4-30-2021

Evaluation of carbon accounting tools available to mixed farming enterprises in Western Australia

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Date 30 April 2021

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Introduction

In recent years consumers and the general public have become increasingly more cognisant of the environmental impact, through the emitting of greenhouse gases measured as carbon dioxide equivalent (CO_2e), that the production of goods and services they consume have on the world.
Global corporate businesses either through desire or market driven necessity are at the forefront of measuring and reducing their carbon footprint and in doing so placing pressure on suppliers to reduce theirs.

The impact of carbon emissions from agricultural enterprises and the role that the agricultural industry plays in the level of carbon emitted or sequestered continues to be debated, but current estimates suggest greenhouse gas emissions from agriculture account for approximately 13% of the national total.

A growing number of farmers are concerned and interested in establishing and monitoring their farm business' carbon emissions. There are reasons for doing this aside from the desire to clarify, understand and reduce their carbon footprint, which include identifying opportunities to improve nutrient utilisation in a cropping enterprise, feed management and utilisation for livestock, or to provide confirmation to domestic and overseas markets either to obtain access to a market or to receive a premium for the produce.

There are a number of carbon emissions accounting tools in the public and private domain available for agricultural producers to use in Australia. Most of these focus on the grain/cropping enterprise or livestock but few exist that cover both enterprises in the same business.

Very few of these accounting tools are specifically designed for Australian producers and there appears to be major and minor inconsistencies in outputs between the tools which make it difficult for producers to have confidence in using the information for planning on farm activities to improve carbon management.

Tools that have comprehensive information on sequestration are also limited. Both mitigation and sequestration measurements are important in informing the planning process of any farm business interested in this space.

The Western Australian Department of Primary Industries and Regional Development established a project with Richard Brake Consulting Pty Ltd to assess the available tools that include livestock and grain production in a mixed farm system for a Western Australian agricultural environment as well as deal with mitigation and sequestration functionality.

Reference is to be paid to:

- Level of detailed inputs vs simplicity of use
- Appropriate inputs and language for Western Australian producers
- Value of outputs and useability of outputs

Also required is the Identification of

- Strengths and weakness of each tool
- Consistency to other tools and calculators
- Gaps or shortcomings in calculations or capture of relevant data

Key Findings

- Whole farm emissions from the calculators ranged from 2,190 t CO_2e to 8,505 t CO2e with an average of 5,127 t CO2e.

- The amount of information and level of detail required varied across all calculators from very simple to highly detailed and was not correlated to the final emissions value.

- Each calculator addressed emissions intensity values, which is the most useful in determining management strategies to offset or reduce carbon emissions, from a simplistic whole of farm value to detailed by emissions type value.

- Each calculator had strengths and weaknesses, no one calculator demonstrated a complete package.

- None of the calculators adequately addressed soil organic carbon movement which appears to be a big omission.

- There is a gap in the market for an online, user friendly carbon calculator that accounts for Western Australian conditions.

- The interpretation of carbon emission results, their application at a farm business level, and the refining of management strategies outside of Emissions Reduction Fund methodologies and third-party interests is not well researched and not well understood. There is a need for further research and extension that is focused on, and directly applicable to farm businesses.

- Currently, producers need to find the most suitable calculator for their business and markets and consistently use it over time to gain an understanding and management of their carbon emissions.

Evaluation of Carbon Accounting Tools

Carbon Accounting Tools

The selection of the calculators to be included in the evaluation was based on the accessibility of the tools to Australian farmers; allowed for the identification of emissions from both cropping and livestock enterprises to provide an overall carbon footprint, and utilised existing production information that was readily available to producers.

Whilst six calculators were considered for inclusion in the evaluation, ultimately only four, being the University of Melbourne's GAF, the Australian Farm Institute's FarmGAS calculator ST, the Cool Farm Alliance's The Cool Farm Tool and SAC Consulting's Agrecalc were assessed as being suitable based on the assessment criteria.

The two that were excluded from evaluation were the CSIRO LOOC-C tool which assesses the outcomes of carbon abatement projects and the CSIRO FarmPrint calculator which is not yet commercially available to the broader farming community and currently only includes dryland broadacre cropping enterprises.

Tools evaluated

Greenhouse Accounting Framework (GAF)

The Beef (B-GAF), Sheep (S-GAF), and Grains (G-GAF) Farm Greenhouse Accounting Framework tools were developed and are maintained by the Primary Industries Challenge Centre and the University of Melbourne using MS Excel spreadsheets and are freely available to download.

The calculators can be found here, http://www.piccc.org.au/resources/Tools.

The tools utilise and are maintained to align with the Australian National Greenhouse Gas Inventory (NGGI) method, to measure the scale and sources of greenhouse gas emissions from farms. They primarily calculate the direct (Scope 1) emissions and Scope 2 (electricity and fuel) emissions, but also include a calculation of carbon sequestration in trees.

For this evaluation SB-GAFv1.3 and GrainsGreenhouseV9.3 calculators were used, and input questions are shown in Appendix 1.

FarmGAS Calculator ST

The FarmGAS Calculator ST is an online platform developed by the Australian Farm Institute that allows farmers, land managers, researchers, and advisors to investigate how different management and production practices might alter the greenhouse gas emissions profile of a farm business or farm enterprise activity.

The calculator can be found here, http://calculator.farminstitute.org.au/login

Producers can use the FarmGAS Calculator ST to create and compare different enterprise and management scenarios for an individual farm or a range of farms.

The online tool has not been updated in the last five years indicating that some of the calculations and methodology within the platform may no longer be appropriate given the emerging scientific advances and discussion regarding greenhouse gas emissions.

The tool includes a financial module that allows the user to compare the financial and emissions performance of a farm with a range of emission reduction scenarios (projects) for that farm. The combination of emissions estimates and financial performance allows the user to evaluate carbon farming projects that might be applicable to their organisation.

Input questions are shown in Appendix 2.

The Cool Farm Tool

The Cool Farm Tool is an online platform that was developed by Unilever, the University of Aberdeen, and the Sustainable Food Lab. It is maintained through the Cool Farm Alliance which includes industry, academia, NGO's, and consultancies and quantifies on-farm greenhouse gas emissions and soil carbon sequestration.

The calculator can be found here, https://coolfarmtool.org/coolfarmtool/

The Cool Farm Tool platform emissions calculations are based on grower inputted data and site sensitive empirical research from a broad range of published data sets and IPCC methods and sits between the IPCC Tier 1 methodology using simple emission factor approaches and the IPCC Tier 3 process-based models that require a greater level of data input and training to interpret.

The platform is one of the few that includes calculations of soil carbon sequestration based on results of published studies built from over 100 global datasets.

Input questions are provided in Appendix 3

Agrecalc

Agrecalc is an on-line platform developed by SRUC (Scotland's Rural College) and SAC Consulting primarily for Scottish farmers that estimates the type, source, and extent of greenhouse gas emissions produced from a whole farm, individual farm enterprises and per unit of saleable product.

The calculator can be found here, https://www.agrecalc.com/

The platform calculates emissions up to the farm gate, including emissions associated with purchased inputs. Any emissions that arise after outputs have left the farm are not included.

Agrecalc is based on a PAS2050 compliant tool and utilises IPCC Tier I and Tier II methodology.

Agrecalc has been included due to its granularity from whole farm to unit of product and focus on farm gate to farm gate emissions.

Input questions are shown in Appendix 4

Evaluation of Carbon Accounting Tools

Tools excluded

CSIRO LOOC-C

LOOC-C is an online tool developed by CSIRO.

The calculator can be found here, https://looc-c.farm/

Its function is to enable land managers to assess options and potential outcomes on specific land areas of eligible greenhouse gas abatement projects under Australia's federal Emissions Reduction Fund.

The tool also gives a prediction of the quantity of Australian Carbon Credit Units that maybe achieved by participating in a carbon farming project.

The tool does not give an assessment of the current greenhouse gas emissions from existing operations on the land area and was excluded for this reason.

CSIRO FarmPrint

The FarmPrint pilot tool is a collaboration involving CSIRO, Macquarie Infrastructure and Real Assets and the Clean Energy Finance Corporation.

The calculator can be found here, https://research.csiro.au/climatesmartagriculture/our-research/improved-footprint/farmprint/

It has initially been designed with a focus on dryland broadacre cropping and takes a cradle-to-farm-gate approach, measuring the greenhouse gas emissions of on-farm activities, as well as the embedded emissions that are found elsewhere in the supply chain – for example in fertilisers, chemicals, and diesel.

FarmPrint does not currently measure emissions from livestock enterprises and is not yet in the public domain and was excluded from the comparison for these reasons.

Evaluation of Carbon Accounting Tools

Evaluated Farm Data

The farm data used for the purpose of the evaluation was from one location representative of a mixed farming business in the high rainfall zone of Western Australia located in the Wandering district.

The same information was used for all calculators, although some required more in-depth information than others, and covered a 12-month production period from February 2020 to January 2021.

The farms' baseline information is listed below.

Cropped area:	2,328 ha
Grazed area:	2,484 ha
2020 rainfall:	455 mm
Five-year average rainfall:	551 mm
Annual average temperature:	16^{o}C
Soil type:	Predominantly Forest Gravels
Crops grown and included:	Barley, Canola, Oats
Flock size:	14,770

Evaluation of Carbon Accounting Tools

Comparison of Information required by each calculator

Each calculator required differing levels of information and detail. Table 1 outlines and compares the information required by each calculator

		PICCC	AFI	The Cool Farm Tool	Agrecalc
Farm Setup					
	Location	Basic	Basic	Detailed	Basic
	Farm size	No	Hectares	Small, medium, large	Yes
	Selection of enterprises	By excel workbook	Yes	Yes	Yes
	Average annual temperature	No	No	Yes	Yes
	Production intensity	No	No	Yes	No
	Price of Carbon	No	Yes	No	No
	Time to complete (mins)	45	90	150	160
Sheep					
	Starting month	No	Yes	No	Yes
	Enterprise area	No	Yes	No	Yes
	Livestock numbers by class	Yes	Yes	Juvenile, Adult reproducing or Adult non reproducing	Yes but limited classes
	Monthly, By Season, Annual Average	By season	Monthly	Annual average	Annual Average
	Liveweight by class	Yes	Yes, but need to change defaults	No	Yes
	Monthly, By Season, Annual Average	By season	By season	No	Annual Average
	Liveweight Gain by class	Yes	Yes, but need to change defaults	No	No
	Monthly, By Season, Annual Average	By Season	By season	-	-
	Dry matter Intake	Yes, but need to change defaults	Yes, but need to change defaults	Yes	No
	Sheep purchased by class	Yes	No	No	Yes
	Monthly, By Season, Annual Average	Annual Average	-	-	Annual Average
	Breed of sheep purchased	Yes	No	No	No
	Sheep sold by class	Yes	No	No	Yes
	Monthly, By Season, Annual Average	Annual Average	-	-	Annual Average
	Total Kgs product turned off	By default	By default	Entered	LWT turned off by class
	Number Shorn by class	Yes	No	No	No
	Monthly, By Season, Annual Average	Annual Average	-	No	No
	Wool shorn kg/head	Yes	Yes	No	No
	Clean wool yield per class	Yes	Yes	No	No
	Total Kgs Wool	By default	By default	% of product turned off	Yes
	Adjust carbon content of wool	Yes	No	No	No
	Proportion of ewes lambing per season	Yes	Yes, but measured in ewes lactating	No	
	Seasonal lambing rates	Percentage	Number of lambs	No	Yes

	Sheep (Cont.)	PICCC	AFI	The Cool Farm Tool	Agrecalc
	Percentage of legumes in pasture	No	Yes	No	No
	Percentage of pasture area burnt	No	Yes	No	No
	Urea fertiliser used on pasture	Yes	Yes	No	Yes
	Urea fertiliser used on cropping area grazed by sheep	Yes	No	No	Yes
	Account for phosphate fertiliser	Yes	No	No	Yes
	Account for lime applied	Yes	No	No	Yes
	Quantity applied	Yes	Yes	No	Yes
	Manure Management	No	No	Yes	Yes
	Electricity source	Yes	No	Yes	Yes
	Annual Electricity consumption	Yes	No	Yes	Yes
	Annual diesel consumption	Yes	No	Yes	Yes
	Annual petrol consumption	Yes	No	Yes	Yes
	Other Fuel Consumption	No	No	Yes	Yes
	Grain purchased for feed	Yes	No	Yes	Yes extensive list
	Hay purchased for feed	Yes	No	Yes	Yes
	Herbicides	Sort of	No	No	No
	Waste water production	No	No	Yes	Yes
	Road Transportation		No	Yes	Yes
Crop					
	Crop type	4	15	5	13
	Irrigated selection	Yes	Yes	No, but has an irrigation section	
	Crop Area	Yes	Yes	Yes	Yes
	Grain yield	Yes	Yes	Yes	Yes
	Fertiliser type	No	2	unlimited	6
	Quantity applied	yes	Yes	Yes	Yes
	Percentage of Nitrogen	Yes	Yes	Yes	Yes
	Percentage of crop area fertilised	No	Yes	Yes	By crop type
	Chemical Use	No	No	Yes	Yes
	Stubble burnt	Yes	Yes	Yes	No
	Ability to adjust crop residue estimates	Yes, but need to change defaults	Yes, but need to change defaults	Yes	Yes
	Ability to adjust emissions factors	Yes, but need to change defaults	Yes, but need to change defaults	No	No
	Soil texture	No	No	Yes	No
	Soil organic matter %	No	No	Yes	No
	Soil moisture	No	No	Yes	No
	Soil drainage	No	No	Yes	No
	Soil pH	No	No	Yes	No
	Annual Electricity consumption	Yes	No	Yes	Yes
	Fuel type and quantity used	Yes	No	Yes	Yes
	Wastewater emissions	No	No	Yes	Yes
	irrigation events	No	No	Yes	No
	Road Transportation	No	No	Yes	yes
	Crop allocated to Livestock	No	No	No	Yes
	Carbon sequestration in trees	No	Yes	Yes	No

Table 1: Comparison of information required by each calculator

Results

The results from each of the calculators are shown in Table 2 and displayed in Chart 1.

There is a large difference between the values generated by the four calculators which can be superficially explained by being designed for a different country in the case of Agrecalc, and not being updated for a number of years in the case of FarmGAS; however, the large range of results raises doubts in the users mind as to the accuracy of the underlying emissions assumptions and subsequent calculations.

The AFI FarmGAS calculator gave the lowest results across the three areas of comparison, which were 75% below the consistently highest calculator being Agrecalc.

PICCC GAF and The Cool Farm Tool were within 10% of each other at the whole farm level, with a bigger variance occurring when the individual enterprises were compared.

	Crop	Sheep	Whole Farm
PICCC GAF	1681.60	3044.17	4725.77
AFI FarmGas	557.80	1632.82	2190.62
The Cool Farm Tool	2093.96	2861.96	4955.92
Agrecalc	3021.01	5487.07	8505.08
Average	1838.59	3256.50	5095.10

Table 2: Calculator results expressed as tonnes CO_2e/year

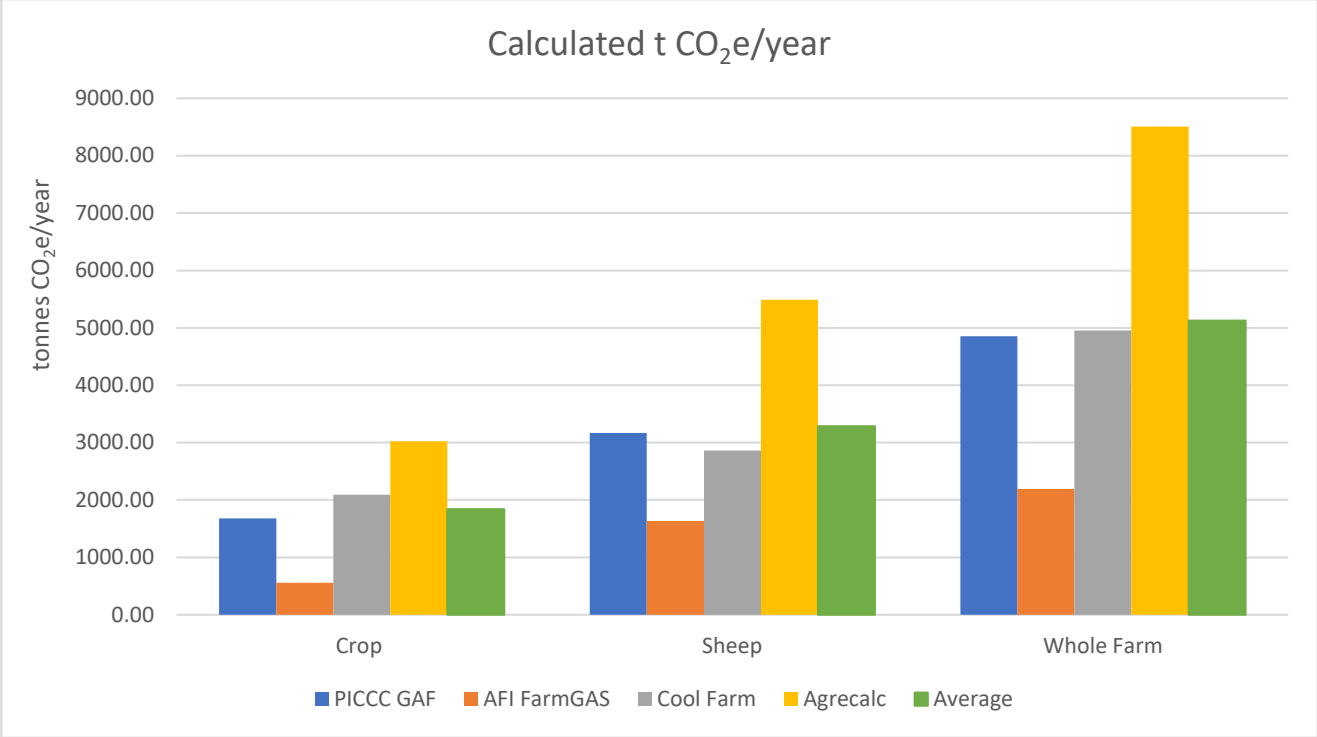


Chart 1: Calculator emissions results by enterprise type and whole farm

Whilst the total emissions by enterprise and the whole farm are important, especially when considering the impact on the financial cost of carbon emissions, for comparative purposes it is worth considering the variation from the average, which is illustrated in Chart 2. The average result is used as the baseline and the variance above or below that is displayed as a percentage.

The most consistent calculator was the PICCC GAF calculators with the results falling within 10% of the average across the crop, sheep, and whole farm calculations. The GAF calculators suggest that "Net farm emissions and emissions intensity values generated by this calculator are generally accurate to within +/- 20%".

The Cool farm tool was the next most consistent with its results falling within a 15% range of the average, whilst the FarmGAS results were 59% below the group average and the Agrecalc results were 67% above average.

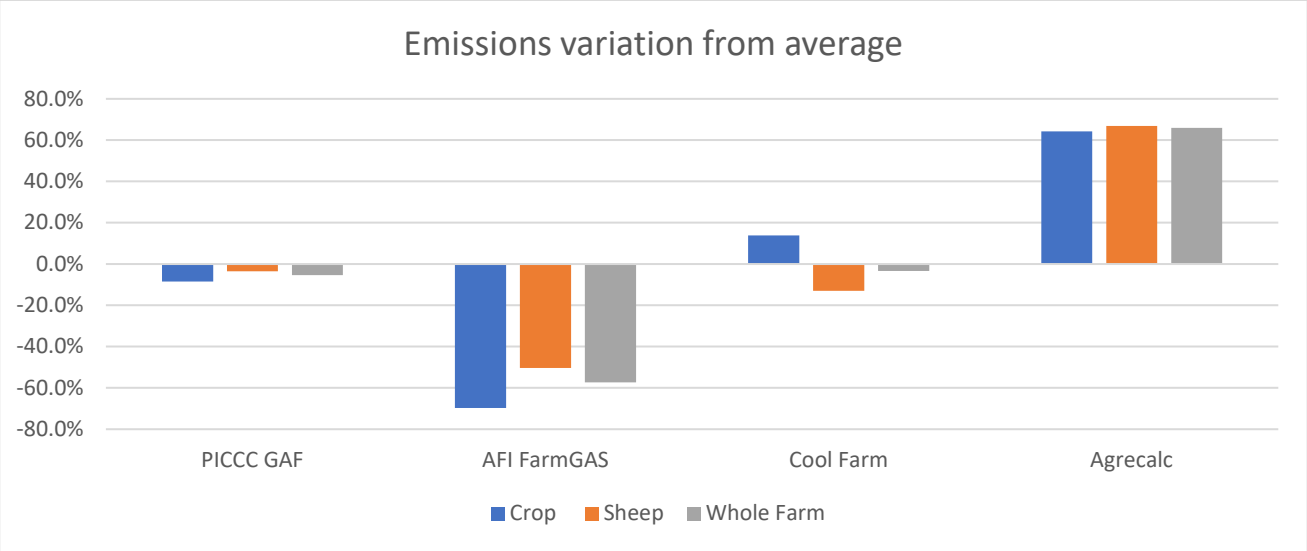


Chart 2: Variation of individual calculator results from the group average

Emissions intensity by kg of product, illustrated in Chart 3 is a more accurate way of assessing the impact of management activities on carbon emissions.

All the tools provided an emissions intensity result for the sheep enterprise, although Agrecalc needed interpreting to local units. Half of the calculators did not provide an emissions intensity for grain whilst the Cool Farm Tool and Agrecalc did.

Emissions associated with barley production in Australia lie between 167kg CO2e and 260kg CO2e/t grain produced and wheat 197kg CO2e and 500kg CO2e/t grain produced[1]. Dryland canola lies between 439kg CO2e and 511kg CO2e/t grain produced[2]. The ranges in the emissions by grain type depend on location within Australia.

Sheep emissions intensity in Western Australia averages 6.7 kg CO2e / kg LWT ranging from 5.8 kgs to 8.1 kg CO2e / kg lwt[3]

[1] Aaron Simmons and Alex Murray – GRDC Research Code DAN00186
[2] Greenhouse gas emissions from the cultivation of canola oilseed in Australia, CSIRO, November 2017
[3] Carbon Footprint and Carbon account workshops, MLA, Sept 2020

All of the calculators produced average crop emissions intensities that fell within expected ranges, although Agrecalc did produce higher levels across all crop types than expected and Cool Farm Tool did in the barley.

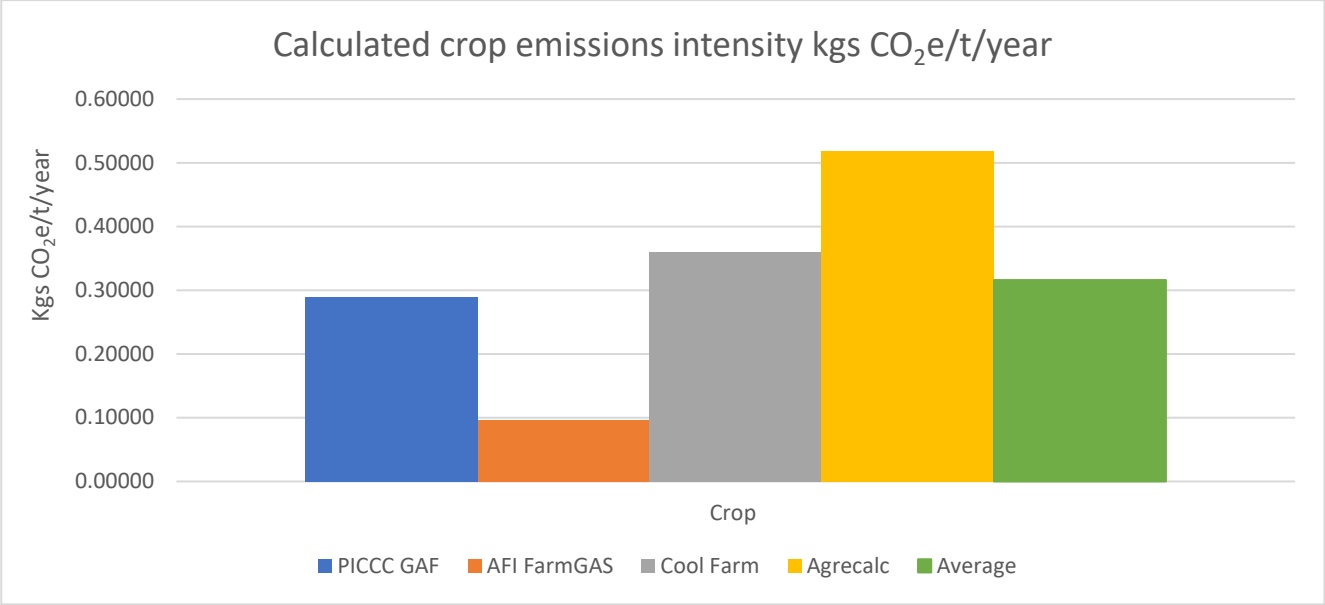


Chart 3: Calculator emissions intensity results for the crop enterprise

In the sheep enterprise, shown in Chart 4, SB-GAF and the Cool Farm Tool produced an emissions intensity within the expected range, whist both Agrecalc and FarmGAS fell outside of expected ranges.

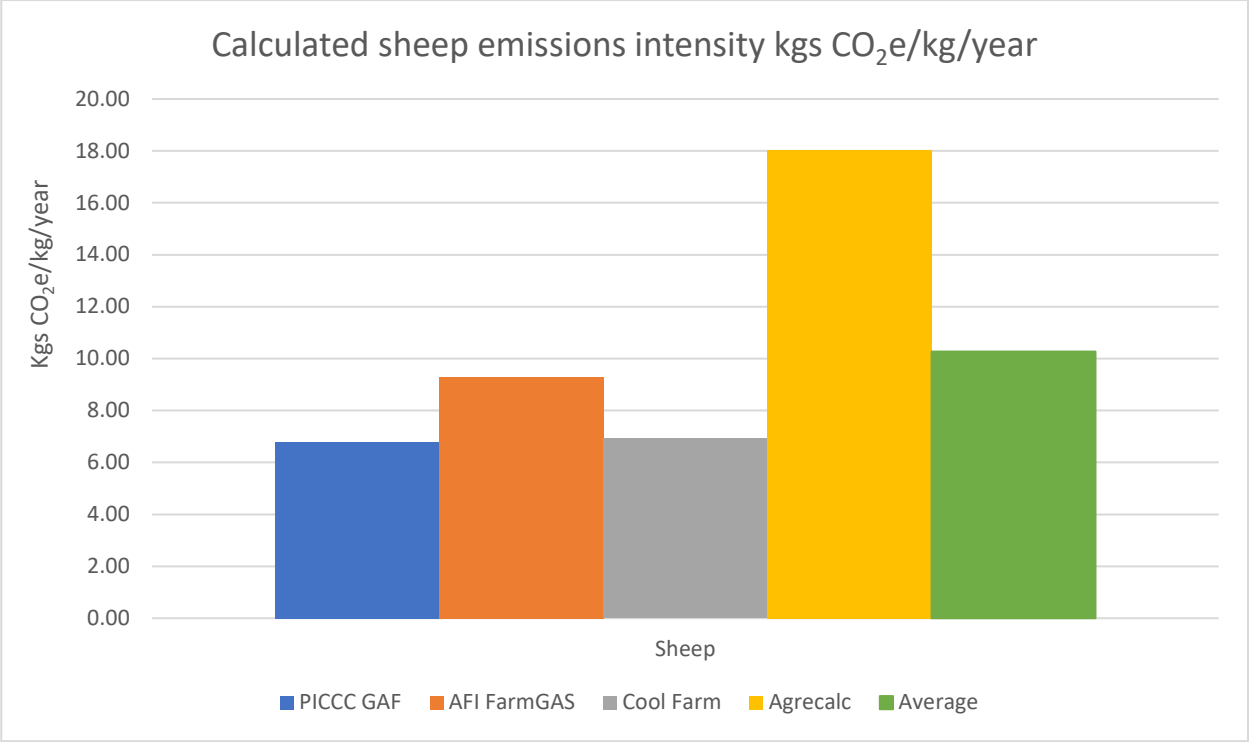


Chart 4: Calculator emissions intensity results for the sheep enterprise

This translated into a similar view for the whole farm analysis shown in Chart 5. The average is dragged higher by the Agrecalc outlier.

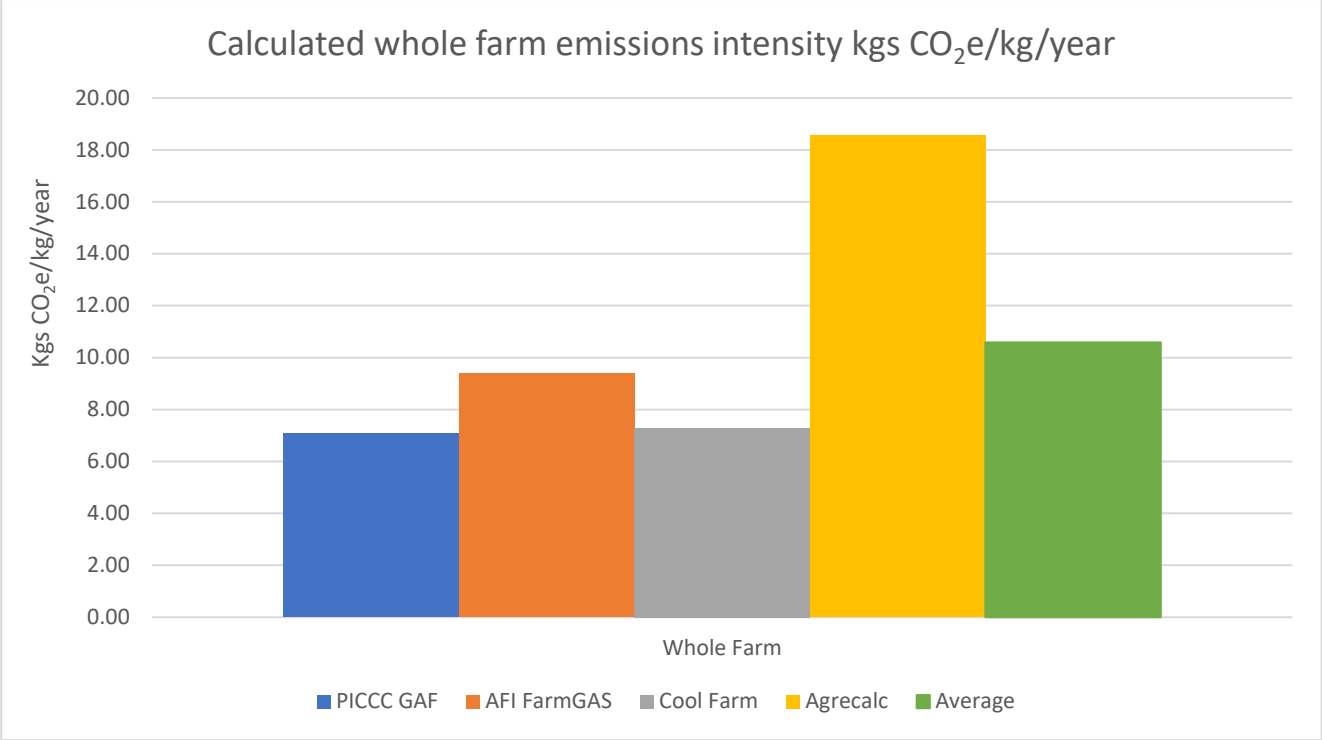


Chart 5: Calculator emissions intensity per kg of product by whole farm

Discussion

Greenhouse Accounting Framework (GAF)

The two excel spreadsheets, one for grain and one for sheep and beef that make up this calculator are easy to download on to a local computer and easy to use with a simple spreadsheet layout.

Data entry into the crop template took approximately 10-15 minutes including the collation of the information. The sheep template took longer at approximately 30 -35 minutes including collating the information.

Information for the sheep calculator was simple and were numbers that most users would have to hand including sheep class numbers, liveweight by class and liveweight gain by class which was broken down into spring, summer, autumn and winter. This negates the need for a dry stock equivalent rating.

Information was also required for the kgs of wool shorn per head per class along with the clean wool yield per class (although this information was not available from the evaluation farm, so the average yield was used across all classes). The calculator accounted for annual sales and purchases of sheep including their liveweight.

Information for the crop calculator was also simple with information that the majority of users will have to hand such as crop area and yield, although the nitrogen component of the fertiliser section would require some thought by the user before entry.

The excel based nature of the calculators allows the user to see the underlying emissions factors and calculations, giving them the ability, if they have the knowledge, understanding and confidence to change the factors and influence the result.

The outputs, attached in Appendix 5, are easy to read, presented in a single data summary spreadsheet showing by greenhouse gas, by where the emissions come from, and in the case of SB-GAFv1.3 the results are broken down into scope 1, 2 and 3 emissions. The crop calculator does not provide this information by crop, but as a summary by type. The sheep calculator provides an overall emission intensity figure but does not break this down by greenhouse gas type or originating source. The crop calculator does not provide any emissions intensity data breakdown.

A Western Australian user would be familiar with, and able to relate to and understand the terminology used in both the questions asked in the input sheets and the results provided in the output summary.

Despite its ease of use of the spreadsheets there are a number of weaknesses.

1. Each workbook is downloaded on to a computer as a standalone workbook so there are no automatic updates with changes. The user must go back to the PICCC website each time to check for the latest version. There is no ability to link farm software into the product in order to utilise existing farm software packages that already collect a lot of the necessary data.

2. Location of the farm to be analysed is simplistic in both calculators limited to a state-based selection dropdown box. There is no question asking average annual temperature or rainfall.

3. The ability to compare scenarios and the impact of management changes is limited to starting a new workbook for each scenario and manually comparing them in an external spreadsheet.

4. Whole farm analysis is similarly limited by the individuality of the workbooks. The user has to manually add each enterprise together externally in order to obtain a whole farm emissions number.

5. Whilst the ability to see the underlying emissions factors and calculations is valued, there is the potential for any of the cells to be accidentally changed by the user, even with the workbook protected, and create a significant error without realising or saving the calculator with a change and forgetting when and where the change occurred.

6. The crop workbook is limited to four crops and the break crops have been grouped into broad categories of pulses and oilseeds, limiting detail.

7. Fertiliser products in both calculators is limited to either tonnes of fertiliser applied as nitrogen in the sheep calculator or kg/ha in the case of the crop calculator.

8. There is a map of Australia with an orange zone, and a question that asks the user whether the farm is located within it. The resolution is low, and there are no locations to define the boundaries, so farms that are located close to the boundary will have difficulty determining whether they are within or outside of the orange area. The orange area determines where annual evapotranspiration to annual rainfall is greater than 0.8, giving a greater chance of leaching nitrates and has a large impact on total emissions.

9. There are no questions allowing a user to define soil type or parameters such as soil organic matter content, pH, drainage etc. As the focus on using the soil as a carbon sink increases and management practices to increase soil carbon explored, this is an area that needs to be considered.

10. Chemical use is simplistic and is accounted for in the sheep calculator by a single question asking for the litres of herbicides/pesticides used, there is no account taken in the crop calculator.

FarmGAS Calculator ST

The FarmGAS calculator's online platform was easy to access and navigate.

Data entry for the template took approximately 90 minutes and included time to gather the required information.

Information for the sheep section was simple and were numbers that most users would have to hand including sheep class numbers although this was broken down monthly and would require accurate tracking of sheep movements. The next section required breeding ewes lactating and the number of lambs at foot again broken down by month. A dry stock equivalent rating by class allows the user to fine tune the calculator to their own breed and feed requirements for each stock class.

Information was also required for the kgs of wool shorn per head per class along with the clean wool yield per class (although this information was not available from the evaluation farm, so the average yield was used across all classes).

The calculator did not ask for annual sales and purchases of sheep.

Liveweights, daily liveweight gain, and feed intake were prefilled with default values, but the user had the ability to adjust the values if desired.

Information for the crop section was simple with crop area and yield required and allows for up to 15 crop types to be selected. The fertiliser section was restricted to just two fertiliser applications which is unlikely to be enough for most growers, so some amalgamation may be necessary which increases the chance of error.

A tab allows the user to define stubble management, and even though in the evaluation the stubble burnt question was selected as No the results still returned a value for stubble burning that was approximately 30t of CO_2e of the total emissions, so there is an anomaly in the calculation here.

The FarmGAS calculator gives the user the ability to adjust the emissions factors used in the calculations should the user have different values, but the underlying calculations are not visible to the user.

For the evaluation, the system defined values were used.

FarmGAS displayed the results online for the crop and sheep enterprise, but only the farm summary is able to be downloaded as a PDF file that presented the results in a tabular format. The outputs are easy to read, showing results by gas and by where the emissions come from. The results are not broken down into scope 1, 2 and 3 emissions and they do not provide emissions by crop type, but as a summary.

FarmGAS provides emission intensity results by greenhouse gas and by originating source.

FarmGAS has scenario functionality that allows users to see the impact of changing management factors on emissions allowing for a more accurate cost/benefit analysis of potential management changes to be undertaken.

FarmGAS has an additional module that enables the user to input financial data that provides a basic gross margin along with a net value/cost of emissions. This section was not used in the evaluation.

A Western Australian user would be familiar with, and able to relate to and understand the terminology used in both the questions asked in the input sheets and the results provided in the output summary.

Results and the output from the FarmGAS calculator are attached in Appendix 6

There are a number of weaknesses with the AFI FarmGAS calculator.

1. The platform has not been updated in a number of years, so some of the prescribed emissions factors and calculators maybe outdated especially where science and research in the livestock space has refined the impact of emissions from individual animals.

2. Location of the farm to be analysed is a state-based selection from a clickable map that then allocates a region. There is no question asking average annual temperature or rainfall.

3. No questions were asked by the platform regarding diesel usage in terms of litres used, electricity use in terms of KWh or any transportation factors such as distance from market or to transport fertiliser to farm if the user was undertaking these activities. Fuel usage can have an impact that needs to be accounted for, especially in the crop enterprise and with larger operations.

4. Fertiliser inputs are limited to two applications which means that the user in certain situations will need to amalgamate applications or products to account for the nutrients applied which may lead to an error, especially where two products are used such as a in a seeding fertiliser scenario.

5. No questions are asked about herbicide, pesticide or fungicide used.

6. There are no questions allowing a user to define soil type or parameters such as soil organic matter content, pH, drainage etc. As the focus on using the soil as a carbon sink increases and management practices to increase soil carbon explored, this is an area that needs to be considered.

7. Doubt regarding the accuracy of underlying calculations and confidence in any results is illustrated by the attribution of a carbon emission to stubble burning, despite setting the options for stubble burning to zero.

The Cool Farm Tool

The Cool Farm Tool online platform was easy to access and navigate. The platform is continuously updated.

There is a large amount of information required for this calculator, most of which the user will have available to them. Data entry took around 150 minutes, and this included an allowance for collating the data. The free functionality allows for up to 5 enterprise assessments. Unlocking full functionality starts at approximately $3,000 for businesses with less than 50 employees and goes upwards from there but would not affect many Western Australian farm businesses.

Farm location is selected via a clickable map, or by providing GPS coordinates and the type of climate, Tropical or Temperate can be selected along with providing the annual average temperature which is used in the calculation of manure and wastewater emissions.

The selection of enterprises in both the crop and the livestock were more broadly relevant to North American production systems some of which are relevant to Western Australian producers; the break crops needed to be entered under either other grains in the case of canola, or other legumes in the case of lupins.

Sheep information required is aggregated into juveniles, adult productive phase, and adult nonproductive phase. The average annual number of head in this phase is required, along with the length of time in this phase.

There are questions around feed mix, with an unlimited number of feed types able to be added and daily dry matter intake is user defined. Manure management is also accounted for.

Enterprise outputs are determined by the user providing the kilograms of finished product, with an allocation for the wool component. The calculator then moves through energy use and transportation.

Crop information required is detailed, and as well as the usual area and tonnes produced questions, also asked a number of soil parameters such as texture, organic matter content, moisture, and pH.

Unlimited fertiliser inputs are provided for, allowing the user to accurately calculate nutrient application rates and fertiliser templates are also provided.

Embedded emissions from crop protection products are accounted for on a more basic level than the fertiliser by selecting a treatment category and the number of applications. A baseline emissions figure of 20.5kg/ha per application regardless of active ingredient and application rate is added to the total. Energy use, irrigation and transportation are also accounted for.

The crop section provides questions to account for carbon changes and sequestration such as “Have you changed tillage practices in the last 20 years” and had a significant effect on the greenhouse gas emissions figures. This section was not included in the evaluation as none of the other calculators had consistent measures for changes in soil carbon.

Scenario analysis is provided for in the full version of the platform.

The Cool Farm Tool displays the results online for the crop and sheep enterprise in an easy to read tabular and chart format. The results show emissions by greenhouse gas and by where the emissions come from. The results are not broken down into scope 1, 2 and 3 emissions. The results provide emissions by individual enterprise assessment, but the free version does not allow these assessments to be aggregated, which must be undertaken manually in order to provide for a whole farm greenhouse gas emissions figure. The results provide an emissions intensity by greenhouse gas and by originating source.

Results and the output from the Cool Farm Tool calculator are attached in Appendix 7

Whilst some of the terminology was slightly different, such as the aggregation of sheep ages, broadly a Western Australian user would be familiar with, and able to relate to and understand the terminology used in both the questions asked in the input sheets and the results provided in the output summary.

There are a number of weaknesses in this platform.

1. The platform is an international platform and has been designed for an international audience. Some of the data calculations may not yet be specifically calibrated for Australian conditions.

2. There are only two climate selections – Temperate (10^{o}C) and Tropical (18^{o}C). Changing this parameter added 130t CO_2e to the emissions. This was a concern given the sample farm had an annual average temperature of 16^{o}C.

3. There is no ability to adjust the underlying emissions factors to suit local conditions and there is no ability to see how the under lying calculations are performed.

4. The use of embedded emissions factors for certain operations such as chemical applications and the aforementioned temperature parameter removes a more customizable approach.

5. Distinction between multiple crop residue disposal methods such as removing straw, incorporating straw or stubble burning cannot be made as the platform only allows the selection of one method. This was ok with the sample farm as only one method is utilised but would be a problem for those farms that utilise multiple sources.

6. The breakdown of the sheep stock classes into juveniles and adults productive and nonproductive with annual average numbers is limiting given the changes in flock size that can occur through a season related to in-paddock feed availability. Similarly, for liveweight and liveweight gain by head and class.

7. An anomaly arose when inputting the sheep data with the progress indicator showing that only 75% of the form had been completed. Upon checking a number of times every section had been completed and the source of this was unable to be established.

8. Whilst a Json download file functionality is provided, there is no easy and clean way to download a useable report for the average user. This may not occur in the full version of the platform.

Agrecalc

The Agrecalc online platform was easy to access and navigate. The platform is continuously updated.

There is a large amount of information required for this calculator, most of which user will have available to them. Data entry took around 160 minutes, and this included an allowance for collating the data. The platform is free for farmers to access and assess, but greater reporting and greenhouse gas mitigation strategies come with additional subscription levels. Subscriptions start at approximately $135 for basic access.

Data entry is via a series of dropdown selection boxes, tick boxes or spreadsheet style forms. As the platform is Scottish designed for a United Kingdom audience some of the terminology and enterprise descriptions will not be immediately obvious to a Western Australian user.

The selection of enterprises in both the crop and the livestock were more broadly relevant to United kingdom production systems some of which are relevant to Western Australian producers although there is no ability to account for lupins. Selection of sheep flock types also bore minimal resemblance to Western Australian flock structures.

Sheep information required is aggregated into six types, with terminology being different from that used in Western Australia, but a helpful description is provided which makes allocation easier. There is no stock class for wethers.

The average annual number of head in each class is required, along with the average liveweight, including weights at weaning and one year of age for certain classes. Average annual purchases, sales and death numbers are accounted for, along with the average liveweights.

There are questions around amount and type of feed used, with 48 different feed types available to be included as well as the ability for user defined feeds. Manure management is also accounted for.

Crop information required is detailed, and as well as the usual area and tonnes produced questions asked other questions such as harvested dry matter percentage by crop type. Up to six fertiliser inputs are provided for, allowing the user to provide nutrient makeup of each product used by crop type including organic manures and lime.

Embedded emissions from crop protection products are accounted for on a more basic level than the fertiliser by selecting a treatment category and the area it was applied to by crop type.

There is a detailed grain reconciliation form and the calculator then moves through energy use and transportation.

Scenario analysis is provided for following subscription upgrades of the platform.

Agrecalc displays the results online for the crop and sheep enterprise in an easy to read tabular and chart format. The results show emissions by greenhouse gas and by where the emissions come from. The results are not broken down into scope 1, 2 and 3 emissions.

The results provide emissions by individual enterprise type, along with a whole farm aggregation. The calculator provides a total emissions intensity by enterprise type. The report also provides practical measures for reducing emissions.

Results and the output from the Agrecalc calculator are attached in Appendix 8

Whilst some of the terminology was different, such as sheep descriptions, for example gimmers and shearlings, broadly a Western Australian user would be familiar with, and able to relate to and understand the terminology used in both the questions asked in the input sheets and the results provided in the output summary.

There are a number of weaknesses to this platform.

1. The platform is a Scottish platform and has been designed for an United Kingdom audience. Some of the data calculations may not be specifically calibrated for Australian conditions.

2. There is no ability to adjust the underlying emissions factors to suit local conditions and there is no ability to see how the underlying calculations are performed.

3. There are no questions allowing a user to define soil type or parameters such as soil organic matter content, pH, drainage etc. As the focus on using the soil as a carbon sink increases and management practices to increase soil carbon explored, this is an area that needs to be considered.

4. Sheep terminology is different to Western Australia (tups, gimmers, and shearlings) and there is no class for wethers.

5. No account is taken of stubble burning.

6. There is no file download functionality in the free version for the average user. This may not occur within the subscription version of the platform.

Evaluation of Carbon Accounting Tools

Summary

It could have been anticipated before starting the evaluation that the results from the four calculators would been different when consideration is given to the large difference in the amount and detail of information that is required by each calculator even with standardized data being entered. What is apparent is that the quality of the raw data is imperative regardless of the calculator used. The PICCC SB-GAF calculator says it best - "The accuracy of results generated by this calculator are highly dependent on the quality and accuracy of data entered into the calculator."

After evaluating each calculator and then comparing them, each had strengths and weaknesses in different areas, and all had functionality that was liked and disliked.

For ease of data entry, simplicity of data required, ease of understanding terminology and providing most confidence in the integrity of the underlying emissions factors used and calculations, it was found that the SB-GAF and Grainsgreenhouse calculators from PICCC was the best.

For amount and detail of information required, detail and readability of reports it was difficult to separate The Cool Farm Tool and Agrecalc, however both would need refining to better represent Western Australian production systems more accurately in their data collection systems.

For the online platforms, both FarmGAS and Cool Farm Tool were easy to navigate and user friendly with the Cool Farm Tool providing cleaner and simpler user interface screens.

It is not surprising that Agrecalc returned the highest values for the crop and sheep enterprise and the whole farm given that it is designed in Scotland and intended for use in the United Kingdom.

It was surprising that the AFI FarmGAS calculator was significantly below the results from the PICCC GAF crop and sheep calculators, reflected in the whole farm position. On reflection, given that the calculator has not been updated for a number of years, it is probably not surprising that as the other calculators are refined and developed the discrepancy in results would widen.

The PICCC SB-GAF and Grainsgreenhouse gas calculators provided the most accurate emissions calculation and values when considered against the average of all the calculators and gave the most confidence as to the accuracy and relevance to Western Australian mixed farming enterprise.

Agrecalc is the only calculator to give practical measures to improve efficiency and reduce emissions. The inclusion of such options and scenario analysis against the status quo will be important in giving land mangers confidence to make changes to production systems.

None of the emissions calculators adequately address the issue of soil organic carbon and its impact on total greenhouse gas emissions from a farm. The inclusion of soil parameters and their influence on total emissions will be important for any calculator to include in the future, especially with management changes that are necessary to reduce net emissions and comparison to other options.

There is a gap in the market for an online, user friendly carbon calculator that accounts for Western Australian conditions; that provides a net greenhouse gas emissions value for a whole farm after considering emissions and sequestration across all enterprises broken down into intensity within the farm business; and is able to identify and quantify the benefits of any management change in a mixed farming situation.

Appendix 1 – PICCC input sheets

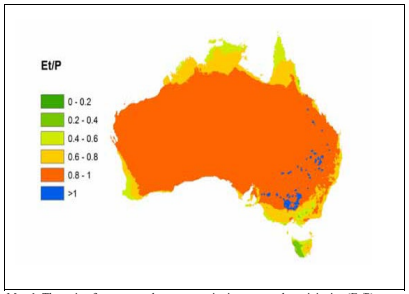
Enter your farm data for each animal class and season

Farm Name Wandering

Choose your region in Australia: SW WA (4)

Is your property in orange zone? (Ref Map. 1): No

	Seasons	Rams	Wethers	Maiden Breeding ewes	Breeding ewes	Other ewes	Ewe lambs	Wether Lambs	Trade lambs and hoggets	Trade wethers	Trade ewes	Units
Livestock Numbers	Spring	200	0	150	6775	0	3321	3321	0	0	0	head
	Summer	200	2985	150	7250	1200	0	0	2985	0	0	head
	Autumn	200	2985	150	7250	1200	0	0	2985	0	0	head
	Winter	200	1579	150	6775	0	3321	3321	2985	0	0	head
	Average	200	1887	150	7013	600	1661	1661	2239	0	0	head
Liveweight	Spring	75	60	50	55	55	30	30	20	60	0	kg/head
	Summer	65	55	45	50	50	30	30	25	55	0	kg/head
	Autumn	65	48	40	45	45	10	10	35	52	0	kg/head
	Winter	65	48	45	50	50	20	20	52	50	0	kg/head
	Average	68	53	45	50	50	23	23	33	54	0	kg/head
Live weight gain (LWG)	Spring	0.05	0.11	0.02	0.11	0	0.2	0.2	0.2	0.11	0	kg/day
	Summer	-0.05	-0.05	0.00	0.00	0.00	0.05	0.05	0.05	-0.05	0.00	kg/day
	Autumn	0.00	-0.03	-0.02	-0.02	0.00	0.05	0.05	0.05	-0.03	0.00	kg/day
	Winter	0.00	-0.02	0.00	0.00	0.00	0.10	0.10	0.10	-0.02	0.00	kg/day
	Average	0.00	0.00	0.00	0.02	0.00	0.10	0.10	0	0	0	kg/day
Feed Availability	Spring	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	t/ha
	Summer	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	t/ha
	Autumn	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	t/ha
	Winter	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	t/ha
	Average	1.73	1.73	1.73	1.73	1.73	1.73	1.73	1.73	1.73	1.73	t/ha



Map 1. The ratio of mean annual evapotranspiration to annual precipitation (Et/P)

Purchase inventory

	Rams	Wethers	Maiden Breeding ewes	Breeding ewes	Other ewes	Ewe lambs	Wether Lambs	Trade lambs and hoggets	Trade wethers	Trade ewes	Purchases - breeding herd	Purchases - trade sheep
No. head purchased	**32**	**0**	**0**	**0**		**0**	**0**					
Purchase weight (LW/hd)	**90**	**55**	**40**	**50**		**44**	**44**					
Live weight / category	2,880.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2,880	0

Purchased sheep	**Merino**	**Cross-bred**
% of sheep purchased	**100%**	**0%**

Sale inventory

											Sales - Breeder operation	Sales - trade sheep
No. head sold	37	0	1269	1773		0	0					
Sale weight (LW/hd)	90	52	52	60		44	44					
Live weight / category (kg)	3,330.0	0.0	65,988.0	106,380.0	0.0	0.0	0.0	0.0	0.0	0.0	175,698	0

LWG (trade sheep)

	Total LWG trade sheep (kg)
kg/hd	0.0 0.0 0.0
kg/category	0.0 0.0 0.0 — 0.0

Number shorn	200	2985	150	7250	1200	3321	3321	2985	0	0	
Wool shorn kg/head	3.501978239	3.50197824	3.501978239	3.501978239	3.501978239	3.501978239	3.501978239	3.501978239	3.501978239	3.501978239	
Greasy wool production (kg/yr)	700.3956479	10453.405	525.2967359	25389.34224	4202.373887	11630.06973	11630.06973	10453.40504	0	0	74984.35806
Clean wool yield	69	69	69	69	69	69	69	69	69	69	%
Clean Wool (t/year)	0.48	7.21	0.36	17.52	2.90	8.02	8.02	7.21	0.00	0.00	51.7

Carbon content of Wool 45.2 %

	Seasons	
Proportion of ewes lambing	Spring	0%
This must be a %	Summer	0%
	Autumn	100%
	Winter	0%
	Total	100%
Seasonal lambing rates	Spring	0%
	Summer	0%
	Autumn	90%
	Winter	0%
	Total	90%

	Seasons	Rams	Wethers	Maiden Breeding ewes	Breeding ewes	Other ewes	Ewe lambs	Wether Lambs	Trade lambs and hoggets	Trade wethers	Trade ewes	Units
Crude Protein (CP)	Spring	18.00	18.00	18.00	18.00	18.00	18.00	18.00	18.00	18.00	18.00	%
	Summer	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	%
	Autumn	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	6.00	%
	Winter	21.00	21.00	21.00	21.00	21.00	21.00	21.00	21.00	21.00	21.00	%
	Average	12.75	12.75	12.75	12.75	12.75	12.75	12.75	12.75	12.75	12.75	%
Dry matter digestibility (DMD)	Spring	73.00	73.00	73.00	73.00	73.00	73.00	73.00	73.00	73.00	73.00	%
	Summer	55.00	55.00	55.00	55.00	55.00	55.00	55.00	55.00	55.00	55.00	%
	Autumn	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	%

	Winter	76.00	76.00	76.00	76.00	76.00	76.00	76.00	76.00	76.00	76.00	%
	Average	63.50	63.50	63.50	63.50	63.50	63.50	63.50	63.50	63.50	63.50	%

		Dryland		Irrigated		
Urea Fertiliser Pasture (enter as tonnes of urea)		0	0.00		0	tonnes
Urea Fertiliser Crops (used for grazing sheep - tonnes urea)		0	0.00		0	tonnes
Other N fertiliser (enter value as tonnes of N)						tonnes N
Total fertiliser			**0**		**0**	tonnes
Single Superphosphate		22				tonnes
Limestone applied to soils	Total for farm					t
	Fraction	1				Fraction

Energy & fuel	
Electricity Source	State Grid
Annual Diesel Consumption (for sheep enterprise)	23743 litres/year
Annual Petrol Consumption (for sheep enterprise)	litres/year
Annual Electricity Use (for sheep enterprise)	KWh
Grain purchased for sheep feed (all grains)	348 tonnes
Hay purchased for sheep feed (tonnes)	tonnes
Herbicides/pesticides	L

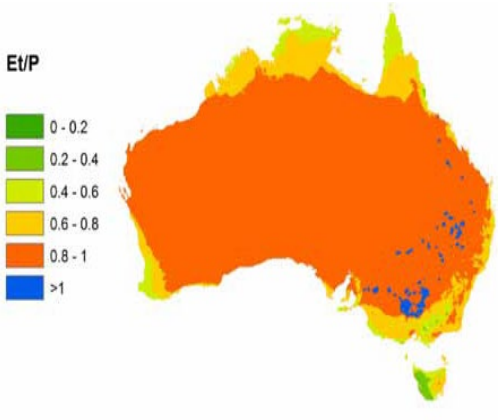
Enter your farm data

Farm Name	**Wandering**

Choose your region in Australia: SW WA

Electriticy Source: State Grid

Farm cropping details	Barley	Oilseeds	Oats	Other Cereals	
Production System	Non-Irrigated Crop	Non-Irrigated Crop	Non-Irrigated Crop	Irrigated Crop	
Is the crop in orange zone? (Ref Map. 1)	No	No	No	No	
Average grain yield	3.36	1.83	3.24	0.00	t/ha
Area sown	990.00	1308.00	30.00	0.00	ha/farm
Nitrogen Fertiliser Use	79.00	75.00	79.00	0.00	kg N/ha
Urea Application (included in the above)	69.00	23.00	69.00	0.00	kg Urea /ha
Sewage Sludge Applied	0.00	0.00	0.00	0.00	kg N/ha
Mass of Lime Applied	0.00	400.00	0.00	0.00	kg/ha
Fraction of Lime as limestone vs dolomite	0.00	0.00	0.00	0.00	Limestone/dolomite
Fraction of the annual production of crop that is burnt (I	0.00	0.00	0.00	0.00	ha/total crop ha
Annual Diesel Consumption	136057.00				litres/year
Annual LPG Use	0.00				litres/year
Annual Electricity Use	0.00				KWh



i.e. does your farm receive more rain or irrigation that evaoporation, so that it can leach nitrate?

Appendix 2 – FarmGAS input sheets

Flock Numbers

Sheep Enterprise Name: Sheep

Starting Month: February

Start season is: Summer

Enterprise Area (ha): 2484

Value of Emissions	Default	Revised	% Change from default
Tonnes CO_2-e	0.00	0.00	0.00%
Carbon Price $/tonne	$18.40		
Total Value:	$0.00	$0.00	0.00%

NUMBERS ON HAND

	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan
Breeding Ewes	7250	6625	6625	6625	6775	6775	6775	6775	6775	6775	6775	5155
Maiden Ewes	150	150	150	150	150	150	150	0	0	0	0	2116
Other Ewes	1200	1200	1200	0	0	0	0	0	0	0	0	1770
Lambs/Hoggets	2985	2985	2985	2985	2985	2985	0	0	0	0	0	3065
Rams	200	200	200	200	200	200	200	200	200	195	195	195
Wethers	2985	2565	02397	1783	1579	0	0	0	0	0	0	2942

	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan
Total number of head per month	14770	13725	13557	11743	11689	10110	7125	6975	6975	6970	6970	15243
Total DSE's per month	19977.5	18370	18202	16388	16469	14890	13397.5	13172.5	13172.5	13165	13165	19505.5

MILK PRODUCTION (EWES LACTATING) AND MILK CONSUMPTION (LAMBS ON MOTHER)

	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan
Breeding Ewes lactating (i.e. lamb at foot):	0	0	0	0	7400	7400	7400	0	0	0	0	0
Number of lambs on their mother:	0	0	0	0	6642	6642	6642	0	0	0	0	0

WOOL PRODUCED - KGS GREASY PER HEAD PER YEAR

	Kilograms	Yield %
Breeding Ewes	3.5	69 %
Maiden Ewes	3.5	69 %
Other Ewes	3.5	69 %
Lambs/Hoggets	3.5	69 %

FARMGAS CALCULATOR ST

WANDERING DPIRD ANALYSIS

TOOLS

Gross Margin Calculator

DOWNLOADS

Download Summary Report
Download CSV Report

USER GUIDE

User Guide and Case Studies

Rams	3.5	69 %
Wethers	3.5	69 %

ESTIMATED DSE VALUES (DRY SHEEP EQUIVALENT)

Breeding Ewes	1.9
Maiden Ewes	1.5
Other Ewes	1
Lambs/Hoggets	0.5
Rams	1.5
Wethers	1

Submit

WANDERING has been saved.

CROP SELECTION, AREA/YIELD AND FERTILISER

Select Crop Type: Barley

Dryland/Irrigated: Dryland

Crop Area (hectares): 990

Grain Yield (tonnes/ha): 3.36

Value of Emissions	Default	Revised	% Change from default
Tonnes CO_2-e	261.09	255.04	-2.32%
Carbon Price $/tonne	18.40		
Total Value:	4,804.01	4,692.72	-2.32%

NITROGEN FERTILISER APPLICATION

For your crop up to two fertiliser applications per year may be entered.

Fertiliser Application	Application 1	Application 2
Fertiliser Type		
Quantity Applied (kgs/ha)	79 kgs/ha	0 kgs/ha
% Nitrogen (N) in Fertiliser	100 %	0 %
% of crop area fertilised	100 %	0 %

Submit

FARMGAS CALCULATOR ST

WANDERING
DPIRD ANALYSIS

CROPS

Crop 1 (990 ha of Barley)

< All Crops

TOOLS

Gross Margin Calculator

DOWNLOADS

Download CSV Report

USER GUIDE

User Guide and Case Studies

Appendix 3 – Cool Farm Tool input sheets

barley_2020

Other Crops • Barley • Finished product: 3,324 tonnes • Yield: 3.36 tonne / ha

1. Crop details

Crop name	Barley	
Harvest year	2020	
Crop area	990	hectares
Harvested amount (total)	3,324	tonnes
Farm-gate ready amount	3,324	tonnes
Assessment name	barley_2020	

1.2 Crop residue management

Default values for dry matter weights are provided for most crops. If you have better data, you can overwrite the default value.

Residue amount	3.52	tonnes / ha	Reset Residue Amount
Residue management	Left distributed on field, OR incorporated, OR mul		

1.3 Co-products

Are there any co-products of this crop which you use or sell?

User notes

Add comments about this section

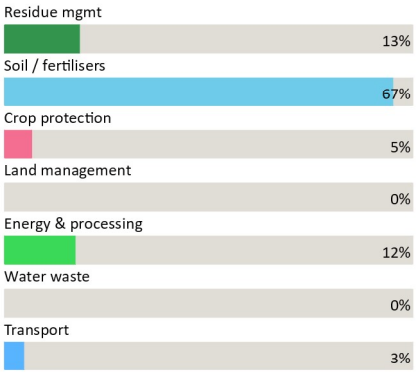
Back Save as Save & continue

Summary

Crop	Barley
Year	2020
Farm-gate amount	3,324 tonne
Yield	3.36 tonne / ha

GHG emissions

Total 1,268,305 kg CO2e



CFT v0.11.43

sheep_2020

Other Livestock • Sheep • Finished product: 393,628 kilograms • Variety: ~

2. Your herd and feed

Juvenile phase

Number of animals 6642

Length of phase 6 months

Grazing

Do animals in this life phase get any of their nutrition from grazing?

Grazing percentage 100 %

Grazing type Open grazing

Grazing quality Medium

Feed mix

1 X Remove

Feed component Temperate Grassland: C

Percentage 100 %

+ add feed

Dry matter intake

Daily DMI per head 0.526 kilograms

Manure management

1 X Remove

Type Daily spread

Percentage 100 %

Days per year 365

+ add manure management

Adult productive phase

Number of animals 7363

Length of phase 12 months

Summary

Variety ~

Year 2020

Finished product 393,628 kg

GHG emissions

Total 2,727,892 kg CO2e

Energy & Processing 2%

Water waste 0%

Transport 0%

Feed production 5%

Manure management 1%

Enteric fermentation 91%

Grazing

Do animals in this life phase get any of their nutrition from grazing?

Grazing percentage 100 %

Grazing type Open grazing

Grazing quality Medium

Feed mix

1 X Remove

Feed component Temperate Grassland: C

Percentage 100 %

+ add feed

Dry matter intake

Daily DMI per head 0.858 kilograms

Manure management

1 X Remove

Type Daily spread

Percentage 100 %

Days per year 365

+ add manure management

Adult non-productive phase

Number of animals 3116

Length of phase 12 months

Grazing

Do animals in this life phase get any of their nutrition from grazing?

Grazing percentage 100 %

Grazing type Open grazing

Grazing quality Medium

Feed mix

1 X Remove

Feed component Temperate Grassland: C

Percentage 100 %

+ add feed

Dry matter intake

Daily DMI per head 1.065 kilograms

Manure management

1 X Remove

Type: Daily spread

Percentage: 100 %

Days per year: 365

+ add manure management

User notes

Add comments about this section

Back Save as Save & continue

CFT v0.11.43

Appendix 4 – Agrecalc input sheets

- Home
- Updates
- About
- Contact Us
- Help
- Logout

Farm Menu

Wandering

- Farm Home
- Edit Farm Details
- Farm Report Data Entry
  - Land & Crops
  - Livestock
  - Energy & Waste
  - Notes
- Results
  - Resource use and Emissions
  - Charts
  - Agrecalc Reports

Wandering > Data Entry for Wandering

widescreen view

Quickjump to another report

Livestock

The information collated in this section is used to calculate direct and indirect N_2O emissions from the storage and application of organic manure, CH_4 from ruminant enteric fermentation and manure management, and CO_2 emissions from embedded emissions associated with purchased feed and bedding.

Enter data from the 12 month period being assessed into the relevant boxes. Some boxes may already contain data if you selected 'insert industry standard data' from the main Farm Report page; this data is deemed by SRUC specialist to be typical of the farming enterprise type you selected at the onset. If you wish to use the pre-populated data, type the figures in the relevant boxes, alternatively if you wish to use other data you feel to be more representative of your farm, enter these figures. Typical values can be seen by hovering over certain input boxes.

Various livestock categories can be found by scrolling down the page. Only the enterprises you selected when you created your Farm Account Details will appear, if you wish to add or remove enterprises go to Edit Farm and select or de-select the relevant enterprises. Once you have finished entering data, move onto the next tab, auto-save will save your data, or you can also manually save your data by using the save button at the bottom of each page.

As you work through the various sections some boxes maybe highlighted in red this indicates what data must be entered or if totals are not 100%.

Show/hide text

Livestock Numbers & Weights | Purchases, Sales, Deaths | Performance | Manure Management | Bedding | Feed | Feed (cont.) | Feed (cont.)
Feed (cont.) | Feed (cont.) | Feed (cont.) | Data Checks

Livestock Numbers & Weights

Open Livestock Monthly Stock Totals Tool

For each applicable livestock category, enter relevant pre-populated live-weight data or enter your actual data, and the average number of livestock managed by you. If required, the Livestock Monthly Stock Totals Tool can be used to assist you in calculating the average number of livestock.

Sheep

	Average live weight at weaning (kg)	Live weight at 1 yr or at slaughter if slaughtered before 1 yr (kg)	Average live weight (kg)	Average number of livestock over 12 month period (no)
Ewes			50	7613
Tups / Rams			70	200
Hoggs (Ewe lamb for breeding 6-12 mnth)	25	45	52	150
Gimmers (Ewe lamb for breeding >12 mnth)	25	45	50	2985
Shearlings (Tups / Rams for breeding 6-12 mnth)	25	45	54	2282
Lamb	25	45	30	6642

Save | Next Page >

Farm Menu

Wandering

- Farm Home
- Edit Farm Details
- Farm Report Data Entry
  - Land & Crops
  - Livestock
  - Energy & Waste
  - Notes
- Results
  - Resource use and Emissions
  - Charts
  - Agrecalc Reports

Land & Crops

The information collated in this section is used to calculate direct and indirect N_2O emissions from the application of nitrogen fertiliser (inorganic and imported organic manure) and from crop residues, and CO_2 emissions from embedded emissions associated with purchased inorganic fertiliser, lime and pesticides.

Enter data from the 12 month period being assessed into the relevant boxes. Various crops can be found by scrolling down the page. If you wish to open or close a crop group, click on the relevant subheading. Once you have finished entering data move onto the next tab, auto-save will save your data or you can also manually save your data by using the save button at the bottom of each page.

As you work through the various sections some boxes maybe highlighted in red this indicates what data must be entered or if totals are not 100%.

Show/hide text

Crop production and use

Open Crop Reconciliation Tool

Enter approximate percentage of the crop that was removed at harvest, the harvested dry matter % and the harvested yields, in tonnes per hectare for each crop. Where applicable straw yields, in tonnes per hectare should also be entered. Enter the total tonnes of each crop sold, home saved for seed, fed to livestock or used for livestock bedding. The crop reconciliation tool can be used to help you check crop use.

Grazing & forage

	Crop Production			Crop Use	
	Percentage of crop removed (%)	Harvested Dry Matter (%)	Harvested or forage yield (t/ha)	Sold (t)	Fed or used for bedding (t)
Pasture grazing (2484.00 ha)	0				

Other forage

	Crop Production			Crop Use	
	Percentage of crop removed (%)	Harvested Dry Matter (%)	Harvested or forage yield (t/ha)	Sold (t)	Fed or used for bedding (t)
Legume forages (clovers, lucerne) (0.00 ha)					

Combinable crops

	Crop Production			Crop Use	

Appendix 5 – PICCC output reports

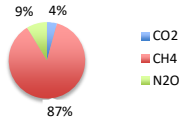
Beef & Sheep Greenhouse Accounting Tool

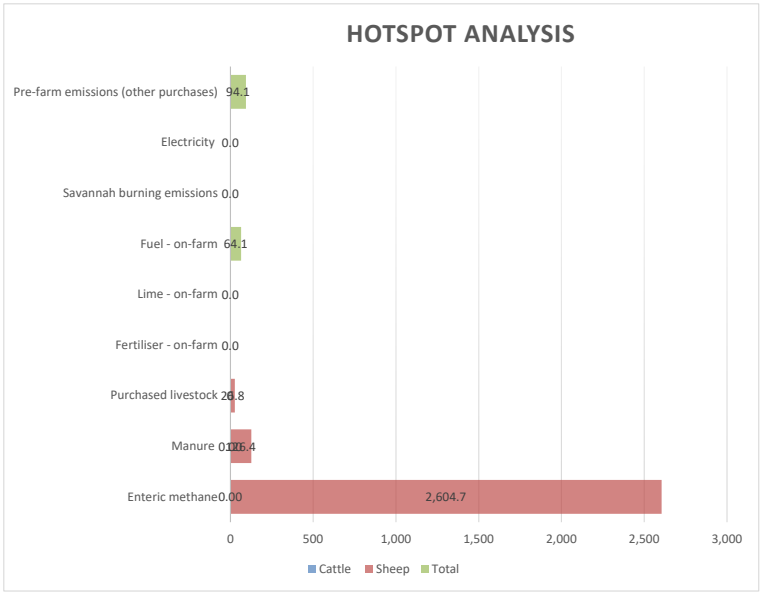
Outputs	beef t CO_2e/farm	sheep t CO2e/farm	total t CO2e/farm
Scope 1 Emissions			
CO_2 - Fuel	0.00	64.06	64.06
CO_2 - Lime	0.00	0.00	0.00
CO_2 - Urea	0.00	0.00	0.00
CH_4 - Fuel	0.00	0.09	0.09
CH_4 - Enteric	0.00	2,604.73	2,604.73
CH_4 - Manure Management	0.00	126.40	126.40
CH_4 - Savannah Burning	0.00		0.00
N_2O - Fertiliser	0.00	0.00	0.00
N_2O - Urine and Dung	0.00	143.95	143.95
N_2O - Atmospheric Deposition	0.00	15.11	15.11
N_2O - Leaching and Runoff	0.00	95.00	95.00
N_2O - Savannah Burning	0.00		0.00
N_2O - Fuel	0.00	0.32	0.32
Scope 1 Total	**0**	**3,050**	**3,050**
Scope 2 Emissions			
Electricity	0.00	0.00	0
Scope 2 Total	**0**	**0**	**0**
Scope 3 Emissions			
Fertiliser	0.00	21.71	21.71
Purchased feed	0.00	69.13	69.13
Herbicides/pesticides	0.00	0.00	0.00
Electricity	0.00	0.00	0.00
Fuel	0.00	3.30	3.30
Lime	0.00	0.00	0.00
Purchased livestock	0.00	26.78	26.78
Livestock on agistment			
Scope 3 Total	**0**	**121**	**121**
Carbon Sequestration			
Carbon sequestration in trees	0.00	0.00	0.00
Net Farm Emissions	**0**	**3,171**	**3,171**

Emissions intensity		
Sheep meat (breeding herd) excl. sequestration	**6.8**	kg CO2-e / kg LW
Sheep meat (breeding herd) inc. sequestration	**6.8**	kg CO2-e / kg LW
Wool excl. sequestration	**26.2**	kg CO2-e / kg greasy
Wool inc. sequestration	**26.2**	kg CO2-e / kg greasy
Beef excl. sequestration		kg CO2-e / kg LW
Beef inc. sequestration		kg CO2-e / kg LW

Summary	t CO2e/farm
CO_2	133
CH_4	2,734
N_2O	273

Breakdown of Scope 1 GHGs





Grains Greenhouse Accounting Framework

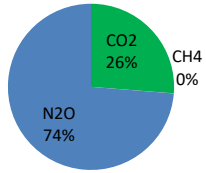
Note no input can be made from this page - to input your data go to the Data input tab

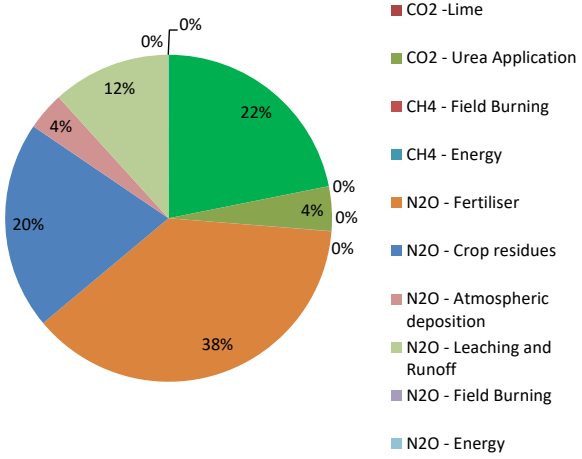
Farm Name	**Wandering**				
State	SW WA				
Farm cropping details	Barley	Oilseeds	Oats	Other Cereals	Units
Production System	Non-Irrigated Crop	Non-Irrigated Crop	Non-Irrigated Cı	Irrigated Crop	
Average grain yield	3.36	1.83	3.24	0	t/ha
Area sown	990	1308	30	0	ha/farm
Nitrogen Fertiliser Use	79	75	79	0	kg N/ha
Fraction of the annual production of crop that is burnt (F)	0	0	0	0	
Residue to crop ratio	1.24	2.10	1.42	1.50	(kg crop residue/kg crop)
Below to above ground residue ratio	0.32	0.33	0.43	0.36	(kg /kg)
Dry matter content	0.88	0.96	0.88	0.88	(kg dry weight/kg crop residue)
Nitrogen content of AG residue	0.01	0.01	0.01	0.01	(kg N/kg DM)
Nitrogen content of BG residue	0.01	0.01	0.01	0.01	(kg N/kg DM)
Fraction of crop residue that is burnt	0.12	0.12	0.12	0.12	Fraction
Fraction of crop residue remaining	0.50	0.50	0.50	0.50	Fraction
Fraction of crop residue removed	0.09	0.09	0.09	0.09	Fraction
Carbon mass fraction in DM	0.40	0.40	0.40	0.40	Fraction
Annual diesel consumption	136057				litres/year
Annual Natural Gas Consumption	0				litres/year
Annual electricity use	0				KWh
Power source	State Grid				

Outputs	**t CO_2e/farm**
CO_2 -Energy	367.10
CO_2 -Lime	0.18
CO2 - Urea Application	73.67
CH_4 - Field Burning	0.00
CH_4 - Energy	0.53
N_2O - Fertiliser	632.46
N_2O - Crop residues	345.72
N_2O - Atmospheric deposition	63.25
N_2O - Leaching and Runoff	196.16
N_2O - Field Burning	0.00
N_2O - Energy	1.05
Net Farm Emissions	1,680.12

Summary	**t CO2e/farm**
CO_2	440.96
CH_4	0.53
N_2O	1238.64

Greenhouse Gas Profile Summary





Citation:
Eckard R.J., Taylor C. (2016). A **G**reenhouse **A**ccounting **F**ramework for **G**rain and cropping properties (G-GAF) based on the Australian National Greenhouse Gas Inventory methodology. Updated July 2016. http://www.greenhouse.unimelb.edu.au/Tools.htm

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Primary Industries Climate Challenges Centre

Robin Nosey
Agriculture Western Australia
29/04/2021

Appendix 6 – FarmGAS output reports

FarmGAS Output - Summary

Farm Name: WANDERING
Scenario Name: DPIRD ANALYSIS Scenario created on: 12/04/2021 10:35 am
Farm Location: Western Australia Scenario revised on: 12/04/2021 12:40 pm
Region: Central Wheat Belt
Notes:

FarmGAS Output Summary - Page 1

GREENHOUSE EMISSIONS	(CO2 equivalent Tonnes)			Enterprise 1			Enterprise 2			Enterprise 3		
LIVESTOCK - Grazing	TOTALS			Beef Cattle (Breeding)			Beef Cattle (Stores)			Sheep		
Source of emission (type)	Default	Revised	Diff	Default	Revised	Diff	Default	Revised	Diff	Default	Revised	Diff
METHANE (CH_4)												
Enteric fermentation (rumination)	1,358.20	1,358.20	0.0%	0.00	0.00	0.0%	0.00	0.00	0.0%	1,358.20	1,358.20	0.0%
Livestock Wastes (faeces/urine)	0.29	0.29	0.0%	0.00	0.00	0.0%	0.00	0.00	0.0%	0.29	0.29	0.0%
Sub-total	1,358.49	1,358.49	0.0%	0.00	0.00	0.0%	0.00	0.00	0.0%	1,358.49	1,358.49	0.0%
NITROUS OXIDE (N_2O)												
Livestock Wastes (faeces/urine)	274.33	274.33	0.0%	0.00	0.00	0.0%	0.00	0.00	0.0%	274.33	274.33	0.0%
Total Grazing Livestock Emissions	1,632.82	1,632.82	0.0%	0.00	0.00	0.0%	0.00	0.00	0.0%	1,632.82	1,632.82	0.0%
per hectare	0.33	0.33	0.0%	0.00	0.00	0.0%	0.00	0.00	0.0%	0.66	0.66	0.0%
per DSE / Head				0.00	0.00	(DSE)	0.00	0.00	(DSE)	0.11	0.11	(DSE)
GROSS MARGIN												
Income					$0.00			$0.00			$0.00	
Variable Costs					$0.00			$0.00			$0.00	
Gross Margin					$0.00			$0.00			$0.00	
GM / hectare					$0.00	ha		$0.00	ha		$0.00	ha
GM / DSE /head /SPU					$0.00	(DSE)		$0.00	(DSE)		$0.00	(DSE)

	(CO2 equivalent Tonnes)			Enterprise 4			Enterprise 5		
LIVESTOCK - Intensive	TOTALS			Feedlot (Beef)			Pigs (intensive)		
Source of emission (type)	Default	Revised	Diff	Default	Revised	Diff	Default	Revised	Diff
METHANE (CH_4)									
Enteric fermentation (rumination)	0.00	0.00	0.0%	0.00	0.00	0.0%	0.00	0.00	0.0%
Livestock Wastes (faeces/urine)	0.00	0.00	0.0%	0.00	0.00	0.0%	0.00	0.00	0.0%
Sub-total	0.00	0.00	0.0%	0.00	0.00	0.0%	0.00	0.00	0.0%
NITROUS OXIDE (N_2O)									
Livestock Wastes (faeces/urine)	0.00	0.00	0.0%	0.00	0.00	0.0%	0.00	0.00	0.0%
Total Intensive Livestock Emissions	0.00	0.00	0.0%	0.00	0.00	0.0%	0.00	0.00	0.0%
per hectare	0.00	0.00	0.0%	0.00	0.00	0.0%	0.00	0.00	0.0%
per DSE / Head				0.00	0.00	(Head)	0.00	0.00	(SPU)
GROSS MARGIN									
Income					$0.00			$0.00	
Variable Costs					$0.00			$0.00	
Gross Margin					$0.00			$0.00	
GM / hectare					$0.00	(Kgs add)		$0.00	(ha)
GM / DSE /head /SPU					$0.00	(Head)		$0.00	(SPU)

FarmGAS Output Summary - Page 2

GREENHOUSE EMISSIONS	(CO2 equivalent Tonnes)			Enterprise 6			Enterprise 7		
CROPPING / HORTICULTURE	TOTALS			Cropping: (3 crops)			Horticulture: (0 crops)		
Source of emission (type)	Default	Revised	Diff	Default	Revised	Diff	Default	Revised	Diff
METHANE (CH_4)									
Field burning (crop stubble)	22.10	0.00	-100.0%	22.10	0.00	-100.0%			
Field burning (pastures / savanna)	0.00	0.00	0.0%						
Sub-total	22.10	0.00	-100.0%	22.10	0.00	-100.0%			
NITROUS OXIDE (N_2O)									
Fertiliser use (Nitrogen-based)	424.04	424.04	0.0%	424.04	424.04	0.0%	0.00	0.00	0.0%
Crop residues (stubble decaying)	103.13	126.02	22.2%	103.13	126.02	22.2%			
Burning of crop stubble	8.53	0.00	-100.0%	8.53	0.00	-100.0%			
Manure from Feedlot (spread)	0.00	0.00	0.0%	0.00	0.00	0.0%			
Manure from Piggery (spread)	0.00	0.00	0.0%	0.00	0.00	0.0%			
Sub-total	535.70	550.06	2.7%	535.70	550.06	2.7%	0.00	0.00	0.0%
Total Cropping/Other Emissions	557.80	550.06	-1.4%	557.80	550.06	-1.4%	0.00	0.00	0.0%
per hectare				0.24	0.24	-1.4%	0.00	0.00	0.0%
GROSS MARGIN									
Income					$0.00			$0.00	
Variable Costs					$0.00			$0.00	
Gross Margin					$0.00			$0.00	
GM / hectare					$0.00	(ha)		$0.00	(ha)

GREENHOUSE EMISSIONS	(CO2 equivalent Tonnes)											
PASTURES / SAVANNA	TOTALS			Pastures			Savanna grasslands			Savanna woodlands		
Source of emission (type)	Default	Revised	Diff	Default	Revised	Diff	Default	Revised	Diff	Default	Revised	Diff
METHANE (CH_4)												
Field burning (pastures / savanna)	0.00	0.00	0.0%	0.00	0.00	0.0%	0.00	0.00	0.0%	0.00	0.00	0.0%
Sub-total	0.00	0.00	0.0%	0.00	0.00	0.0%	0.00	0.00	0.0%	0.00	0.00	0.0%
NITROUS OXIDE (N_2O)												
Fertiliser use (Nitrogen-based)	0.00	0.00	0.0%	0.00	0.00	0.0%	0.00	0.00	0.0%	0.00	0.00	0.0%
Crop residues (stubble decaying)	0.00	0.00	0.0%	0.00	0.00	0.0%	0.00	0.00	0.0%	0.00	0.00	0.0%
Burning of pasture/savanna	0.00	0.00	0.0%	0.00	0.00	0.0%	0.00	0.00	0.0%	0.00	0.00	0.0%
Manure from Feedlot (spread)	0.00	0.00	0.0%	0.00	0.00	0.0%	0.00	0.00	0.0%	0.00	0.00	0.0%
Manure from Piggery (spread)	0.00	0.00	0.0%	0.00	0.00	0.0%	0.00	0.00	0.0%	0.00	0.00	0.0%
Sub-total	0.00	0.00	0.0%	0.00	0.00	0.0%	0.00	0.00	0.0%	0.00	0.00	0.0%
Total Pastures/Savanna Emissions	0.00	0.00	0.0%	0.00	0.00	0.0%	0.00	0.00	0.0%	0.00	0.00	0.0%
per hectare				0.00	0.00		0.00	0.00		0.00	0.00	

TOTAL FARM GHG EMISSIONS	Default	Revised	Diff	
Enterprises excluding trees/soil	2,190.62	2,182.88	-7.74	-0.35%
per hectare	0.45	0.45	-0.00	
Carbon Price	$18.40			
NET value/cost of emissions	$40,307.38	$40,164.97	$-142.40	

FARM INCOME/EXPENDITURE	
Enterprise Income	$0.00
Enterprise Variable Costs	$0.00
Gross Margin	$0.00
Other Income	$0.00
Other Costs	$0.00
Net Farm Income	$0.00

CARBON SEQUESTRATION		
Farm Trees	0.00	$0.00
Other	0.00	$0.00
Sequestration Sub-total	0.00	$0.00

	Default	Revised	
NET FARM EMISSIONS	2,190.62	2,182.88	Tonnes CO2 equivalent net emissions (More carbon is emitted than stored).
Carbon Price	$18.40		
NET value/cost of emissions	40,307.38	40,164.97	

Emission Factors used in Calculations

Global Warming Conversion Factors	Default	Revised
Carbon Dioxide (CO2)	1	1
Methane (CH4)	21	21
Nitrous Oxide (N2O)	310	310

Livestock 1

	Default	Revised
MEF (Manure emission factor)		
Temperate (NSW/ACT, Vic, SA, TAS, WA south)	0.000014	0.000014
Warm (QLD, NT, WA northern	0.000054	0.000054

Feedlot and Pigs - MCF (Methane Conversion Factor)

Beef Feedlot	Default	Revised
Anaerobic lagoon	0.9	0.9
Liquid systems (slurry)	0.35	0.35
Solid Storage & Drylot	0.015	0.015
Spread on pastures & crops	0.015	0.015
Digestor	0.1	0.1

Pigs	Default	Revised
Anaerobic lagoon	0.9	0.9
Liquid systems (slurry)	0.35	0.35
Solid Storage & Drylot	0.015	0.015
Spread on pastures & crops	0.005	0.005
Digestor	0.1	0.1

Beef Feedlot - Emission Potential	Default	Revised
Manure Management System 1:	0.17	0.17
Manure Management System 2:	0.17	0.17

Livestock 2

FracGASM (the amount of N volatilised in each manure management system (MMS))

Enterprise:	Beef Feedlot		Pigs		Beef/sheep (grazing)	
Manure Management System	**Default**	**Revised**	**Default**	**Revised**	**Default**	**Revised**
Anaerobic lagoon	N/A	N/A	0.4	0.4		
Liquid systems (slurry)	N/A	N/A	0.48	0.48		
Solid Storage & Drylot	0.3	0.3	0.45	0.45		
Spread on pastures & crops	N/A	N/A	0.07	0.07		
Digestor	N/A	N/A	0.001	0.001		
Pasture range / paddock					0.2	0.2

Nitrous Oxide Manure Emission Factors		Default	Revised
Manure deposited on soil by	Faecal	0.005	0.005
grazing livestock:	Urine	0.004	0.004

Manure applied on soil from intensive livestock operations	Beef Feedlot		Pigs	
	Default	**Revised**	**Default**	**Revised**
Anaerobic lagoon	0.001	0.001	0.001	0.001
Liquid systems (slurry)	0.001	0.001	0.001	0.001
Solid Storage & Drylot	0.02	0.02	0.02	0.02
Spread on pastures & crops	0.01	0.01	0.01	0.01
Digestor	0.001	0.001	0.001	0.001

Soils 1

"Direct" soil Nitrous Oxide emissions from:

	Default	Revised
Nitrogen-fixing crops & pastures (i.e. Legumes, pulses)	0.0125	0.0125
Direct N2O emissions factor - crop residues (e.g. stubble)	0.0125	0.0125
Nitrogen in synthetic fertiliser applied to:	**Default**	**Revised**
Pasture - dryland	0.004	0.004
Pasture - irrigated	0.004	0.004
Crop - dryland	0.003	0.003
Crop - irrigated	0.021	0.021
Horticulture	0.021	0.021

	Default	Revised
Nitrogen in organic fertiliser applied to crops & pastures	0.01	0.01

Soils 2

"Indirect" soil Nitrous Oxide emissions from:

	Default	Revised
Atmospheric deposition (Nitrogen in fertiliser & animal wastes)	0.01	0.01
Nitrogen fertiliser - fraction volatilised (FracGASF)	0.1	0.1
Nitrogen fertiliser - fraction lost through leaching and runoff (FracLEACH)	0.3	0.3
Nitrogen fertiliser - Leaching/runoff emission factor	0.0125	0.0125

Nitrogen fertiliser - fraction available for leaching/runoff (FracWET)	Default	Revised
Pasture - dryland	0.508	0.508
Pasture - irrigated	1	1
Crop - dryland	0.223	0.223
Crop - irrigated	1	1
Horticulture	0.911	0.911

Nitrogen in animal wastes - fraction of enterprise area where nitrogen will leach/runoff (FracWET) and fraction of nitrogen lost through leaching/runoff (FracLEACH)

	FracWET		FracLEACH	
	Default	**Revised**	**Default**	**Revised**
Beef Breeding cattle (grazing)	0.823	0.823	0.3	0.3
Beef Stores (grazing)	0.823	0.823	0.3	0.3
Sheep	0.51	0.51	0.3	0.3
Beef Feedlot	0.223	0.223	0.3	0.3
Piggery	0.668	0.668	0.3	0.3

Burning factors

Factors used in calculations of emissions from burning of Crop Residues (stubble), Temperate Grasslands and Savannas (Grasslands & Woodlands)

Broadacre Crops

	Crop Residues (stubble burning)	
Gas species	**Default**	**Revised**
Methane (CH_4)	0.0035	0.0035
Nitrous Oxide (N_2O)	0.0076	0.0076
Oxides of Nitrogen (NOx)	0.21	0.21
Carbon Monoxide (CO)	0.078	0.078
Non-Methane volatile oxides (NMVOC)	0.0091	0.0091

Temperate Pastures

Areas	**Total Area**	**Area Burnt**
Dryland with legumes	0.0	0.0
Dryland other	0.0	0.0
	0.0	0.0

Fuel Loads	**Default**	**Revised**
Dryland - legumes	0.0	0.0
Dryland - other	0.0	0.0

Emission Factors

Gas species	**Default**	**Revised**
Methane (CH_4)	0.0035	0.0035
Nitrous Oxide (N_2O)	0.0076	0.0076
Oxides of Nitrogen (NOx)	0.21	0.21
Carbon Monoxide (CO)	0.078	0.078
Non-Methane volatile oxides (NMVOC)	0.0091	0.0091

	Default	**Revised**
Burning Efficiency	0.72	0.72
Carbon Mass Fraction - CC	0.46	0.46
Nitrogen to Carbon Ratio - NC	0.46	0.012

Savanna Grasslands

Areas	**Total Area**	**Area Burnt**
	0.0	0.0

Gas species	**Default**	**Revised**
Methane (CH_4)	0.0012	0.0012
Nitrous Oxide (N_2O)	0.0066	0.0066
Oxides of Nitrogen (NOx)	0.21	0.21
Carbon Monoxide (CO)	0.078	0.078
Non-Methane volatile oxides (NMVOC)	0.0091	0.0091

	Default	**Revised**
Fuel Load (t DM/ha)	3.0	
Patchiness	1.0	
Severity	1.0	
Burning Efficiency	0.76	0.76
Carbon Mass Fraction	0.439	0.439
Nitrogen to Carbon Ratio	0.0087	0.0087

Savanna Woodlands

Areas	**Total Area**	**Area Burnt**
	0.0	0.0

Woodland type:

Burning Season:

	Portions of fuel class (%)	**Severity of the fire**	**Patchiness of the fire**		**Burning Efficiency**	
			Default	**Revised**	**Default**	**Revised**
Aggregated	0.0			N/A	0.40	N/A
Fine	0.0			N/A	0.00	N/A
Coarse	0.0			N/A	0.00	N/A
Heavy	0.0			N/A	0.00	N/A
Shrub	0.0			N/A	0.00	N/A

'Patchiness' of the fire is the % of the burn fire scar area fully burnt. It is based on Burning Season and Severity of the fire.

'Burning Efficiency' is the product (multiplication) of the fraction of fuel exposed to flame and the fraction of the fire scar area that is burnt.

Emission factors										
Woodland Fuel Types	**Aggregated Fuel**		**Fine**		**Coarse**		**Heavy**		**Shrub**	
Gas species	**Default**	**Revised**	**Default**	**Revised**	**Default**	**Revised**	**Default**	**Revised**	**Default**	**Revised**
Methane (CH_4)	0.0012	0.0012								
Nitrous Oxide (N_2O)	0.0066	0.0066								
Oxides of Nitrogen (NOx)	0.21	0.21								
Carbon Monoxide (CO)	0.078	0.078								
Non-Methane volatile oxides (NMVOC)	0.0091	0.0091								

Composition of Biomass	**Carbon Mass Fraction**		**Nitrogen to Carbon Ratio**	
by Woodland Fuel Type	**Default**	**Revised**	**Default**	**Revised**
Aggregated	0.439	0.439	0.0087	0.0087
Fine	0.4940	0.4940	0.0101	0.0101
Coarse	0.5010	0.5010	0.0081	0.0081
Heavy	0.5010	0.5010	0.0081	0.0081
Shrub	0.5020	0.5020	0.0093	0.0093

Appendix 7 – Cool Farm Tool output reports

sheep_2020

Other Livestock • Sheep • Finished product: 393,628 kilograms • Dataset: Default • Variety: ~

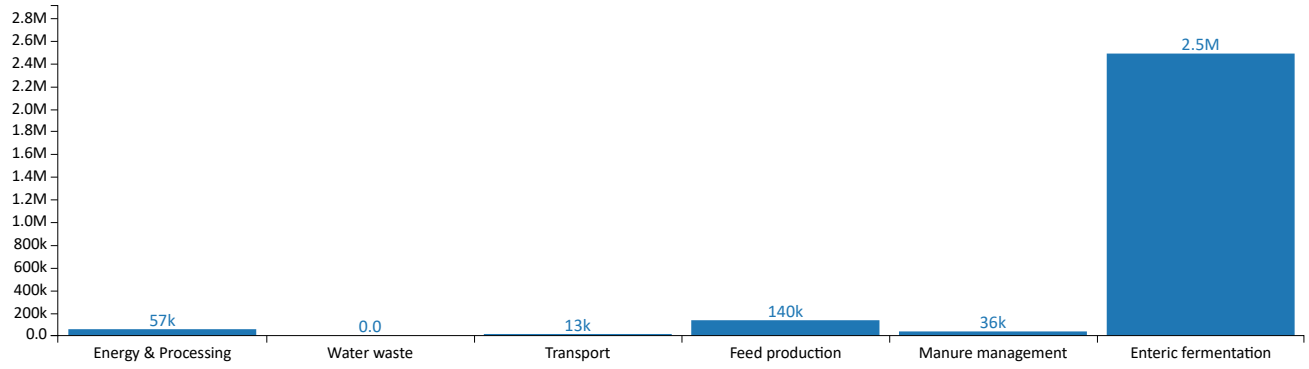
Total emissions

2.73M
kg CO2e

Emissions per kilogram

6.93
kg CO2e

Total Emissions (kg CO2e)

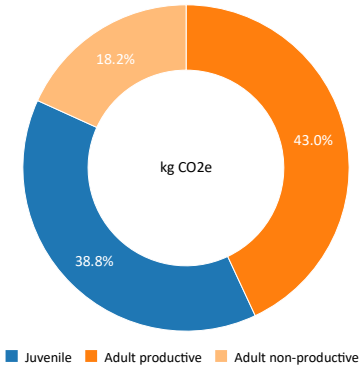


Detailed data (all values in kg)

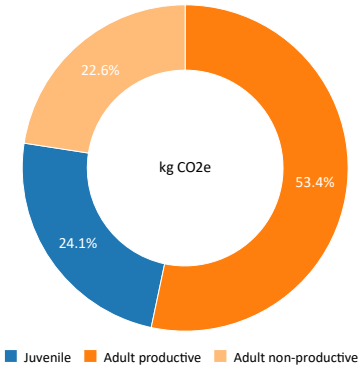
Hide data

Sources	CO_2	N_2O	CH_4	Total CO_2 eq	Per kg
Energy use (field)	57.33k	0	0	57.33k	0.15
Energy use (processing)	0	0	0	0	0
Water waste	0	0	0	0	0
Transport	12.78k	0	0	12.78k	0.03
Feed production	135.47k	0	0	135.47k	0.34
Manure management	35.83k	0	0	35.83k	0.09
Enteric fermentation	0	0	99.46k	2.49M	6.32

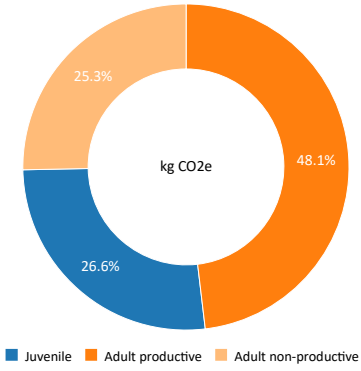
Manure emissions



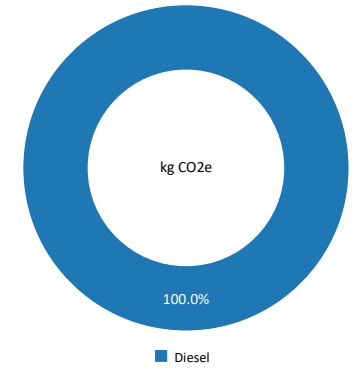
Enteric emissions



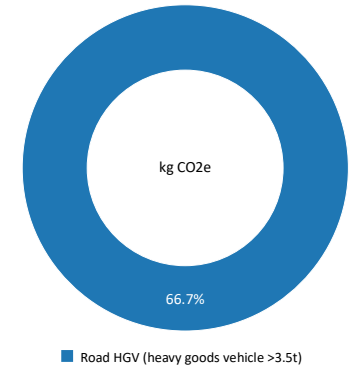
Feed emissions



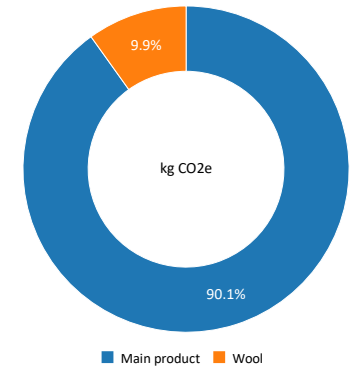
Energy, fuel and water emissions



Transport emissions



Co-product emissions

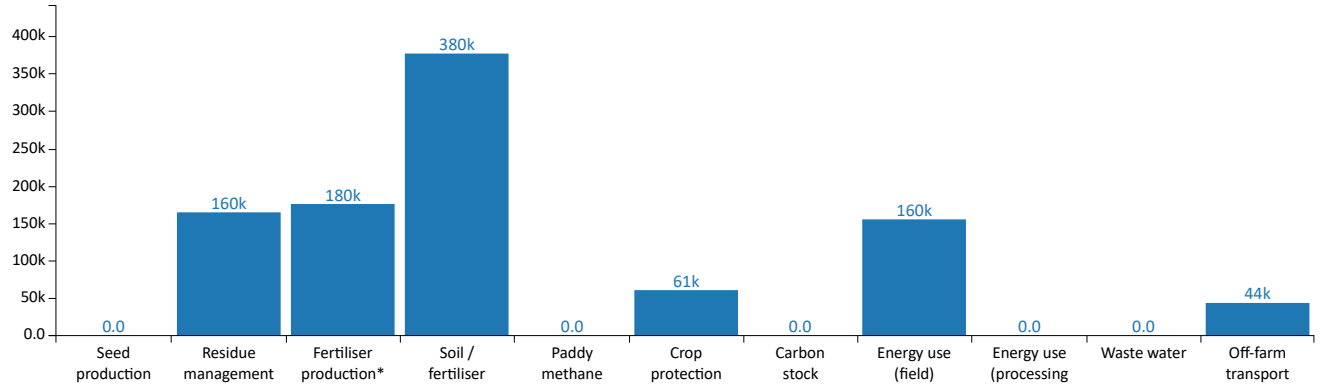


barley_2020

Other Crops • Barley • Finished product: 3,324 tonnes • Dataset: Default • Yield: 3.36 tonne / ha

Total emissions	Emissions per hectare	Emissions per tonne
976.76k kg CO2e	**986.63** kg CO2e	**293.85** kg CO2e

Total Emissions (kg CO2e)



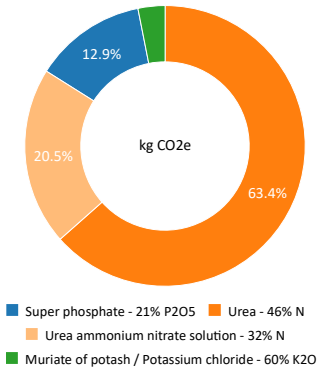
Detailed data (all values in kg)

Hide data

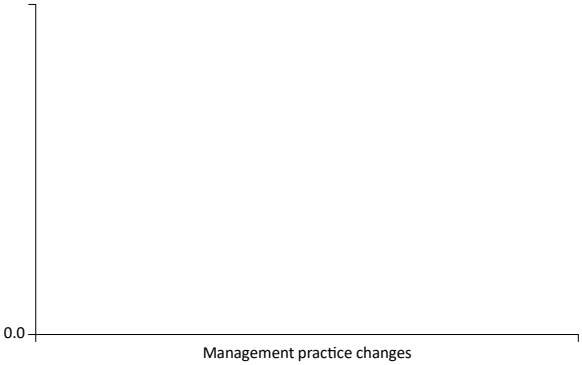
Sources	CO_2	N_2O	CH_4	Total CO_2 eq	Per ha	Per tonne
Seed production	0	0	0	0	0	0
Residue management	0	551.99	0	164.49k	166.16	49.49
Fertiliser production*	175.89k	0	0	175.89k	177.66	52.91
Soil / fertiliser	116.67k	873.02	0	376.83k	380.64	113.37
Paddy methane	0	0	0	0	0	0
Crop protection	60.88k	0	0	60.88k	61.50	18.32
Carbon stock changes	0	0	0	0	0	0
Energy use (field)	155.06k	0	0	155.06k	156.63	46.65
Energy use (processing)	0	0	0	0	0	0
Waste water	0	0	0	0	0	0
Off-farm transport	43.60k	0	0	43.60k	44.04	13.12

** Calculated with validated default values for fertiliser production.*

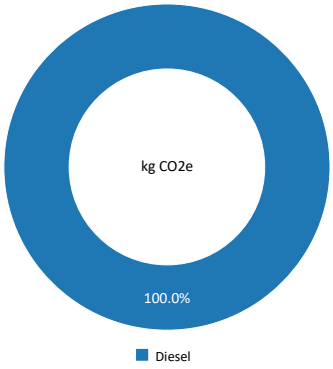
Fertiliser production emissions



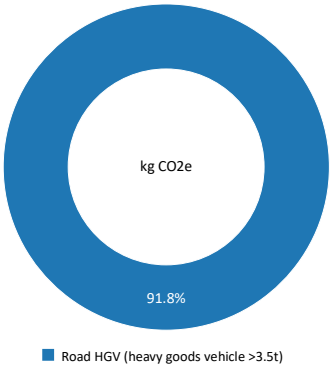
Carbon stocks and sinks



Energy, fuel and water emissions



Transport emissions



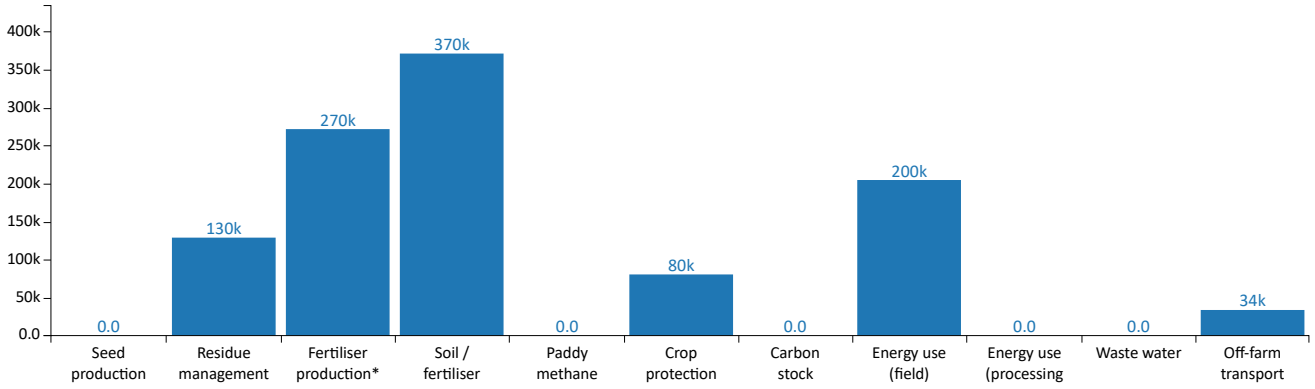
CFT v0.11.42

canola_2020

Other Crops • Other Grain • Finished product: 2,400 tonnes • Dataset: Default • Yield: 1.83 tonne / ha

Total emissions	Emissions per hectare	Emissions per tonne
1.09M kg CO2e	**834.19** kg CO2e	**454.63** kg CO2e

Total Emissions (kg CO2e)



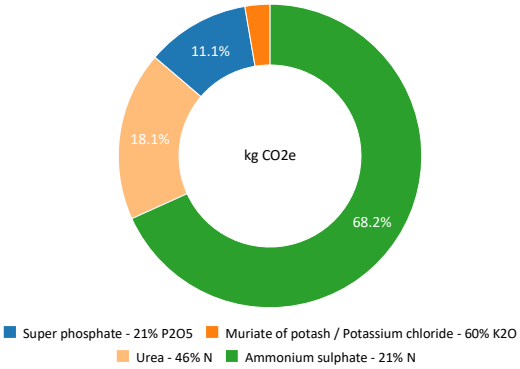
Detailed data (all values in kg)

Hide data

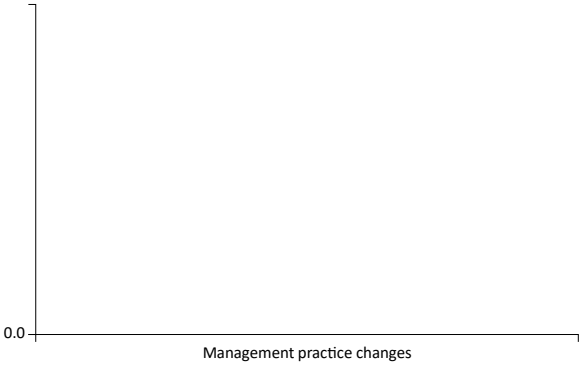
Sources	CO_2	N_2O	CH_4	Total CO_2 eq	Per ha	Per tonne
Seed production	0	0	0	0	0	0
Residue management	0	433.02	0	129.04k	98.65	53.77
Fertiliser production*	271.88k	0	0	271.88k	207.86	113.28
Soil / fertiliser	47.96k	1.08k	0	371.28k	283.85	154.70
Paddy methane	0	0	0	0	0	0
Crop protection	80.44k	0	0	80.44k	61.50	33.52
Carbon stock changes	0	0	0	0	0	0
Energy use (field)	204.87k	0	0	204.87k	156.63	85.36
Energy use (processing)	0	0	0	0	0	0
Waste water	0	0	0	0	0	0
Off-farm transport	33.61k	0	0	33.61k	25.70	14

** Calculated with validated default values for fertiliser production.*

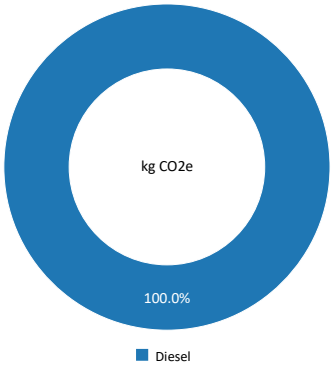
Fertiliser production emissions



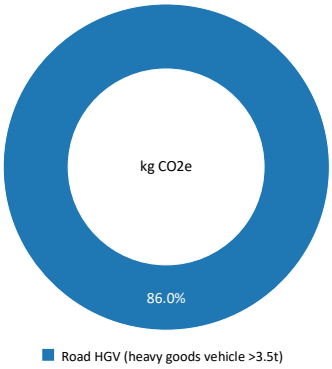
Carbon stocks and sinks



Energy, fuel and water emissions



Transport emissions



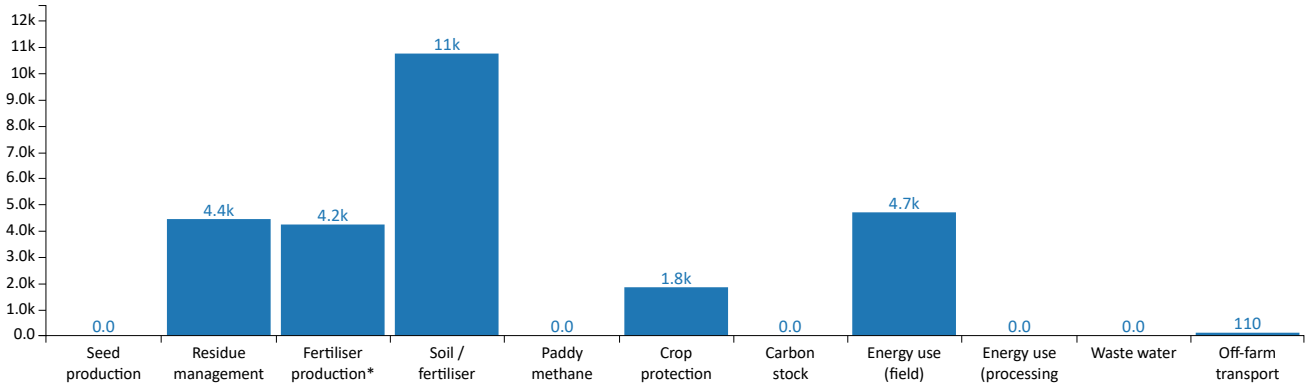
CFT v0.11.42

oats_2020

Other Crops • Oats • Finished product: 97 tonnes • Dataset: Default • Yield: 3.23 tonne / ha

Total emissions	Emissions per hectare	Emissions per tonne
26.08k kg CO2e	**869.36** kg CO2e	**268.88** kg CO2e

Total Emissions (kg CO2e)



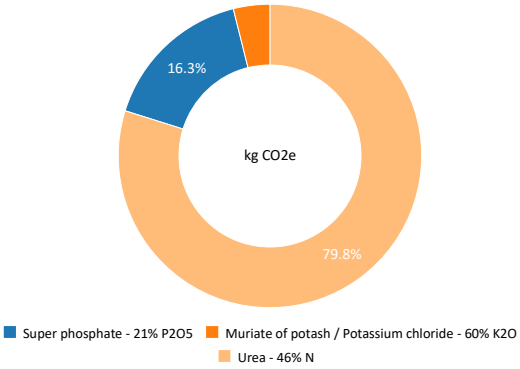
Detailed data (all values in kg)

Hide data

Sources	CO_2	N_2O	CH_4	Total CO_2 eq	Per ha	Per tonne
Seed production	0	0	0	0	0	0
Residue management	0	14.89	0	4.44k	147.93	45.75
Fertiliser production*	4.24k	0	0	4.24k	141.17	43.66
Soil / fertiliser	3.30k	25.02	0	10.76k	358.55	110.89
Paddy methane	0	0	0	0	0	0
Crop protection	1.84k	0	0	1.84k	61.50	19.02
Carbon stock changes	0	0	0	0	0	0
Energy use (field)	4.70k	0	0	4.70k	156.60	48.43
Energy use (processing)	0	0	0	0	0	0
Waste water	0	0	0	0	0	0
Off-farm transport	108.34	0	0	108.34	3.61	1.12

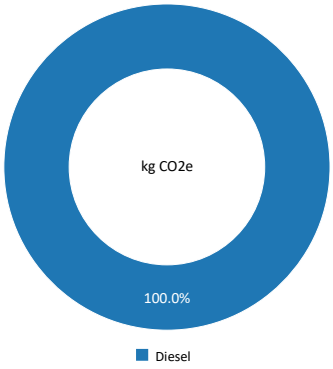
** Calculated with validated default values for fertiliser production.*

Fertiliser production emissions

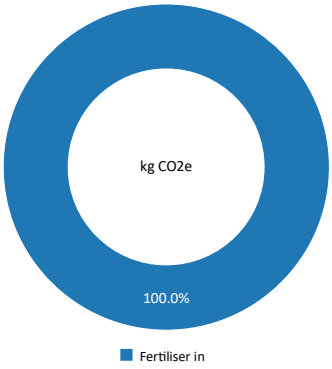


Carbon stocks and sinks

Energy, fuel and water emissions



Transport emissions



CFT v0.11.42

Appendix 8 – Agrecalc output reports

The free version allows benchmark comparisons between the performance of your enterprise and the average for the sector – for example beef. For more detailed benchmark comparisons of the same system – for example – spring calving lowland suckler herd – please subscribe to the Full Version of Agrecalc

Agrecalc Report - Agricultural Resource Efficiency

Sector: Combinable Crops
Crop: Malting winter barley
Group:
Producer:
Farm: Wandering

Region: Not specified
Year calc relates: End Jan 2021
Reporting date: 27th Apr 2021
Report reference: Wandering
Compared to: None

Quick glance enterprise emissions

	* kg CO_2e/ kg grain	Opportunity Level	Comparison
Manure and fertiliser	0.38	tbd	
Pesticides	0.001	tbd	
Lime		tbd	
Fuel	0.05	tbd	
Electricity		tbd	
Crop residues		tbd	
Other		tbd	
Total emissions **	0.43	tbd	

Other: transport, waste

Physical performance of enterprise

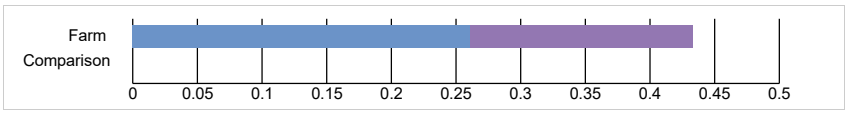
	Value	Comparison
Area of malting winter barley sold (ha)	903.61	
Grain yield (t/ha)	3.36	
Straw yield (t/ha)		
Fertiliser use (t per t grain)	0.10	
Fertiliser use (t per ha)	0.34	
Electricity use (kWh per t grain)		
Red diesel use (l per t grain)	17.41	
Red diesel use (l per ha)	58.44	

Whole farm sustainability indicators

Nitrogen Use	37.73	kg/ha	**Water use**		litres
Phosphate Use	8.88	kg/ha	**Stocking density**	0.26	LU/ha
Potash Use	5.23	kg/ha	**Sequestration**		tCO_2e
Waste		kg	**Renewable energy used**		kWh

Emissions by gas and benchmark comparison

CO_2 : 0.26 kg CO_2e/unit output
CH_4 : kg CO_2e/unit output
N_2O : 0.17 kg CO_2e/unit output



* Your carbon footprint is expressed in units of CO_2 equivalents (CO_2e) per unit of output e.g. kg CO_2e per kg malting winter barley grain sold. This allows the efficiency of the enterprise to be compared. The main greenhouse gases emitted by agriculture are CH_4 = Methane (Predominantly from animal digestion); N_2O = Nitrous oxide (Predominantly from manure and fertiliser); CO_2 = Carbon dioxide (Predominantly from burning of fossil fuels).

** Total emissions may differ due to rounding. Emissions may be skewed on a year to year basis due to timing of sales therefore results are best monitored over a three year (minimum) period.

Improve efficiency and environmental credentials

What does a carbon footprint actually tell you?
There is a strong correlation between efficiency, profitability and low carbon emissions. The lower your carbon footprint the more effective inputs have been at generating saleable product i.e. increased utilisation of costly inputs. Each farm and system have natural limitations but, within this context, the process can identify carbon 'hotspots' on farm and is therefore a steer to improve efficiency and reduce greenhouse gas emissions.

How accurate does the information need to be?
The more accurate the information entered, the more meaningful the output. Where possible on farm records should be used to provide accurate farm-level data.

Agrecalc report guide

A: Quick glance enterprise emissions The 'opportunity level' (high, medium or low) is the likelihood for improvement gauged against other farms in that sector.

B: Physical performance of enterprise It is much easier to relate to performance indicators, actual sales, feeds and other inputs used. This becomes particularly useful when comparing years and for group comparisons.

C. Whole farm sustainability indicators Sustainability is the ability to deliver a product the customer wants year after year without adversely impacting the environment. Carbon is, however, only one part of the wider sustainability 'formula', some wider indicators are shown in this section.

D. Whole farm emissions by gas and benchmarking comparison Carbon footprinting similar farm types allows a business to benchmark environmental performance against a group average.

E. Potential actions to reduce emissions Examples of practical measures that could reduce emissions are shown below. Technical advice should be sought before making any business changes.

Mitigation area	Actions
Energy and fuels	Install smart meter to monitor electricity use - assess efficiency of equipment and activities. Use thermostats, time clocks, motion sensors and low energy bulbs. Record fuel use per tractor and activity - assess efficiency of vehicles and operations. Undertake regular machinery checks and maintenance, use correct tyre pressure, improve journey planning.
Renewable energy	Undertake a renewable energy feasibility study. Consider installing a wind turbine, an anaerobic digester, developing farm-scale micro hydro electricity, using a combined heat and power plant, growing trees as biomass fuel, using solar panels, ground source heat pumps or woodchip burners.
Fertiliser and manure	Analyse soil and organic manure - ensure efficient use of organic and inorganic fertiliser. Apply nitrogen at optimum rate and timing for crops, maximise use of available organic manure.
Locking carbon into the soil	Create carbon sinks. Protect peatland and moorland from damage by avoiding over grazing, consider reduced tillage and ploughing in stubble and other crop residues, control soil erosion, create wildlife corridors along water margins, field margins and headlands, retain and conserve semi-natural grasslands, manage existing woodlands on farm and create new ones.

Any questions regarding this report or to discuss other financial and carbon efficiency measures please contact your local SRUC office or the Rural Business Unit.

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Agrecalc Report - Agricultural Resource Efficiency

Sector: Oilseeds
Crop: Oilseed rape
Group:
Producer:
Farm: Wandering

Region: Not specified
Year calc relates: End Jan 2021
Reporting date: 27th Apr 2021
Report reference: Wandering
Compared to: None

Quick glance enterprise emissions

	* kg CO_2e/ kg oilseed	Opportunity Level	Comparison
Manure and fertiliser	0.49	tbd	
Pesticides	0.002	tbd	
Lime	0.11	tbd	
Fuel	0.09	tbd	
Electricity		tbd	
Crop residues		tbd	
Other		tbd	
Total emissions **	0.69	tbd	

Other: transport, waste

Physical performance of enterprise

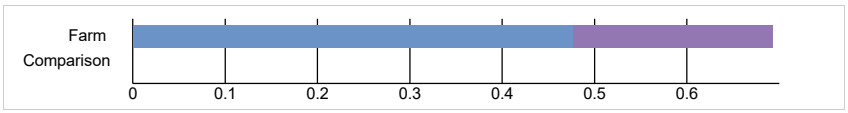
	Value	Comparison
Area of oilseed rape sold (ha)	1,308.00	
Seed yield (t/ha)	1.83	
Straw yield (t/ha)		
Fertiliser use (t per t seed)	0.19	
Fertiliser use (t per ha)	0.35	
Electricity use (kWh per t seed)		
Red diesel use (l per t seed)	31.87	
Red diesel use (l per ha)	58.44	

Whole farm sustainability indicators

Nitrogen Use	37.73	kg/ha	**Water use**		litres
Phosphate Use	8.88	kg/ha	**Stocking density**	0.26	LU/ha
Potash Use	5.23	kg/ha	**Sequestration**		tCO_2e
Waste		kg	**Renewable energy used**		kWh

Emissions by gas and benchmark comparison

CO_2 : 0.48 kg CO_2e/unit output
CH_4 : kg CO_2e/unit output
N_2O : 0.22 kg CO_2e/unit output



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Locking carbon into the soil	Create carbon sinks. Protect peatland and moorland from damage by avoiding over grazing, consider reduced tillage and ploughing in stubble and other crop residues, control soil erosion, create wildlife corridors along water margins, field margins and headlands, retain and conserve semi-natural grasslands, manage existing woodlands on farm and create new ones.

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Agrecalc Report - Agricultural Resource Efficiency

Sector: Combinable Crops
Crop: Winter oats
Group:
Producer:
Farm: Wandering

Region: Not specified
Year calc relates: End Jan 2021
Reporting date: 27th Apr 2021
Report reference: Wandering
Compared to: None

Quick glance enterprise emissions

	* kg CO_2e/ kg grain	Opportunity Level	Comparison
Manure and fertiliser	0.39	tbd	
Pesticides	0.001	tbd	
Lime		tbd	
Fuel	0.05	tbd	
Electricity		tbd	
Crop residues		tbd	
Other		tbd	
Total emissions **	0.44	tbd	

Other: transport, waste

Physical performance of enterprise

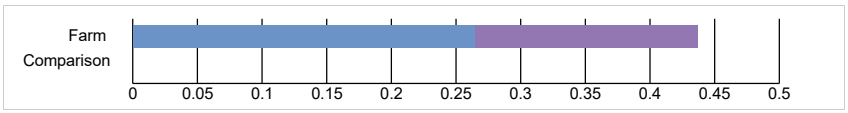
	Value	Comparison
Area of winter oats sold (ha)	30.00	
Grain yield (t/ha)	3.24	
Straw yield (t/ha)		
Fertiliser use (t per t grain)	0.11	
Fertiliser use (t per ha)	0.35	
Electricity use (kWh per t grain)		
Red diesel use (l per t grain)	18.04	
Red diesel use (l per ha)	58.44	

Whole farm sustainability indicators

Nitrogen Use	37.73	kg/ha	**Water use**		litres
Phosphate Use	8.88	kg/ha	**Stocking density**	0.26	LU/ha
Potash Use	5.23	kg/ha	**Sequestration**		tCO_2e
Waste		kg	**Renewable energy used**		kWh

Emissions by gas and benchmark comparison

CO_2 : 0.27 kg CO_2e/unit output
CH_4 : kg CO_2e/unit output
N_2O : 0.17 kg CO_2e/unit output



* Your carbon footprint is expressed in units of CO_2 equivalents (CO_2e) per unit of output e.g. kg CO_2e per kg winter oats grain sold. This allows the efficiency of the enterprise to be compared. The main greenhouse gases emitted by agriculture are CH_4 = Methane (Predominantly from animal digestion); N_2O = Nitrous oxide (Predominantly from manure and fertiliser); CO_2 = Carbon dioxide (Predominantly from burning of fossil fuels).

** Total emissions may differ due to rounding. Emissions may be skewed on a year to year basis due to timing of sales therefore results are best monitored over a three year (minimum) period.

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Agrecalc report guide

A: Quick glance enterprise emissions The 'opportunity level' (high, medium or low) is the likelihood for improvement gauged against other farms in that sector.

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D. Whole farm emissions by gas and benchmarking comparison Carbon footprinting similar farm types allows a business to benchmark environmental performance against a group average.

E. Potential actions to reduce emissions Examples of practical measures that could reduce emissions are shown below. Technical advice should be sought before making any business changes.

Mitigation area	Actions
Energy and fuels	Install smart meter to monitor electricity use - assess efficiency of equipment and activities. Use thermostats, time clocks, motion sensors and low energy bulbs. Record fuel use per tractor and activity - assess efficiency of vehicles and operations. Undertake regular machinery checks and maintenance, use correct tyre pressure, improve journey planning.
Renewable energy	Undertake a renewable energy feasibility study. Consider installing a wind turbine, an anaerobic digester, developing farm-scale micro hydro electricity, using a combined heat and power plant, growing trees as biomass fuel, using solar panels, ground source heat pumps or woodchip burners.
Fertiliser and manure	Analyse soil and organic manure - ensure efficient use of organic and inorganic fertiliser. Apply nitrogen at optimum rate and timing for crops, maximise use of available organic manure.
Locking carbon into the soil	Create carbon sinks. Protect peatland and moorland from damage by avoiding over grazing, consider reduced tillage and ploughing in stubble and other crop residues, control soil erosion, create wildlife corridors along water margins, field margins and headlands, retain and conserve semi-natural grasslands, manage existing woodlands on farm and create new ones.

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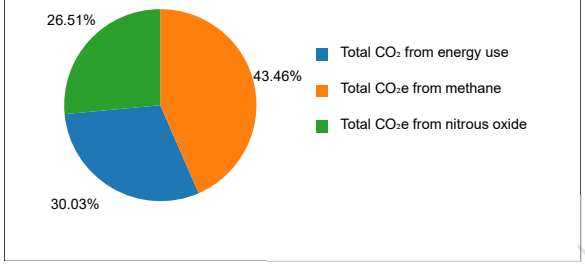
Resource use and Emissions Charts

Emissions by gas and by source for the whole farm and per enterprise are presented below.

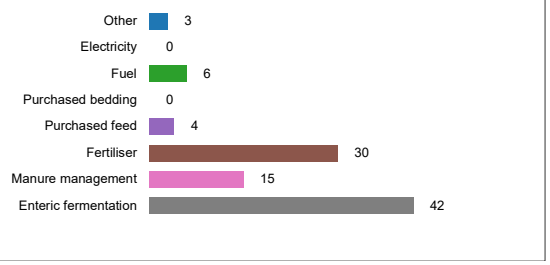
If you have created other reports or scenarios for your farm, you can view the results in chart format by selecting another report from the Quickjump to another scenario drop down list.

Wandering (Wandering 2021)

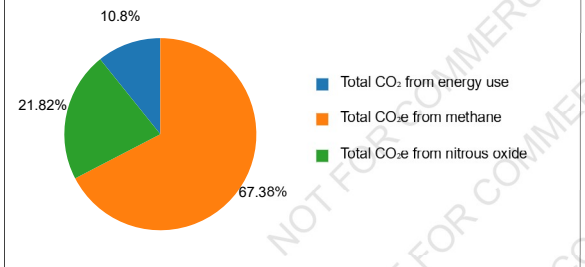
Whole farm emissions by gas (%)



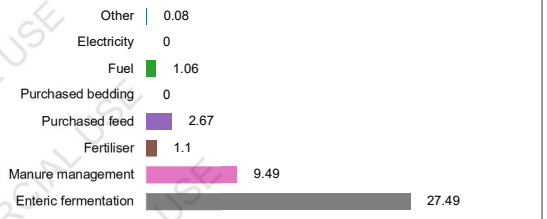
Whole farm emissions by source (%)



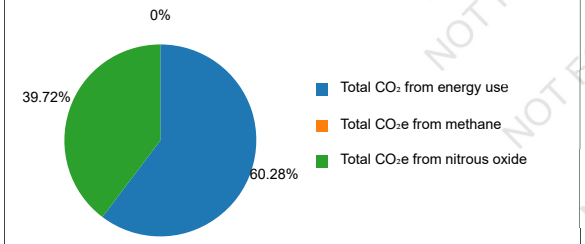
Sheep emissions by gas (%)



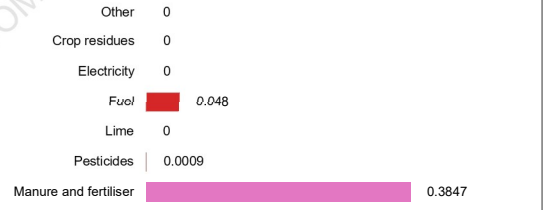
Sheep emissions by source (kg CO_2e/kg dwt)



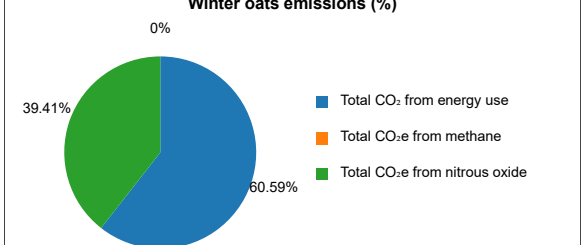
Malting winter barley emissions (%)



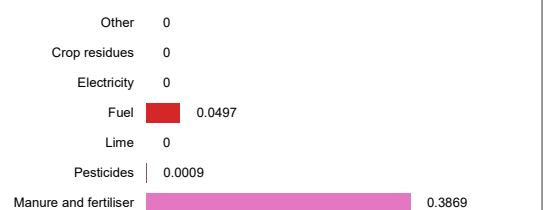
Malting winter barley emissions by source (kg CO_2e/kg grain)



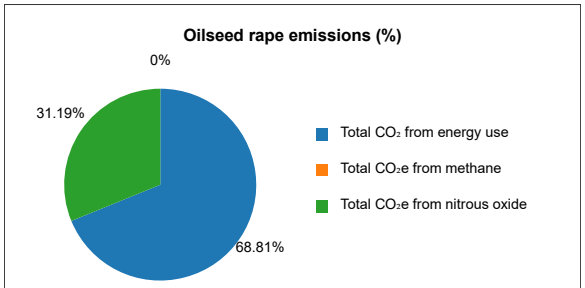
Winter oats emissions (%)



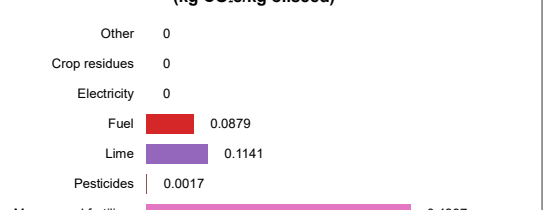
Winter oats emissions by source (kg CO_2e/kg grain)



Oilseed rape emissions (%)



Oilseed rape emissions by source (kg CO_2e/kg oilseed)



The free version allows benchmark comparisons between the performance of your enterprise and the average for the sector – for example beef. For more detailed benchmark comparisons of the same system – for example – spring calving lowland suckler herd – please subscribe to the Full Version of Agrecalc

Agrecalc Report - Agricultural Resource Efficiency

Sector: Sheep
Enterprise type: Crossbred ewe flock
System: Store/finisher
Group:
Producer:
Farm: Wandering

Region: Not specified
Year calc relates: End Jan 2021
Reporting date: 27th Apr 2021
Report reference: Wandering
Compared to: None

Quick glance enterprise emissions

	* kg CO_2e/ kg dwt	Opportunity Level	Comparison
Enteric fermentation	27.49	tbd	
Manure management	9.49	tbd	
Fertiliser	1.10	tbd	
Purchased feed	2.67	tbd	
Purchased bedding		tbd	
Fuel	1.06	tbd	
Electricity	0.00	tbd	
Other	0.08	tbd	
Total emissions **	41.88	tbd	

Other: crop residues, lime, transport and waste

Physical performance of enterprise

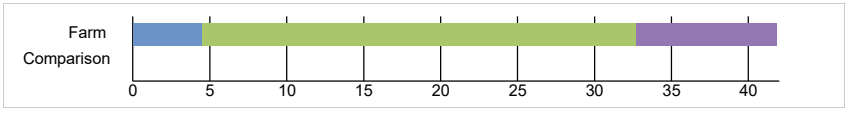
	Value	Comparison
Area of land utilised (ha)	2,484	
Female breeding stock (no)	10,598	
Lamb sale weight (kg lwt/head)		
Lamb sale weight (kg dwt/head)		
Wool sales (kg)	16,752	
Purchased feed use (kg/ewe)	46	
Homegrown feed use (kg/ewe)		
Mortality (%)	6	
Lambing percentage (%)	90	
Ewe cull rate (%)	29	
Enterprise net output (kgs)	140,321	

Whole farm sustainability indicators

Nitrogen Use	37.73	kg/ha	**Water use**		litres
Phosphate Use	8.88	kg/ha	**Stocking density**	0.26	LU/ha
Potash Use	5.23	kg/ha	**Sequestration**		tCO_2e
Waste		kg	**Renewable energy used**		kWh

Emissions by gas and benchmark comparison

CO_2 : 4.52 kg CO_2e/unit output
CH_4 : 28.22 kg CO_2e/unit output
N_2O : 9.14 kg CO_2e/unit output



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Mitigation area	Actions
Energy and fuels	Install smart meter to monitor electricity use - assess efficiency of equipment and activities. Use thermostats, time clocks, motion sensors and low energy bulbs, increase lagging on hot water pipes, reduce number of hot washes in dairy and renew milk pump or other equipment Record fuel use per tractor and activity - assess efficiency of vehicles and operations. Undertake regular machinery checks and maintenance, use correct tyre pressure, improve journey planning
Renewable energy	Undertake a renewable energy feasibility study. Consider installing a wind turbine, an anaerobic digester, developing farm-scale micro hydro electricity, using a combined heat and power plant, growing trees as biomass fuel, using solar panels, ground source heat pumps or woodchip burners
Fertiliser and manure	Analyse soil and organic manure - ensure efficient use of organic and inorganic fertiliser. Apply nitrogen at optimum rate and timing for crops, maintain clover content of swards, consider covering slurry stores and injecting slurry
Livestock management	Increase livestock productivity. Improve feed conversion efficiency, increase calving or lambing percentage, reduce mortalities, increase weaning percentage, reduce age of calving, regularly review animal health plans, analyse silage or other homegrown forage
Locking carbon into the soil	Create carbon sinks. Protect peatland and moorland from damage by avoiding over grazing, consider reduced tillage and ploughing in stubble and other crop residues, control soil erosion, create wildlife corridors along water margins, field margins and headlands, retain and conserve semi-natural grasslands, manage existing woodlands on farm and create new ones.

Any questions regarding this report or to discuss other financial and carbon efficiency measures please contact your local SRUC office or the Rural Business Unit.

Resource use and Emissions

A summary of emissions from carbon dioxide, methane and nitrous oxide for the whole farm and per enterprise is presented below. Total emissions are also expressed per unit of output, per hectare and per livestock unit equivalent to allow comparisons to be made. Per unit of output is the most common way to express emissions associated with the production of food products.

Details of where the emissions came from can be seen by selecting View detailed results.

If you have created other reports or scenarios for your farm, you can view the results by selecting another report from the Quickjump to another report drop down list.

If you wish to compare resource use and emissions to the results from the previous two years, or to another scenario select the Comparisons and Year on Year Results from the Results menu on the left hand side of the page. Pie and bar charts of the results can also be found by selecting Charts from the same Results menu.

Examples of practical measures to improve efficiency and reduce emissions are shown at the foot of the page.

Wandering (Wandering 2021)

View summary results

		Whole Farm	Sheep	Malting winter barley	Winter oats	Oilseed rape
		kg CO_2e	kg CO_2e	kg CO_2e	kg CO_2e	kg CO_2e
CARBON DIOXIDE						
Direct Emissions	**Diesel** [1]	500,011	138,721	145,639	4,835	210,815
	Electricity [1]	77	77			
	Other fuels [1]					
	Renewable electricity [1]					
	Renewable heat [1]					
	Direct CO_2	**500,087**	**138,798**	**145,639**	**4,835**	**210,815**
Direct & Indirect emissions (embedded in purchased inputs)	**Fertiliser**	1,415,120	94,072	644,387	20,842	655,819
	Lime	273,750				273,750
	Feed	349,392	349,392			
	Bedding					
	Pesticides	7,177	258	2,694	89	4,137
	Waste plastic / packaging					
	Disposal of carcasses	9,863	9,863			
	Transport					
	Indirect CO_2	**2,055,303**	**453,584**	**647,081**	**20,931**	**933,706**
	Total CO_2 from energy & waste	**2,555,390**	**592,382**	**792,720**	**25,766**	**1,144,521**
METHANE						
Enteric	**Fermentation (feed digestion)**	3,601,952	3,601,952			
	Manure mgmt	95,313	95,313			
	Total CO_2e from methane	**3,697,265**	**3,697,265**			
NITROUS OXIDE						
Volatilisation, leaching & run-off	**Inorganic and imported organic manure input to soil**	1,107,936	49,945	522,425	16,761	518,805
	Grazing deposition, manure management and organic manure input to soil	1,147,483	1,147,483			
Vegetation, stubble & roots	**Crop N residues**					
	Total CO_2e from nitrous oxide	**2,255,418**	**1,197,427**	**522,425**	**16,761**	**518,805**
Total CO_2e emissions from farming		**8,508,073**	**5,487,075**	**1,315,145**	**42,527**	**1,663,326**
Sequestration by forestry	**(kg CO_2e)**					
Net emissions from land use		**8,508,073**				
Whole farm CO_2e emissions per kg of farm output	**($KgCO_2e$/kg output)** [2]	**1.50**				
Product CO_2e emissions						
Meat	**Total $KgCO_2e$**		**5,174,815**			
	($KgCO_2e$/kg lwt)		**18.85**			
	($KgCO_2e$/kg dwt)		**41.88**			
Wool	**Total $KgCO_2e$**		**312,259**			
	($KgCO_2e$/kg wool)		**18.64**			
Milk	**Total $KgCO_2e$**					
	($KgCO_2e$/kg FPC milk) [3]					
Eggs	**Total $KgCO_2e$**					
	($KgCO_2e$/kg eggs)					
Forage, grain, seeds, roots	**Total $KgCO_2e$**			**1,315,145**	**42,527**	**1,663,326**
	($KgCO_2e$/kg crop)			**0.43**	**0.44**	**0.69**
Straw	**Total $KgCO_2e$**					
	($KgCO_2e$/kg straw)					
Emissions per LU equivalent	**($KgCO_2e$/LU)**		**4,451**			
Emissions per hectare	**($KgCO_2e$/ha)**	1,768	2,209	1,328	1,418	1,272
Farm and enterprise output	**(Kg)**	**5,669,821**	**140,321**	**3,033,430**	**97,200**	**2,398,870**

(1) - Power for farming activity (excludes personal and household demand)

(2) - Beef, sheep, dairy, pig & poultry meat expressed per net kg dwt of cold carcase; milk expressed per kg FPC milk, poultry eggs expressed per kg, crops and straw expressed per kg

(3) - Fat protein corrected (FPC) milk

Practical Measures To Improve Efficiency And Reduce Emissions

Energy and fuels

Install smart meter to monitor electricity use, assess efficiency of equipment and activities, use thermostats, time clocks, motion sensors and low energy bulbs, increase lagging on hot water pipes.

Record fuel use per tractor and activity, assess efficiency of vehicles and operations, undertake regular machinery checks and maintenance, use correct tyre pressure, improve journey planning.

Renewable energy

Undertake an energy audit to investigate the scope for renewable activities, such as wind, solar or hydro-electric power, anaerobic digesters, ground source heat pumps, biomass.

Fertiliser and manure

Prepare a farm nutrient management plan to identify opportunities for better utilisation of organic and inorganic fertiliser, analyse soil and organic manure, apply nitrogen at optimum rate and timing for crops, maintain or increase clover content of swards or other legume crops.

Livestock management

Carry out technical benchmarking of farm performance to highlight scope for improvements, increase calving or lambing percentage, reduce mortalities, increase weaning percentage, reduce age of calving, regularly review animal health plans, analyse silage or other homegrown forage.

Locking carbon into the soil

Protect peatland and moorland from damage by avoiding over grazing, consider reduced tillage and ploughing in stubble and other crop residues, control soil erosion, create wildlife corridors along water margins, field margins and headlands, retain and conserve semi-natural grasslands, manage existing woodlands on farm and create new ones.

Further information

Technical advice should be sought before making any business changes. Further information about SRUC services or to find your local office, please visit the page: http://www.sruc.ac.uk/info/20005/sac_consulting (opens in a new tab / window)

For further information and advice on practical measures you can implement to reduce emissions and improve the efficiency of your business can be found in the Practical Guides on the Farming for A Better Climate section of SRUC's website. These can be accessed by visiting the page: http://www.sruc.ac.uk/downloads/120198/improve_farm_efficiency (opens in a new tab / window)