VEGETABLE CARBON CALCULATOR

Protocol

VG09187 Australian Vegetable Industry Carbon Footprint Tool: Stage 2

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 emissions associated with 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.
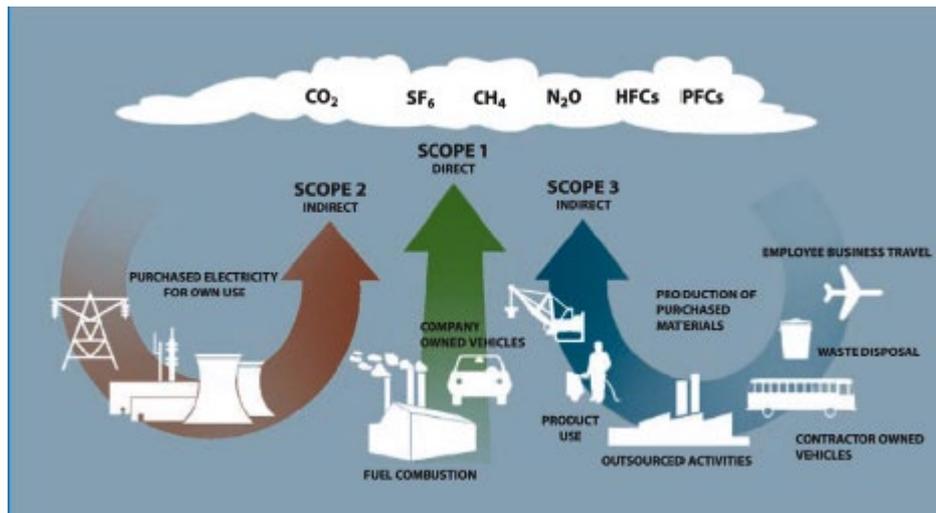
3.3 Scope 1, 2 and 3 emissions

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).
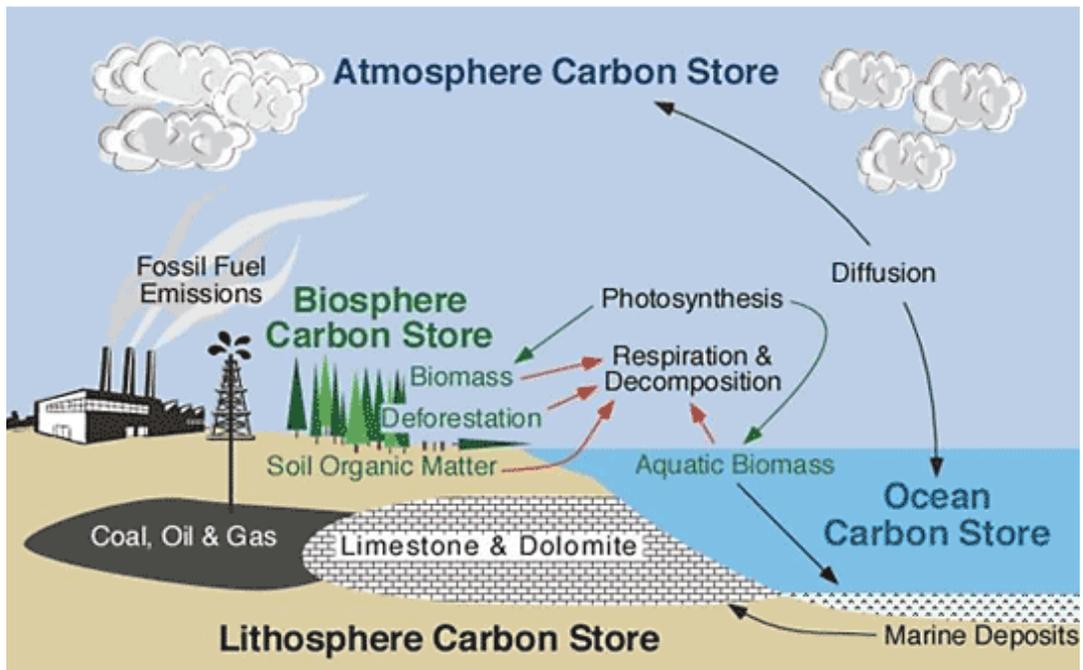
Figure 3.2: The carbon cycle

(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$_2$e/GJ)			
	CO$_2$	CH$_4$	N$_2$O	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$_2$e/GJ)			
		CO$_2$	CH$_4$	N$_2$O	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.
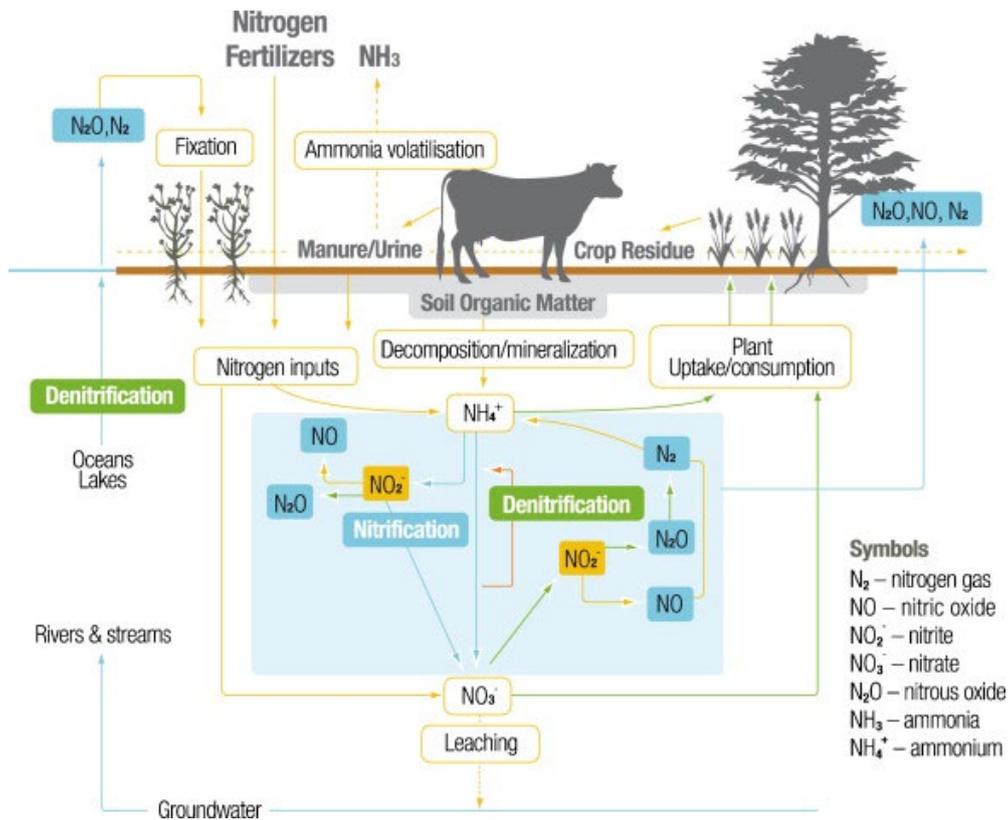
Figure 4.1: The nitrogen cycle

(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 contributions to emissions

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).

When interpreting the emissions associated with each crop, it must be remembered that this is not a life cycle tool. For example; emissions associated with the production of farming inputs like fertiliser or diesel are not included. These (amongst other things) would need to be considered in the determination of a genuine crop footprint.

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.

6 References

BSI (2008a) PAS 2050:2008, Specification for the assessment of the life cycle greenhouse gas emissions of goods and services. www.bsigroup.com. Accessed: September 2010.

BSI (2008b) Guide to PAS 2050: How to assess the carbon footprint of goods and services. www.bsigroup.com. Accessed: September 2010.

DCCEE (2009) National carbon offset standard. Version 1, November 2009. www.climatechange.gov.au. Commonwealth of Australia. Accessed: December 2010.

DCCEE (2010a) National greenhouse accounts factors, July 2010. www.climatechange.gov.au. Commonwealth of Australia. Accessed: September 2010.

DCCEE (2010b) National greenhouse and energy reporting system measurement: Technical guidelines for the estimation of greenhouse gas emissions by facilities in Australia, June 2010. www.climatechange.gov.au. Commonwealth of Australia. Accessed: September 2010.

DCCEE (2010c) Australian national greenhouse accounts, National inventory report 2008, Volume 1. www.climatechange.gov.au. Commonwealth of Australia. Accessed: September 2010.

Graves, R.E., Hattemer, G.M., Stettler, D., Krider, J.N. and Chapman, D. (2000) Chapter 2, Composting, In: National engineering handbook, Part 637 environmental engineering. United States Department of Agriculture, National Resources Conservation Service. http://www.wsi.nrcs.usda.gov. Accessed: November 2010.

IPCC (2006) 2006 IPCC guidelines for national greenhouse gas inventories, Volume 4: Agriculture, forestry and other land use, Prepared by the national greenhouse gas inventories programme, Eggleston, H.S., Buenida, L., Miwa, K., Ngara, T. And Tanabe, K. (eds). www.ipcc.ch. Accessed: September 2010.

Jenkins, A. and van Zwieten, L. (2003) How to compost on a farm. Agnote DPI-448. New South Wales Department of Primary Industries. www.dpi.nsw.gov.au. Accessed: September 2010.

Pidwirny, M. (2008) Carbon cycle. In: Encyclopedia of earth, Cleveland, C.J. (ed). www.eoearth.org. Accessed: December 2010.

Reece, M. (2004) Special issue paper 9 – Densities of oil products, Energy Statistics Working Group Meeting, IEA, Paris, France, 16-17 November 2004. www.iea.org.org. Accessed: November 2010.

Ugalde, D., Brungs, A., Kaebernick, M., McGregor, A. and Slattery, B. (2007) Implications of climate change for tillage practice in Australia. Soil and Tillage Research 97(2): 318-330.

WRI and WBSCD (2004) The greenhouse gas protocol, A corporate accounting and reporting standard, revised edition. www.ghgprotocol.org. Accessed: December 2010.

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.