4.Development of Version 2

Following on from the Early Adoption Testing updates were made to the tool to reflect the changes requested by the growers.

The most significant changes associated with Version 2.0 of the tool included:

- A page on data confidentiality and other terms and conditions (still being reviewed by SARDI lawyers);
- Modifications to survey questions;
- Year-by-year functionality added to the tool, so that results can be compared year on year;
- Addition of an easier system for growers to include their fertiliser use; and
- Simplification of fuel, electricity and fertiliser allocation to individual crops.

8. Technology Transfer

After version 2.0 had been demonstrated to the project reference group the tool was then rolled out to industry. The roll out process included training and calculator demonstrations.

8.1. Training and Demonstrations

Throughout November and December 2010 a series of workshops were run across the country to provide opportunities for members of the vegetable industry to see the vegetable carbon calculator in action and learn how to use it on their own farms.

- The workshops or training sessions were designed to :
- Reiterate the important elements of "Understanding Carbon";
- Provide a thorough overview of the Vegetable Carbon Calculator; and
- Give direction on what farmers can to do after completing the calculator.

A meeting with Woolworths was arranged as part of this milestone. The carbon calculator was demonstrated to Armineh Mardirossian, Group Manager, Corporate Responsibility Community & Sustainability Woolworths Limited. Armineh, commented on the calculator saying it "is very impressive and I am very pleased with the outcome."

The "in person" seminars are presented in the table below.

Seminar Workshop Location	State/Territory	Date	Number of Attendees
Virginia Horticulture Centre	South Australia	3/12/10	0*
Amsteel Golf Club, Cranbourne	Victoria	1/12/10	10
Argosy Hotel, Devonport	Tasmania	13/12/10	18
Meander Valley Enterprise Centre	Tasmania	14/12/10	4
Cobbitty	New South Wales	15/11/10	10
Darwin	Northern Territory	22/11/10	30
Katherine	Northern Territory	23/11/10	6
Gatton	Queensland	Jan 2011	TBA (estimate 30)
Total Attendees			104

*This session was postponed due to very hot weather. Session will be run as a webinar in 2011.

The following webinar format training sessions have also be run to educate growers on how to use the calculator.

Webinar	Date	Number of Attendees
Alice Springs	24/11/10	18
South Australia	7/12/10	4
Western Australia	16/12/10	3
South Australian (additional to cover seminar)	April 2011	20(estimate)
Total Attendees		45

The greatest challenge associated with the training of growers has been attracting the required numbers to make seminars viable. November, December and January are typically sowing and irrigating times for vegetable growers and this means that many find it difficult to leave the farm and attend workshops. For this reason the workshop in Queensland, will now be run in January 2011. Further webinar sessions are also scheduled to run in the New Year to ensure that all growers are provided with the opportunity to be trained in using the Vegetable Carbon Calculator.

8.2.Refinement and update of Calculator

Comments and suggestions from a series of users, reviewers and agricultural academics have also been incorporated into the tool. These suggestions came from:

- Workshop participants;
- Agricultural scientists and agronomists within SARDI;
- Engineering and technical staff at The Australian Wine Research Institute;
- DO Consulting;
- Department of Primary Industries Victoria; and
- Houston's Farm.

Predominantly the nature of suggestions received from these organisations related to a simplification of the way in which greenhouse gas emissions were being calculated from:

- Fertiliser;
- Waste water; and

- Crop residues.

9. Web Design and Functionality

9.1. Web Platform

The Vegetable Carbon Calculator website has been programmed using a combination of HTML, JavaScript, and CSS languages. For the more complex database and calculations, PHP with MySQL has been utilised. The website is hosted on a Linux server running Red Hat Enterprise Linux housed in Adam Internet's data centre in Adelaide.

9.2. Design/Theme

The Vegetable Carbon Calculator website and Manual were designed to communicate a fresh, modern and bright feel. The slick green colour scheme along with the repetition of diagonal lines was developed to reflect an agricultural focus.

The Manual aims to provide simple and clear instructions for growers on how to navigate their way through the site. Screenshots were used to illustrate the simple steps required to use the Vegetable Carbon Calculator.

9.3. Training/Media Campaign

To promote the launch of the Vegetable Carbon Calculator website, a number of communication methods were used. This included editorial and advertising space through the Good Fruit and Vegetable magazine. Advertisements were placed in the November & December editions of the magazine, with a postcard insert also distributed with the December edition.

Once dates had been set for the training seminars and webinars - further promotion was conducted via the mainstream media, with press releases sent to relevant rural-focused media outlets including television, newspapers and radio. The release detailed when and where the training sessions would occur, and directed people to the website for more information.

There has been considerable media interest in the project, particularly from the ABC in rural areas.

Interviews were performed with:

- ABC Queensland (for rural programs);
- ABC Burnie, Tasmania;
- ABC Perth, WA (for rural programs); and
- ABC Sydney (for rural programs).

10. Recommendations

In terms of scientific development, carbon accounting is a relatively new discipline. There are still many areas of uncertainty, particularly in calculating emissions from agricultural processes. This project has highlighted the uncertainty associated with the following carbon accounting practices:

- Agricultural soils;
- Vegetable crop residues;
- Fertiliser emissions associated with vegetable farms;

Of particular importance is the role of fertiliser emissions from vegetable farms. Although the Australian methodologies for carbon accounting do have an emissions factor for synthetic fertiliser from vegetable farms, the uncertainty around this number is high. There is limited information on emission factors associated with organic fertilisers and no information with regard to how organic fertilisers perform on vegetable farms. If agriculture is to be included in future carbon pricing schemes, the emission factors associated with fertiliser will need to be significantly improved. The Vegetable Carbon Calculator Protocol clearly outlines the approach taken with regard to fertiliser emissions.

The project team have recently been contracted to develop a carbon calculator for stone fruit orchards. This work is expected to begin in January 2011. The Orchard calculator will build upon the platform developed for the vegetable industry.

There are a number of other horticulture industries which could benefit from having a dedicated carbon footprinting tool. In addition, the comparison and benchmarking information developed as part of this project has value for many other horticultural sectors. The project team have applied for a multi-industry project to develop carbon footprinting tools for other sectors with HAL.

11. References

11.1. Works Cited

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12. Appendices

UNDERSTANDING CARBON

Manual

VG09152 Australian Vegetable Industry Carbon Footprint Tool: Grower Adoption and Education

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HAL

Know-how for Horticulture™

Understanding Carbon
Manual

Editors:
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Project Overview

'Understanding Carbon' is a training program that has been designed specifically for the Australian Vegetable Industry. The training will give growers a clearer understanding of carbon footprinting: what it means to them as a grower and a business owner, how they can prepare for carbon footprinting, and the benefits of carbon footprinting to them and their business.

Growers will also be taught about the changes they can make to ensure they have a more sustainable farm and business. The training will be delivered using in-person seminars, as well as webinars (i.e. an online presentation, with sound via teleconference), in each State.

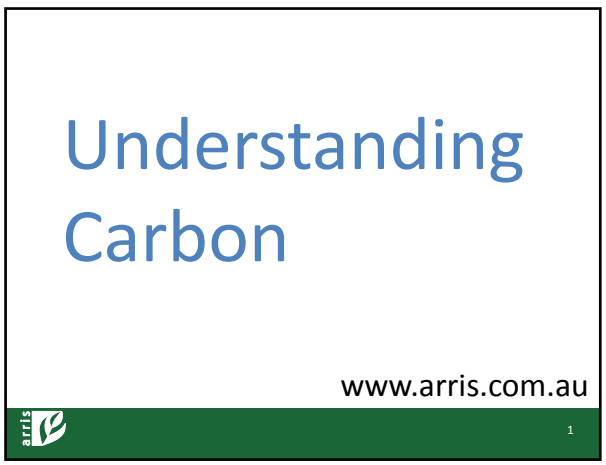
The program has been developed as a lead in to the introduction of a carbon calculator, which is currently being developed specifically for the Australian Vegetable Industry. It's anticipated that the online tool will be released in late 2010. This program has been funded by Horticulture Australia Limited and Woolworths with matching funds from the Federal Government.

This manual has been written as a resource to support the 'Understanding Carbon' training program. It provides Australian vegetable growers with all of the latest information on greenhouse gas emissions and associated carbon footprinting and management systems.

'Understanding Carbon' is being run as part of VG09152 Australian Vegetable Industry Carbon Footprint Tool: Grower Adoption and Education. This project supports VG09187 Australian Vegetable Industry Carbon Footprint Tool: Stage 2 (National Development and Adoption of the Tool).

The objective of this manual and the associated seminars is to provide information to growers regarding:

- the proposed mechanism of climate change;
- the different ways of calculating a carbon footprint;
- on-farm carbon footprints;
- product (vegetable) carbon footprints; and
- trends in the international marketplace.



Project Overview

- VG09152 – Australian Vegetable Industry Carbon Footprint Tool: Grower Adoption and Education ('Understanding Carbon' presentation)

and

- VG09187 - Australian Vegetable Industry Carbon Footprint Tool: Stage 2 (On-Farm Footprint Tool)

VG09187 – Australian Vegetable Industry Carbon Footprint Tool

- This tool will help growers to work out their on-farm carbon footprint.
- This tool is NOT for business comparisons.
- It will be used by growers for continual on-farm improvement - as Freshcare does for food safety.

Presentation Content

- Climate Change Background
- Carbon Accounting Methods
- The carbon footprint of an **Organisation**
  - National Greenhouse and Energy Reporting Act (NGER)
- The carbon footprint of a **Product**
  - Carbon labelling
- Becoming carbon neutral
  - Green marketing campaigns

Climate Change

Have you noticed a change in the climate?

Has it affected the way you grow your produce?

Over the past few decades, concerns associated with climate change have continually increased. Scientists are convinced that the world's climate is changing. The message we receive from mainstream media suggests that over recent decades droughts have increased, storm events have increased and rainfall patterns are changing. These effects are all considered 'elements' of climate change.

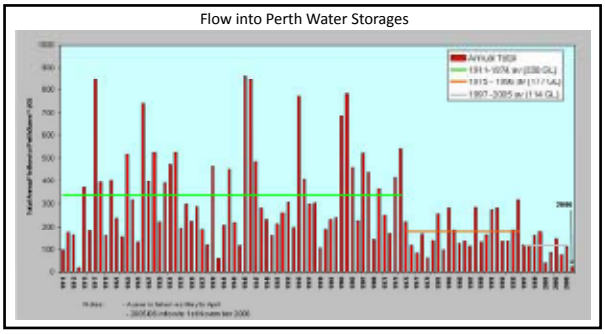
The Intergovernmental Panel on Climate Change (IPCC) is a leading scientific body, established by the United Nations Environment Programme (UNEP) and the World Meteorological Organization (WMO) to provide a clear scientific view on the current state of climate change and its potential environmental and socio-economic consequences (1).

The IPCC produces Assessment Reports, collating and summarising scientific consensus on climate change. Their Fourth Assessment Report (2007) concluded that the evidence of a warming climate is 'unequivocal' (2). There is strong evidence to suggest that human activity, namely the production and release of greenhouse gases into the atmosphere, is the major cause of climate change (1).

Major evidence of climate change occurring around the world includes:

- Arctic Sea ocean ice and glaciers diminishing [see Slide 8] (14);
- increased severe weather events;
- increase in average temperatures; and
- reduced rainfall run off [see Slide 10].

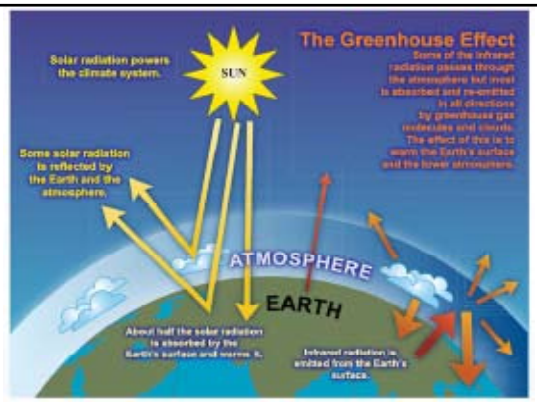
Importantly for the Australian Vegetable Industry, climate change has also resulted in reduced run off in many catchments in Australia due to changes in rainfall and


Flow into Perth Water Storages

increases in evaporation (3). Climate change may not just result in reduced rainfall, but is also likely to affect rainfall patterns with summer rains becoming more predominant in some areas. In some cases this reduction has been severe and has impacted dramatically on the water inflows into dams which supply communities with water. The figure above shows how rainfall levels have decreased in Perth. A decline of 10-20% in rainfall has seen a magnified reduction in dam inflow by 30-60%.

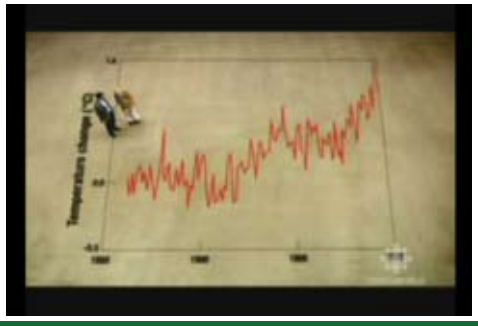
There are still some who debate whether or not climate change is occurring. This booklet presents the commonly held views of the Australian Government and the wider scientific community. It is worth noting that Australian observations and international scientific consensus support the claim that the average global temperature is increasing (4). There is never-the-less some uncertainties associated with climate change science.

Climate Change



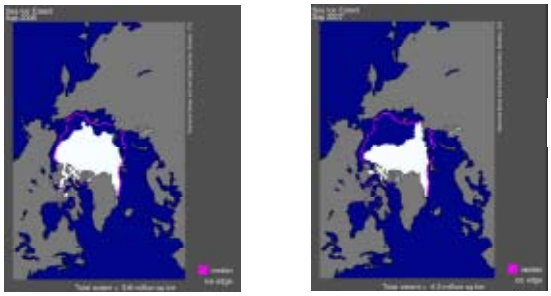
The Evidence

VIDEO



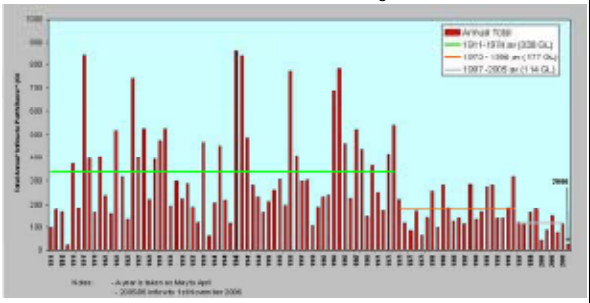
Arctic sea ice in 2005 & 2007

National Snow and Ice Data Centre



Reduced Run Off

Flow into Perth Water Storages



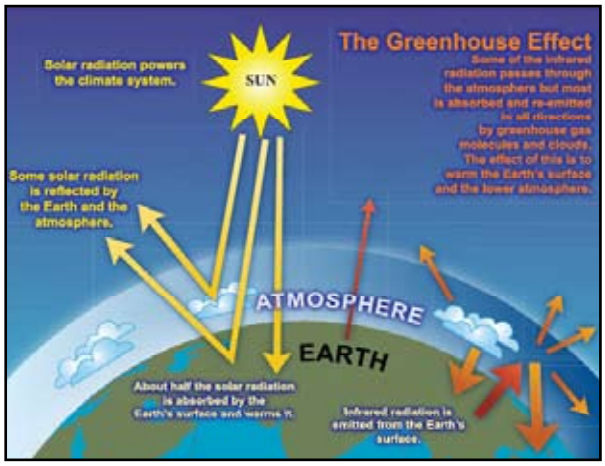
The Greenhouse Effect

Our planet is surrounded by gases, called the atmosphere. The atmosphere is predominantly comprised of nitrogen (78%), oxygen (21%) and argon (0.9%), along with a set of gases called greenhouse gases. These greenhouse gases act as a blanket, trapping the sun's heat and contributing to the warmth of the planet.

Greenhouse gases are important. Without them, the earth would be too cold to be habitable. Greenhouse gases are produced in nature, for example by volcanos. Human practices, such as burning fossil fuels, also create greenhouse gases. When the emissions are caused by humans we refer to this as an anthropogenic emission.

Since the industrial revolution the concentration of greenhouse gases in the atmosphere has been increasing.

The presence of greenhouse gases in the atmosphere (0.1% by volume) helps to keep the Earth's average global surface temperature at 14°C. That's 33°C warmer than if there were no greenhouse gases at all (2). This process is known as the greenhouse



effect (see the figure above), because the Earth's atmosphere behaves like the roof of a greenhouse. The gases in the atmosphere that are responsible for re-radiating heat towards the Earth's surface are known as greenhouse gases.

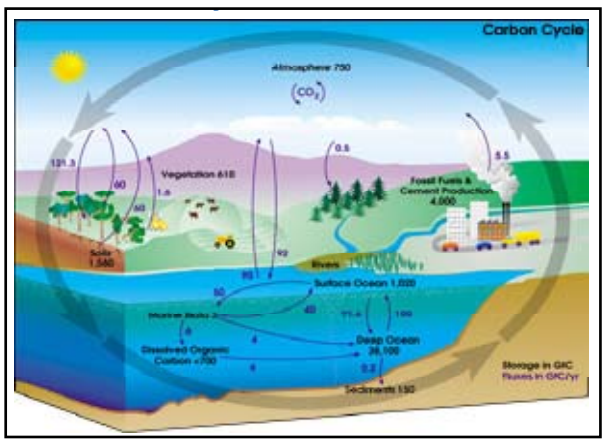
The main greenhouse gases arising from human activity, and associated with vegetable production, are:

- carbon dioxide;
- methane; and
- nitrous oxide.

The Carbon Cycle

The carbon cycle is used to illustrate the flows of carbon between the different systems that exist on earth. There are four main pools of carbon, which are:

- the atmosphere;
- the terrestrial biosphere, which is usually defined to include fresh water systems and non-living organic material, such as soil carbon;
- oceans, including dissolved inorganic carbon and marine biota; and
- sediments including fossil fuels (5).



The carbon cycle is made up of both long-term and short-term cycles. The short-term cycle includes the rapid exchange of carbon between plants and animals through respiration and photosynthesis, and through gas exchange between the oceans and the atmosphere (5).

An example of a short-term carbon cycle within the vegetable industry is photosynthesis associated with vegetable and vegetable plant growth. In the same way the decomposition of discarded parts of the plant are not considered an emission source.

Most carbon accounting methods exclude the short-term carbon cycle.

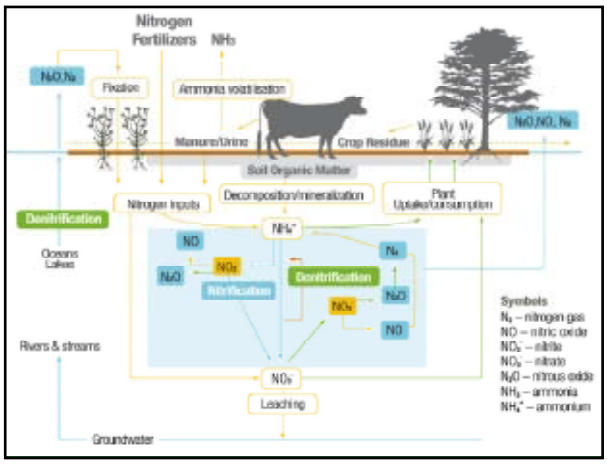
Note: The carbon footprinting tool in development for the vegetable industry (VG09187 Australian Vegetable Industry Carbon Footprint Tool: Stage 2) will ONLY account for the long-term carbon cycle.

The Nitrogen Cycle

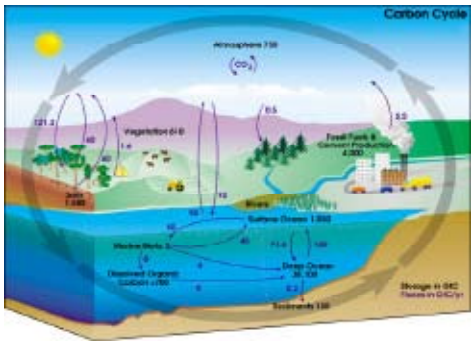
Nitrous oxide (N_2O) can be formed by a number of processes, and is determined by soil properties and external conditions such as moisture content, oxygen availability, amount and form of nitrogen and other influences such as tillage practices.

The chemical and biological pathways which see nitrogen, converted to N_2O is complex. The important thing to take away from the nitrogen cycle is that all forms of nitrogen, (i.e. synthetic, natural, organic or animal manure) added to soil will emit a varying degree of N_2O. This will contribute to the carbon footprint of your farm.

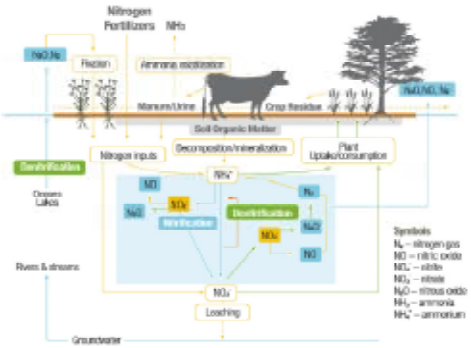
Note: The carbon footprinting tool in development for the vegetable industry (VG09187 Australian Vegetable Industry Carbon Footprint Tool: Stage 2) will account for N_2O emissions.



The Carbon Cycle



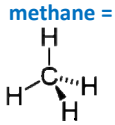
The nitrogen cycle



Global Warming Potential

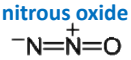
- Used to compare different gases
- Reporting regulations in Australia use:

methane = 21 x carbon dioxide



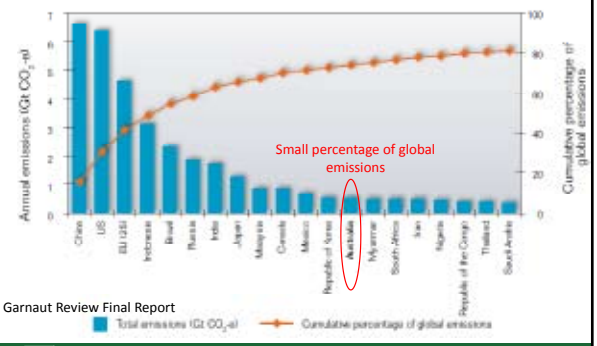
O=C=O

nitrous oxide = 310 x carbon dioxide

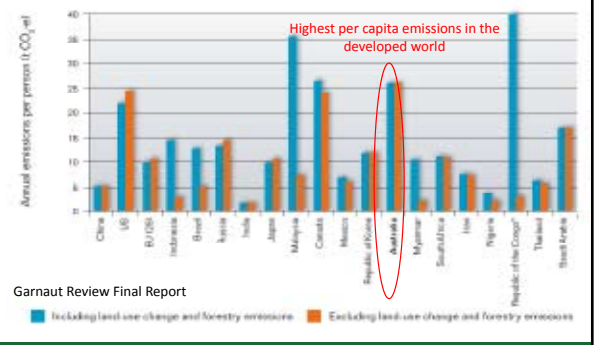


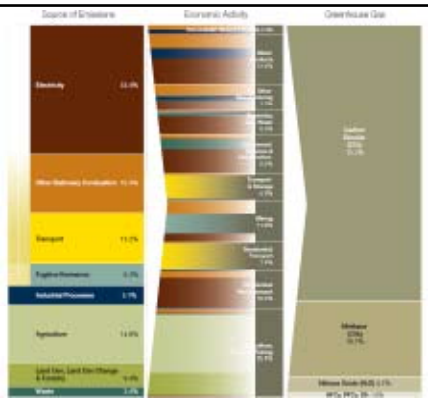
O=C=O

The 20 largest Emitters, c. 2004 data



The 20 largest Emitters, c. 2004 data





Carbon Accounting Methods

What is a carbon footprint?

There are a lot of different definitions for carbon footprinting. Basically, it is a neat ecological term to help us conceptualise our environmental impact. Your carbon footprint is a measurement of your environmental impact in terms of greenhouse gas emissions.

In Australia mandatory greenhouse gas accounting is only applicable to very large businesses and facilities. This is regulated by an emissions threshold. If your company emits more that 25 kilotonnes (1 kilotonne= 1000 tonnes) of carbon dioxide emissions (CO_2-e), then you must account for your carbon emissions under the National Greenhouse and Energy Reporting Act. [see Slide 30-31] You must also account for your carbon dioxide emissions if you consume or produce more than 100TJ of energy.

How much is 25kt of CO_2-e?

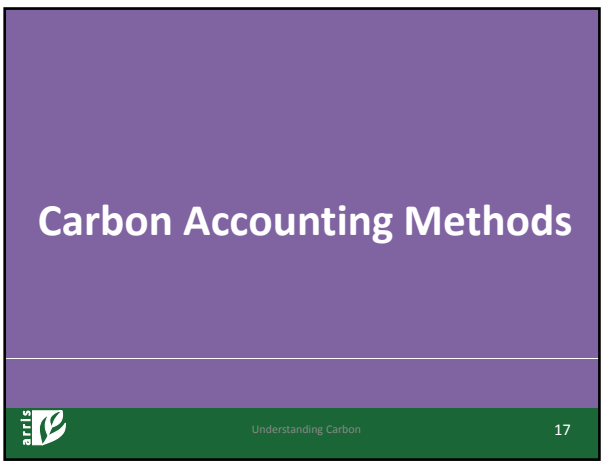
It's about the amount of emissions that would be generated from the consumption of 20,000-30,000 MWhr/yr of electicity. If that's difficult to picture, then consider this: 2,600,000 litres of diesel contains 100TJ of energy [see Slide 32]. Most, if not all, horticultural business will not exceed the mandatory threshold and therefore will not have to participate in mandatory carbon accounting. However, this does not mean that vegetable growers are excluded from the voluntary carbon accounting systems. In Australia, guidance on how to participate in the voluntary carbon market is found in the National Carbon Offset Standard (6).

Within the National Carbon Offset Standard there are two predominant methods used in quantifying carbon emissions. The first considers emissions associated with facilities, such as farms or steel works. For the purpose of vegetable growers anything within their farm gate is considered their facility. The Life Cycle Assessment completed using the Carbon Calculator Tool (VG09187 Australian Vegetable Industry Carbon Footprint Tool: Stage 2) will ONLY consider the activities within a growers fenceline that contribute to the production of vegetables. The other main form of accounting considers the carbon embedded in a particular product, such as a jar of jam or a bag of capsicums. This method accounts for all of the greenhouse gas emissions involved in producing a product, packaging it and delivering it to the point of sale and often beyond. Life Cycle Assessments are used to quantify emissions associated with a particular product.

Which method is suitable for you?

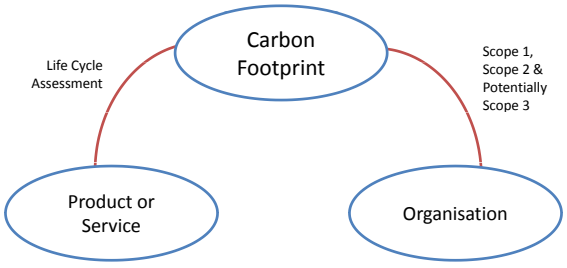
This will depend upon your carbon accounting requirements. Horticulture Australia in conjunction with the South Australian Research and Development Institute (SARDI) and Arris Pty Ltd are developing a vegetable carbon calculator (VG09187 Australian Vegetable Industry Carbon Footprint Tool: Stage 2) to simplify on farm emissions estimations for vegetable growers. It's anticipated the online tool will be available to use in late 2010. For more information about the tool and its development, visit:

www.vegiecarbontool.com



What is a carbon footprint?

The National Carbon Offset Standard



Carbon Footprint: The Farm

Understanding On-Farm Emissions

On-farm emissions can be thought of as all emissions occurring within the farm gate or farm boundary (see image below).

This might include emissions from:

- tractor operations;
- motorbike and ute operations;
- fertiliser application; and
- electricity (pumping, lighting and cooling).

Understanding the emissions that occur from your farm is a critical step in being able to reduce your overall carbon footprint.

On-farm emissions estimations are based on the World Resources Institute's Greenhouse Gas Protocol. The protocol is a widely used accounting tool for Governments and businesses to understand, quantify, and manage greenhouse gas emissions within their organisation or facility. The Greenhouse Gas (GHG) Protocol provides standards and guidance for companies preparing a greenhouse gas emissions inventory. It covers the six greenhouse gases within the Kyoto Protocol. The standard was designed to help companies calculate their greenhouse gas emissions fairly and consistently.

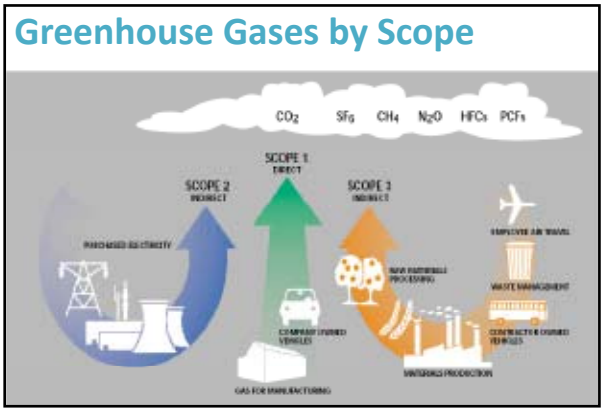
The GHG Protocol's main feature is the use of three 'Scopes' used to help delineate greenhouse gas emissions for accounting purposes.

The GHG Protocol clearly defines the Scope's as follows:

Scope 1: Direct greenhouse gas emissions. These are emissions that occur from sources directly controlled or owned by the company (i.e. emissions from tractors, utes, motorbikes and fertiliser applied to the farm).

Scope 2: Indirect greenhouse gas emissions from utilities (i.e. electricity).

Scope 3: Other greenhouse gas emissions.

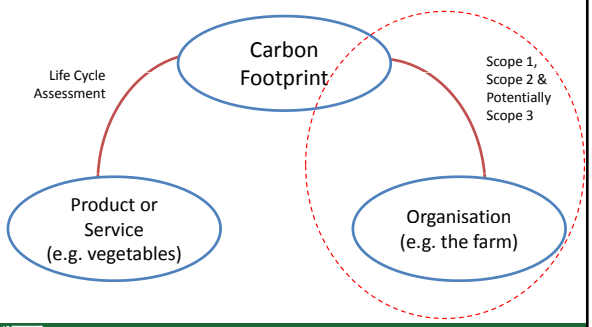


Scope 2 is reserved for emissions from the generation of purchased utilities. For the vegetable industry this is likely to be limited to electricity. Scope 2 emissions physically occur at the electrical generators site. However these emissions must be included within the greenhouse gas inventory of the company that uses this electricity.

Scope 3 emissions occur from sources not owned or controlled by the farm but are necessary to produce and sell that farms products. Examples include warehousing, freight and supermarket emissions.

Carbon Footprint: The Farm

The National Carbon Offset Standard



Carbon Footprint - Organisation

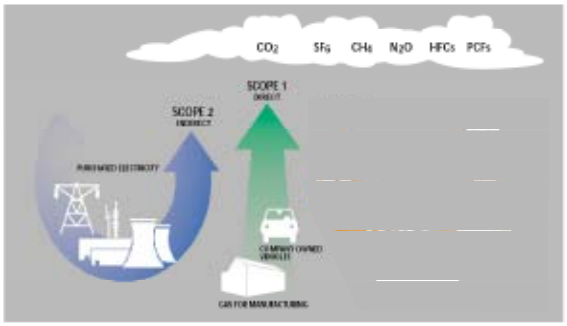
- Used by **corporations** and **governing** bodies
- Australian Government Methodologies
- Used internationally
- Identifies emission reduction opportunities
- Not sufficient for comparative purposes

The Organisation

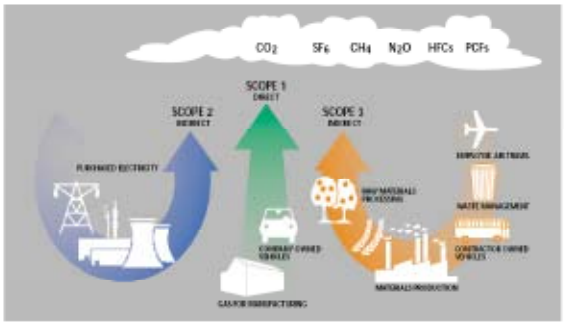
International Standard ISO14064

- The **GHG Protocol** was published in 2004
- The International Standards Organisation built on the method and formalised it **with ISO 14064, released in 2006**
- The two standards are **consistent** and can be used together in a **complimentary** manner

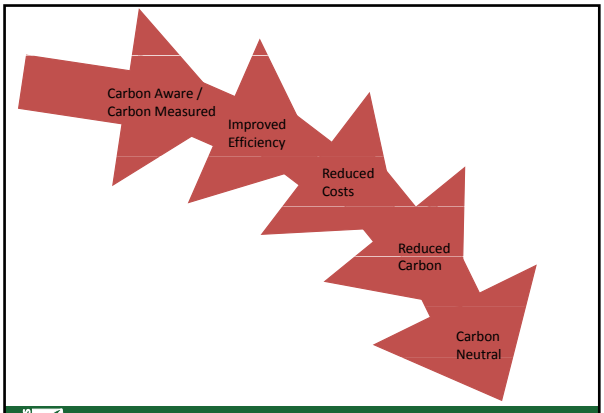
Greenhouse Gases by Scope

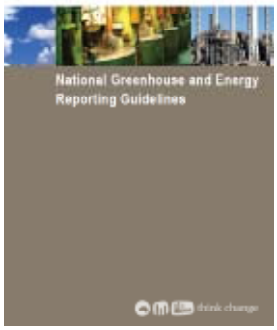


Greenhouse Gases by Scope



$GHG_{Diesel} = E_f \times Q_{Diesel}$





National Greenhouse and Energy Reporting Scheme (NGER)

NGER Thresholds

	2008 -2009 Reporting year 1	2009 -2010 Reporting year 2	2010 - onwards Reporting year 3 onwards
Facility thresholds	25 kt CO_2-e 100 TJ	→	
Corporate group thresholds	125 kt CO_2-e 500 TJ energy	87.5 kt CO_2-e 350 TJ energy	50 kt CO_2-e 200 TJ energy
Corporations to apply for registration by	31 August 2009	31 August 2010	31 August 2011
Corporations to report by	31 October 2009	31 October 2010	31 October 2011
Government to publish data by	28 February 2010	28 February 2011	28 February 2012

How much is 100 TJ energy or 25ktCO_2-e GHG emissions?

- **20,000-30,000 MWhr/yr** of electricity consumption, depending on state
- **2,600 kL** of Diesel is 100TJ (but only 7 kt CO_2-e)
- **3,000 kL** of Petrol is 100TJ (but only 6.9 kt CO_2-e)

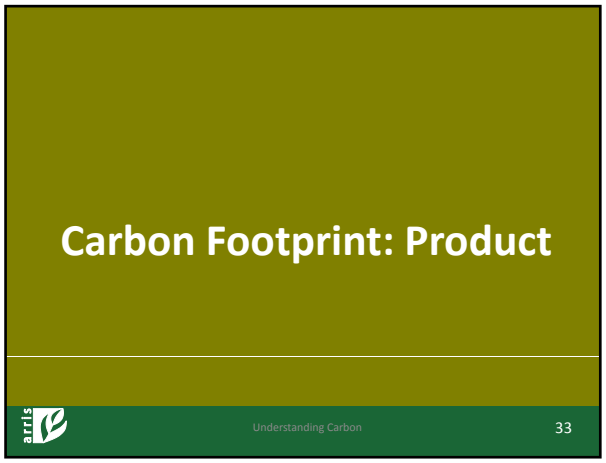
Carbon Footprint: Product

Understanding Life Cycle Emissions

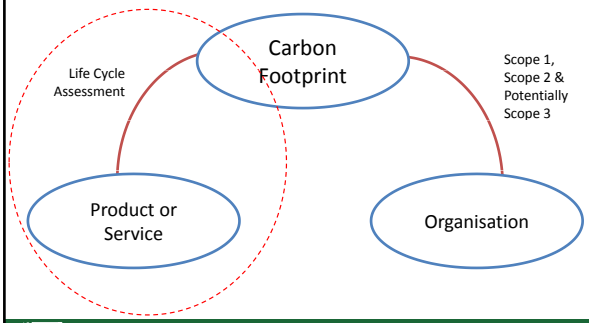
The National Carbon Offset Standard also provides guidance for companies wishing to make claims about the carbon impact of the products they produce. For the vegetable industry, 'products' refers to the vegetables being grown and sold by a grower.

In order to calculate the emissions associated with products, the National Carbon Offset Standard recommends the use of Life Cycle Assessment (LCA). This is a method used to identify the environmental impact of a product over all stages of the product's life including growing, harvesting, processing, warehousing, transport, cooking and waste disposal (7).

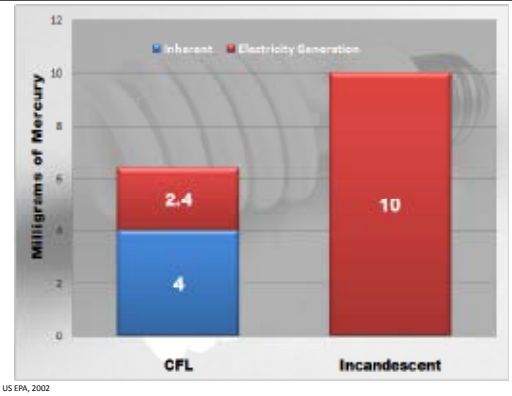
When completing a Life Cycle Assessment, the scope, including system boundary and level of detail, depends on the subject and the intended use of the study. The depth and the breadth of an LCA can differ considerably depending on the goal of a particular Life Cycle Assessment.



The National Carbon Offset Standard



VIDEO

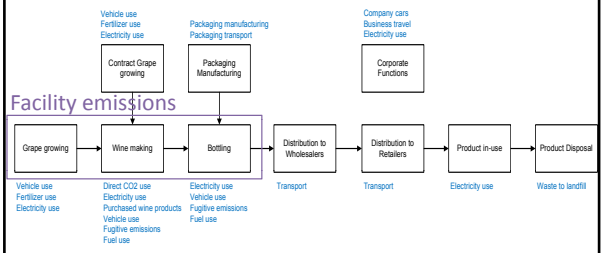


Source: US EPA, 2002

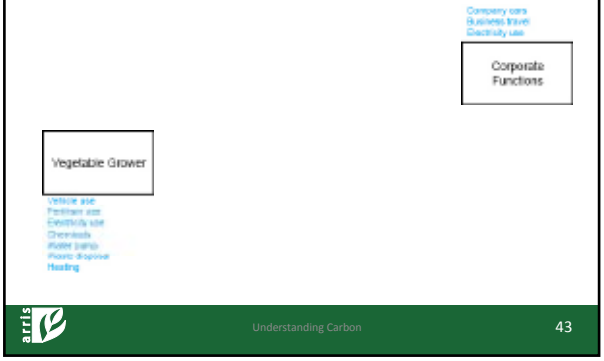
Product Example

- This example looks at carbon dioxide and chip production
- A breakdown of the carbon in a life cycle assessment from the farm to landfill
- The percentage figures are the greenhouse gas contributions for each component of the value chain

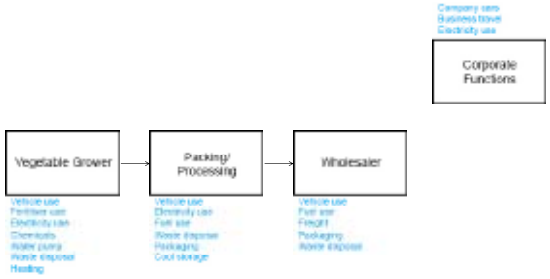
Life Cycle Example – Winery



Life Cycle Example – Producer



Life Cycle Example – Producer/Packer/Wholesaler



Life Cycle Example – Producer/Packer/Wholesaler

Understanding Carbon 45

Carbon Labelling

At this point there is NO statutory or regulatory requirement for Australian growers to comply with any carbon labelling for produce/products sold on the Australian market.

However, recent research suggests that more than 70% of Australian and New Zealand consumers would value information about the carbon footprint of a product when making purchasing decisions (8).

Internationally some entrepreneurial producers have capitalised on this by developing and using a 'carbon label' which presents the life cycle carbon emissions associated with the product in much the same way as the fat and salt content are displayed on food products.

The purpose of a carbon label is to communicate to the consumer the carbon impact of particular products. The objective is to give consumers an opportunity to make informed decisions on the items they purchase.

On an international scale, retailers are increasingly investing in the development of carbon labelling programs for food and grocery items. The examples above can be found on products in supermarkets in the UK, France and Japan.

Carbon Labelling in Australia

At present there are no products with a carbon label sold on Australian supermarket shelves. However, several retailers around the world (including retailers in Australia) are currently reviewing carbon footprint methods with a view to including them in supplier guidelines. This may include the use of carbon labels, or the establishment of minimum standards for emissions performance.

Environmental group Planet Ark are aiming to introduce carbon labelling in Australia towards the end of 2010. But supermarket chains in Australia, including Woolworths who have sponsored this training program, are not enforcing carbon labelling as a requirement at this stage.

A spokesperson from Woolworths Supermarkets has said they do not intend to introduce carbon labelling to their products in the near future. They do however support vegetable growers in making sustainable choices on their farms. Woolworths said carbon labelling would most likely only be introduced if their customers requested it in the future.

NOTE: Carbon labelling may be a market access issue for Australian businesses seeking to access international markets.

International Examples

Carbon Labelling

- The **purpose** is to communicate the **carbon impact** of a product
- The **objective** is to provide an opportunity for consumers to make **informed decisions** on the items they purchase
- Carbon labelling internationally, has been driven by **consumers** not **retailers**

Carbon Labelling and Retailers

VIDEO

Just-food

UK: Tesco adds carbon footprint to milk

18 August 2009| Source: just-food.com

Tesco yesterday (17 August) began including carbon footprint information on milk as part of the UK retailer's aim for all its products to carry carbon labels.

Tesco has set the target of having "footprinted" 500 products by the end of the year.

The move comes in response to increasing awareness among consumers of the impact of the food supply chain on climate change. According to Tesco, 50% of shoppers now understand the meaning of the term "carbon footprint", up from 32% last year.

Tesco also said that consumers increasingly "want to be green", with over half of shoppers included in its survey stating that they would actively seek out products that had lower carbon footprints.

Tesco community and government director David North said that Tesco had decided to introduce carbon labels to milk because it is a "prominent", "iconic" product that will enable the company to help consumers "understand climate change".

Carbon Labelling Internationally

Carbon Labelling in Australia

Carbon labels on food to be introduced in 2010

THE AUSTRALIAN

GROCERY shoppers bewildered by nutritional information disclosing a product's fat content and sugar levels may soon be confronted with a new label revealing its greenhouse gas emissions.

Consumers will be able to compare, buy and reject products based on their greenhouse emissions as early as next year after the launch of a carbon footprint labelling scheme today. Australia will be the third country, after Britain and the US, to get the foot-shaped Carbon Reduction Label, which is being billed as the greenhouse equivalent of a nutritional panel.

Environmental group Planet Ark will run the voluntary scheme in conjunction with Britain's Carbon Trust.

Becoming Carbon Neutral

'The Jewel in the Crown...'

There are many companies who are keen to promote their 'green' credentials by developing and marketing carbon neutral products. Most products that are sold as carbon neutral still have carbon emissions associated with their life cycle; however, these emissions are balanced out by the use of carbon offsets. Carbon offsets can be thought of as negative carbon emissions. One tonne of carbon offsets cancels out one tonne of carbon emissions.

When embarking upon a carbon neutrality project it is important to note that the National Carbon Offset Standard makes it clear that any carbon neutrality projects associated with products must use Life Cycle Assessment techniques to estimate the carbon impact of products. They recommend the use of ISO 14040-44, which includes a peer review stage to ensure all emissions have been accurately accounted.

Carbon offsets can take many forms but are generally produced through forestry, methane capture or renewable energy projects. The Victorian Environmental Protection Authority and RMIT University have developed a very informative website about carbon offsets.

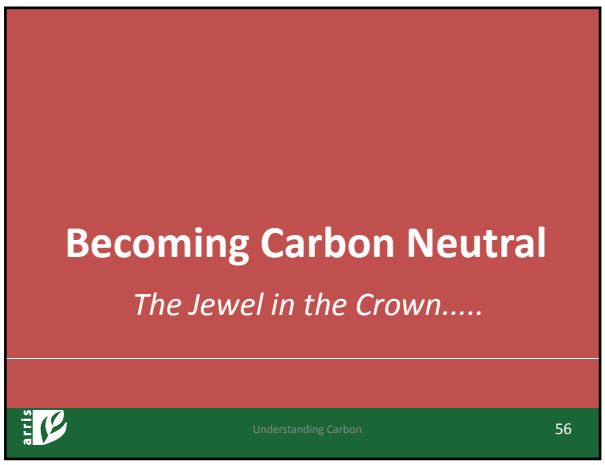
www.carbonoffsetguide.com.au

Taylors

One Australian company has chosen to brand some of their products as Carbon Neutral. Taylors have completed a Life Cycle Assessment on their 'Eighty Acres' wines to show that it is 100% carbon neutral.

www.taylorswines.com.au/eighty-acres

This decision has been beneficial to the company, who gained significant publicity for their product when it was chosen to be served at an official function at the 2009 United Nations Climate Change Conference in Copenhagen, Denmark. Since the Summit, Taylors have signed a deal to distribute the 'Eighty Acres' range in Denmark. (9)



Carbon Offsets and Carbon Neutrality

- The National Carbon Offset Standard
- Carbon offset program with real credibility
- Can be used in product marketing
- ISO 14044 – Life Cycle Assessment

Carbon Neutral Products

Forest Sinks

As many vegetable producers are land holders, it may be possible for growers to produce carbon offsets by establishing forest sinks. To create a forest sink, growers must meet a number of requirements.

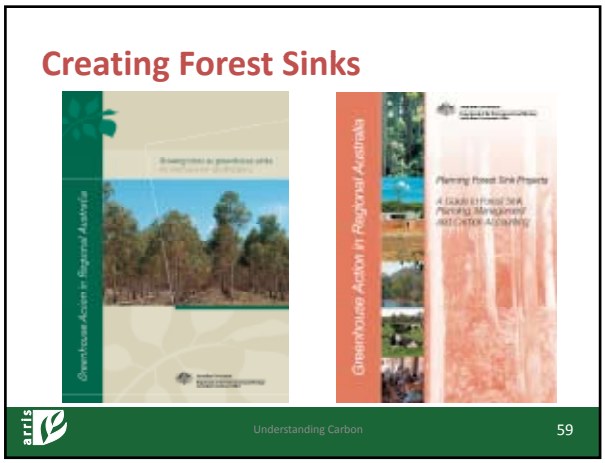
The plantation must:

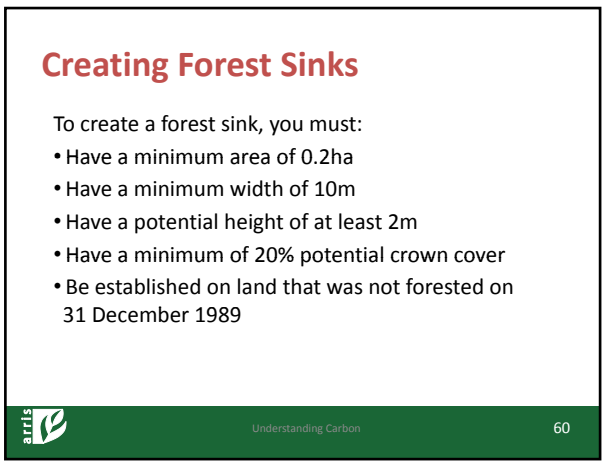
- have a minimum area of 0.2 hectares;
- have a minimum width of 10 metres;
- have a potential height of at least 2 metres;
- have a minimum of 20% potential crown cover; and,
- be established on land that was not forested on 31 December 1989.

Gaining certification of a forest to generate saleable offsets can be a costly exercise, which could exceed $100,000. To reduce this cost, small growers and landholders may want to consider pooling forests so that one certifier can consider a number of different plantations in the same exercise.

Further information on forest sink projects is available at the Department of Climate Change website.

www.climatechange.gov.au/land/forest-sinks.html





Greenwashing

The term ‘greenwashing’ is used to explain misleading environmental claims. For example, stating that your products are carbon neutral when this is not the case is considered to be ‘greenwashing’. The Australian Competition and Consumer Comission (ACCC) monitors ‘green’ claims in the marketplace and has prosecuted a number of companies who have misled consumers.

The ACCC recently released a report on how the Trade Practices Act applies to claims about carbon embedded in goods and services (10). The actual legislation, which is important with regard to ‘greenwashing’ is the Trade Practices Act which prohibits misleading and deceptive conduct. It is important to note the Act also prohibits acts that are likely to mislead or deceive.

Further information on ‘green’ marketing can be found on the ACCC’s website.

http://www.accc.gov.au/content/index.phtml/itemId/815763

For specific information about carbon claims and the Trade Practices Act please refer to:

http://www.accc.gov.au/content/index.phtml/itemId/833279

Greenwashing Case Studies

Saab Australia’s “Grrrreen” campaign

Between 27 July and 1 September 2007, GM Holden, trading as Saab Australia, published newspaper and magazine advertisements across Australia promoting the Saab range of motor vehicles. The “Grrrrreen” campaign used phrases such as “Every Saab is green. With carbon emissions neutral across the entire Saab range” and “Shift to Neutral”.

In proceedings undertaken by the Australia Competition and Consumer Commission (ACCC), the Federal Court found GM Holden Ltd’s claims to be false and misleading (11). For example, the advertisements said that in the first year following the purchase of a Saab motor vehicle, GM Holden would plant, on behalf of the purchaser, 17 native trees which would offset the carbon dioxide emissions for the life of that motor vehicle. When in fact, the 17 trees would only provide a carbon dioxide emission offset for a single year’s operation of the motor vehicle. [Slide 62]

Coopers

A Coopers marketing campaign was investigated by the Australian Competition and Consumer Commission (ACCC) in 2008, after the company claimed that its beer was better for the environment. The advertisements labelled Coopers as Australia’s greenest beer, and used the line “big beer – tiny footprint.” (12)

Consumer organisation ‘Choice’ complained about the ads to the ACCC, saying they were false and misleading (13).

Coopers ended up changing their slogan to “Reduce Carbon Emissions: Walk to the pub.” [Slide 63]

Greenwashing

Greenwash – *verb:* the act of misleading consumers regarding the environmental practices of a company or the environmental benefits of a product or service.

TerraChoice 2007

Saab 'Grrrrrreen' claims declared misleading by Federal Court

www.accc.gov.au

September 18 2008

ACCC to probe green beer claims

www.theage.com.au

August 25, 2008

The ACCC and carbon claims

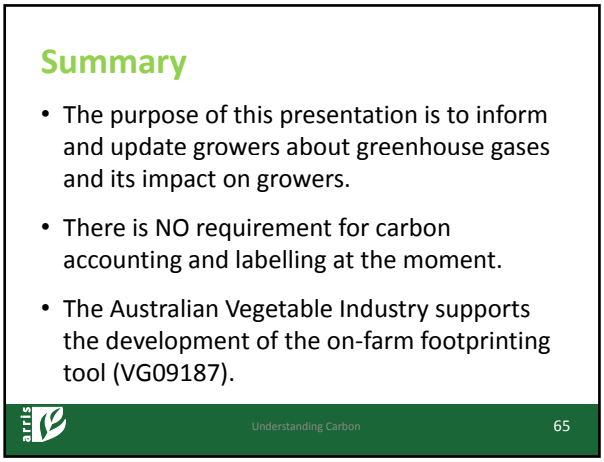
- Think about the **message** that will be taken away by your target audience
- Provide accurate and complete information to consumers
- Misleading conduct can include **silence**
- **Clarify** your carbon claims
- When making claims of **carbon neutrality**, spell out exactly what is included in your claim to avoid misleading consumers
- If you are making statements as to the future, ensure you have a **reasonable basis**

Summary

The purpose of the 'Understanding Carbon' presentation and this supporting manual is to inform and update Australian vegetable growers about greenhouse gases and its impact on growers.

While it is not compulsory for growers to calculate their on-farm carbon footprint at this stage, it is becoming increasingly important for growers to be aware of the concept as it may be more greatly introduced by industry or retailers in the future.

The Australian Vegetable Industry has shown its interest in carbon footprinting by supporting the development of the on-farm footprinting tool (VG09187Australian Vegetable Industry Carbon Footprint Tool: Stage 2).



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Horticulture Australia Pty Ltd Climate Research Programs

Current* Programs/Projects (*Information current as of 13/05/10)

* Across-horticulture program
* Climate Change Research Strategy for Primary Industries – Phase 2
* Managing Climate Variability Program
* Critical thresholds ('tipping points') and climate change impacts/adaptation in horticulture (HG08037)
* Vegetable Carbon Footprint Project (VG09142)

Completed Programs/Projects

* Australian horticulture's response to climate change and climate variability (AH06019)
* Climate Change Research Strategy for Primary Industries – Phase 1
* Houston's Farm Carbon Footprint project (VG07195)
* Scoping study into climate change and climate variability for the vegetable industry (VG05051)
* Understanding and identifying the threats and opportunities posed by climate change for the banana industry (BA08014)
* Vegetable Industry Carbon Footprint Scoping Study - Discussion Papers and Workshop (VG08107)

For more information about these projects visit:
http://www.horticulture.com.au/areas_of_Investment/Environment/Climate/climate_research_programs.asp?src=side

VEGETABLE CARBON CALCULATOR

Manual

VG09187 Australian Vegetable Industry Carbon Footprint Tool: Stage 2

HAL
Know-how for Horticulture™

Government of South Australia

SARDI
South Australian Research and Development Institute

arris

Woolworths
the fresh food people

CONTENTS

The Project

VG09187 Australian Vegetable Industry Carbon Footprint Tool: Stage 2

This project has developed an online vegetable carbon footprinting tool for the Australian Vegetable Industry.

The project has two elements:

- Development of a vegetable carbon footprinting tool in consultation with industry. This project is funded by Australian vegetable growers through Horticulture Australia Ltd (HAL) (VG09187); and
- Vegetable industry carbon education, with seminars, information products and extension activities to prepare the vegetable industry for operating in a carbon constrained world. This component is funded by Woolworths and HAL (VG09152).

Although using a different approach, these projects build on work completed by Houston's Farm in May 2009. The tool considers greenhouse gas emissions from vegetable production within the farm gate boundary, including emissions from:

- vegetable production;
- plot/soil management;
- crop washing and processing; and
- farm management.

Vegetable Carbon Calculator Manual

www.vegiecarbontool.com.au

The Vegetable Carbon Calculator Manual is a guide for vegetable growers on how to use the online tool (www.vegiecarbontool.com.au). It includes step-by-step instructions on how to use the Vegetable Carbon Calculator, as well as some training on how to interpret the results.

The Manual is also designed to give growers a clearer understanding of carbon footprinting: what it means to them as a grower and a business owner and how they can prepare to farm to reduce their carbon impact.

This training manual is intended as a supporting reference, to work alongside a seminar program which involves a demonstration of the Carbon Calculator and associated website. Through the training, the project aims to identify the benefits associated with growers understanding their carbon footprint and will highlight opportunities for vegetable growers. Growers will also be educated on the changes they can make to ensure their ongoing sustainability from both a business and environmental perspective.

Introduction

What is the Vegetable Carbon Calculator?

The Vegetable Carbon Calculator is an online tool designed to help the Australian Vegetable Industry calculate their on-farm greenhouse gas emissions. The Carbon Calculator will help growers identify the carbon footprint of their entire operation (within the farm boundary), as well as for specific crops or crop categories. It will identify the carbon emissions associated with:

- fertiliser use;
- electricity;
- fuel;
- waste;
- refrigerant gases; and
- land use change.

The online tool is designed to be easy to use, and should only take growers 30-45 minutes to complete.

The Carbon Calculator will provide information to help growers understand their carbon footprint and increase their sustainability. It is also expected that the tool will help growers to identify strategies to reduce greenhouse gas emissions within the Australian Vegetable Industry.

The tool is designed to be used once a year, every year. Growers are encouraged to complete the tool at the end of their business/farm's financial year, when they have collated all of their financial and production records.

How does it work?

The Vegetable Carbon Calculator uses a library of emission factors which convert farming inputs into greenhouse gas emissions. All of the calculations occur 'behind the scenes', meaning the tool appears simple, yet in the background many calculations are being performed.

Who will use it?

The Vegetable Carbon Calculator has been designed predominantly for Australian vegetable growers. It will give growers the ability to improve their on-farm efficiencies and become more sustainable. The results produced by the Carbon Calculator will show growers the total greenhouse gas emissions produced by their farm, as well as on a per crop basis. It is also expected that service providers to the vegetable industry may utilise this tool.

Why does the Australian Vegetable Industry need a Carbon Calculator?

The Carbon Calculator will help growers to identify their carbon emissions. As Lord Kelvin said, "You can't improve what you can't measure" and this is certainly the case with greenhouse gas emissions.

It is likely that growers will need to gain a clearer understanding of their carbon emissions over the next few years, as retailers become increasingly interested in the carbon footprint of the products they sell. Estimating on-farm carbon emissions is an appropriate place for vegetable growers to start to satisfy the demands of environmentally conscious retailers. Interest is also increasing amongst consumers, who want to know more about the carbon footprint of the products they are purchasing.

It is expected that over the next few years the cost of power, fuels and fertiliser will all increase, partly due to the greenhouse gas emissions associated with these farming inputs. It is therefore critical that the Australian Vegetable Industry develop an understanding of carbon emissions so that future efforts can be focused on improving areas of the industry which are most vulnerable to carbon pricing.

Carbon footprinting in Australia*

There is no statutory requirement for growers to undertake carbon accounting on their farms. However the Australian Vegetable Industry has shown its support for the process of carbon footprinting via the development of this on-farm footprinting tool, the Vegetable Carbon Calculator (HAL Project VG09187).

At this point there is NO statutory or regulatory requirement for Australian vegetable growers to comply with any carbon labelling for produce/products sold in the Australian market. However, carbon labelling may become a market access issue for Australian businesses seeking to access international markets in the future.

Recent research suggests that more than 70% of Australian and New Zealand consumers would value information about the carbon footprint of a product when making purchasing decisions (1). Environmental group Planet Ark are aiming to introduce carbon labelling in Australia towards the end of 2010. But most supermarket chains in Australia are not enforcing such labelling as a requirement at this stage, suggesting it would only be introduced if consumers demanded it in the future.

VG09152 Australian Vegetable Industry Carbon Footprint Tool: Grower Adoption and Education.
To find out more about carbon footprinting visit the 'Training' page of the Vegetable Carbon Calculator website (www.vegiecarbontool.com.au), and read more about 'Understanding Carbon' – a training package developed as a lead-in to the release of the Vegetable Carbon Calculator.

* These statements are correct at the time of printing - December 2010.

Climate Change Basics

What is Climate Change?

Have you noticed a change in the climate? Has it affected the way you grow your produce? Over the past few decades concerns associated with climate change have increased. Climate scientists are convinced that the world's climate is changing. The message received from mainstream media suggests that in the past few decades droughts have increased, storm events have increased and rainfall patterns are changing. These effects are all considered elements of climate change.

The Intergovernmental Panel on Climate Change (IPCC) is a leading scientific body, established by the United Nations Environment Programme (UNEP) and the World Meteorological Organization (WMO) to provide a clear scientific view on the current state of climate change and its potential environmental and socio-economic consequences.

The IPCC produces Assessment Reports, collating and summarising scientific consensus on climate change. Their Fourth Assessment Report (2007) concluded that the evidence of a warming climate is 'unequivocal'. They also suggest there is strong evidence that human activity, namely the production and release of greenhouse gases into the atmosphere, is the major cause of this climate change.

Is Climate Change an issue for Australia?

In absolute terms, Australia only contributes small amounts of greenhouse gases to the global atmosphere. When compared against larger emitters such as China, India, the European Union and the United States, opponents of action against climate suggest that there is no reason for Australia to take action. This is to be expected as globally Australia is small country, both in terms of population and economic productivity. However, when analysed on a per capita basis, Australia is very carbon intensive, possibly the most intensive.

The Carbon Cycle

The carbon cycle is used to illustrate the flows of carbon between the different systems that exist on Earth. There are four main pools of carbon, which are:

- the atmosphere;
- the terrestrial biosphere (i.e. the Earth's surface), which is usually defined to include fresh water systems and non-living organic material, such as soil carbon;
- oceans, including dissolved inorganic carbon and marine biota; and
- ocean sediments, including fossil fuels.

The carbon cycle, as shown in Figure 1, is made up of both long-term and short-term cycles. The short-term cycle includes the rapid exchange of carbon between plants and animals through respiration and photosynthesis, and through gas exchange between the oceans and the atmosphere. An example of a short-term carbon cycle within the vegetable industry is photosynthesis associated with vegetable and vegetable plant growth, and subsequent decomposition of discarded parts of the plant. Short-term carbon cycles are not considered an emission source.

Most carbon accounting methods exclude the short-term carbon cycle.

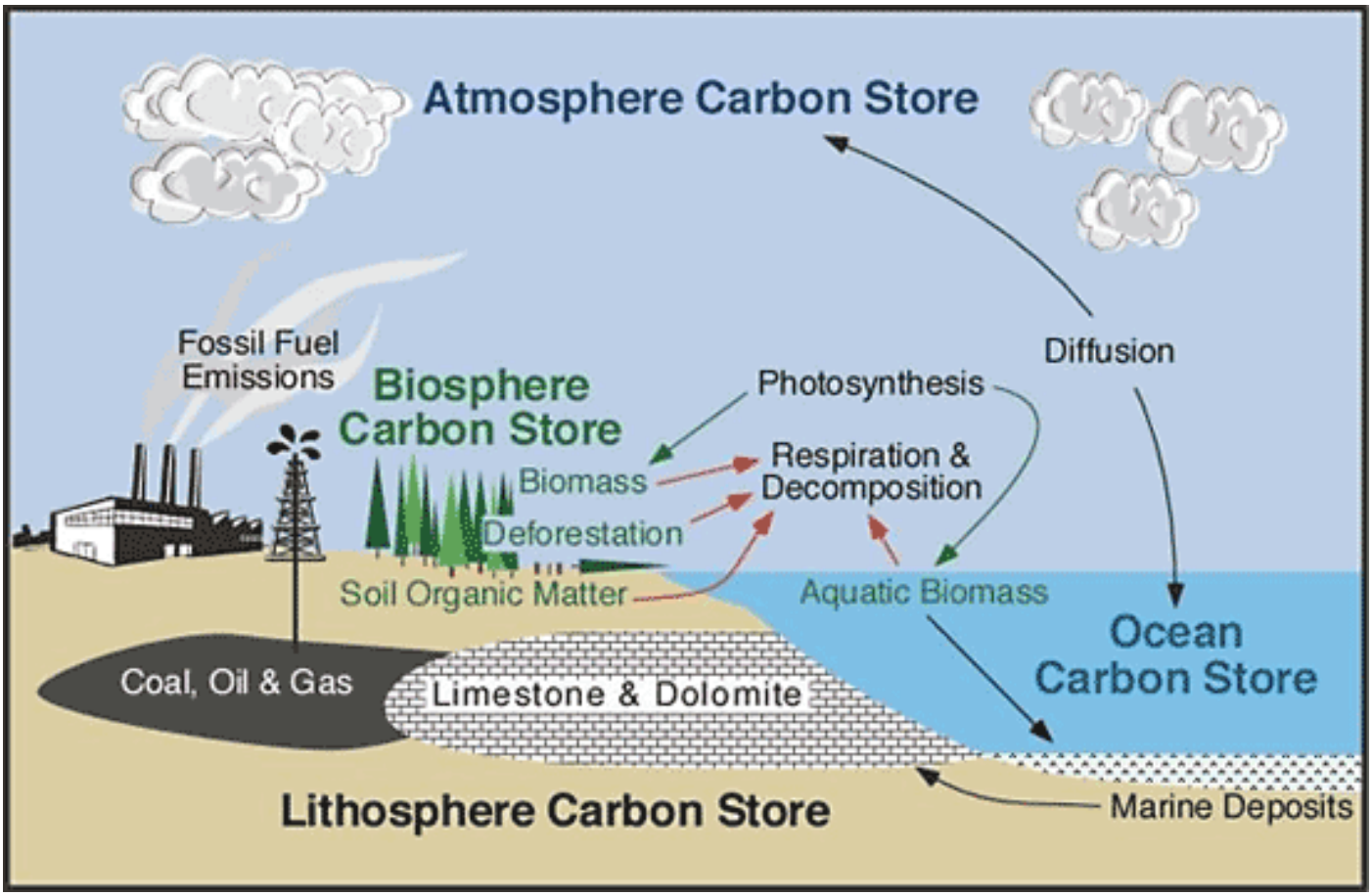


Figure 1. The carbon cycle. Source: Dr Michael Pidwirny, University of British Columbia Okanagan

The Nitrogen Cycle

Nitrous oxide (N_2O) is a potent greenhouse has. It can be formed by a number of processes (as shown in Figure 2), and is determined by soil properties and external conditions such as moisture content, oxygen availability, the amount and form of nitrogen and other influences such as tillage practices. The chemical and biological pathways which see nitrogen converted to N_2O are complex. The important thing to take away from the nitrogen cycle is that all forms of nitrogen, (i.e. synthetic, natural, organic or animal manure) added to soil will emit a degree of N_2O, contributing to the carbon footprint of your farm.

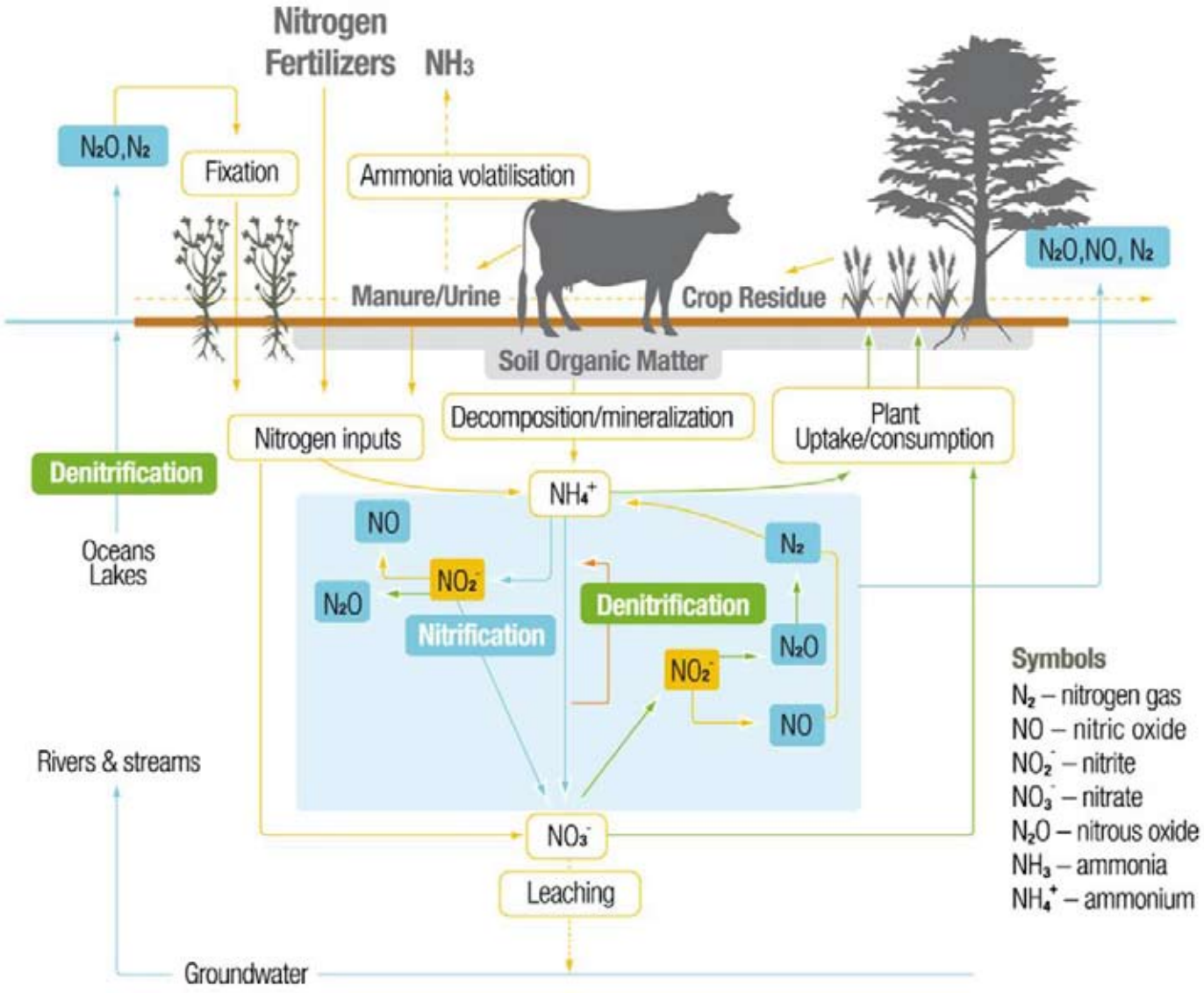


Figure 2. The nitrogen cycle. Source: image supplied by David Ugalde, Department of Climate Change, Canberra.

Before you start

Data you will need to complete the tool

In order to estimate your on-farm carbon footprint, you will need to collect information relating to your farming inputs.

It is important to collect this information before you begin using the tool, as it will make the process much easier.

You will need:

- Electricity bills or meter records for the past 12 months.
- Fuel bills or fuel receipts for the past 12 months. This includes gas, petrol, diesel, LPG and wood.
- An estimate of the amount of waste processed on-farm.
- Fertiliser you applied to your farm over the past 12 months.
  This includes all organic, biodynamic, natural and synthetic fertilisers. You will need the percentage of Nitrogen expressed as N.
- If you have a cold room or industrial freezer on site, you will need any service documents from the past 12 months. If you do not have service records you will need to have the charge size of your refrigeration system.

Once you have the necessary information, you are ready to proceed to the Vegetable Carbon Calculator website.

Carbon Calculator: Setup

www.vegiecarbontool.com.au

Go to www.vegiecarbontool.com.au

(i.e. Type this address into the address bar on your web browser.)

Click on the 'Calculator' tab at the top of the screen (in the grey banner).

Register / Login

First time users

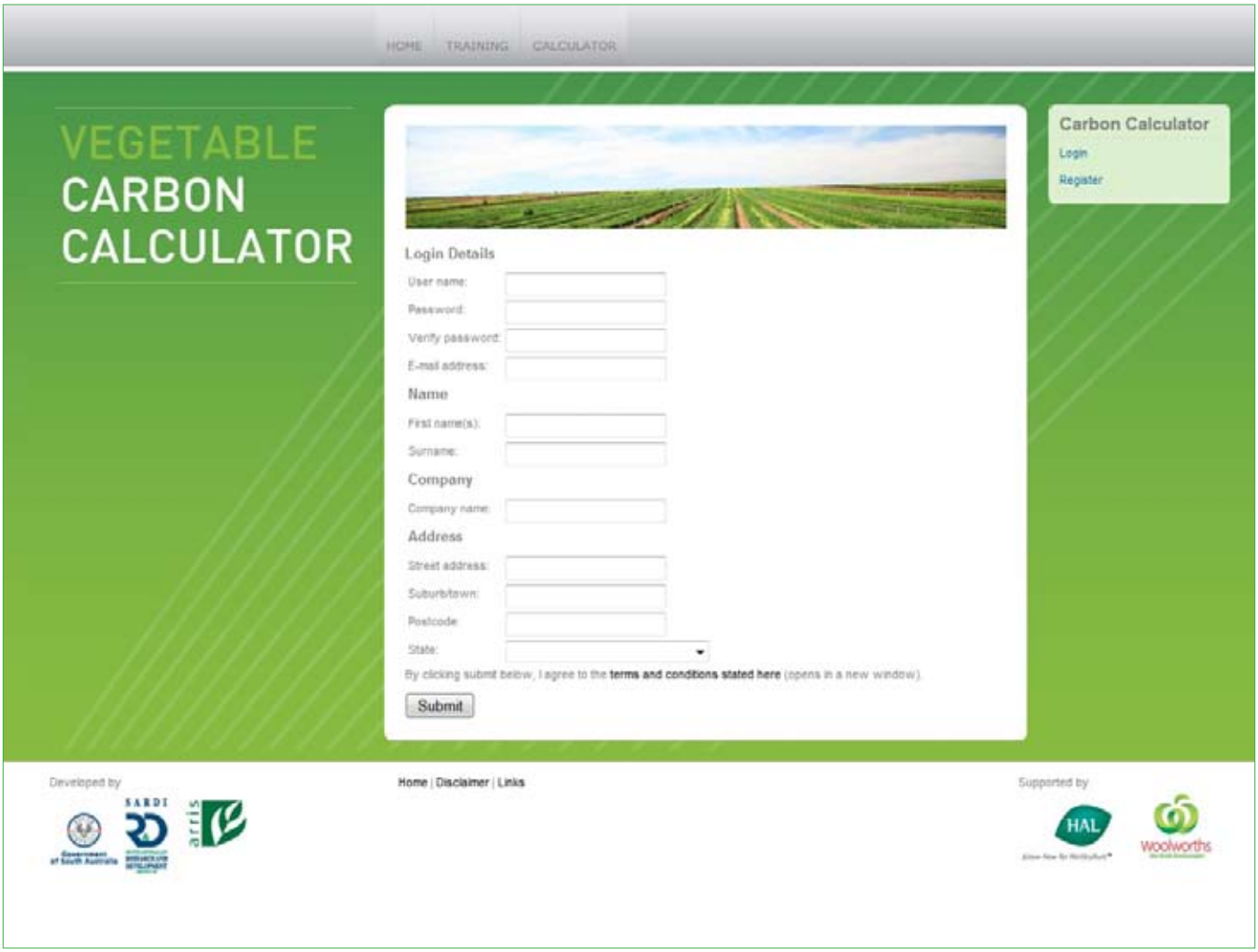
Click 'Register' (in the top right-hand corner).

This will take you to the registration form.

Fill in your details and click 'Submit'.

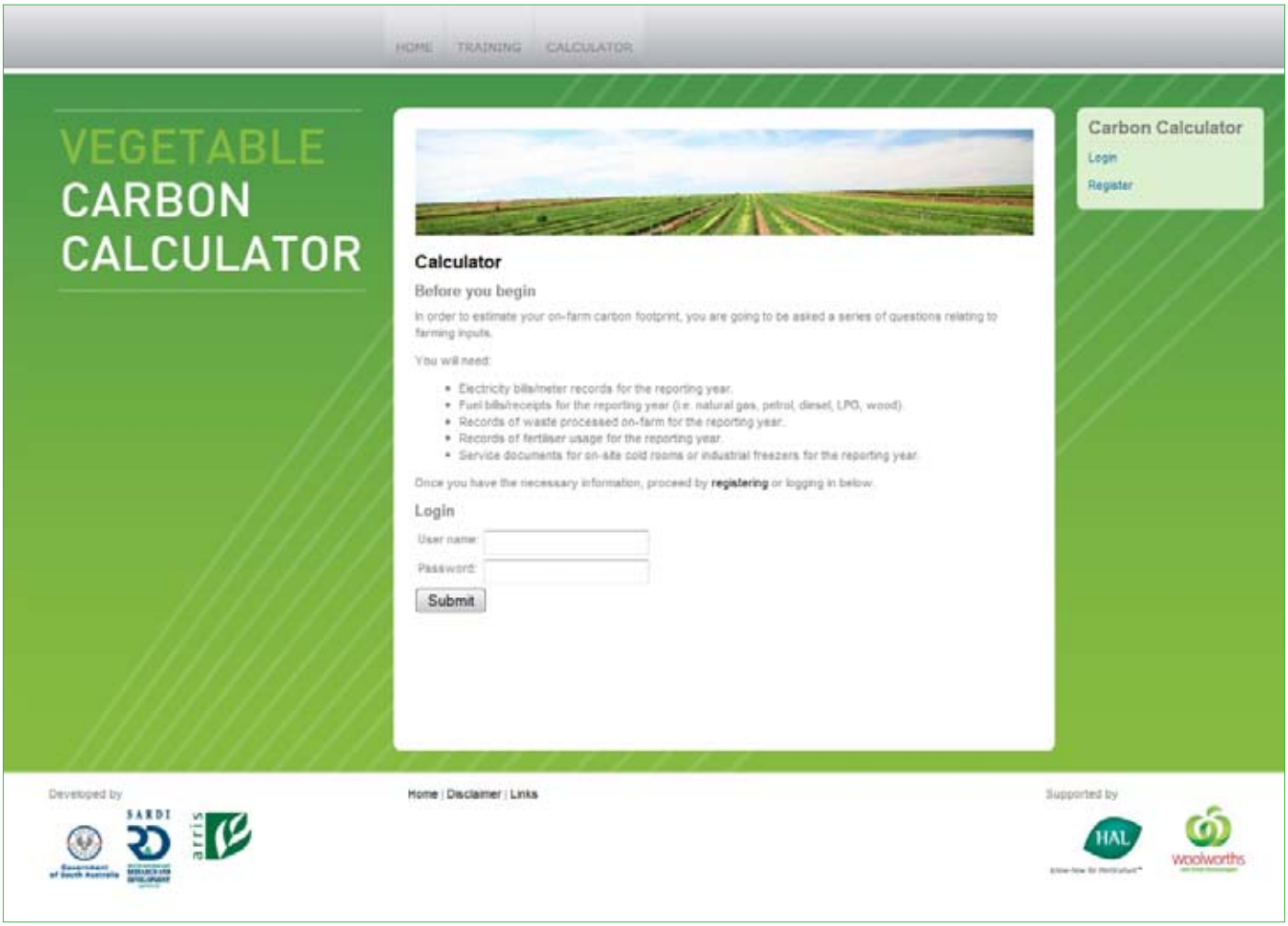
After creating a successful registration, a link will appear on the screen. To proceed, and begin adding information about your farm(s), click on the link.

After entering your details, click 'Submit'.



Already registered?

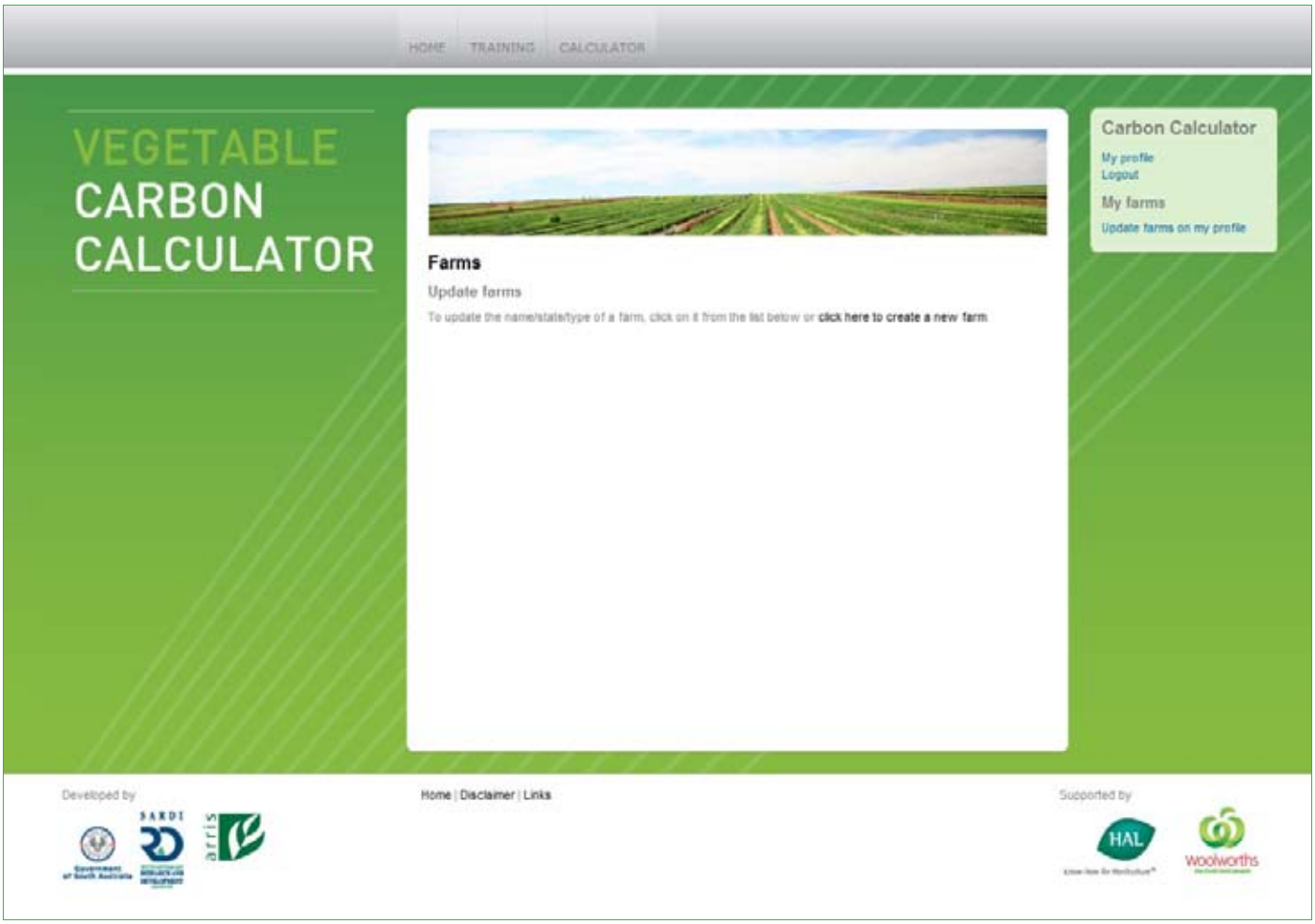
Type in your Username and Password. Click ‘Submit’.



Carbon Calculator: Farms

Create a new farm

For first time users you will need to create a farm to which data will later be attributed.
To do this, click on the link ‘to create a new farm’.

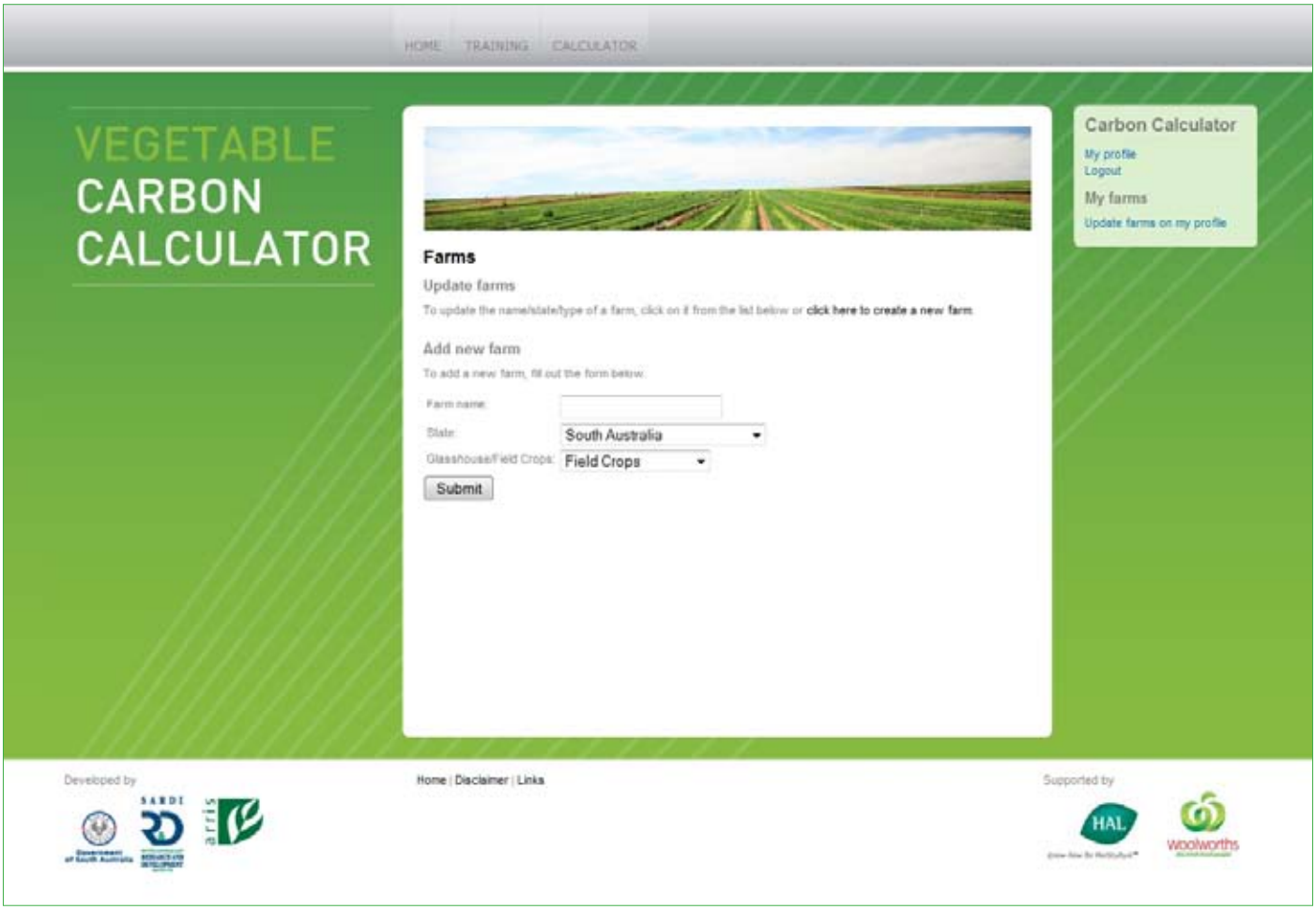


Give the farm a name and select the State in which the farm is located (using the drop down menu). The State selection is important as this will ensure the appropriate State based emission factors are used.

The farm must either be classified as a Field Crop farm or as a Glasshouse Crop farm. This distinction is due to different emission calculations. If your farm has elements of both field crops and glasshouse crops you will need to create two separate farms: one for the glasshouse and another for the field crops.

Once you have entered all of this information, click 'Submit'.

If you have more than one farm, repeat the instructions above until you've entered all of your properties into the database. The last farm to be added to the list will be the 'active' farm (or the default).



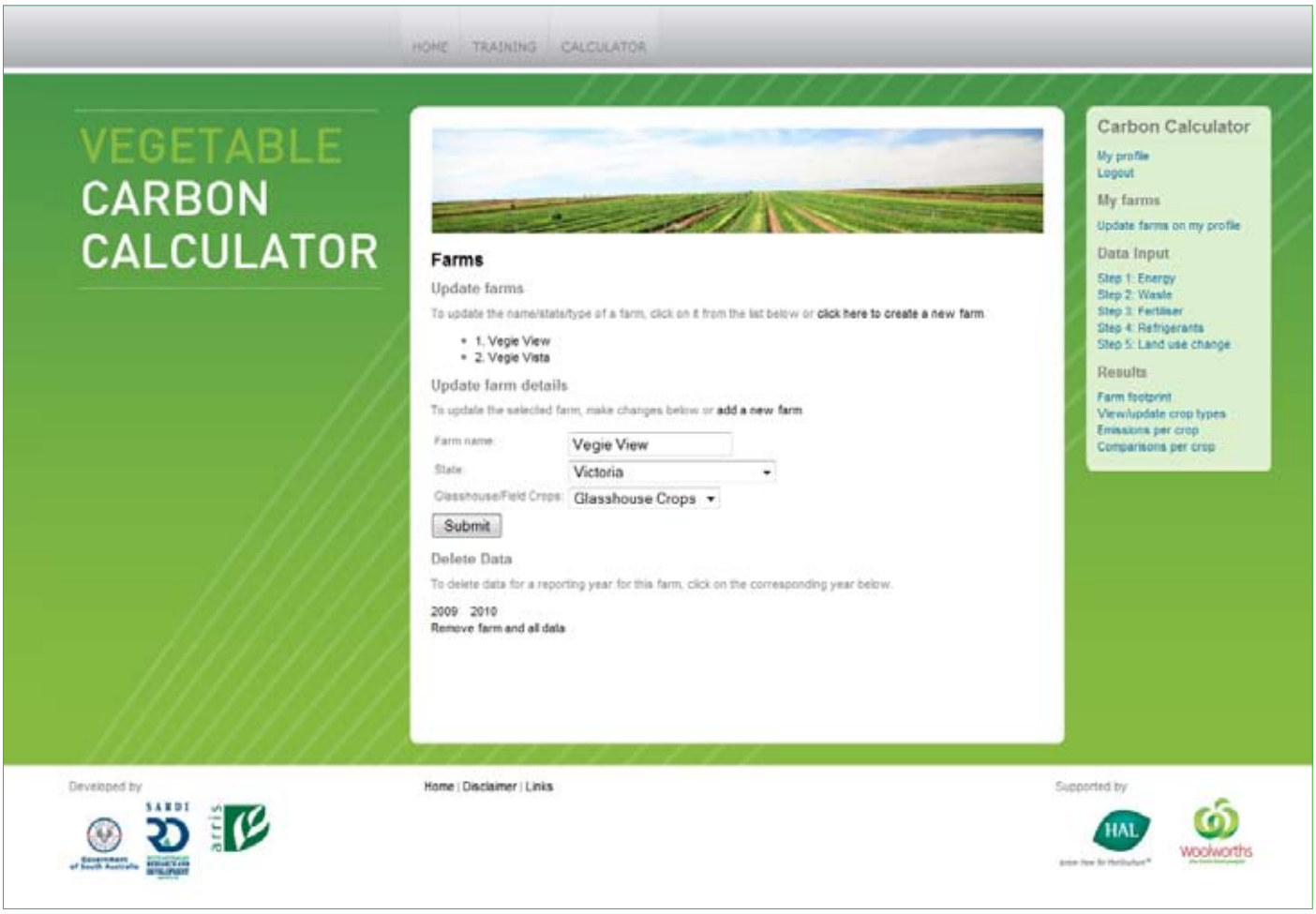
Update farm details

For users who have already created a farm(s), you can edit information about each farm on the 'Update farms' page, by clicking on it in the list.

You can then change the name/state/type of farm, and click 'Submit' to update the information.

A farm can be deleted from the database, by clicking the link on this page - 'Remove farm and all data'.

NOTE: You can access this page at any time when using the Carbon Calculator. Simply click on 'Update farms on my profile' listed under 'My farms' in the right hand column.



Carbon Calculator: Step-by-Step

Once all of the information about your farm(s) has been added, you can move on to the Carbon Calculator data input survey.

Before you start the survey, ensure that you have all of the input data listed earlier. It will make the process much quicker if you have all of the data on hand. The questions throughout the survey should be relatively self explanatory.

NOTE: If at any point while entering your data (Steps 1-5) you want to go back to a previous Step to edit your inputs, you can access each step by clicking the relevant link in the menu on the right hand side of the screen. If you change any of the data, you will need to re-submit that data by clicking the 'Save & Next' button at the bottom of the page.

Step 1: Energy

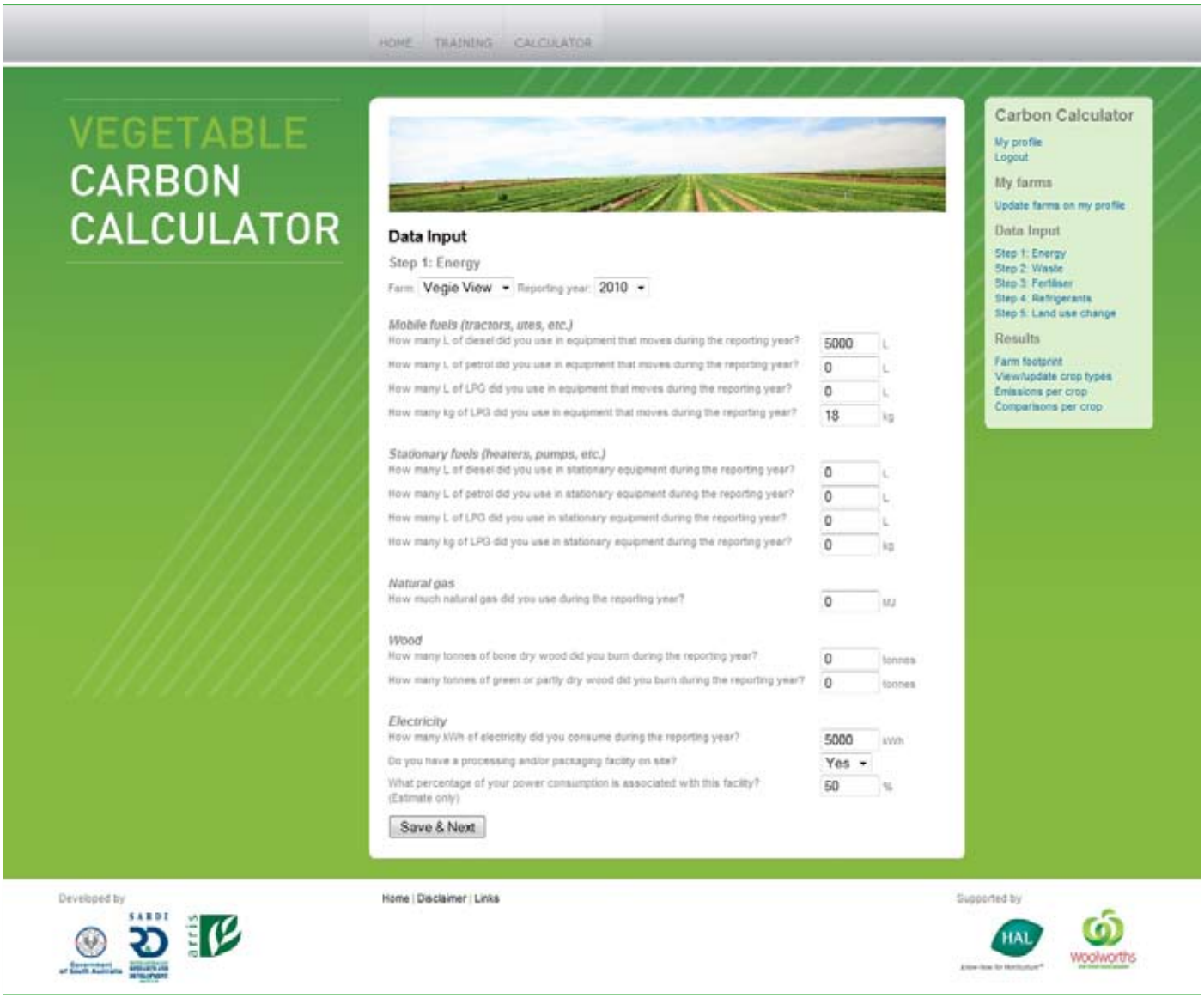
Click on the 'Step 1: Energy' (listed under 'Data Input' in the right hand column)

This will bring up the Data Input page for Energy.

Ensure that you have selected the correct farm and year from the drop down boxes at the top of this form.

Answer the questions as accurately as you can. If the question is not applicable to your farm (for example if you do not use LPG), then you can skip over the question and leave the input space blank.

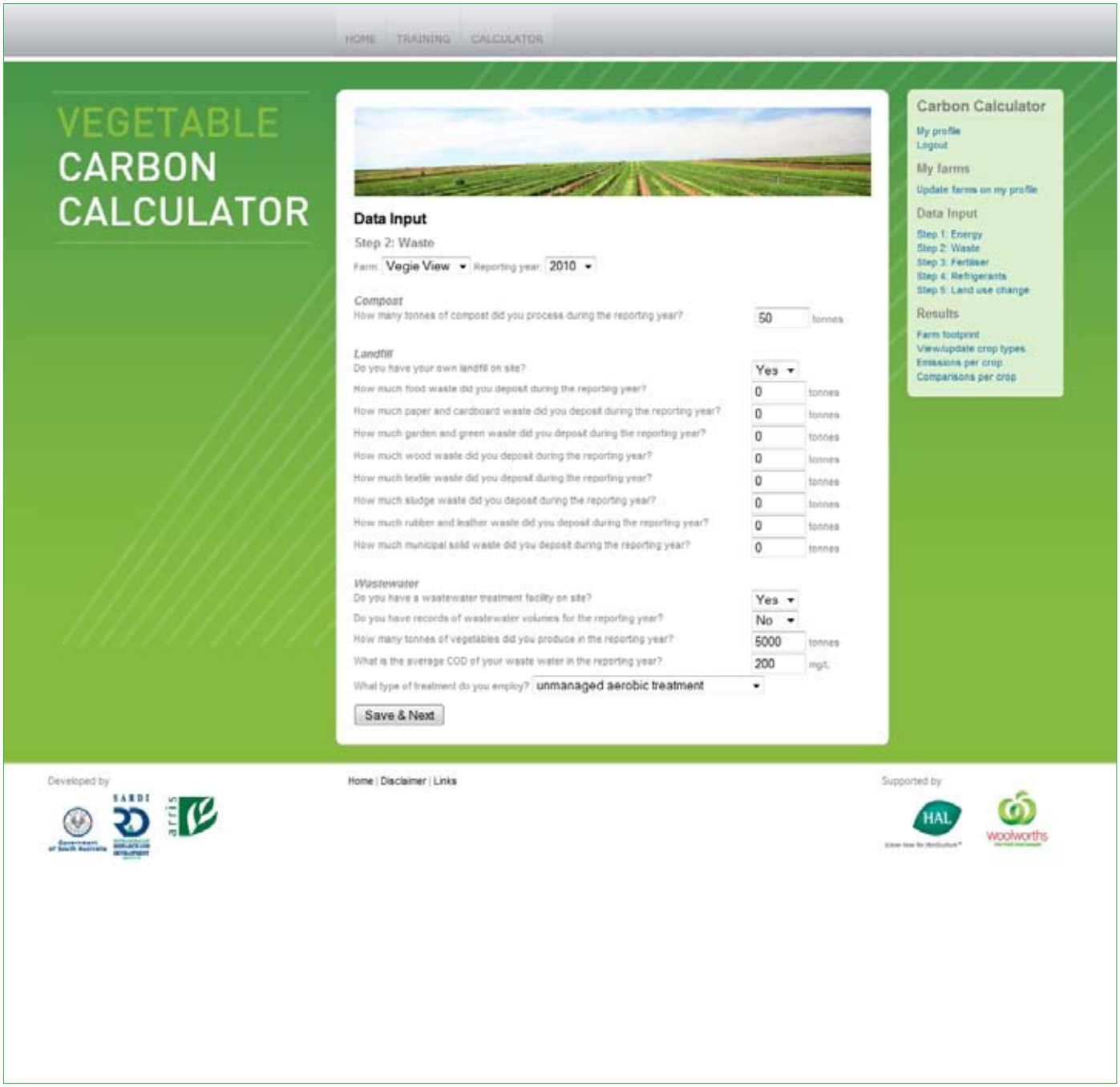
When you reach the end of the questions, click the 'Save & Next' button.



Step 2: Waste

Enter the relevant data in the boxes provided.

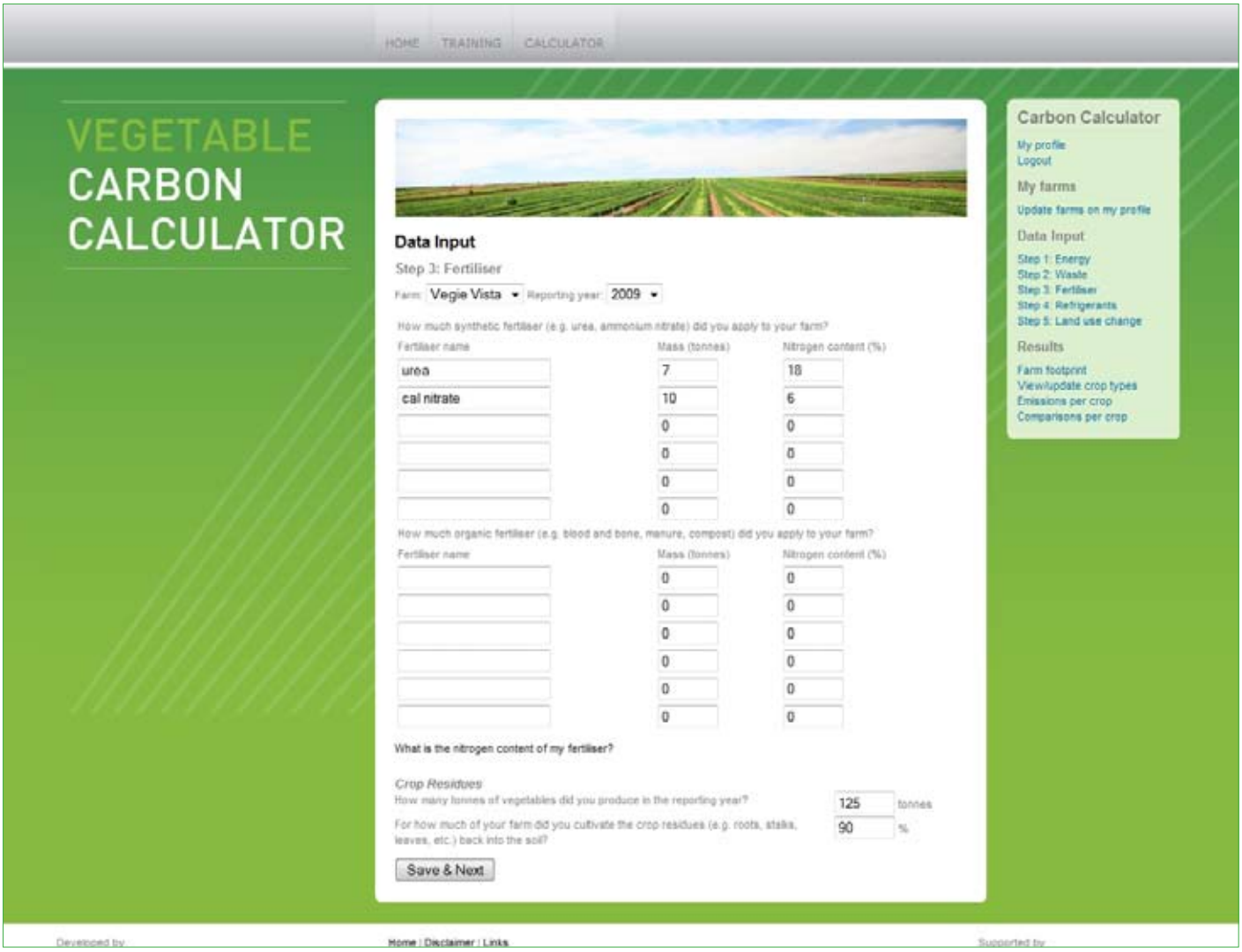
Click ‘Save & Next’.



Step 3: Fertiliser

Enter the relevant data in the boxes provided.

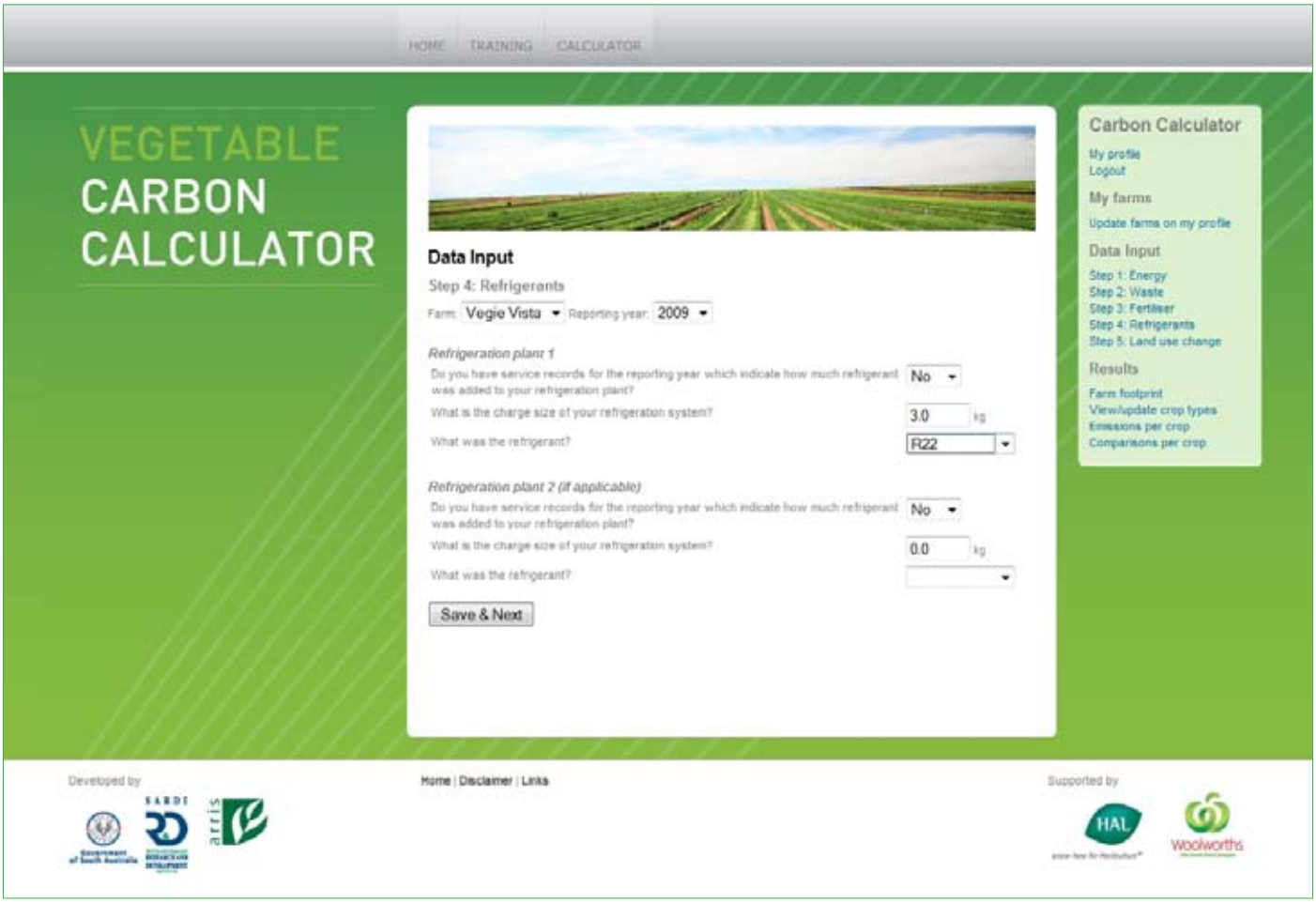
Click ‘Save & Next’.



Step 4: Refrigerants

Enter the relevant data in the boxes provided.

Click ‘Save & Next’.



Step 5: Land use change

Enter the relevant data in the boxes provided.

Click ‘Save & Submit’.

This will take you to the ‘Results’ page.

Results: Farm Footprint Only

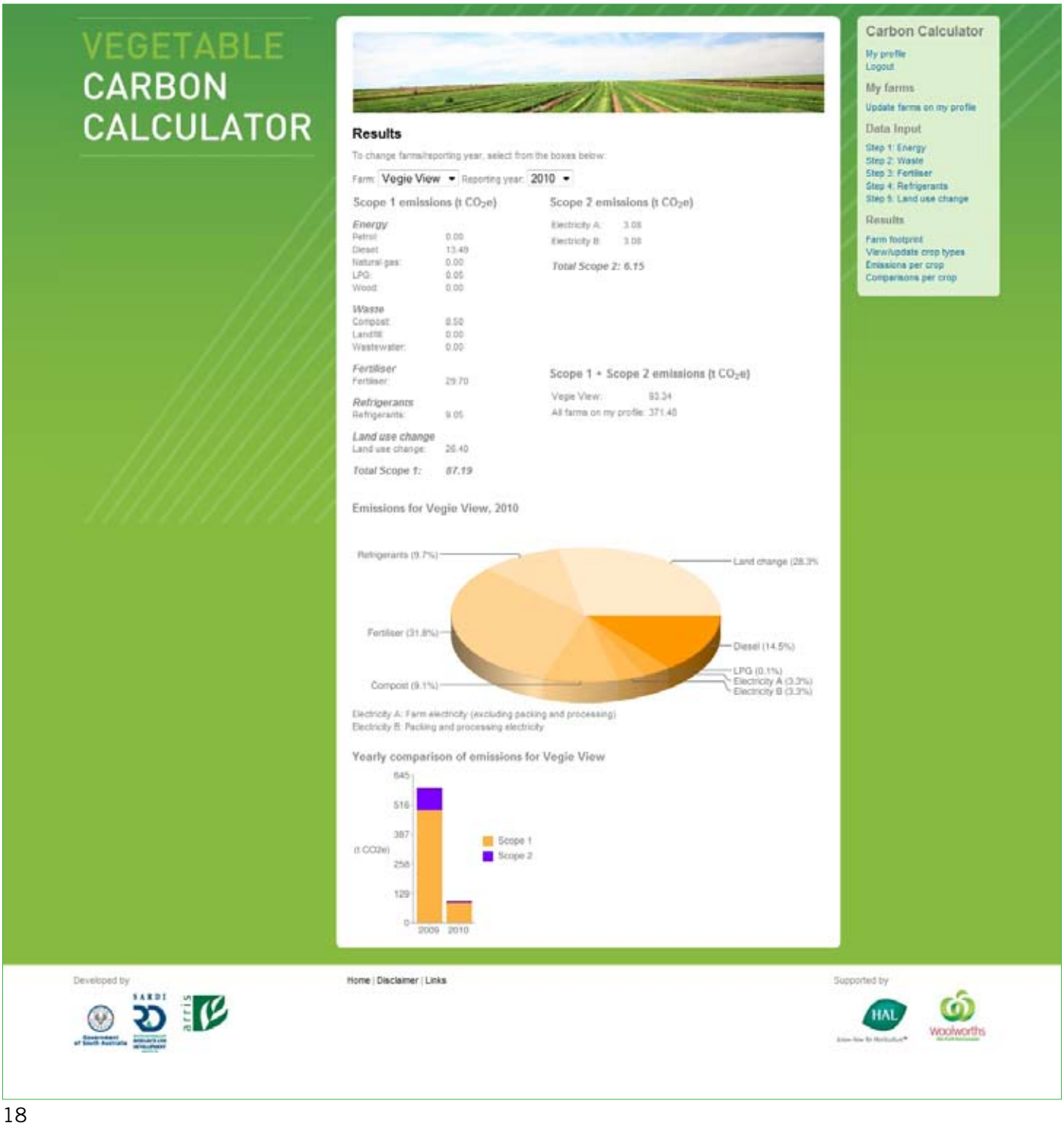
Farm Footprint

Now that you've completed the Data Input section of the tool, the data can be used by the Carbon Calculator to estimate the carbon footprint of your farm.

The farm footprint is displayed in two separate ways: as a table listing the results, and as a pie chart. The table presents the total on-farm carbon footprint, highlighting both the Scope 1 and Scope 2 emissions by type. The pie chart illustrates how each emission component contributes to the farm's overall carbon footprint. For users who have entered data in multiple years, a second chart shows the year on year changes to carbon emissions.

For some users of the tool, it is expected that this will be your end point. Other users may wish to proceed with the tool to allocate on-farm emissions to the specific crops grown on the farm.

NOTE: You can access the Farm Footprint Results page at any time, using the links on the right hand side of the page. Just click on 'Farm footprint', under the Results heading.



Carbon Calculator: Add Crops

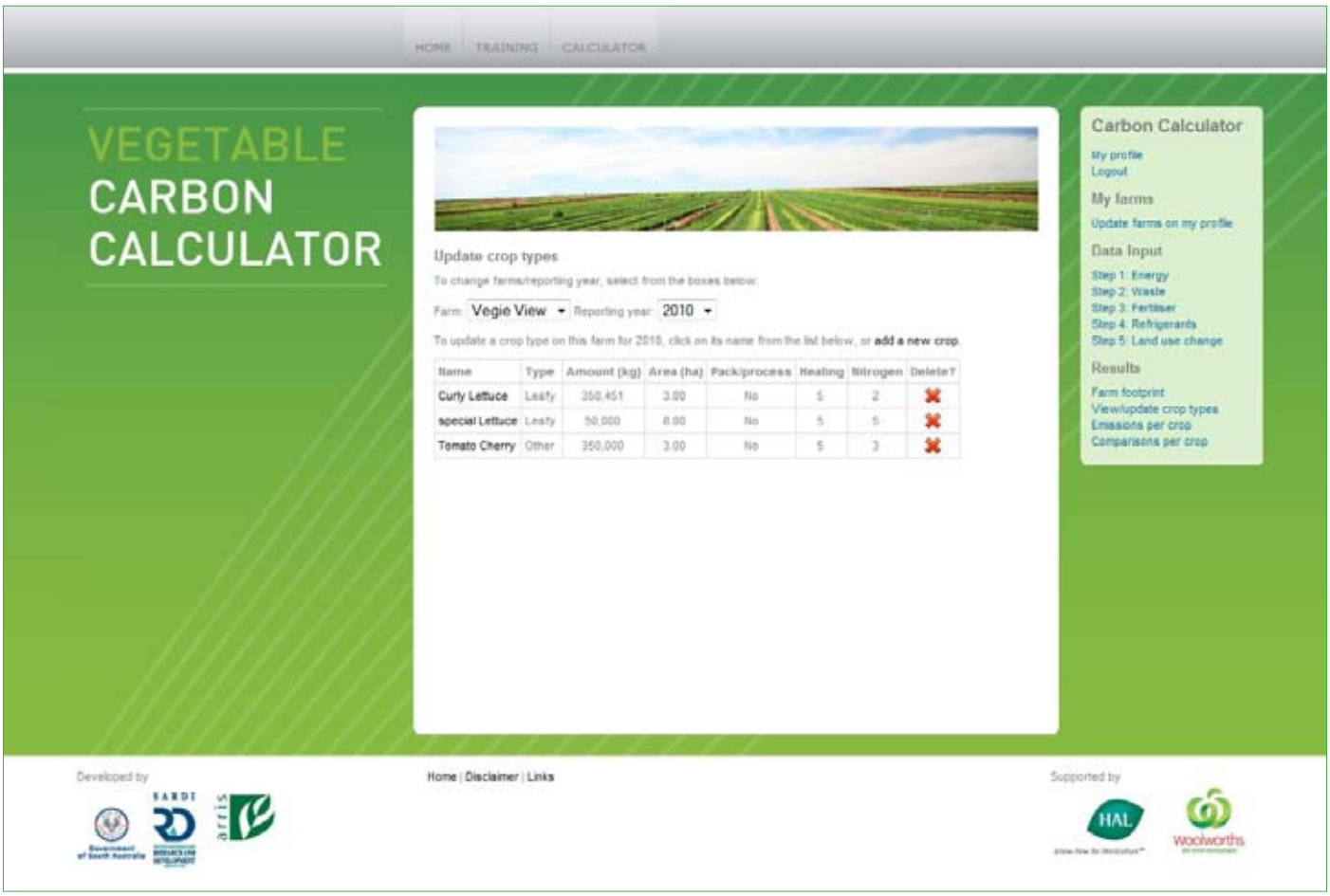
Add crop types

Click on ‘View/update crop types’ (listed under ‘Results’ in the right hand column)

Farm: Use the drop down menu to select your farm.

Reporting year: Use the drop down menu to select the appropriate year.

Next, click on the link ‘add a new crop’.



Add a new crop

Farm: Use the drop down menu to select your farm.

Reporting year: Use the drop down menu to select the appropriate year.

Crop name: Type in the appropriate crop name.

Crop type: Use the drop down menu to select the crop type/category your crop fits into (i.e. Brassica, Cucurbit, Leafy, Root, Other).

Amount produced: Type in the amount of that crop you produce on your farm (kg/yr).

Area farmed: Enter the area farmed of that crop (ha/yr).

Packaged & processed on site: Select 'Yes' or 'No' from the drop down menu. (This question will only appear for farms who pack or process on-site.)

Tractor intensity scale: Enter the amount you use a tractor to grow the individual crop on a scale of 1-10 relative to the other crops you produce. (Field Crop farms only)

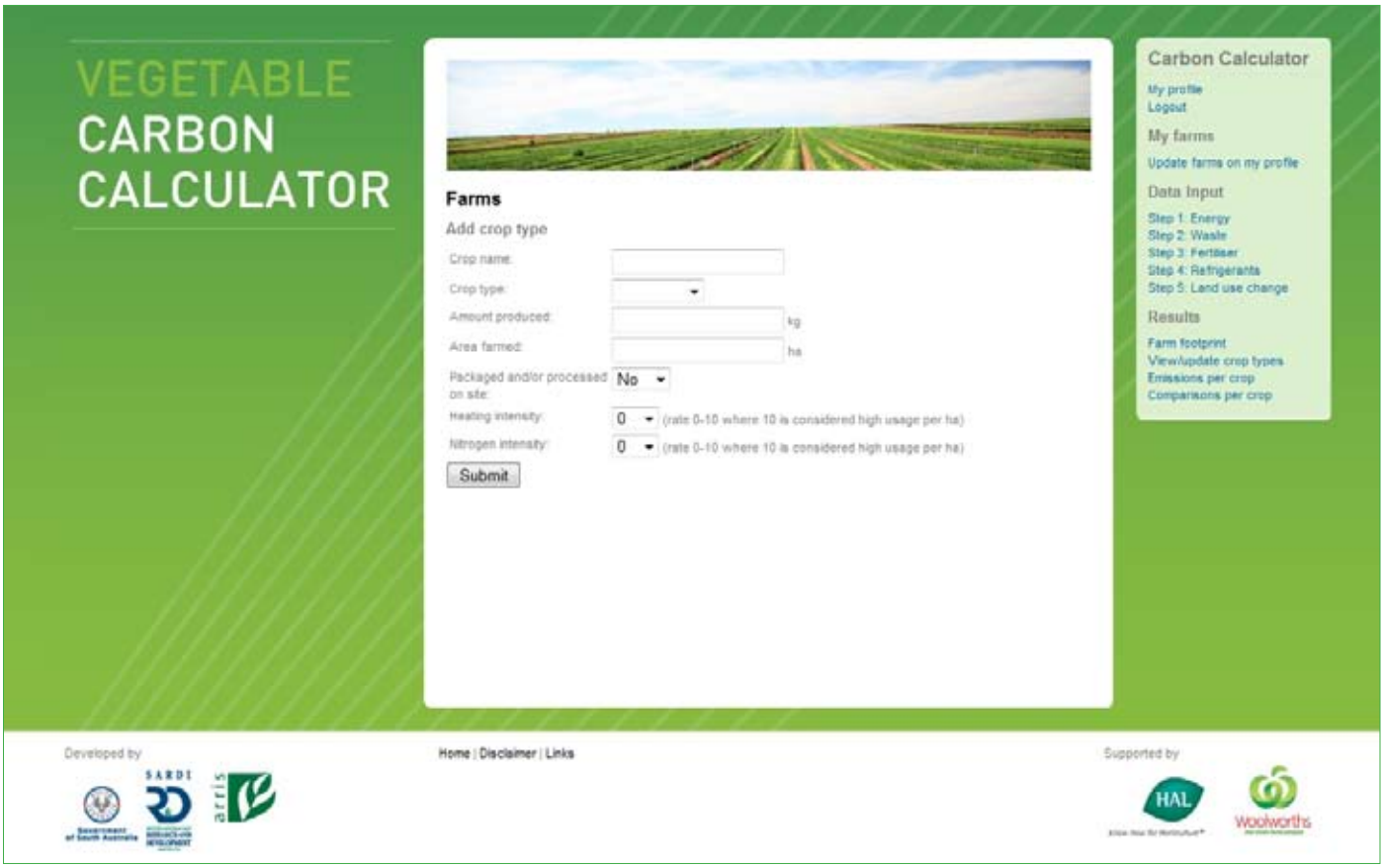
Irrigation scale: Enter the amount of irrigation you use to grow the individual crop on a scale of 1-10 relative to the other crops you produce. (Field Crop farms only)

Heating scale: Enter the amount of heating you use to grow the individual crop on a scale of 1-10 relative to the other crops you produce. (Glasshouse Crop farms only)

Nitrogen scale: Enter the amount of nitrogen you use to grow the individual crop on a scale of 1-10 relative to the other crops you produce. (Field or Glasshouse Crop farms)

Once all of these details have been entered, click 'Submit'.
Repeat the steps above for each of the crops produced on each of your farms.

NOTE: You can update/edit the crop information at any time, by clicking on the 'View/update crop types' link in the right hand column. Remember to select the Farm, and the Reporting year from the drop down menus, then click on the crop's name from the list and make the necessary edits.



Results: By Crop Type

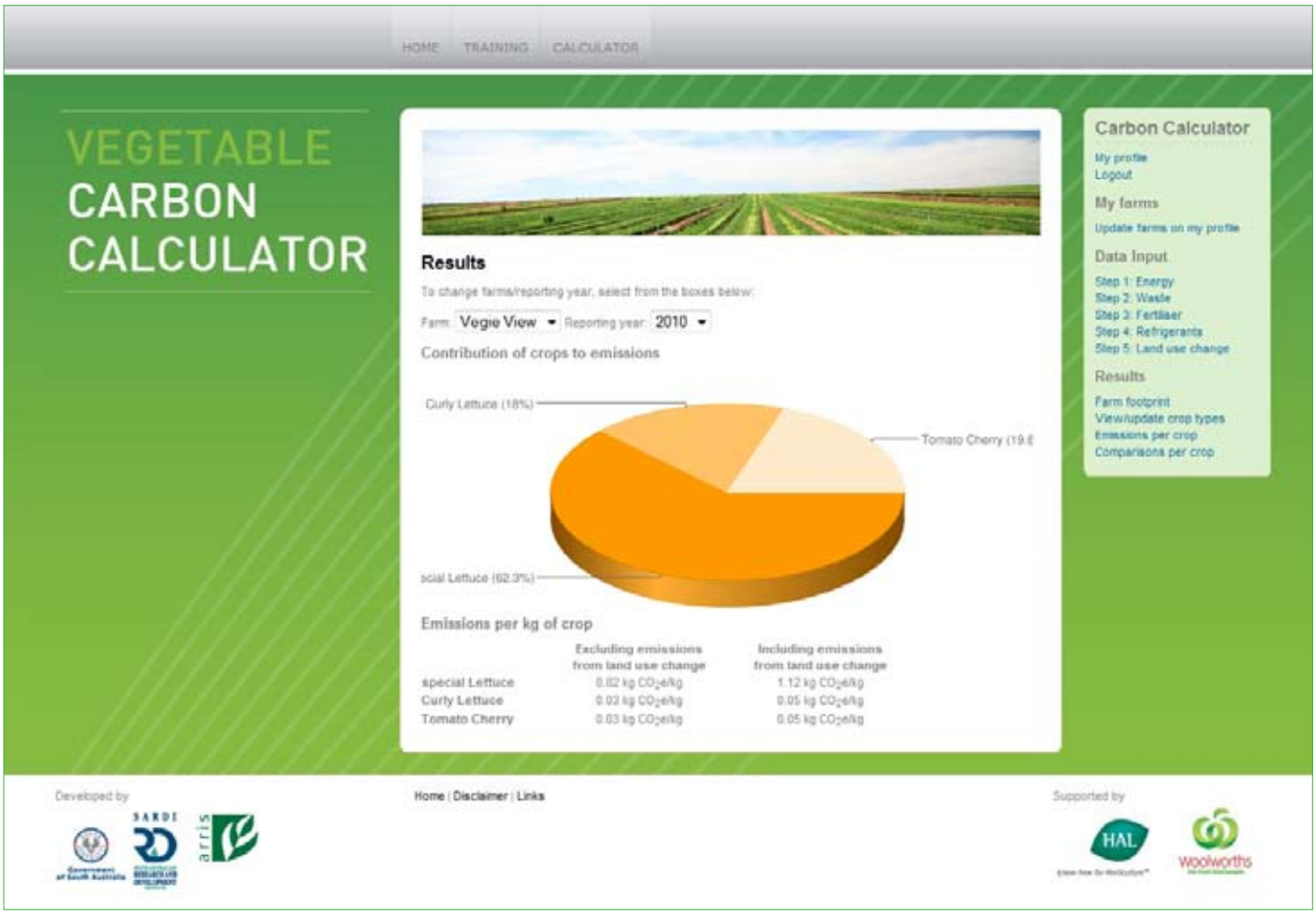
After entering information about the specific crops produced on your farm, users are able to gain an insight into how each of the different crops affects their carbon footprint.

Emissions per crop

Click on ‘Emissions per crop’ in the right hand column, listed under the ‘Results’ heading.

The information about each crop is presented in two ways.

The first is a pie chart which shows how each crop contributes to the overall farm footprint. The larger the segment of the pie the more that crop contributes to the farms carbon footprint. The second display shows the carbon impact of each crop in terms of kg of carbon dioxide equivalent per kg of crop.

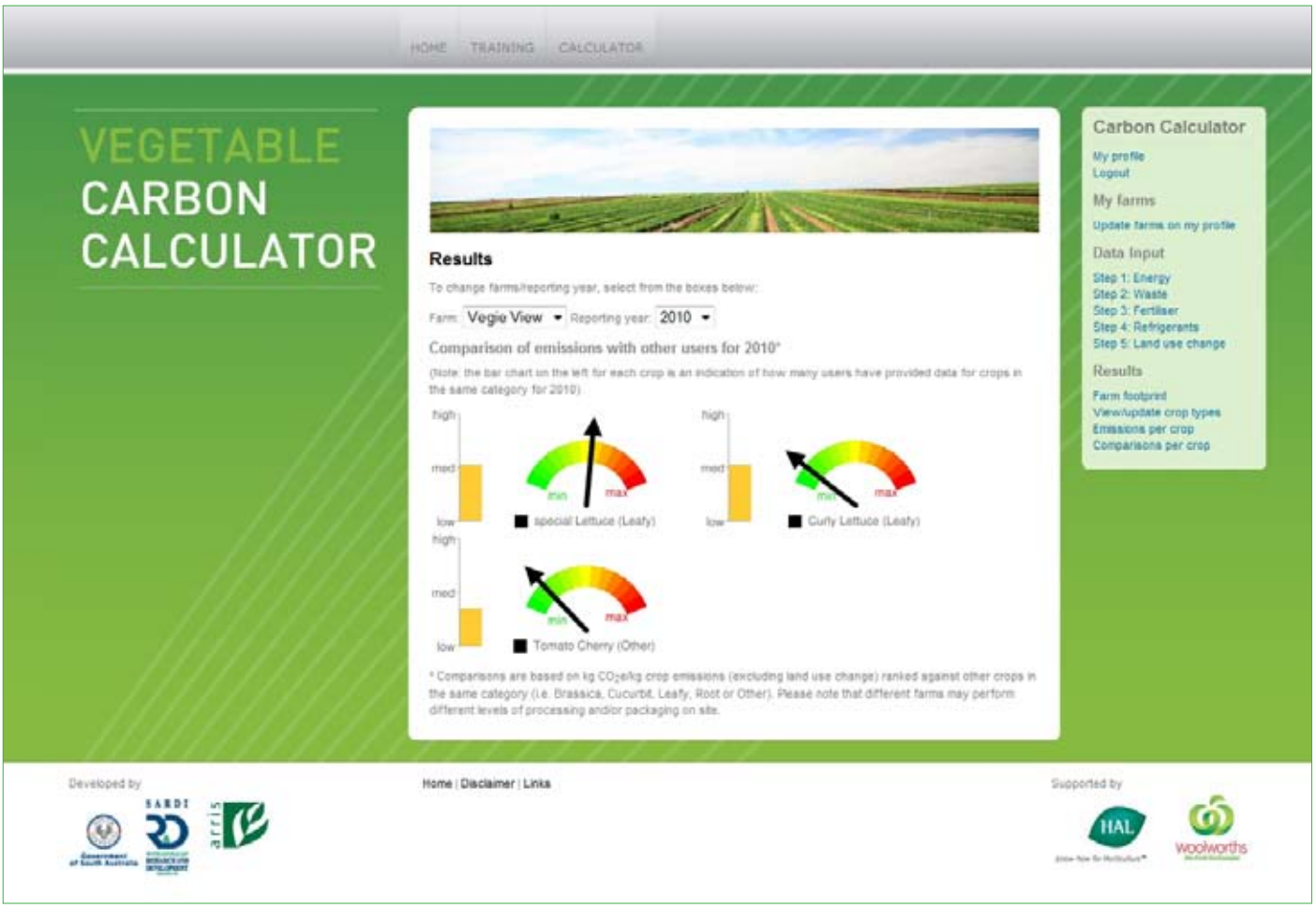


Comparisons per crop

Click on ‘Comparisons per crop’ in the right-hand column, listed under the ‘Results’ heading.

This will show the emission of crops on the active farm versus all crops in the same category per kg.

The information is presented in the form of a chart similar to that normally used to represent bushfire warnings. The arrow on the chart indicates the relative carbon impact of the specific crop when compared to averages of the specific crop type.



Further Information

For additional advice on carbon footprinting, the following web-links may be of assistance.

Department of Primary Industries Victoria

Carbon toolkits in agriculture network update

http://new.dpi.vic.gov.au/agriculture/climate/ctan/carbon-toolkits-in-agriculture-network-update

AUSVEG

Enviroveg Program

http://ausveg.com.au/enviroveg/programs.htm

Australian Government

Department of Climate Change and Energy Efficiency

http://www.climatechange.gov.au/

Australian Farm Institute

Farm Gas

http://farmgas.farminstitute.org.au/publicpages/AFIPublic.aspx?ReturnUrl=%2fdefault.aspx

National Climate Change Research Strategy for Primary Industries

http://ccrspi.org.au/

Horticulture Australia Limited

Environment Portfolio

http://www.horticulture.com.au/areas_of_Investment/Environment/HAL_environment_portfolio.asp

Reference List

1. L.E.K. Consulting. ANZ Carbon Footprint Report 2008. Sydney: L.E.K. Consulting Australian and New Zealand, 2008.

2. Olsen, D (11 June 2010) ALDI to partner with Planet Ark on carbon labelling, viewed June 17th 2010, http://www.dynamicbusiness.com.au/articles/articles-news/aldi-planet-ark-carbon-labelling-1671.html

VEGETABLE CARBON CALCULATOR

Protocol

VG09187 Australian Vegetable Industry Carbon Footprint Tool: Stage 2

HAL Know-how for Horticulture™

Government of South Australia

SARDI South Australian Research and Development Institute

arris

Woolworths the fresh food people

Contents

1 Introduction

The Vegetable Carbon Calculator has been developed by the South Australian Research and Development Institute (SARDI) in partnership with Arris Pty. Ltd. It is now available for use at www.vegiecarbontool.com.au. It provides a simple means for Australian vegetable growers to understand their carbon footprint.

This protocol has been written to accompany the Vegetable Carbon Calculator. It describes the general approach to the development of the tool and provides some relevant background information on carbon accounting. It then details the specific calculation techniques employed in an order corresponding with the online tool. It is not intended that this protocol will be read by every user of the Vegetable Carbon Calculator, only those that wish to understand the background calculations employed in more detail. A manual for the Vegetable Carbon Calculator is also available on the website and this will be the more relevant reference document for most users.

2 Approach to the Vegetable Carbon Calculator

The Vegetable Carbon Calculator builds on greenhouse gas accounting work performed by Houston's Farm. While Houston's Farm used life cycle assessment methodologies, this was not thought appropriate for the industry as a whole[1]. Simplicity and ease of use was deemed critical in ensuring that the tool would be widely used and helpful for the Australian vegetable industry.

The tool is designed to estimate the direct on-farm greenhouse gas emissions, together with indirect emissions related to the generation of electricity that is used on-farm. The emissions associated with on-farm packaging and/or processing facilities are also included. The calculator does not include emissions associated with the wider vegetable supply chain; for example fertiliser production and transportation of vegetables.

It is intended that the Vegetable Carbon Calculator will allow members of the Australian vegetable industry to understand which aspects of their on-farm production contribute most significantly to their greenhouse gas emissions. It will also help farmers understand how the carbon footprints of their crops compare with those of other users.

[1] Life cycle assessment considers all emissions associated with a product's life cycle, from cradle to grave. This includes all supply chain emissions from the farm to the consumer. Houston's Farm developed a life cycle type understanding of the greenhouse gas emissions associated with lettuce production on their farm. One of Houston's Farm's recommendations was not to use life cycle assessment techniques due to the inherent complexity. For this reason the Vegetable Carbon Calculator has been designed to estimate Scope 1 and 2 greenhouse gas emissions only.

3 Greenhouse gas/carbon accounting

3.1 Carbon, carbon dioxide and carbon dioxide equivalents

The principal greenhouse gas of interest is carbon dioxide (CO_2). However, there are a number of other gases that also contribute to global warming; notably methane (CH_4) and nitrous oxide (N_2O). Each gas has a different influence on climate change for a given quantity and this is described by their global warming potential (GWP). Emission levels can be converted to a carbon dioxide equivalent value (i.e. the quantity of carbon dioxide that would have the same influence on global warming) using the GWPs reported in Table 3.1.

Table 3.1: Global warming potential of the three key greenhouse gases

Gas	GWP
Carbon dioxide (CO_2)	1
Methane (CH_4)	21
Nitrous oxide (N_2O)	310

(From: DCCEE 2010a)

It should also be noted that typically when the term carbon is used in reference to accounting and footprinting, emissions of all the greenhouse gases are often what is actually being described. The correct terminology is carbon dioxide equivalent emissions, generally presented as CO_2e.

3.2 Emission factors

Emission factors describe the quantity of carbon dioxide equivalents emitted per unit of activity. For example per litre of diesel used or per kW.hr of electricity consumed. They are extensively used in carbon accounting and in the Vegetable Carbon Calculator.

3.3 Scope 1, 2 and 3 emissions

In carbon accounting emissions are typically categorised under different "Scopes". This helps to promote consistency and prevent double counting between organisations. The Australian Government's Department of Climate Change and Energy Efficiency (DCCEE 2009) define the different emission scopes as follows:

Scope 1 emissions: The release of greenhouse gas into the atmosphere as a direct result of activities at a facility.

Scope 2 emissions: The release of greenhouse gas into the atmosphere as a result of electricity generation, heating, cooling or steam that is consumed by a facility.

Scope 3 emissions: The release of greenhouse gas into the atmosphere that is generated in the wider economy as a consequence of a facility's activities but that are physically produced by another facility.

This demarcation of emissions is also illustrated in Figure 3.1. The Vegetable Carbon Calculator considers only Scope 1 and Scope 2 emissions.

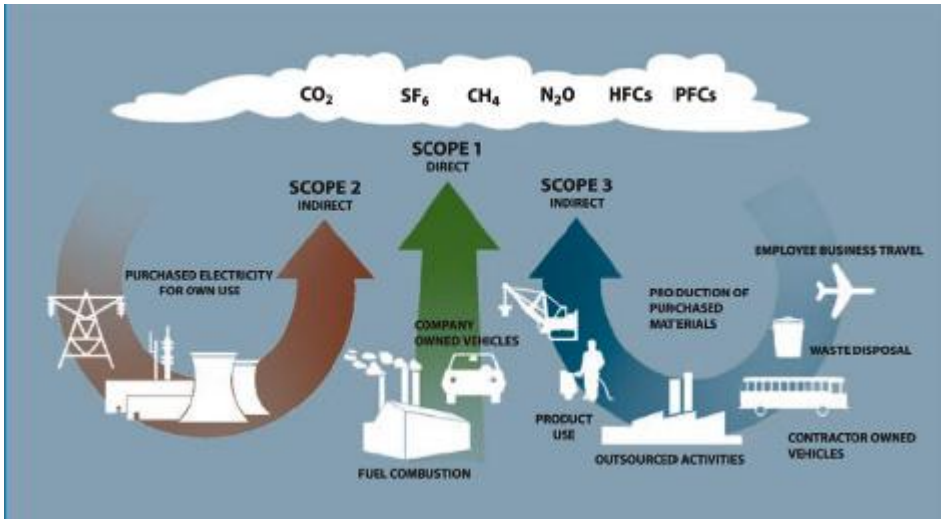


Figure 3.1: Representation of emissions included in Scope 1, 2 and 3

(From: WRI and WBCSD 2004)

3.4 The carbon cycle

The carbon cycle describes the flows of carbon between the earth's different carbon stores as illustrated in Figure 3.2. In this cycle, carbon occurs as a constituent of numerous different compounds, not just carbon dioxide. The carbon cycle can be further divided into a short-term and a long-term carbon cycle. The short-term carbon cycle accounts for processes taking less than 100 years, while the long-term carbon cycle accounts for processes taking longer than 100 years.

The Vegetable Carbon Calculator excludes emissions that are part of the short-term carbon cycle, in keeping with similar protocols and standards. An important implication of this is that carbon dioxide sequestered from the atmosphere by plants during photosynthesis is not considered in calculations, however, neither is carbon dioxide emissions associated with crop residues decomposing in soil.

Soil organic matter is both a source and sink of atmospheric carbon dioxide, however, there is considerable uncertainty regarding the impact of different techniques in agricultural systems (BSI 2008a). For this reason emissions and sequestrations arising from changes in soil carbon have been excluded from the Vegetable Carbon Calculator, except for that associated with direct land use change (i.e. clearing of native grassland or forest for agricultural use).

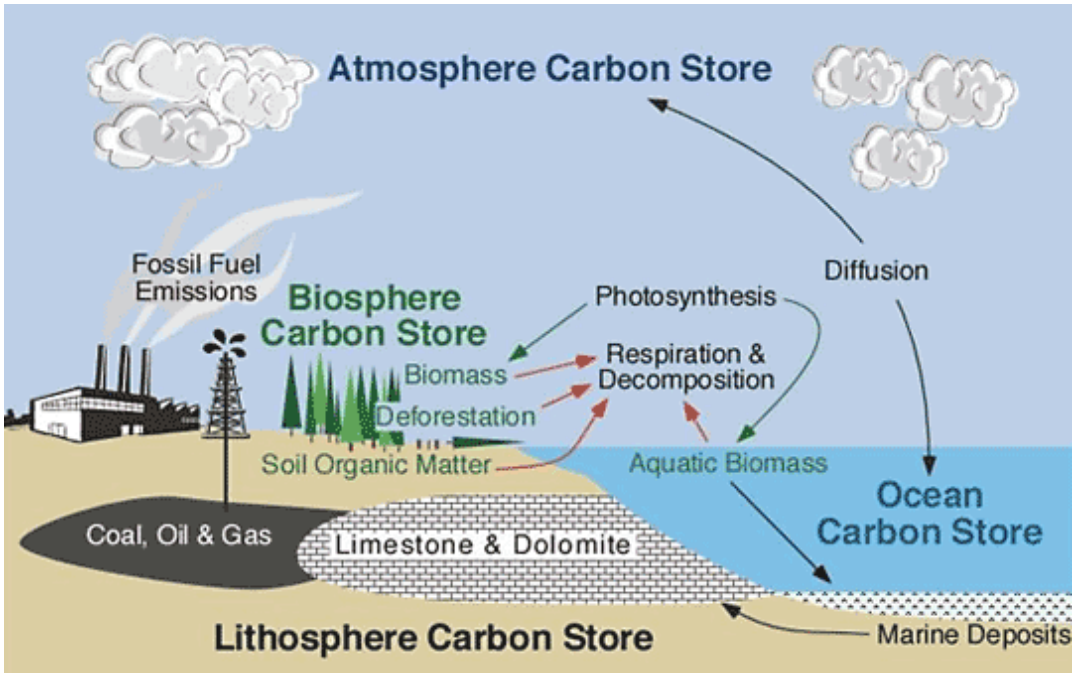


Figure 3.2: The carbon cycle

(From: Pidwirny 2008)

4 Calculation methodology

In this section the calculation methodology employed at each stage of the calculator are detailed.

The methods were principally derived from publications produced by The Australian Government's Department of Climate Change and Energy Efficiency (DCCEE 2010a, 2010b, 2010c).

It is intended that this will be read in conjunction with inspection of the Vegetable Carbon Calculator itself.

4.1 Energy sources

4.1.1 Mobile liquid fuels

Emissions in this category are those associated with mobile equipment including tractors, forklifts, utes, and other mobile farm machinery. The Vegetable Carbon Calculator allows user inputs for petrol, diesel and liquefied petroleum gas (LPG). Quantities of LPG can be input on either a mass (kg) or volume (L) basis. An LPG density of 540 kg/m^3 (Reece 2004) has been used to convert mass based inputs to volumes. Volumes of fuel are converted into an equivalent energy using the relevant fuel energy content reported in Table 4.1. These are then converted into emissions using the corresponding emission factors.

Table 4.1: Mobile liquid fuel emission factors

Fuel	Energy content (GJ/kL)	Emission factor (kg CO_2e/GJ)			
		CO_2	CH_4	N_2O	Total
Diesel	38.6	69.2	0.2	0.5	**69.9**
Petrol	34.2	66.7	0.6	2.3	**69.6**
LPG	26.2	59.6	0.6	0.6	**60.8**

(From: DCCEE 2010a)

4.1.2 Stationary liquid fuels

Emissions in this category are those associated with combustion of liquid fuels in stationary equipment including generators, heaters and pumps. Calculations are performed similarly to those for mobile fuels, but with the emission factors presented in Table 4.2.

Table 4.2: Stationary liquid fuel emission factors

Fuel	Energy content (GJ/kL)	Emission factor (kg CO_2e/GJ)			
		CO_2	CH_4	N_2O	Total
Diesel	38.6	69.2	0.1	0.2	**69.5**
Petrol	34.2	66.7	0.2	0.2	**67.1**
LPG	25.7	59.6	0.1	0.2	**59.9**

(From: DCCEE 2010a)

4.1.3 Natural gas

The emissions associated with the consumption of natural gas are calculated using the emission factors presented in Table 4.3. A user input of natural gas consumption in units of energy (MJ) from their natural gas bill is required.

Table 4.3: Natural gas emission factors

Fuel	Emission factor (kg CO_2e/GJ)			
	CO_2	CH_4	N_2O	Total
Natural gas	51.2	0.1	0.03	**51.33**

(From: DCCEE 2010a)

4.1.4 Wood

Emissions in this category are those associated with combustion of wood. Emissions are calculated in a similar manner to those from combustion of mobile and stationary liquid fuels. The emission factors employed are presented in Table 4.4. As biomass combustion is part of the short-term carbon cycle, carbon dioxide emissions are assigned a zero emission factor.

Table 4.4: Wood emission factors

Fuel	Energy content (GJ/t)	Emission factor (kg CO_2e/GJ)			
		CO_2	CH_4	N_2O	Total
Dry wood	16.2	0.0	0.08	1.2	**1.28**
Green and air dried wood	10.4	0.0	0.08	1.2	**1.28**

(From: DCCEE 2010a)

4.1.5 Electricity

Emissions related to consumption of electricity from the grid are calculated based on a user input of electricity consumption (kW.hr) and the emission factors presented in Table 4.5. Notably the emissions associated with electricity from some states are much higher than from others. This is related to the different techniques used for electricity generation. For example; Tasmania, which generates much of its power in hydroelectric power stations, has much lower greenhouse gas emissions for a given quantity of electricity than Victoria, where coal-fired power stations are predominantly employed.

While there is an inefficiency associated with the transmission and distribution of electricity that results in an additional emission this is not included in the Vegetable Carbon Calculator as this is defined as a Scope 3 emission (DCCEE 2010a).

In order to allocate electricity used for packaging and/or processing, the user is also required to estimate the percentage of power employed in these operations, if applicable.

Table 4.5: Electricity emission factors

State	Emission factor (kg CO_2e/kWh)
New South Wales and ACT	0.90
Victoria	1.23
Queensland	0.89
South Australia	0.72
Western Australia	0.82
Tasmania	0.32
Northern Territory	0.68

(From: DCCEE 2010a)

4.2 Waste

Waste processing emissions are only included in the Vegetable Carbon Calculator if the operations are performed on-farm. If they are performed off-farm, at a premise controlled by another company or council, any associated emissions are regarded as Scope 3 emissions and are therefore not included within the Vegetable Carbon Calculator.

It should be noted that as emissions of carbon dioxide from waste biomass are part of the short-term carbon cycle they are also not included by the Vegetable Carbon Calculator.

4.2.1 Compost

Calculations of the emissions associated with composting are based on a user input of the quantity of wet compost processed and the emission factors presented in Table 4.6.

Please note that there is an emission associated with composting, and there is a further emission if this compost is then used as fertiliser. This additional emission is considered as part of section 4.3.1.

Table 4.6: Composting emission factors

	Emission factor (kg CO_2e/kg compost)		
	CH_4	N_2O	Total
Compost	0.08	0.09	**0.17**

(From: DCCEE 2010a)

4.2.2 Landfill

Methane emissions from on-farm landfills are calculated based on user inputs of the quantities of different waste types and the emission factors presented in Table 4.7. The Municipal (broad stream) category can be utilised if the user is unsure of the makeup of the waste going into their on-farm landfill.

Table 4.7: Landfill emission factors

Waste type	Emission factor (kg CO_2e/kg waste)
Food	0.9
Paper and cardboard	2.5
Garden and green	1.3
Wood	2.7
Textile	1.5
Sludge	0.3
Rubber and leather	2.5
Municipal (broad stream)	1.0

(From: DCCEE 2010a)

4.2.3 Wastewater

If the user has information on the volume of wastewater produced on their farm, they can enter this value. If they do not have this information recorded, an approximate volume of wastewater is determined based on an entry of the quantity of vegetables produced. It is assumed that 20 kL of wastewater are created for each of tonne of vegetables produced (DCCEE 2010a). The user is also asked to input the average chemical oxygen demand (COD) of their wastewater. If they do not know the COD of their wastewater they can use the default value provided of 200 mg/L (DCCEE 2010a). The volume, either directly entered or derived, and the COD concentration of the incoming wastewater are used to calculate the mass of COD entering the on-farm wastewater treatment facility.

The user must also select the type of wastewater treatment employed. The options available are presented in Table 4.8 together with the assumed percentage of the COD treated anaerobically for each of the treatment options. The default selection is unmanaged aerobic treatment.

The quantity of methane produced is calculated based on the mass of COD entering the plant, the fraction of that mass treated anaerobically, an assumed 15% of COD removed from wastewater as sludge (DCCEE 2010a) and an emissions factor of 5.3 kg CO_2e / kg COD (DCCEE 2010b).

It is assumed that there is no capture of methane for combustion, flaring or transfer off-site. Furthermore it is assumed that sludge is transferred off-site for further treatment or alternatively composted on-farm or deposited in an on-farm landfill in which case the emissions associated with sludge treatment are calculated as part of sections 4.2.1 and 4.2.2.

Table 4.8: Wastewater treatment type and percentage of COD treated anaerobically

Treatment type	COD treated anaerobically
Managed aerobic treatment	0%
Unmanaged aerobic treatment	30%
Anaerobic digester/reactor	80%
Shallow anaerobic lagoon (<2 metres)	20%
Deep anaerobic lagoon (>2 metres)	80%

(From: DCCEE 2010b)

4.3 Fertiliser

4.3.1 Synthetic and organic fertilisers

All types of fertiliser that contain nitrogen are considered by the Vegetable Carbon Calculator, both synthetic and organic. Increases in the available nitrogen in soil, enhance nitrification and denitrification rates, which then increase the production of nitrous oxide (IPCC 2006). Additional nitrous oxide also enters the atmosphere as a result of leaching and run-off and through volatilisation. These principles are illustrated in the context of the nitrogen cycle in Figure 4.1.

In the Vegetable Carbon Calculator the user must enter the quantities and nitrogen content of all the synthetic and organic fertilisers they have used. All registered fertilisers must display a chemical analysis, which will specify the nitrogen content. For some unregistered local organic fertilisers like animal manure and compost, however, the nitrogen content may not be available. For the purpose of ease of use of the Vegetable Carbon Calculator some indicative values of organic materials are provided so the user may quickly estimate the nitrogen content of those fertilisers. These values are reported in Table 4.9. For composts containing a mixture of components it is recommended that an average value based on the compost recipe be used. However, for simplicity, if a compost mixture is dominated by one ingredient, e.g. cattle manure, it may be appropriate just to use the nitrogen content of that principal ingredient. The moisture contents assumed in deriving these values are presented in brackets. While there can be wide variations in moisture content that will significantly alter the results it was deemed important to present the values on a wet basis rather than a dry basis to maximise their utility to farmers.

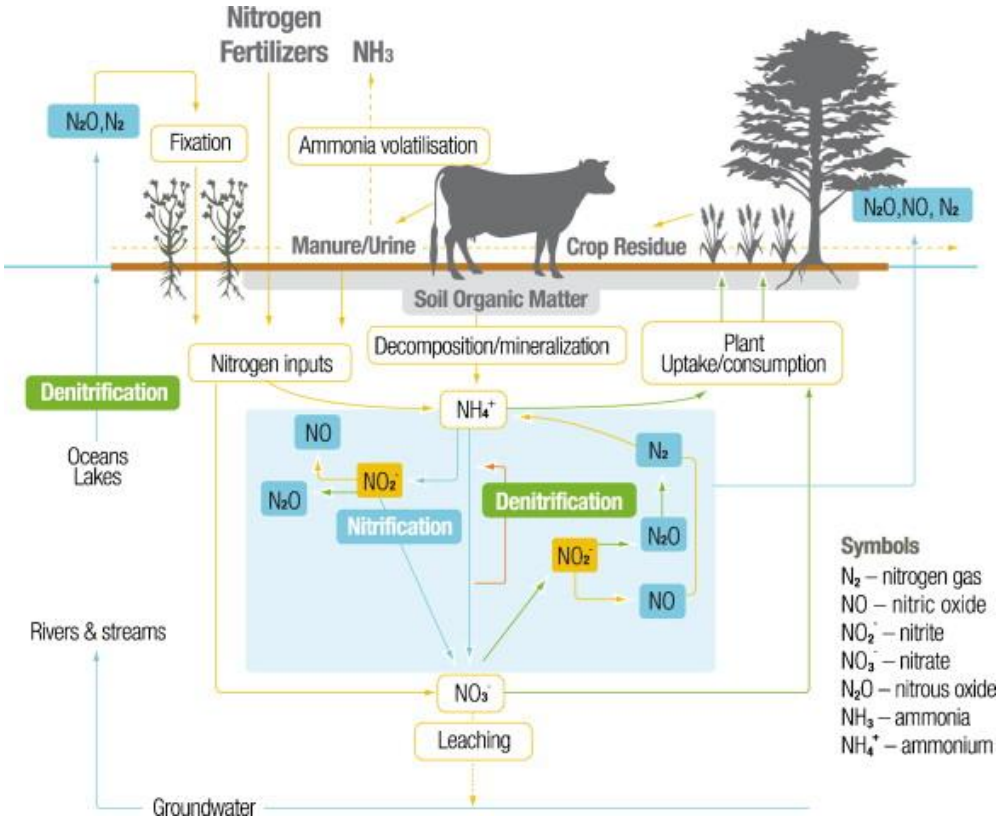


Figure 4.1: The nitrogen cycle

(From: Ugalde et al. 2007)

Table 4.9: Nitrogen content of organic fertilisers/compost components

Material	Nitrogen content (%)
Blood and bone	9.1 (30% water)
Vegetable wastes	1.5 (50% water)
Broiler litter	1.7 (37% water)
Grass clippings	1.7 (50% water)
Cattle (dairy) manure	1.4 (50% water)
Horse manure	0.8 (50% water)
Non-legume hay	1.2 (10% water)
Tree prunings	0.8 (20% water)
Straw	0.6 (12% water)
Softwood sawdust	0.08 (20% water)
Hardwood sawdust	0.05 (20% water)
Newspaper	0.04 (6% water)

(Adapted from: Jenkins and van Zwieten 2003, and Graves et al. 2000)

Direct nitrous oxide emissions from fertiliser addition are calculated principally according to the guidelines published by the intergovernmental panel on climate change (IPCC 2006). A blanket emissions factor of 0.01 kg N_2O-N / kg N (IPCC 2006) has been used for direct nitrous oxide emissions resulting from both synthetic and organic fertiliser application. Results are then converted from an

elemental mass to a molecular mass of nitrous oxide, which is in turn converted to a carbon dioxide equivalent emission using the global warming potential of nitrous oxide reported in Table 3.1.

It is important to note that there is significant uncertainty inherent in this emission factor. Results will vary considerably with crop type, application rate and specific climate amongst many other factors. Given that the Vegetable Carbon Calculator is designed as a general tool to be applied across a range of different vegetables and farming practices, it was deemed most appropriate to employ the general IPCC emissions factor.

An Australian technique with state specific data has been employed to estimated nitrous oxide emissions associated with leaching and run-off (DCCEE 2010c). Australia is the driest inhabited continent with substantially less run-off than all others (DCCEE 2010c) and it was thought most appropriate to use this Australian technique.

Fertiliser volatilisation has been assumed to be 0.1 kg NH_3-N + NO_x-N per kg of synthetic fertiliser N applied and 0.2 kg NH_3-N + NO_x-N per kg of organic fertiliser N applied (IPCC 2006).

4.3.2 Crop residues

Direct nitrous oxide emissions from crop residues returned to soils have been calculated principally according to DCCEE (2010c) for field crop farms and have been excluded for glasshouse crop farms. The user simply inputs their total quantity of vegetable production and the fraction of their farm for which they return crop residues to the soil. Emissions are calculated employing a residue to crop ratio of 1.5, a dry matter content of 0.8, a dry matter carbon fraction of 0.4, and an elemental N:C ratio of 0.008. As with the other fertiliser related calculations an emissions factor of 0.01 kg N_2O-N / kg N has been employed, and results have been converted from an elemental mass to a molecular mass of nitrous oxide and then to a carbon dioxide equivalent emission.

4.4 Refrigerants

Fugitive refrigerant emissions from refrigeration systems can contribute to global warming. Hydrofluorocarbon (HFC) and hydrochlorofluorocarbon (HCFC) can have very high global warming potentials, as shown in Table 4.10. In the vegetable industry it is assumed that many farms will have on-site refrigeration systems servicing cold rooms and stores.

If service records are available for refrigeration systems it may be possible to estimate the quantity of refrigerant leaked based on the amount of refrigerant that was added to recharge the system. The Vegetable Carbon Calculator allows for the user to input this information if available. Often this information will not be readily available. In this instance the emissions are estimated based on a user input of the total charge size of the refrigeration system together with an assumed annual refrigerant loss of 16% (DCCEE 2010a). Results are converted to carbon dioxide equivalent values using the global warming potentials presented in Table 4.10.

Table 4.10: Global warming potential of selected HFCs and HCFCs

Gas	GWP (kg CO_2e/kg)
R-22	1,810
R-23	11,700
R-32	650
R-41	150
R-43-10mee	1,300
R-125	2,800
R-134	1,000
R-134a	1,300
R-143	300
R-143a	3,800
R-152a	140
R-227ea	2,900
R-236fa	6,300
R-245ca	560
R-404a	3,300
R-407c	1,600
R-410a	1,725

(Adapted principally from: DCCEE 2010a)

4.5 Land use change

Emissions associated with land use change have been calculated according to PAS 2050 (BSI 2008a, 2008b). Where native forest or grassland has been cleared to accommodate vegetable production the associated greenhouse emissions are accounted for by distributing them over 20 years (the year in which the land use change occurred and the 19 years following). The annual emission factors used by the Vegetable Carbon Calculator in each of these 20 years are presented in Table 4.11.

Table 4.11: Land use change emission factors for land conversion to annual cropland

Previous land use	Emission factor (t CO_2e/ha/yr)
Native forest	23
Native grassland	2.2

(Adapted from: BSI 2010a)

5 Outputs and allocation

In this section the Vegetable Carbon Calculator outputs are described together with the methodology used to allocate emission from a farm to individual crops on that farm.

5.1 Farm footprint

The individual on-farm emissions are listed by type and are also presented in the form of a pie chart, clearly illustrating how each farming input contributes to the farm's carbon footprint. Where data has been entered for multiple years, an additional chart illustrates the relative levels in those years.

For some users of the tool this will be the end point.

5.2 Crop footprint

To allocate whole farm emissions to individual crops on that farm the user must input data on each of the crops produced. Different allocation methods are used for field crop and glasshouse crop farms and these are detailed in the sections 5.2.1 and 5.2.2.

For each crop the required information includes the quantity produced, the area farmed and whether packaging and/or processing are performed on site. For field crop farms the intensity of tractor use, irrigation and nitrogen application per ha for each of the crops must be rated on a scale of 0-10. For glasshouse crop farms the intensity of heating and nitrogen application per ha for each of the crops must be rated on a scale of 0-10.

It should be noted that the emissions allocated to individual crops will be heavily dependent on the user inputs of these intensity factors and the applicability of the allocation rules to specific farms. This allocation methodology was adopted to allow farmers to quickly allocate farm emissions to individual crops, even where specific data on inputs for each crop are unavailable.

The contribution of individual crops to the farm footprint is displayed as a pie chart. The emissions per kg of each crop produced are also listed, both including and excluding emissions associated with land use change. The reasoning behind this is that the internationally accepted carbon accounting methods for land use change employ a somewhat arbitrary time period (20 years). Consequently, the 2010 emissions of a farm which cleared native land in 1991 would be significantly higher than a farm that cleared that same native land in 1990. The results excluding land use change are used for comparisons of emissions with other users. A ranking system is used in these comparisons to prevent rogue inputs skewing results. Additionally, a bar chart provides an indication of the number of vegetables added by users for each vegetable category (i.e. Brassica, Cucurbit, Leafy, Root, or Other).

5.2.1 Allocation methods for field crop farms

Diesel

It is assumed that the majority of diesel consumed on-site is associated with tractor use. The relative tractor intensity for each crop is calculated from the user tractor intensity inputs and multiplied by the relative area of that crop. These values are then normalised. This parameter is assigned a 90% weighting in the allocation of diesel-related greenhouse gas emissions to crops, while the relative crop production quantity is assigned a 10% weighting.

Electricity

Electricity-related emissions associated with packaging and/or processing facilities are only assigned to crops that are packaged and/or processed on site. Emissions are allocated based on relative production quantities of those crops.

Apart from packaging and/or processing facilities it is assumed that the majority of electricity consumed is associated with on-farm electric irrigation pumps. The relative irrigation intensity for each crop is calculated from the user irrigation intensity inputs and multiplied by the relative area of that crop. These values are then normalised. This parameter is assigned a 90% weighting in the allocation of non-packaging and processing facility electricity-related greenhouse gas emissions to crops, while the relative crop production quantity is assigned a 10% weighting.

Fertiliser

The relative nitrogen intensity for each crop is calculated from the user nitrogen intensity inputs and multiplied by the relative area of that crop. These values are then normalised. This parameter is then used to allocate fertiliser-related emissions to each crop.

Other

All other emissions are allocated to individual crops based on relative crop production quantities.

5.2.2 Allocation methods for glasshouse crop farms

LPG, Wood and Natural Gas

It is assumed that the majority of LPG, wood and natural gas consumed on-site are associated with heating. The relative heating intensity for each crop is calculated from the user heating intensity inputs and multiplied by the relative area of that crop. These values are then normalised. This parameter is then used to allocate LPG, wood and natural gas related emissions to each crop.

Electricity

Electricity-related emissions associated with packaging and/or processing facilities are only assigned to crops that are packaged and/or processed on site. Emissions are allocated based on relative production quantities of those crops.

Non-packaging and processing facility electricity-related greenhouse gas emissions are allocated to crops based on relative production areas.

Fertiliser

The relative nitrogen intensity for each crop is calculated from the user nitrogen intensity inputs and multiplied by the relative area of that crop. These values are then normalised. This parameter is then used to allocate fertiliser-related emissions to each crop.

Other

All other emissions are allocated to individual crops based on relative crop production areas.

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Abbreviations:
DCCEE: Australian Government, Department of Climate Change and Energy Efficiency.
IEA: International Energy Agency.
IPCC: Intergovernmental Panel on Climate Change.
PAS: Publicly Available Specification.
WBCSD: World Business Council for Sustainable Development.
WRI: World Resources Institute.

7 Additional resources

For additional information on carbon accounting methods the following websites are recommended:

(1) The Department of Climate Change and Energy Efficiency.

www.climatechange.gov.au.

- This is the relevant Australian Government department.
- There are many relevant official documents on this website, including the National Carbon Offset Standard, which provides guidance on voluntary carbon accounting procedures for Australian companies.

(2) The Greenhouse Gas Protocol Initiative.

www.ghgprotocol.org

- The Greenhouse Gas Protocol Initiative was jointly convened in 1998 by the World Business Council on Sustainable Development (WBCSD) and the World Research Institute (WRI).
- A number of carbon accounting publications and tools are available for download from their website.

(3) The Intergovernmental Panel on Climate Change (IPCC).

www.ipcc.ch

- The Intergovernmental Panel on Climate Change (IPCC) is the leading international body for the assessment of climate change. It was established by the United Nations Environment Programme (UNEP) and the World Meteorological Organization (WMO) to provide the world with a clear scientific view on the current state of knowledge in climate change and its potential environmental and socio-economic impacts.
- Numerous relevant technical publications are available for download from their website.