Photo courtesy of DPIRD

Calculating Carbon Emissions in WA's Grain Industry

Findings from the Carbon Neutral Grain Pilot Project – a research partnership between CBH Group, Wide Open Agriculture and the Department of Primary Industries and Regional Development (DPIRD)

Executive summary

Rationale

Sustainability, traceability, ESG and greenhouse gas (GHG) emissions market signals are increasing for international and domestic food and feed grain commodities. Measuring and mitigating GHG emissions will become one of the standard elements of natural capital management required by the finance sector for lending to sustainable, climate-resilient, nature-positive farm businesses. Further, measuring a farm's baseline carbon account will become a standard part of annual farm financial and production reviews carried out by farm business advisors, agronomists, bankers or growers themselves. Although CBH has been accounting for some of its supply chain GHG emissions for the last eight years, measuring GHG emissions from cropping enterprises is a relatively new commercial practice requiring standardisation, research, trials, benchmarking and practice change.

Scope

The pilot project gathered 36 data sets from Western Australian cropping enterprises in 2021 and 2022.

- 8 x 2020 farm cropping data sets (courtesy Boortmalt)
- 28 x 2021 farms cropping data sets
- Additional reference farm information from Viridis (CSIRO FarmPrint)
- Wheatbelt spread of farm locations
- 30% mixed operations (*livestock excluded in calculations)
- Emissions only, no soil or vegetation sequestration activities included
- Anonymised data sets; grower owns the data and receives results

Dataset Stats	Count	Area (ha)	Grain (t)
Wheat	35	66,279	211,678
Barley	31	25,402	82,662
Canola	27	35,669	63,974
Lupins	27	11,364	22,440
Oats	13	7,190	26,949
Lentils	1	2,024	2,429
Malt Barley	4	896	2,702
Field Peas	4	1,396	1,805
Vetch	1	743	743
Beans	1	674	1,415
Hay	2	1,370	9,111
TOTAL	**144**	**151,636**	**416,797**

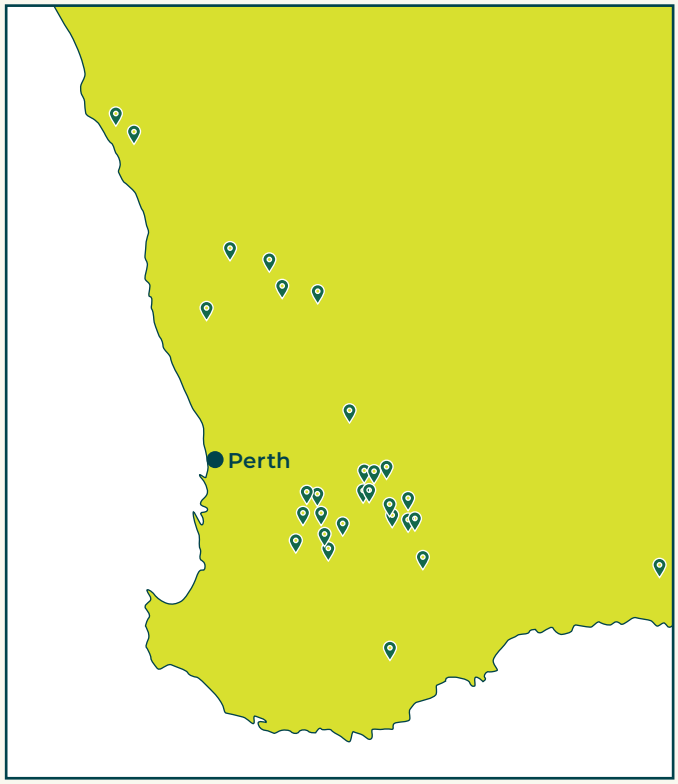


Figure 1: Western Australian pilot project cropping data sets from 36 properties over 2020 and 2021.

Over 150 Western Australian growers, corporate croppers, farm business advisors, supply chain companies including banks and fertiliser companies, state and national tertiary and public sector researchers including MLA, GRDC and DPIRD participated in the project.

Key Outcomes

The project produced baseline GHG emissions data for WA cropping enterprises and compared GHG calculators so that grain growers and industry can confidently assess their on-farm carbon footprint.

Average Total (Absolute) GHG Emissions

The average total GHG emissions per cropping enterprise was found to be 3,692 tonnes CO_2-e (not accounting for any livestock or sequestration activities).

Emissions sources

Emissions are classified as Scope 1, 2 and 3:

Scope 1: All emissions on-farm from agricultural activity

Scope 2: Emissions from the production of purchased electricity

Scope 3: All emissions associated with producing inputs such as fertilisers, herbicides, services etc.

As shown in Figure 2, more than 70% of all GHG emissions are from Scope 1 on-farm operations sources. Fertiliser and crop residue contribute more than 50% of these emissions. The other emissions come from Scope 3 pre-farm sources and 95% of these emissions are produced during the production of fertilisers and herbicides/pesticides used on-farm. Scope 2 emissions were negligible at the on-farm stage of crop production.

Emissions intensity by grain

GHG emissions intensity is a measure of the amount of GHG emissions per tonne of product. It provides a valuable productivity, efficiency and investment measure for farm management decisions. Emissions intensity fluctuates annually depending on seasonal rainfall, temperatures, crop rotation, yield, crop residues, disease, management approaches to nitrogen and fertiliser, lime, chemical and fuel use. The project found that production of wheat, barley, lupins and oats emit between 219 and 248kg CO_2-e per tonne of grain (Figure 3), whereas canola emits more than double this, at 551kg CO_2-e per tonne of grain. This is mainly due to its higher fertiliser inputs and lower yields.

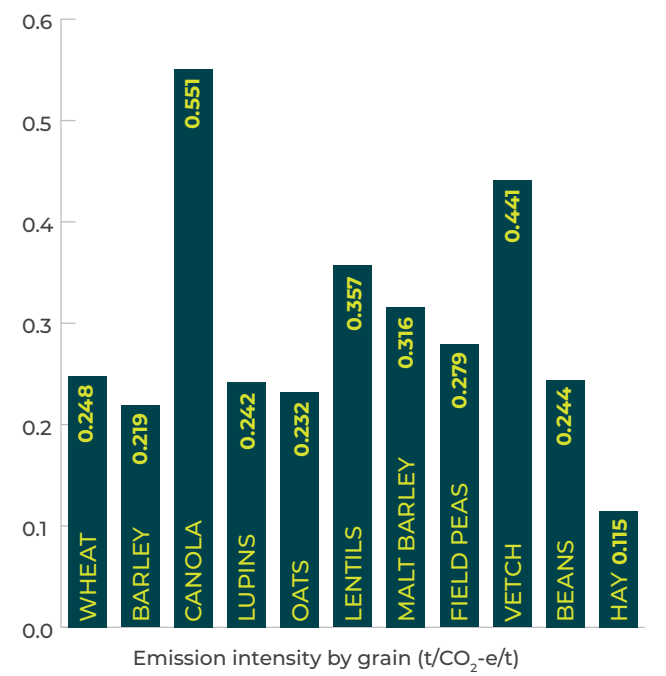


Figure 3: Comparison of GHG emission intensity between grains

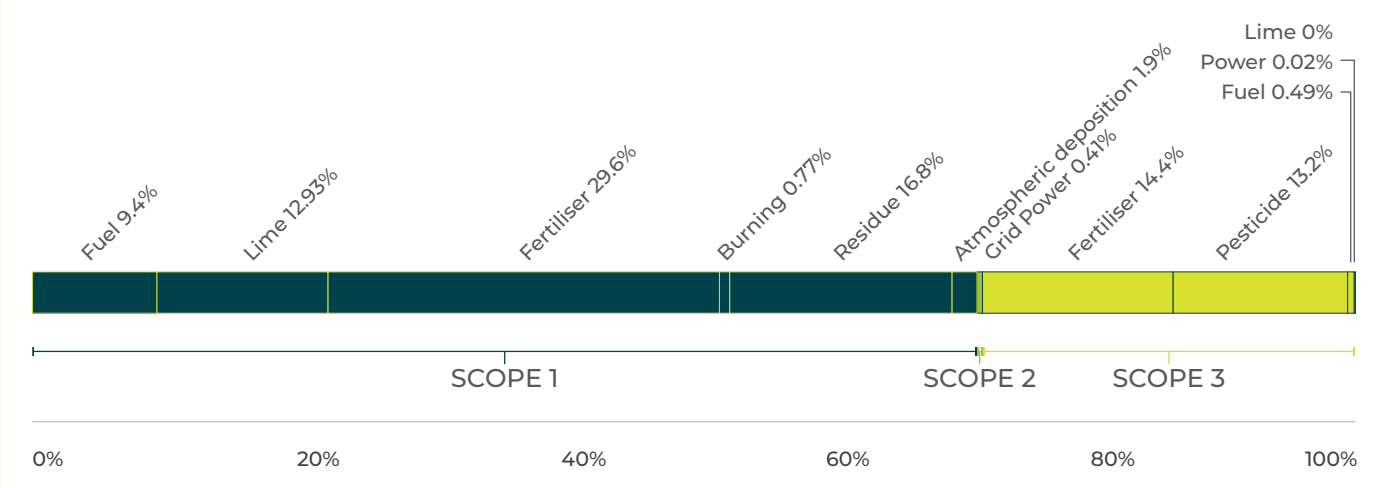


Figure 2: Breakdown of GHG emissions by source and scope

Average total cost to offset all emissions

In order to give some sense of the relative costs in becoming carbon neutral, the project used a median price for carbon credits of AUD $31.36 per tonne CO_2-e (based on ACCU spot prices in May 2022) and found that the average cost to offset the grain emissions is $9.97 per tonne of grain produced or $24.50 per hectare.

Calculator comparison

Because GHG emissions measurement for Australian farms is a relatively new discipline, GHG calculators are not yet standardised. The project compared the on-farm use of the three leading GHG emissions calculators: University of Melbourne PICCC G-GAF Cropping GHG Accounting Framework V10.4 (PICCC Grains-GAF), Cool Farm Tool from the multinational Cool Farm Alliance, and the CSIRO/FlintPro FarmPrint calculator, which is currently under commercialisation.[1]

The project recommends that cropping enterprises use the PICCC Grains-GAF calculator to determine GHG emissions. This calculator is free, excel based, and part of a suite of agricultural GHG calculators fully aligned to the Intergovernmental Panel on Climate Change (IPCC) and the Australian National Greenhouse Gas Inventory (NGGI). It is sufficiently accurate for grain growers and farm business advisors to measure cropping GHG emissions annually as a standard part of farm business financial reviews.

Conclusions

Creating a traceable, low carbon emissions export grain supply chain which underpins future market access is within reach for Western Australian grain growers.

The creation of annual, anonymised sector-wide GHG emissions benchmarks for farm carbon accounting at relatively low cost will facilitate practice change which will:

- improve the productivity of farm inputs i.e. nitrogen, urea, other fertilisers, lime and soil ameliorants, herbicides, pesticides, fungicides, fuel type (diesel vs renewables)
- measure and mitigate overall GHG emissions from farm businesses
- measure and mitigate GHG emissions intensity by farm enterprise, cropping vs livestock
- increase farm sustainability credentials, lowering climate risk for financial lenders to farms

Project Partners

This pilot was a three-way private/public net-zero transition project initiated by the grower owned bulk handling cooperative, CBH Group, Australia's largest grain exporter, with ASX-listed regenerative food and agriculture company, Wide Open Agriculture, and primary industries research partner, the Western Australian Department of Primary Industries and Regional Development (DPIRD).

CBH GROUP

Wide Open Agriculture

GOVERNMENT OF WESTERN AUSTRALIA
Department of **Primary Industries and Regional Development**

1. *FarmPrint is not yet publicly available and only four of the 36 data sets were analysed using this calculator.*

1. Project Rationale

Australian export grain customers are requesting more sustainability and Environment, Social, Governance (ESG) criteria.

Global energy markets are transforming away from fossil fuels (coal, oil, gas) into renewable energy sources. International shipping, food and feed supply chains have started to decarbonise in response to the United Nations Framework Convention on Climate Change (UNFCCC) 2015 Paris Agreement guidance to reduce greenhouse gas (GHG) emissions. Australia is a signatory to the Paris Agreement and has a nationally determined contribution (NDC) target to reduce GHG emissions by 43% by 2030, reaching net zero by 2050.

Over the near to medium term, international trade agreements and future market access for carbon-intensive goods will be subject to equalising sovereign carbon border adjustment policies (tariffs or carbon border adjustment mechanisms (CBAMs)). The EU, China, Japan, Singapore and the US are already introducing or considering carbon border adjustment mechanisms. While trade in food and agricultural products is presently not included in carbon border adjustment mechanism development, that may not remain the case into the future.

Many food and feed grain processors and food and beverage manufacturers trading through multinational supply chains are reviewing their sustainability or ESG strategies.

Business	Scope 1	Scope 2	Scope 3
Heineken	<90% by 2030		<21% by 2030
	Net zero by 2040		
AB Inbev (SBTi)	<25% by 2025 (2017 baseline)		
	Net zero by 2040		
Pepsico	<75% by 2030		<40% by 2030
	Net zero by 2040		
Nestlé	<20% by 2025		
	<50% by 2030 (baseline of 92M tonnes in 2018)		
Mars	Net zero by 2040		
Unilever	<50% by 2030		
	Net zero by 2039 “source to point of sale”		

Figure 4: Multinational food businesses' 2030 net zero targets.

Australia is a net exporter of wheat to produce breads, noodles, pastas and feed for animal and aquaculture protein. Although Australia produces just three per cent of the world’s wheat (about 25 million tonnes per annum), it accounts for 10-15% of the world’s 100 million tonne annual global wheat trade. The Australian export grain trade is dependent on shipping. The International Maritime Organisation has assertive targets to decarbonise the global shipping industry by 40% by 2030 and 70% by 2050.

In 2021, the CBH Group conducted an extensive survey of export grain customers on sustainability issues. These results have been communicated to Western Australian grower co-operative members. Grain processors reported receiving escalating market signals from downstream food manufacturers and retailers about consumers’ sustainability purchasing criteria, especially around chemical residues in food, food safety and environmental provenance.

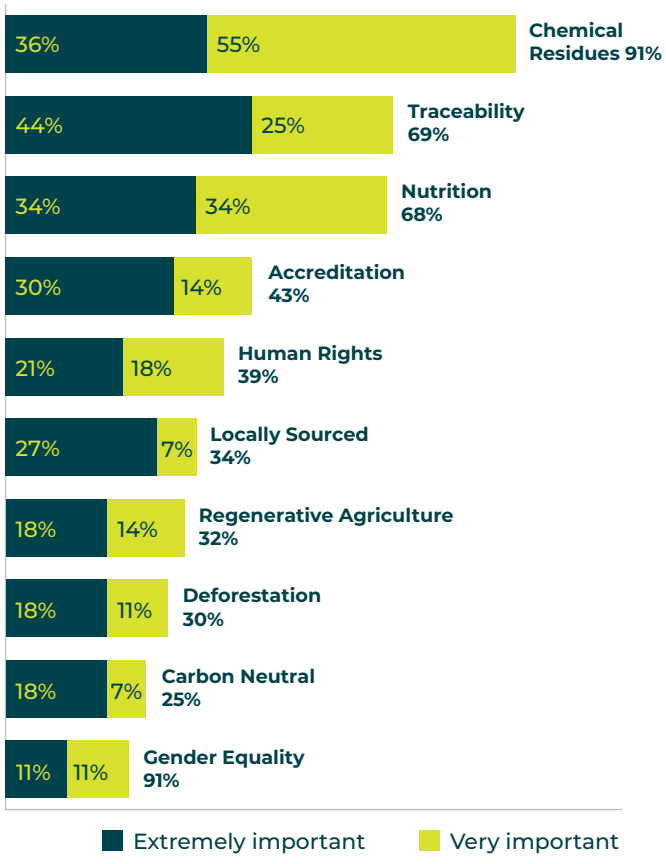


Figure 5: CBH grain customers ranking of important issues into very important and extremely important factors.

Although ranked 9 out of 10 top issues in this survey, 25% of customers surveyed ranked carbon neutral grain as very important or extremely important.

WA's primary industries are responsible for 10% of state emissions (1.7% of Australia's 520M t CO_2-e).

The WA agricultural landscapes provide a range of opportunities to – sequester carbon; reduce emissions associated with food growing and develop biodiversity stewardship systems.

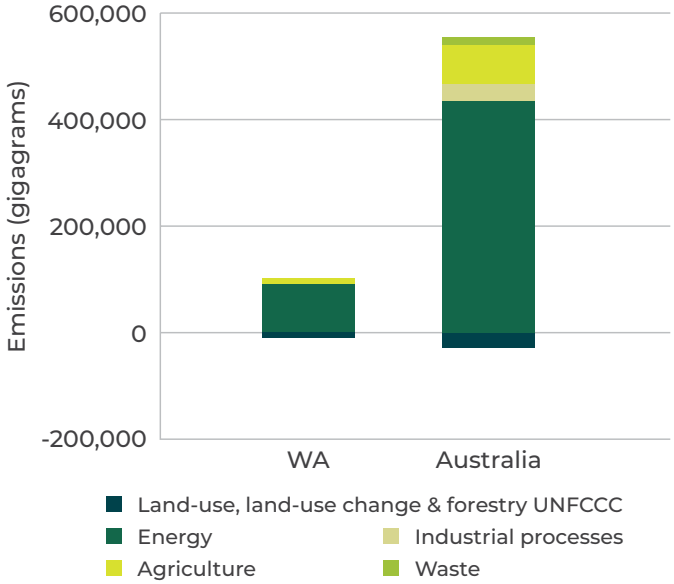
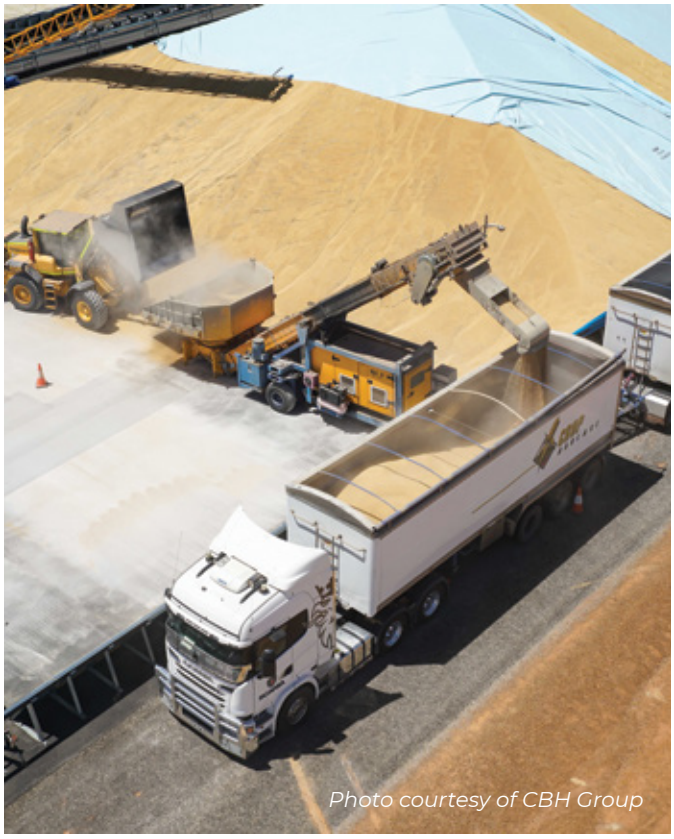


Figure 6: Western Australia's 2020 GHG inventory in comparison to Australia's total GHG emissions.
Source: https://ageis.climatechange.gov.au/sggi.aspx



Voluntary disclosure of financial and transition risks of climate change

Responding to the Intergovernmental Panel on Climate Change Sixth Assessment Report (Lawrence et al. 2022) and the international Financial Stability Board's Taskforce for Climate Related Financial Disclosure (TCFD),[2] in late 2021, the Australian Prudential Regulatory Authority (APRA)[3] finalised voluntary prudential guidance for managing the financial risks of climate change. This guidance extends to all institutions operating in the Australian financial sector, including the Reserve Bank of Australia, superannuation funds, insurers and underwriters, the Australian Securities and Investment Commissions ASIC, Australian Stock Exchange ASX, and retail banks and financial institutions.

Global and Australian banks and financial institutions are reviewing their exposure to the physical and transition risks of climate change in their loan portfolios, including for food, agribusiness, agricultural and land-based businesses, regardless of whether these businesses are listed or privately held. Some banks have started providing preferential access to capital for businesses which can demonstrate climate resilience through TCFD aligned corporate strategies, measurement and mitigation of GHG emissions, or improved management of other emerging indicators of natural capital such as water catchment health, biodiversity or remnant vegetation. In May 2022, ASIC indicated they intend to increase scrutiny of ESG and listed company climate transition claims, signalling their expectation that prudential climate risk disclosure will become mandatory in Australia sooner rather than later.

Over the coming decade, it is possible that the UNFCCC, dual climate and biodiversity COPs (Conference of Parties), the international Financial Stability Board, World Economic Forum, G20, IFRS (ISSB), World Bank and the Network for Greening the International Financial System will support the convergence of the two international financial taskforce frameworks on managing climate change risk and nature loss, i.e. the TCFD and Taskforce for Nature Related Financial Disclosure (TNFD).[4] Therefore, it is likely that disclosure will become mandatory in the Australian financial system.

2. https://www.fsb-tcfd.org/
3. https://www.apra.gov.au/news-and-publications/apra-finalises-prudential-guidance-on-managing-financial-risks-of-climate
4. https://tnfd.global/

Environment, Social, Governance (ESG) credentials and the Australian grain industry

In response to the global economic imperative to sequester carbon, investors are providing new capital to the emerging financial asset class of carbon farming and environmental services. This is changing agricultural land use in some parts of Australia. New carbon avoidance or sequestration methodologies are approved by the federal Emissions Reduction Fund administered by the Clean Energy Regulator.[5] Measuring GHG emissions will become one metric of natural capital management in the farm sector.

For export-oriented Western Australian grain growers, climate change and these transformative economic developments present both physical and transition risks and capital allocation and market access challenges, as well as productivity, income diversification and market access opportunities.

Currently, approximately seven percent of grain exported from Western Australia is certified under the International Sustainability and Carbon Certification (ISCC).[6] The ISCC is a German origin carbon emissions and sustainability certification which is widely recognised by the international grain trade. Use of the ISCC Certification for Australian grain (originally only canola) exported into the European Union was negotiated by Australia under a sectoral/Life Cycle Analysis (LCA) emissions data package originally prepared by CSIRO on behalf of the Australian Oilseeds Federation and major Australian grain exporters.

The Australian grain marketers have been offering a premium to growers for grain certified under the ISCC EU and ISCC Plus sustainability certifications for over ten years. The importance of maintaining, and growing Sustainable Accreditation is very likely to keep increasing as end customers demand increased traceability and sustainability measures for market access, including GHG emissions data.

In Australia, CBH Marketing and Trading, and Sustainable Grain Australia[7] facilitate the sustainability certification of Australian grain, oilseeds and pulses under the ISCC scheme.

Australian grain growers are guided by several national frameworks, surveys, codes of practice and certification schemes to demonstrate their sustainability and ESG credentials:

- **The Australian Farm Institute and National Farmers' Federation**
- **Australian Agricultural Sustainability Framework AASF v3.0**[8] includes measures of natural capital
- **Grain Growers Limited** have produced the **Behind Australian Grain**[9] sustainability framework and have a Climate Change policy supported by members with targets of 15% reduction in grains emission intensity by 2030[10]
- **Grain Producers Australia** have an Australian Grain Guide[11]
- **Ag Innovate Australia**[12] is a not-for-profit supported by all Rural Research and Development Corporations to invest in common research challenges such as emissions measurement and management in primary industries
- **Agrifutures Community Trust in Rural Industries**[13]
- **Food Alliance WA DPIRD Trust in Primary Industries Project**[14] is a 2019 survey of the Western Australian public that measured the trust levels in environmental management practices of WA primary industry producers, including fishing

However, Australian grain sectors do not have any absolute emissions reduction targets and Western Australian grain growers are currently not subject to any formal, regulated state government or industry wide reduction targets.

5. http://www.cleanenergyregulator.gov.au/ERF/Method-development-tracker; http://www.cleanenergyregulator.gov.au/maps/Pages/erf-projects/index.html
6. https://www.iscc-system.org/; https://www.cbh.com.au/marketing-and-trading/iscc
7. http://www.australianoilseeds.com/iscc_certification/sustainable_grain_australia
8. https://www.farminstitute.org.au/product/aasf-australian-agricultural-sustainability-framework/
9. https://www.behindaustraliangrain.com.au/
10. https://www.graingrowers.com.au/policy/sustainability-climate-change-and-natural-resource-management/climate-change-policy-graingrowers
11. https://www.grainproducers.com.au/australian-grains-guide
12. https://www.aginnovationaustralia.com.au/
13. https://www.agrifutures.com.au/national-rural-issues/community-trust/
14. https://wafarmers.org.au/about/food-alliance-trust-in-ag/

Australian grain growers and GHG emissions

Some of the grain which Western Australian grain growers sell internationally is already covered by end customers' commercial upstream 2030 GHG emissions reduction targets. Companies including ABInBev, Heineken, Boortmalt, and PepsiCo have started approaching their upstream grain grower suppliers to ask "What is the emissions profile of your grain? Can we partner with you to measure and lower it?"

The mixed farming research enterprise at DPIRD Katanning Research Station has conducted Life Cycle Analysis emissions research in the red meat supply chain and found the following absolute emissions and emissions intensity, which includes some grains emissions.

The national GRDC Australian Grains Baseline and Mitigation Assessment was published in February 2022, using 2005 emissions data.[15] The GRDC reports that "our low emissions intensive production (greenhouse gases emitted per tonne of production) has been important to securing access to the European Union canola market, which is valued at $1 billion per annum and is likely to be a competitive advantage to Australian grain exports in many markets going forward."

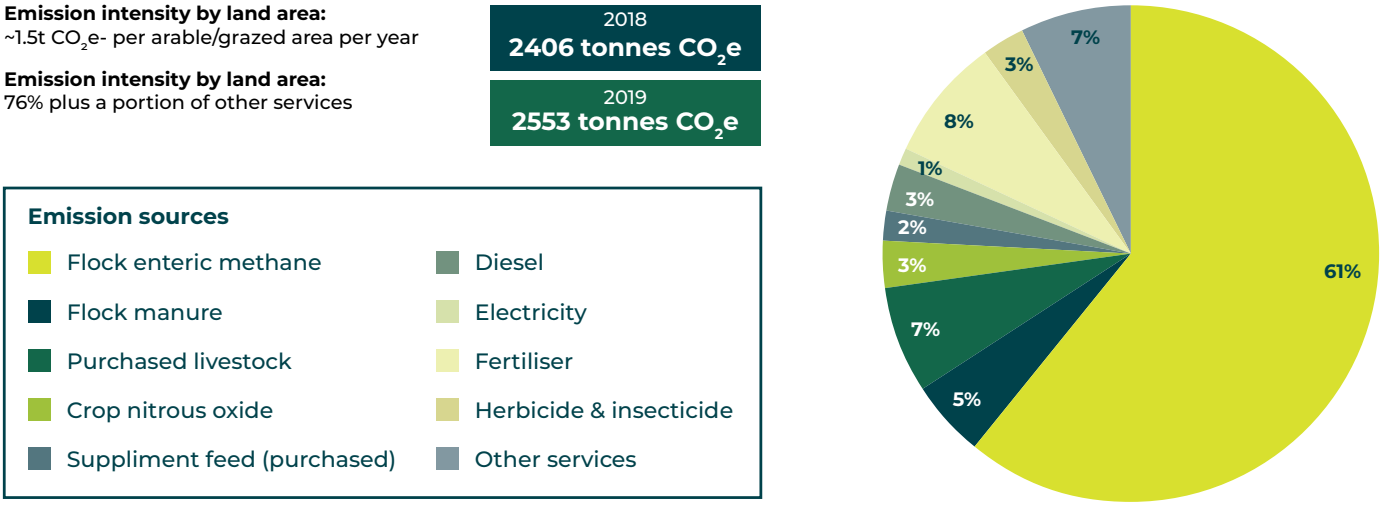
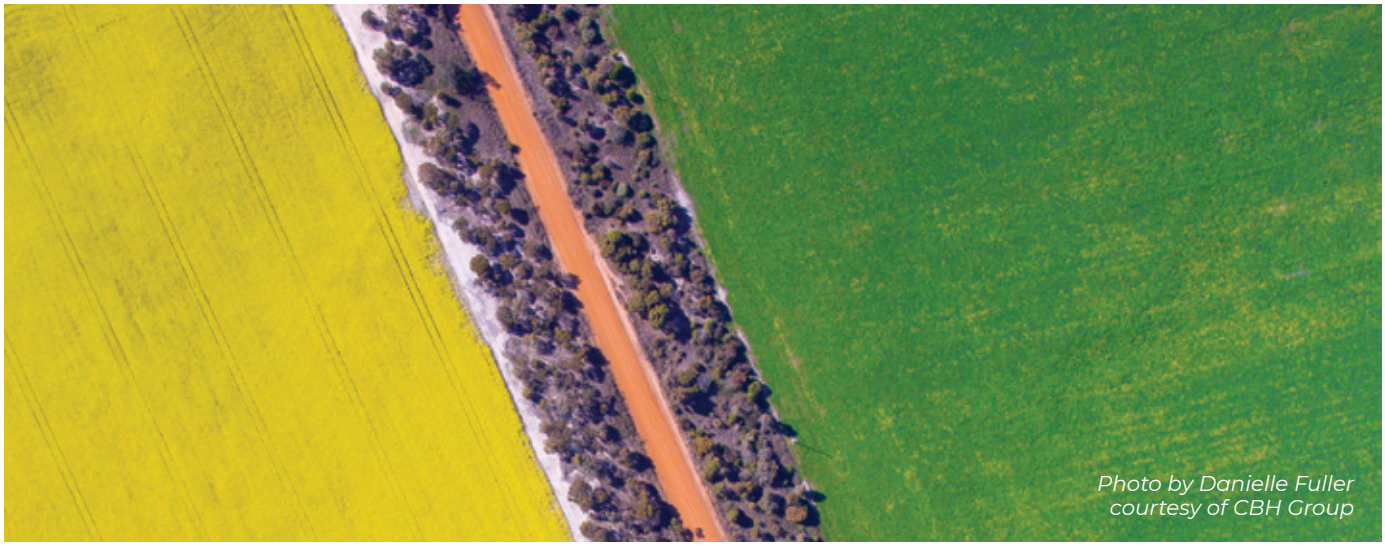


Figure 7: Katanning Research Facility Emissions intensity.



15. https://grdc.com.au/about/our-industry/greenhouse-gas-emissions

Photo courtesy of CBH Group

The assessment identifies three sources of GHG emissions in the grain sector: Scope 1 emissions are generated from on-farm activities, Scope 2 emissions are produced from electricity used on-farm, and Scope 3 emissions are generated from off-farm activities that occur upstream or downstream of the farm gate. The assessment also provides baseline data for each Scope. In addition, the GRDC and CSIRO conclude that Australian grain growers are already efficient, low emissions intensity producers of grain, producing approximately 315 kgs CO_2-e per tonne of grain (on 2005 levels of national emissions).[16] However, more multi-season GHG emissions benchmarking data is required from the farm business advice and farm sector parts of the export grain supply chain.

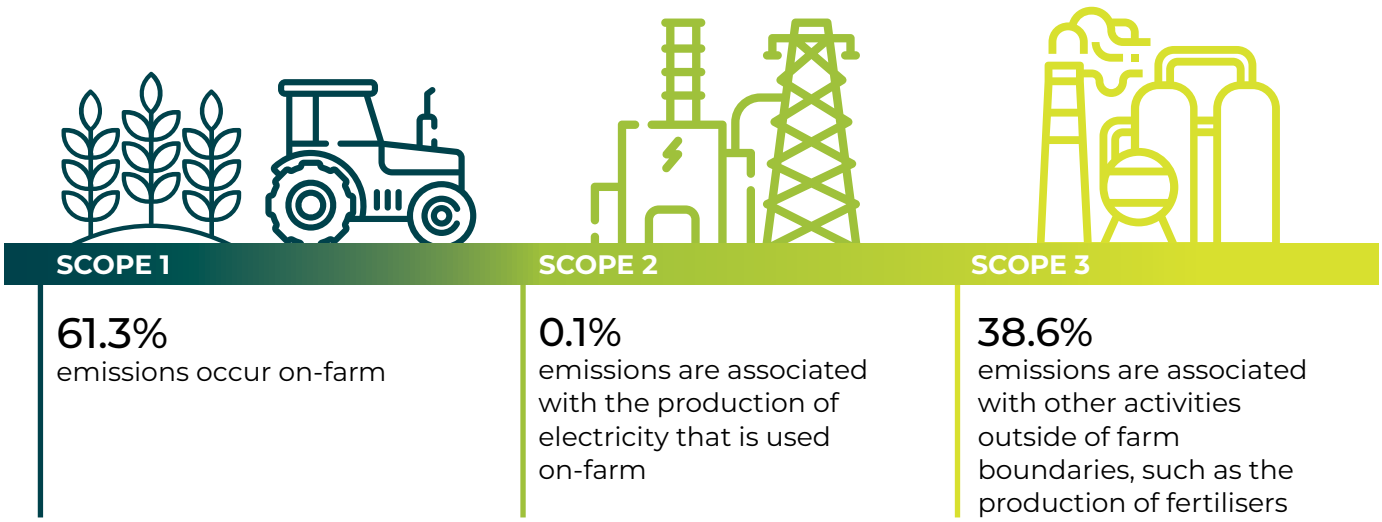


Figure 8: Where GHG emissions come from
Source: https://grdc.com.au/about/our-industry/greenhouse-gas-emissions

16. https://grdc.com.au/about/our-industry/greenhouse- gas-emissions; https://grdc.com.au/about/our-industry/greenhouse-gas-emissions/Emissions-Factsheet-V7.pdf

	Scope 1	Scope 2	Scope 3
Fertiliser	15.1%	-	22.5%
Lime	11.0%	-	1.3%
Residue	20.4%	-	
Protection	-	-	10.7%
Operations	11.0%	-	3.7
Irrigation	0.8%	0.0%	0.4%
Soil carbon	2.9%	-	-
Storage	0.0%	0.1%	0.0%

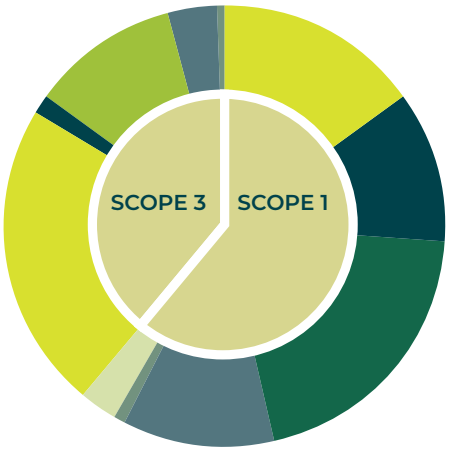


Figure 9: Breakdown of grain production GHG emissions by contribution
Source: https://grdc.com.au/about/our-industry/greenhouse-gas-emissions

Table 1: Absolute GHGs emissions and emissions intensity measurements by CBH Group.

	Scope 1 CO_2-e	Scope 2 CO_2-e	Total CO_2-e	Energy Consumed (GJ)
2020/21	12,992	42,380	**55,372**	418,813
2019/20	11,553	44,557	**56,110**	394,151
2018/19	11,444	49,823	**61,267**	424,354
2017/18	10,502	44,313	**54,815**	382,397
2016/17	12,180	54,406	**66,586**	449,423
2015/16	10,300	52,954	**63,254**	401,551
2014/15	9,249	53,836	**63,085**	387,989
2013/14	9,836	55,258	**65,094**	396,497
2012/13	8,395	56,590	**64,985**	371,967

2. Project Objectives

Creating low-carbon pathways to market for Western Australian export grain

Responding to these market developments, the Carbon Neutral Grain Pilot was designed to raise supply chain ambition and confidence in measuring upstream GHG emissions behind the farm gate i.e. Scope 1, 2 and 3 emissions from Western Australian cropping enterprises, and to generate a WA specific data set.

The objectives of the Carbon Neutral Grain Pilot were to:

1. Ground-truth available farm GHG calculators for WA cropping conditions and share feedback on the GHG calculators with their developers/owners
2. Make a recommendation about the best fit-for-purpose GHG calculator of the three leading calculators
3. promote GHG emissions measurement, mitigation and practice change with an influential group of conventional and self-identified regenerative growers by producing a contemporary and WA-specific cropping data set (wheat, barley, canola, oats and lupins) that accounts for:
    - total farm emissions
    - emissions intensity by commodity type
    - estimated cost per tonne and hectare to offset carbon emissions in order for the grain to achieve theoretical carbon neutrality (not accounting for any on-farm soil or vegetative carbon sequestration activities)
    - feedback for GHG calculator developers as to their fit for purpose, accuracy, ease of use, interoperability, possible improvements
    - further insights into influential factors affecting emissions from cropping in a WA production context
    - any emissions profile differences between conventional and self-identified regenerative growers, acknowledging that there is no standard industry definition for regenerative practices

The Carbon Neutral Grain Pilot was designed to raise supply chain ambition and confidence in measuring upstream GHG emissions behind the farm gate

Photo courtesy of CBH Group

3. Project Scope

Data for Scope 1 (from operations), Scope 2 (energy-inputs) and Scope 3 (emissions from upstream inputs and suppliers) GHG emission sources was collected from 36 cropping farm enterprises around West Australia.

- 8 data sets were collected in 2020 and generously supplied by Boortmalt and 28 of the data sets were collected in 2021 by the project.
- The data covered a total of 151,636 hectares of family farm cropping enterprises in the WA wheatbelt, from four port zones.
- An additional 100,000 hectares of corporate cropping GHG emissions data was provided by Viridis for use in the CSIRO FarmPrint/FlintPro calculator.
- The farms/enterprises ranged from 695ha to 21,027ha with an average size of 4338ha and a median size of 2664ha.
- A total of 416,797 tonnes of grain were considered (around 2% of the 2021 WA crop), which included barley, canola, lupins, oats and wheat. Data from the production of other grains (beans, field peas, hay, lentils, malt barley and vetch) was also considered but due to lower numbers of farm examples it was not included in the summary results.
- Several growers in the pilot self-identified as 'regenerative'. Note that there is no standard definition of regenerative practices. Typically regenerative principles include: no til (minimised soil disturbance), keep soil covered all year round, maintain living root all year round, maximise plant and animal diversity, incorporate livestock and minimise synthetic outputs. All growers in the project have been anonymised.

Although 30% of the operations from which data was collected were mixed operations, only GHG emissions from cropping enterprises were considered. Livestock enterprises were not included. In addition, on-farm soil carbon or vegetation sequestration carbon farming mitigation activities were not considered. Growers have retained ownership of their personal data.

Dataset Stats	Count	Area (ha)	Grain (t)
Wheat	35	66,279	211,678
Barley	31	25,402	82,662
Canola	27	35,669	63,974
Lupins	27	11,364	22,440
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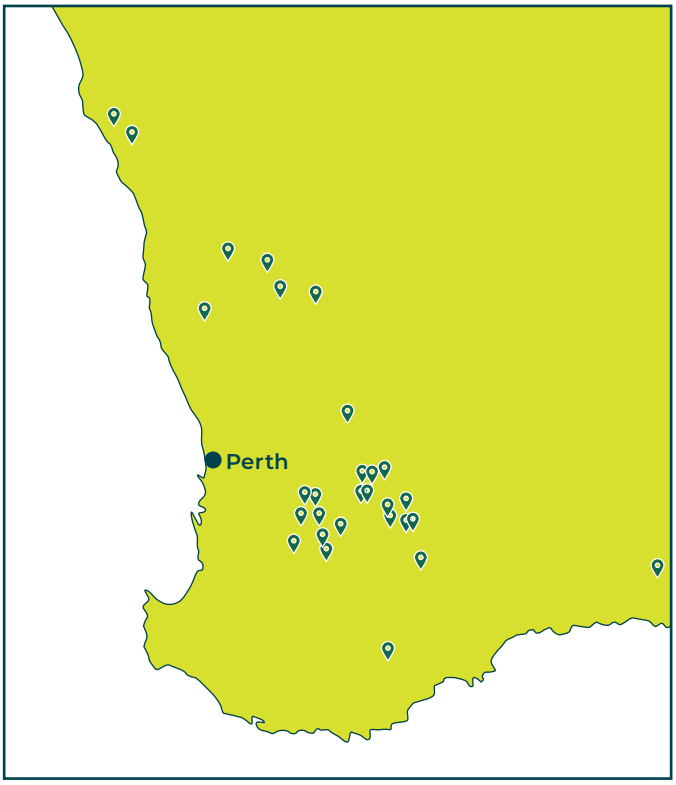

Figure 10: Western Australian pilot project cropping data sets from 36 properties over 2020 and 2021.

4. Project Methodology

Calculator comparison and emissions benchmarking

1. Data was collected from all three Scopes of farm cropping emissions and anonymised
2. The anonymised data was entered into the three leading on-farm GHG emissions calculators: PICCC G-GAF Cropping GHG Accounting Framework V10.4 (PICCC Grains-GAF),[17] Cool Farm Tool[18] from Cool Farm Alliance and CSIRO/FlintPro FarmPrint.[19] It is important to note that only four of the 36 data sets were entered into the FarmPrint calculator.
3. Results generated from the PICCC Grains-GAF calculator were collated to determine benchmark GHG emissions data for the WA grains sector

Professional development workshops

Two professional development workshops were held over the 6-month project period. The first pilot workshop in November 2021 involved 80+ farm business advisor members from the Australian Association of Agricultural Consultants AAAC WA branch. The workshop introduced:

- climate change science
- ESG and sustainability finance sector and market responses to climate change
- types of greenhouse gases, their global warming potential and which ones are prevalent in agriculture
- the Australian GHG emissions regulatory framework; and
- described levers inside farm businesses for understanding, measuring, managing and lowering carbon emissions such as soil organic matter, soil carbon, crop residues, fertiliser and nitrogen use efficiency, lime use, pesticides, herbicides and fungicides use, diesel fuel and renewables use, nitrogen loss pathways, and controlled traffic systems

The second workshop in March 2022 included 100+ growers, farm business advisors, industry supply chain, banks and research participants, both Western Australian and national participants. The workshop:

- reviewed the latest GHG emissions research for Australian agriculture and reviewed the comparisons of the 3 leading GHG calculators for cropping
- communicated the GHG emissions data results from 36 Western Australian cropping programs; and
- discussed opportunities to standardise GHG emissions measurement and reporting for cropping

17. https://www.piccc.org.au/resources/Tools. This calculator has been updated to v10.63 as at June 2022
18. https://coolfarmtool.org/
19. https://www.csiro.au/en/research/environmental-impacts/sustainability/farmprint

Photo by Lleyton Curtin courtesy of CBH Group

5. Project Results

GHG Calculator Comparison

The project compared three leading GHG calculators to build confidence in GHG emissions measurement practice change for Western Australian cropping businesses. However, due to CSIRO constraints, only four cropping data sets were processed by CSIRO through the CSIRO Farm Print/FlintPro calculator.

The development of carbon calculators for farm businesses is a new and emergent commercial space in Australia and internationally. Unlike farm financial software, farm GHG calculators are not yet standardised, with various degrees of alignment to internationally accepted climate science from the IPCC (Figure 11),[20] the Australian National Greenhouse Gas Inventory (NGGI),[21] and Australian greenhouse gas agricultural research.

The three leading GHG emissions calculators assessed during this project were:

1. **University of Melbourne PICCC Greenhouse Accounting Frameworks GAFs Grains-GAF v10.4**[22]

The Primary Industries Climate Challenges Centre (PICCC) at the University of Melbourne provides a series of MS Excel based GHG emissions calculators aligned to the IPCC and the Australian National Greenhouse Gas Inventory NGGI. The calculators are based on 20 years of Australian agricultural emissions research, are free and publicly available from the website. The suite includes Grains-GAF, which is a calculator specifically designed for use by the Grains industry. This project assisted in updating the PICCC Grains-GAF, which at time of publication of this report is currently v10.7.

International Policy Drivers: IPCC Guidelines

Methodological tiers varying in complexity to be chosen on the basis of national circumstance.

Tier 1

- Simple first order approach.
- Use Coarse activity data from global datasets, simplifying assumptions, IPCC default parameters, large uncertainties.

Tier 2

- A more accurate approach, using local research.
- More disaggregated activity data, country specific parameter values, smaller uncertainties.

Tier 3

- Higher order methods.
- Detailed modeling and/or inventory measurement systems driven by data at higher resolution and much lower uncertianties.

Tier 1a, 1b, 2a, 2b etc

Emerging.

Figure 11: IPCC methodological tiers for calculator alignment. Acknowledgement to Professor Richard Eckard, University of Melbourne PICCC.

20. *More information about the* Intergovenmental Panel on Climate Change *IPCC Policy Guidelines for national GHG emissions measurement can be found at* https://www.ipcc.ch/
21. https://www.industry.gov.au/policies-and-initiatives/australias-climate-change-strategies/tracking-and-reporting-greenhouse-gas-emissions
22. https://www.piccc.org.au/resources/Tools

2. CSIRO FarmPrint being commercialised by FlintPro (Mullion Group)[23]

FarmPrint is a GHG emissions calculator designed by CSIRO and funded by Macquarie Viridis. It is currently being commercialised by FlintPro (Mullion Group), who are also one of the original designers of FullCAM and the current natural capital data engine service provider to the Department of Agriculture, Water and the Environment's Agriculture and Biodiversity Stewardship Program. The calculator is aligned to the IPCCC and the Australian National Greenhouse Gas Inventory NGGI. It is under commercialisation and not yet publicly available.

3. Cool Farm Tool, Cool Farm Alliance[24]

The Cool Farm Tool is a web based GHG emissions calculator designed to be used through northern hemisphere-based multinational supply chains (across sovereign national GHG emissions inventories) with investment from leading global food and beverage companies in the Cool Farm Alliance including ABInBev, ADM, Boortmalt, Danone, Heineken, Kellogs, Lactalis, Mars, Nestle, Nutrien Ag Solutions, PepsiCo. The calculator is user-friendly and free with log-in. However, it is only aligned to the first generic climate science data level (not all 3 data levels) of the IPCC and is not yet aligned to the Australian National Greenhouse Gas Inventory NGGI. Temperature parameters, fertiliser and emissions factors are not necessarily fit for Australian cropping production conditions.

Table 2: GHG calculators tested in Carbon Neutral Grain Pilot.

GHG Calculators	IPCC All 3 Tiers Aligned	Public	NGGI Aligned	Digitised	FullCAM
University Melbourne Primary Industries Climate Challenge Centre PICC Grains-GAF v10.4	●	●	●		
CSIRO FarmPrint - being commercialised by FlintPro (Mullion Group)	●		●	●	●
Cool Farm Tool (Cool Farm Alliance)		●		●	

Photo by Bronnie Joel courtesy of CBH Group

23. https://flintpro.com/ and https://www.csiro.au/en/research/environmental-impacts/sustainability/farmprint
24. https://coolfarmtool.org/

As shown, the PICCC Grains-GAF v10.4 and CSIRO FarmPrint are fully aligned to Australia's GHG emissions National Greenhouse Gas Inventory or NGGI, but only the PICCC Greenhouse Accounting Frameworks GAFs is publicly available.

Total GHG emissions, emission sources and emissions intensity results were compared between calculators. However, as previously mentioned, due to CSIRO constraints, only four cropping data sets were processed by CSIRO through the CSIRO Farm Print/FlintPro calculator.

Absolute (Total) GHG Emissions results comparison between calculators

Total GHG emissions is measured as tonnes of CO_2-equivalents (CO_2-e). The PICCC Grains-GAF and Cool Farm Tool were used to determine the average total GHG emissions for each of the 36 Western Australian cropping enterprises (Table 3) and for each grain (Table 4). The PICCC Grains-GAF calculator determined total GHG emissions to be just 55 tonnes CO_2-e more than the Cool Farm Tool.

Table 3: Comparison between calculators of the average total GHG emissions results

All farms: Average total emissions	GGAF	CFT
Total tonnes CO_2-e	3642	3587

Of note, total GHG emissions by grain type were higher using the Cool Farm Tool than the PICCC Grains-GAF tool and the differences were not consistent between grains (refer to column in Table 4 indicating % difference between calculators).

Table 4: Comparison between calculators of the average total GHG emissions results by grain

All farms: Average total emissions by commodity (t)			% difference
Commodity	GGAF	CFT	
Wheat	1501	1674	11.6%
Barley	595	718	20.7%
Canola	1305	1326	1.6%
Lupins	201	352	74.8%
Oats	481	504	4.8%

Further details on Western Australia's state GHG emissions from annual national greenhouse gas cropping and livestock inventory data (IPCC AR5) can be found at:

www.agric.wa.gov.au/climate-change/greenhouse-gas-emissions-wa-agriculture

Further details on the Australian Grains Baseline and Emissions Assessment from GRDC and CSIRO (2005 IPCC AR3 data) can be found at:

www.grdc.com.au/about/our-industry/greenhouse-gas-emissions/GRDC_MainFinalReport_170122_CONFIDENTIAL.pdf

Emissions by source results comparison between calculators

Data entry and emissions calculations by source

The inputs and data entry are presented very differently by the two calculators. As shown in Table 4, the PICCC Grains-GAF calculator organises data entry and presents emissions from sources by location, i.e. Scope 1 on-farm use of sources, Scope 2 electricity and Scope 3 off-farm source production. However, as shown in Table 6, the Cool Farm Tool data entry organises data entry and presents emissions from sources according to farm activity or resource.

Table 5: Average total GHG emissions by source using the PICCC Grains-GAF v10.4 calculator

Average total emissions by source	GGAF Average CO_2-e (tonnes)	% Scope	% Combined Scopes
Scope 1 Emissions (on-farm):			
CO_2 – Fuel	347	13.38%	9.51%
CO_2 – Lime	460	17.78%	12.64%
CO_2 – Urea	242	9.33%	6.63%
CH_4 – Field Burning	21	0.81%	0.57%
CH_4 – Fuel	0	0.02%	0.01%
N_2O – Fertiliser	611	23.58%	16.77%
N_2O – Atmospheric Deposition	71	2.73%	1.94%
N_2O – Field Burning	8	0.30%	0.21%
N_2O – Crop Residue	621	23.98%	17.05%
N_2O – Leaching and Runoff	208	8.03%	5.71%
N_2O – Fuel	2	0.07%	0.05%
Sub-total excl hay	**2590**	**100.00%**	**71.10%**
Scope 2 Emissions (off-farm):			
Electricity	15	100.00%	0.41%
Sub-total excl hay	**15**	**100.00%**	**0.41%**
Scope 3 Emissions (pre-farm):			
Fertiliser	533	51.36%	14.63%
Herbicides/Pesticides	486	46.81%	13.33%
Electricity	1	0.08%	0.02%
Fuel	18	1.75%	0.50%
Lime	0	0.00%	0.00%
Sub-total excl hay	**1038**	**100.00%**	**28.49%**
TOTAL Scope 1, 2 and 3 GGAF	**3643**		**100%**

Table 6: Average total GHG emissions by source using the Cool Farm Tool

Average total emissions by source	CFT Average t	% Combined Scopes
Seed production	0	0.0%
Residue management	606	16.9%
Fertiliser production	715	19.9%
Soil / fertiliser	1608	44.8%
Paddy methane	0	0.0%
Crop protection	152	4.2%
Carbon stock changes	10	0.3%
Energy use (field)	372	10.4%
Energy use (processing)	0	0.0%
Waste water	0	0.0%
Off-farm transport	123	3.4%
TOTAL Scope 1, 2 and 3 CFT	**3587**	**100%**

The two graphs below attempt to provide a more direct visual comparison:

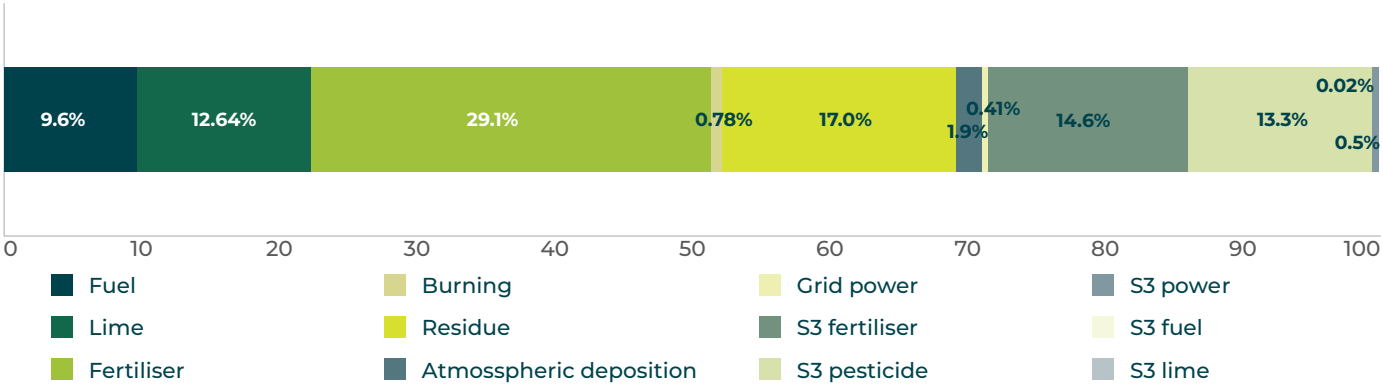

Figure 12: All Grains Average – emission by type: PICCC Grains-GAF – April 2022 figures

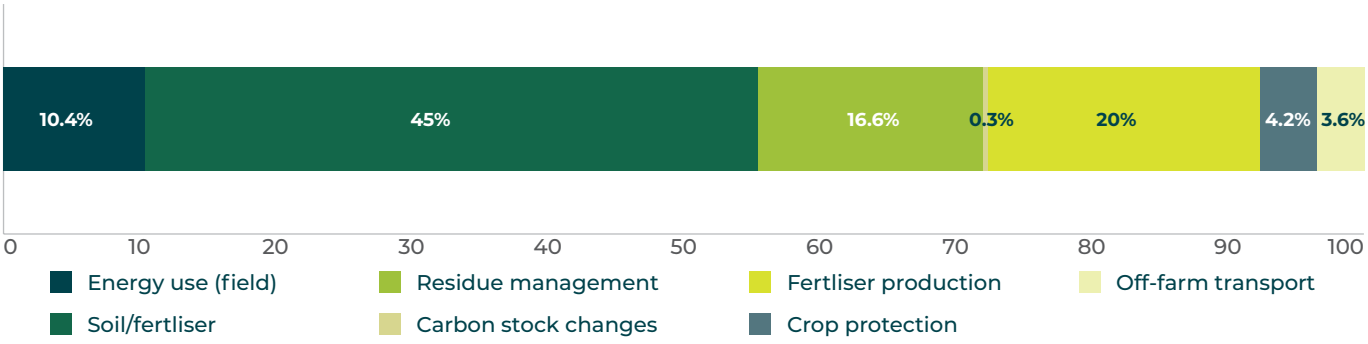

Figure 13: All Grains Average – emission by type: Cool Farm Tool

Figure 14 provides a comparison between the results generated by the GGAF and CFT calculator for the GHG emissions from the sources organised by Scope. Grains-GAF and Cool Farms Tool presented similar emissions results.

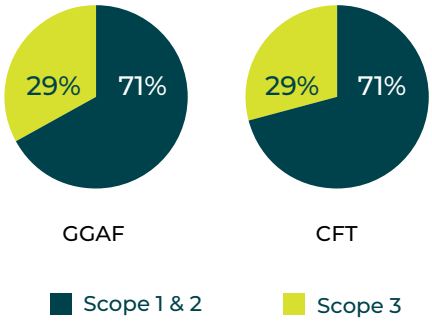

Figure 14: Comparison of source GHG emissions results organised by Scope between the GGAF and CFT calculators

Emissions intensity results comparison between calculators

GHG emissions intensity is measured as CO_2-equivalents (CO_2-e) per tonne or hectare and enables comparison between different GHG emission generators. It is a valuable productivity, efficiency and investment measure for farm management decisions as it enables clear comparison between grains and enterprises.

All three calculators calculate GHG emissions intensity. Figure 19 in Appendix B provides a comparison between the calculators for GHG emissions results for each of the 36 farm enterprises, including the results from the four data sets entered into the CSIRO FarmPrint calculator (circled in blue). Average total GHG emissions intensity per farm was determined to compare calculators. However, only the PICCC Grains-GAF and Cool Farm Tool emissions intensity results were compared, due to the limited data set used by the CSIRO FarmPrint calculator. Table 7 shows that the two calculators produced similar figures for the average emissions intensity for the 36 data sets used in this study, with the Cool Farm Tool figure being 1.5% lower than that of the Grains-GAF calculator.

Table 7: Comparison between calculators of average total GHG emissions intensity results

All farms: Average total emissions	GGAF	CFT
Total tonnes CO_2-e	0.309	0.304

Figure 16 provides the results for average GHG emissions intensity for each Scope generated by each calculator and shows that the Grains-GAF and Cool Farm Tool calculators generate similar results. Although the CSIRO FarmPrint calculator generates similar average emission intensity for the Scope 1 and 2 sources to the other calculators, it generates considerably higher Scope 3 emission intensity.

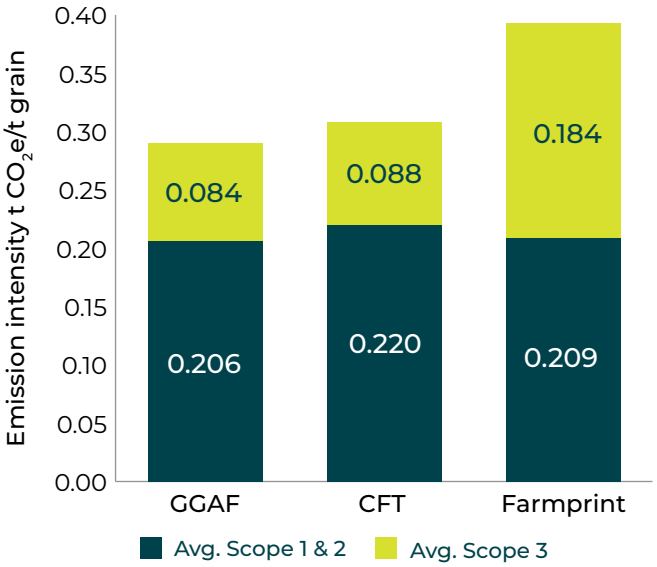

Figure 15: Calculator comparisons of the average total emissions intensity of all farms, all grain crops

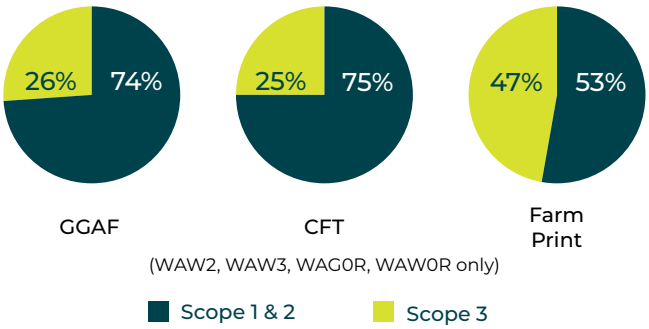

Figure 16: Comparison of GHG emissions intensity by Scope between calculators

The average total GHG emissions intensity results were also compared for each grain (Table 8). The emissions intensity results generated by the PICCC Grains-GAF calculator were consistently lower than those generated by the Cool Farms Tool calculator.

Table 8: Comparison of average total emissions intensity for each grain commodity between PICCC Grains-GAF and Cool Farms Tool.

All farms: Average total emission intensity by commodity (tCO2-e/t grain)		
Commodity	**GGAF**	**CFT**
Wheat	0.248	0.277
Barley	0.219	0.264
Canola	0.551	0.560
Lupins	0.242	0.423
Oats	0.232	0.243

Average Total Cost to Offset All Emissions comparison between calculators

In order to give some sense of the relative costs in becoming carbon neutral, the average cost for each farm to neutralise total GHG emissions was determined. A median price for carbon credits of AUD $31.36 per tonne CO_2-e (based on ACCU prices in May 2022) was used. Table 9 shows the comparison between the PICCC Grains-GAF and Cool Farms Tool calculators for this cost due to the different average total GHG emissions results from these calculators.

Table 9: Comparison of average cost to neutralise emissions between PICCC Grains-GAF and Cool Farm Tool

All farms: Average cost to neutralise emissions at $31/t	GGAF	CFT
Total cost (grains only)	$99,680	$111,978

Summary of data calculation comparison between calculators

The pilot found that the PICCC Grains-GAF and Cool Farm Tool calculators were more closely aligned than the research-based CSIRO Farm Print calculator, which required more detailed data entry for pesticides, herbicides and fungicides and produced a higher average Scope 3 emissions result.

GHG Emissions Data Baselines

Emissions sources

Unlike livestock enterprises, where methane (CH_4) from ruminant beef cattle, dairy cattle and sheep is the main GHG, cropping enterprises generate nitrous oxide (N_2O), from fertilisers, crop residues (stubble), leaching and run-off, herbicides, pesticides and fungicides, and carbon dioxide (CO_2) from fuel and urea.

This study found similar breakdowns of emissions sources when compared with GRDC/CSIRO 2021 Australian Grains Baseline and Mitigation Assessment.[25]

Emissions intensity

The average GHG emission intensity per farm was found to be 309kg CO_2-e per tonne of grain (Table 7). This is slightly lower than the national baseline of 315 kgs CO_2-e per tonne grain reported by the GRDC/CSIRO Australian Grains Baseline and Mitigation Assessment, using 2005 emissions data. The average GHG emissions intensity for wheat, barley, lupins and oats were found to be similar and between 219 and 248 kg CO_2-e per tonne of grain. However, the average GHG emissions intensity for canola was 551 kg CO_2-e per tonne of grain (Figure 17), which is more than twice that of the other grains. This is mainly due to higher fertiliser inputs and lower yields of canola compared to the other grains. In addition, the average GHG emissions intensity generated by wheat enterprises in WA was 220kg CO_2-e per tonne of wheat, which is 30% lower than those of the national baseline data.

25. https://grdc.com.au/about/our-industry/greenhouse-gas-emissions/Paper-Sevenster-Maartje-GHG-footprint-Grains-February-2022.pdf

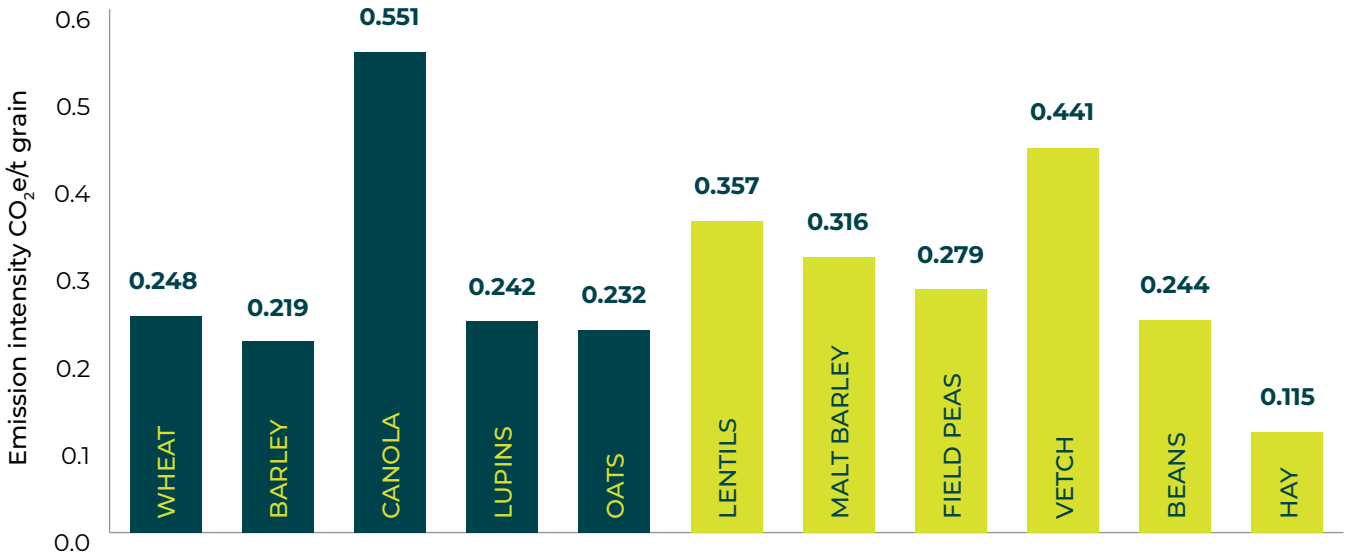

Figure 17: Comparison of average GHG emissions intensity between grains, determined using the PICCC Grains-GAF calculator

Emissions intensity fluctuates annually depending on seasonal rainfall, temperatures, crop rotation, yield, crop residues, disease, management approaches to nitrogen and fertiliser, lime, chemical and fuel use.

Average Total Cost to Offset All Emissions

The average cost to offset the grain emissions was found to be $9.97 per tonne of grain produced or $24.50 per hectare utilising an offset cost of $31.36 per tonne of CO_2-e.

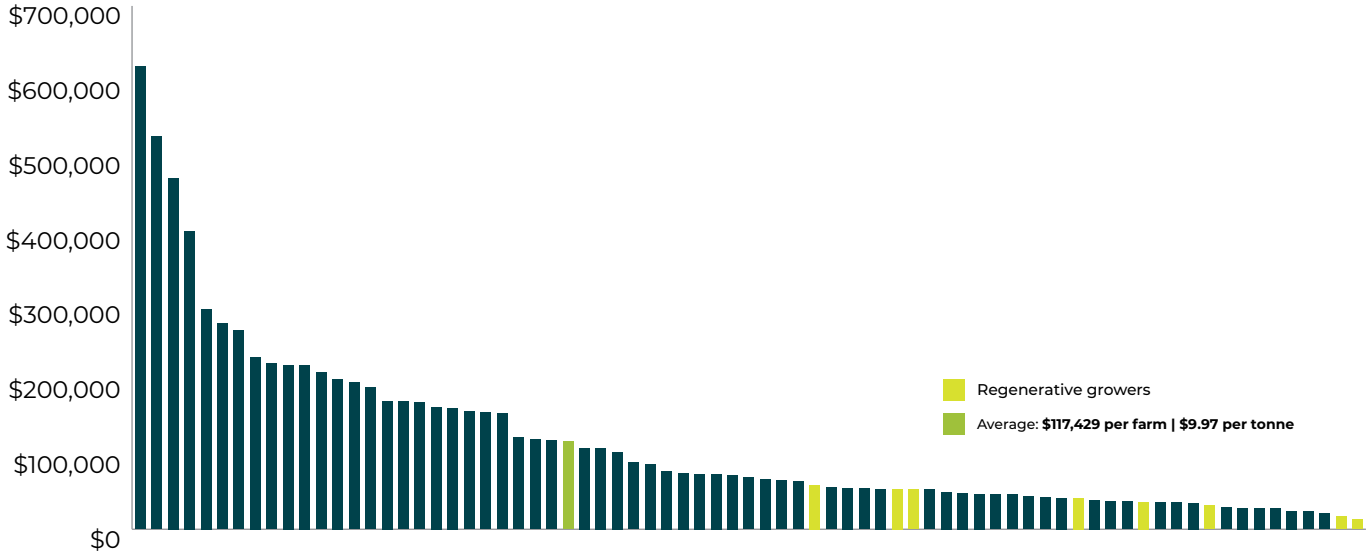

Figure 18: Comparison of total costs to offset GHG emissions between farm enterprises. Note that this figure includes self-identified regeneration growers (in light green) but does not include sequestration activities. It also applies only to cropping enterprises and does not account for the operation's scale or enterprise mix.

6. Project Outcomes and Conclusions

GHG measurement and traceability

The project concludes that standardised upstream supply chain Scope 1, 2 and 3 Greenhouse Gas emissions measurement and traceability is within reach for WA cropping enterprises. The dual approach of measuring and mitigating both absolute GHG emissions and GHG emissions intensity in WA cropping enterprises is strongly recommended.

In addition, the project **provides support for anonymised CO_2-e data to be included in Western Australian farm financial benchmarks**. It is likely that at least one of the leading farm business advisory groups in Western Australian will soon publish anonymised CO_2-e metrics for cropping as part of their annual benchmark series. If the two leading Western Australian farm financial benchmarks published CO^2-e metrics, around 23% of the 3,500 growers producing grain in WA could be reporting on GHG emissions within 2 years. Hence this pilot project's capacity building work with the Australian Association of Agricultural Consultants AAAC WA chapter.

In the drying, warming climate in the southwest land division of Western Australia, is it possible for grain growers to remain profitable, measure and mitigate emissions to create low carbon pathways to market, or even achieve carbon neutrality inside their businesses? **The short answer is that the results of the study demonstrate that creating traceable, low-carbon export grain from WA cropping enterprises is within reach**. Note: "low-carbon" is within reach. However, carbon neutrality is aspirational and is not necessarily achievable in the short to medium term.

Calculating farm sector emissions is not yet standardised – this will be one of the workstreams of the newly formed national Ag Innovate Australia initiative hosted by Agrifutures.

Calculator comparison

The project found that Western Australian cropping enterprises can use the University of Melbourne PICCC Grains-GAF Cropping v10.4 calculator for the accurate and reliable determination of on-farm emissions retrospectively on an annual basis, as part of regular farm business financial and production reviews. For those croppers who also have livestock, the suite of PICCC GAF tools includes GHG calculators for sheep and beef, dairy, horticulture, pork, chicken, and other enterprises. DPIRD came to the same conclusion in their 2021 review of GHG calculators for mixed farming enterprises.[26]

Feedback provided to calculator developers

The project assisted the University of Melbourne PICCC to update its Grains-GAF Cropping calculator from 2015 to 2022 data, now included in version 10.7. The project also provided feedback to the Cool Soils project at Charles Sturt University aligned to the Cool Farm Tool about improving temperature parameters, urea and lime calculations, and chemical input data, and provided feedback to the CSIRO Farm Print/FlintPro developers about reducing and standardising the amount of agricultural chemical data required by the calculator.

Photo courtesy of CBH Group

...creating traceable, low-carbon export grain from WA cropping enterprises is within reach.

26. https://www.agric.wa.gov.au/carbon-farming/carbon-calculators-%E2%80%93-western-australian-example-farms

7. Project recommendations

Carbon in Agriculture Extension Training

Practice change is needed by Western Australian grain growers to measure baseline farm GHG emissions, what overall absolute emissions per farm and emissions intensity per tonne of grain could typically look like, and which seasonal conditions, operational and management decisions are the strongest factors influencing cropping carbon emissions, and mitigation and sequestration opportunities. The farm business advice sector can support grain growers to engage in this practice change.

Many farm business consultants, agronomists and growers still require training to understand the major contributors to greenhouse gas emissions in farming enterprises. This project recommends the carbon emissions in agriculture training designed by Professor Richard Eckard, which is available through PICCC.[27]

Calculator design

Alignment with all three data tiers of the IPCC and the Australian National Greenhouse Gas Inventory is strongly recommended. Calculators such as the Cool Farm Tool that are not fully aligned to both these data protocols will remain generic and convenient for multinational food processors, but not fit-for-purpose to the (Western) Australian farm sector (cropping) conditions.

Calculator Limitations. Currently none of the calculators are specifically tailored to reflect each farm's rainfall and agroecological zone and soil type.

Digitisation. On-farm GHG calculators and operational software would benefit from being able to interface with a natural capital data engine such as FlintPro. Digitisation and commercialisation through FlintPro would provide a geospatial tool which could measure carbon from vegetation and emissions from operations. The PICCC Grains-GAF calculator at this stage, is only excel based, not web based. It also would benefit from a geospatial FullCAM function such as in the natural capital data engine FlintPro.[28]

Restricted data entry. A high level of data entry required for chemical inputs, such as that in the CSIRO FarmPrint calculator, was found to be a barrier to effective on-farm use. Feedback on data entry into the GHG calculators from the March 2022 pilot workshop is provided in Appendix A.

Standardised data entry for chemical actives. A standardised data entry approach for the most widely used chemical actives and adjutants would save time and help minimise the "hassle factor" for data entry.

Apportionment of GHG emissions by enterprise mix. Standardised protocols or guidance for apportionment of GHG emissions between cropping, fodder, pasture and livestock enterprises within a whole farm enterprise would be useful to eliminate variance and human error between farm businesses.

Supply chain interoperability. Large parts of the Western Australian grain supply chain are already digitised, but lack of interoperability is a barrier to full supply chain emissions measurement. Growers GHG data should be in a format that is easily accessible to downstream supply chain participants, allowing the expansion of LCA boundaries.

Standardised farm sector GHG calculators, GHG footprints of upstream inputs especially fertilisers and ag chemicals, apportionment of Scope responsibility through commercial grain sale transactions, grower data ownership protocols, software development and API interoperability, mass balance calculations and retrospective versus prospective reporting timeframes would need to be addressed.

27. https://www.piccc.org.au/education/carbonneutraltraining
28. *FlintPro is the natural capital data intelligence platform which is being used by the federal Department of Agriculture and Water Resources for the Australian Agricultural Biodiversity Stewardship Package. FlintPro is also the commercialisation partner of CSIRO's FarmPrint GHG calculator.*

Emissions mitigation

Green fertiliser and nitrous oxide inhibitors are mitigation “game changers.” According to the project data set, fertiliser and crop residues are the two greatest sources of Scope 1 nitrous oxide emissions and fertiliser is the largest source of Scope 3 nitrous oxide emissions. Improved understanding of efficient nitrogen use combined with the use of fertilisers made from renewable feedstock such as green hydrogen ammonia or nitrous oxide inhibitor technologies will be ‘game changers’ for reducing GHG emissions from cropping enterprises.

Emissions mitigation and sequestration practice change should be the left and right hands of farm business work gloves. Sequestration strategies were not addressed in this project. More research, benchmarking and trialling of strategies to improve soil organic matter, soil carbon and environmental plantings for cropping enterprises is required.

Upstream and downstream supply chain mitigation collaboration. Supply chain measurement and trialling of end-to-end (paddock to plate) GHG emissions for any given quantity of grain through multiple commercial transactions would enable whole-of-supply chain emissions tracing and accountability.

8. Project Stakeholders

Partners

This project began in 2020 as a private sector net-zero transition MoU between Australia's largest grain exporter, the Western Australian grower-owned co-operative, CBH Group, and the small-cap listed regenerative food and agriculture company, Wide Open Agriculture.

The Department of Primary Industries and Regional Development joined the project in 2021 as research partner, representing the Western Australian state government. DPIRD is coordinating the WA state government's primary industries Sectoral Emissions Reduction Strategy (SERS) for setting a 2050 emissions reduction target for primary industries.[29]

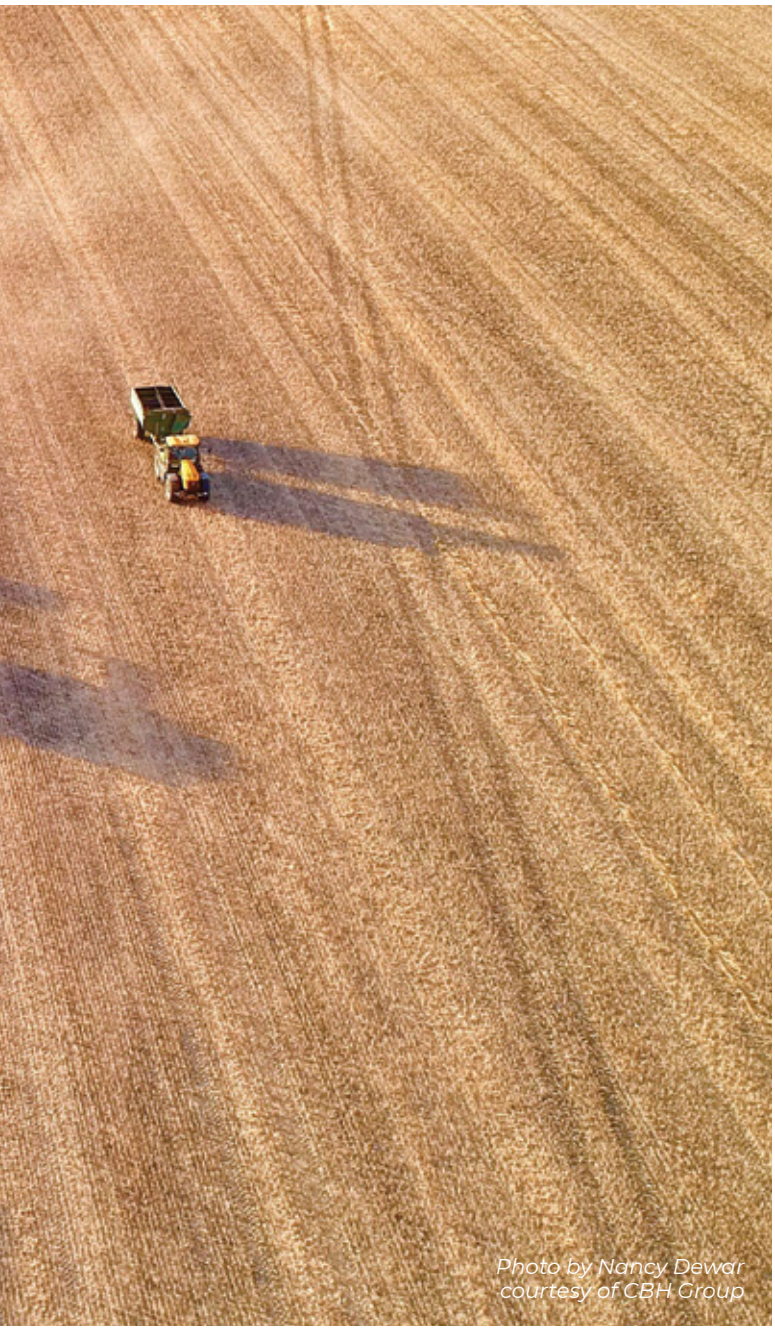

Photo by Nancy Dewar courtesy of CBH Group

Consultants and Presenters

The project was designed by Larissa Taylor, Director Savoir Consulting (ESG, Sustainability, Food and Agribusiness) and delivered by Larissa Taylor with Ben White, Ben White Consulting, and Richard Brake, Richard Brake Consulting. All three consultants have complimentary skills in supply chain industry engagement and cropping and livestock data analysis and have been working on various aspects of decarbonising Western Australian agricultural supply chains over the past 5 years or more. Ben White was the lead data analyst for the project.

The project was fortunate to have the participation of Australia's leading agricultural greenhouse gas researcher Professor Richard Eckard, Director of the University of Melbourne Primary Industries Climate Challenges Centre (PICCC).

Additional workshop presentations and panel discussions included:

- Professor Richard Eckard, Director, University of Melbourne Primary Industries Climate Challenges Centre
- Associate Professor Louise Barton, UWA School of Agriculture and the Environment
- Wayne Pluske, Director Equii
- Professor Fran Hoyle, Soils West, Murdoch University
- Phoebe Neighbour, Energetics
- Elizabeth O'Leary, Head of Agriculture and Natural Assets, Macquarie Group
- Mandy Curnow, Low Emissions Research Lead, DPIRD
- Dr Amir Abadi Ghadim, Senior Researcher DPIRD Centre
- Dr Cassandra Schefe, Director Cool Soils Initiative, Charles Sturt University
- Dr Rob Waterworth, CEO, The Mullion Group (FlintPro)
- Doug McNicholl, Head of Sustainability, Meat & Livestock Australia

29. https://www.wa.gov.au/service/environment/environment-information-services/sectoral-emissions-reduction-strategies

Photo courtesy of FORM via CBH Group

Stakeholders

The CBH WOA DPIRD Carbon Neutral Grain Pilot succeeded in attracting widespread commercial and research stakeholder engagement from the WA grain supply chain:

- CBH Group – originator, funder
- Wide Open Agriculture – funder
- DPIRD – funder
- Growers from Western Australia, various and anonymous, pro-bono data and time contribution
- University of Melbourne Primary Industries Climate Challenges Centre PICCC
- Australian Association of Agricultural Consultants, AAAC Western Australian Chapter
- Meat and Livestock Australia MLA
- Grains Research Development Corporation GRDC
- Australian Export Grain Innovation Centre AEGIC
- Grains Australia Ltd GAL
- Grain Growers Limited GGL
- Australian Farm Institute AFI
- Grain Industry Association of Western Australia GIWA
- Grower Group Alliance GGA
- Charles Sturt University, Cool Soils Initiative
- WA Biodiversity Science Institute WABSI
- Murdoch University, Soils West
- Curtin University, Food Agility CRC Node
- University of Western Australia, Centre for Agricultural Economic Development
- InterGrain
- Macquarie Viridis
- Warakirri Cropping
- Boortmalt
- PepsiCo
- Mauri
- CSBP
- Nutrien
- CBH Fertiliser
- Summit
- Rabobank
- National Australia Bank
- ANZ
- CBA
- Farmanco
- Planfarm
- ConsultAg
- Equii
- West Midlands Group
- Stirlings to Coast Farmers
- Corrigin Farm Improvement Group
- SEPWA
- Northern Agricultural Catchments Council
- others

9. Acknowledgements

Special thanks are due to:

Participating growers and their farm business advisors who sourced and contributed raw data after a record sized and late 2021 harvest, at a time when many were taking a well-earned break or under pressure to review their 2022 production plans in the light of supply chain disruption and increasing input costs

- Professor Richard Eckard, Director of the University of Melbourne Primary Industries Climate Challenge Centre PICCC and developer of the Greenhouse Accounting Framework GAF set of carbon calculators for his participation in and presentations to the workshop
- Australian Association of Agricultural Consultants AAAC, WA
- Dr Maartje Sevenster, CSIRO Life Cycle Assessment and Natural Capital Protocol, and colleagues
- Mandy Curnow, Low Emissions Research Lead, DPIRD and colleagues
- CBH Group for providing their Scope 1 and 2 GHG emissions
- Boortmalt and 8 of their WA barley growers for providing 2020 cropping GHG emissions data
- Macquarie Viridis for providing CSIRO Farm Print insights from their corporate cropping program
- Research and agronomy colleagues from the Department of Primary Industries and Regional Development, University of Western Australia, Murdoch University, Charles Sturt University, Mullion Group FlintPro, Equii, Energetics, Planfarm, Farmanco

Photo by Nancy Dewar courtesy of CBH Group.

10. Project glossary/key terms

Carbon emissions or greenhouse gas GHG emissions, sustainability, ESG (environment, sustainability, governance), carbon neutral agriculture, Western Australian grain, Western Australian cropping, low carbon supply chain, decarbonising grain, natural capital, total GHG emissions, GHG emissions intensity, emissions intensity wheat, emissions intensity barley, emissions intensity canola, GHG calculators, CO_2-e (carbon dioxide equivalent greenhouse gas for the 6 major gases), Scopes 1, 2, 3, cost to offset emissions, regenerative agriculture

Table 10: CO_2-e - the number of metric tons of CO_2 emissions with the same global warming potential as one metric ton of another greenhouse gas[31]

Greenhouse Gas	AR2 GWPs (2008-09 to 2014-15)	AR4 GWPs (2015-16 to 2019-20)	AR5 GWPs (2020-21 onwards)	2020-21 GWPs / 2019-20 GWPs
Carbon dioxide	1	1	1	0%
Methane	21	25	28	12%
Nitrous oxide	310	298	265	-11%
Perfluoromethane (tetrafluoromethane)	6,500	7,390	6,630	-10%
Perfluoroethane (hexafluoroethane)	9,200	12,200	11,100	-9%
Sulphur hexafluoride	23,900	22,800	23,500	3%
Hydrofluorocarbons (HFCs)	dependent of HFC type	dependent of HFC type	dependent of HFC type	dependent of HFC type

31. http://www.cleanenergyregulator.gov.au/NGER/About-the-National-Greenhouse-and-Energy-Reporting-scheme/global-warming-potentials

11. Further information

Western Australia's state GHG emissions from annual national greenhouse gas cropping and livestock inventory data (IPCC AR5):
https://www.agric.wa.gov.au/climate-change/greenhouse-gas-emissions-wa-agriculture

DPIRD's Carbon Neutral by 2030 Strategy for the Katanning Research Facility:
https://www.agric.wa.gov.au/carbon-farming/katanning-research-facility-carbon-footprint-assessment-and-strategy-achieve-carbon

Australian Grains Baseline and Emissions Assessment from GRDC and CSIRO:
https://grdc.com.au/about/our-industry/greenhouse-gas-emissions/GRDC_MainFinalReport_170122_CONFIDENTIAL.pdf

Carbon emissions in agriculture resources and carbon neutral agriculture training available at University of Melbourne Primary Industries Climate Challenges Centre PICCC
https://piccc.org.au/education/carbonneutraltraining

Taskforce for Climate Related Financial Disclosure TCFD https://www.fsb-tcfd.org/

Taskforce for Nature Related Financial Disclosure TNFD https://tnfd.global/

Carbon sequestration resources: Western Australia's Carbon Farming and Land Restoration Program
https://www.agric.wa.gov.au/carbon-farming/western-australian-carbon-farming-and-land-restoration-program

Clean Energy Regulator Carbon Farming Methodologies
http://www.cleanenergyregulator.gov.au/ERF/Forms-and-resources/methods

Photo by Joss Taylor courtesy of CBH Group

Appendix A: Feedback from Data Collection Provided at Pilot Workshop March 2022

Reference:

Measuring Farm Baseline GHG Emissions for Western Australian Cropping Detailed Data Review: Presentation #2 Ground-truthing Three GHG Calculators x 36 Farm-Cropping Years (2020 and 2021) CBH WOA DPIRD Carbon Neutral Grain Pilot, 24 March 2022, Ben White & Richard Brake

1 For ease of use and data entry the University of Melbourne PICCC Grains-GAF v10.4 calculator was preferred. It is also trusted against a very well regarded body of carbon emissions in agriculture research from the Primary Industry Climate Challenges Centre PICCC and Professor Richard Eckard, Meat and Livestock Australia, and private sector red meat agronomic collaborators like Queensland based Integrity Agriculture. It is aligned to the 3 Tiers of the IPCC, aligned to the NGGI, available free to industry for immediate use, and has 'sister' GHG calculators for red meat, pork, chicken, horticulture, dairy and other agricultural enterprises. https://www.piccc.org.au/resources/Tools

2 While not yet publicly available, the CSIRO FarmPrint GHG calculator is aligned to the 3 Tiers of the IPCC, NGGI aligned and could be a viable tool if it was digitised and offered to market with API interoperability features via commercialisation partner FlintPro. The pilot recommends that CSIRO FarmPrint streamline and simplify chemical data entry which is currently way too detailed and time consuming for the emissions impact of the data produced https://flintpro.com/ and https://www.csiro.au/en/research/environmental-impacts/sustainability/farmprint

3 While already invested in and used internationally by multinational food companies, with a user-friendly interface, the Cool Farm Tool is only aligned to Tier 1 of the IPCC methodologies and not aligned to the NGGI, so not yet fit for purpose for Australian production conditions. Being such a generic GHG calculator supports multinational companies operating across sovereign emissions boundaries. However Cool Farm Tool is unlikely to gain wide acceptance with growers and farm business advisors in (Western) Australia until full alignment to IPCC and NGGI takes place because it is currently not providing sufficiently granular and trusted data to drive accurate on-farm productivity insights https://coolfarmtool.org/

4 The following specific challenges and improvements to GHG calculators were discussed at the second CBH WOA DPIRD Carbon Neutral Grain Pilot workshop on 24th March 2022 in Perth:

4.1 Challenges: GHG calculators for decarbonising Australian cropping sector

- Interoperability: data is typically dumped from another operational platform eg AgWorld and has to be converted:
  - integration and API options?
  - uniform data protocol?
- Integrity of data and operator skills
  - unskilled operators means 'GIGO' garbage in, garbage out
- Apportionment/attribution of GHGs between cropping and livestock enterprises – no standard or guidance yet
- Engaging growers and farm business advisors to measure GHG emissions regularly will remain challenging until the process is simplified, digitised and the financial or market access rewards for doing so become more obvious
  - farm business relationship with banks on climate risk exposure is key
- Sustainability/ESG market signals mean baseline GHG emissions knowledge will be central to any commercial operation
- Many international grain customers already have Scope 3 2030 GHG reduction targets and 2050 net zero targets!
- Start measuring emissions now to build low carbon pathways to market, it could take years
  - possible carbon border adjustment mechanisms CBAMs!
- Knowing farm baseline GHG emissions gives partnership options to lower emissions with processors or input suppliers in the grain supply chain and also gives insight into environmental markets participation

4.2 Unintended consequences of non-standardised GHG farm calculators – Can we get to 'standardised' like financial accounting software?

- Pursuit of minimising GHG farm emissions using the calculators could possibly suggest poor production practices:
- No lime?
- Remove all residues?
- Poor fertiliser strategies – short/long term?
- How to incorporate results from sequestration strategies?
- Or possibly lead to cherry-picking calculators
- which give the most favourable result
- Note: no standards exist yet for apportionment or attribution of GHGs within the farm business enterprise or from the farm upstream and downstream in the supply chain – risk of doublecounting?
- More research, rigour, commercialisation, confidence is required for measuring upstream Scope 3 GHG emissions in Australian food and agriculture systems

4.3 GHG emissions measurement practice change: what could be improved? 1/2

- Continuous evolution of GHG calculators is strongly encouraged; recommend
- Full alignment to 3 tiers of IPCC and Australian National Greenhouse Gas Inventory NGGI
- Digitisation and geospatial alignment to FullCAM
- Published transparent and detailed emissions factors and version control notes for users
- Note that version changes to calculators can deliver large variations in GHG outputs – this may have commercial consequences for growers/buyers/consumers
- Soil carbon changes – we need confidence!
- Integration of mixed operations – sheep are an important part of WA grain production systems
- Alternatives required to Microsoft Shared Experience (dropdowns in CSIRO FarmPrint)
- GHG calculators: simplicity, interoperability, functionality, relevance, fit for purpose – may need to be tailored for grains

4.4 GHG emissions measurement practice change: what could be improved? 2/2

- Reduced data entry minimises ambiguity
- Pesticide inputs:
  - Drop-down list of active ingredients and label rates – APVMA?
  - Or… standard assumptions for pesticides pending crop type and location?
  - Reduce the significant time required for pesticide data entry!
- Fertiliser inputs:
  - Broken down by trade name and composition?
  - Manufacturers only supply a range of ingredient contents on SDS
- Lime inputs:
  - Integrated products, how to treat?
  - By pit and/or $CaCO_3$ / NV content include Morrel lime?
- Consider grain aeration in Scope 2
  - Circa 1.2kWh/t/month for aeration cooling
  - Drying pending moisture content

Appendix B

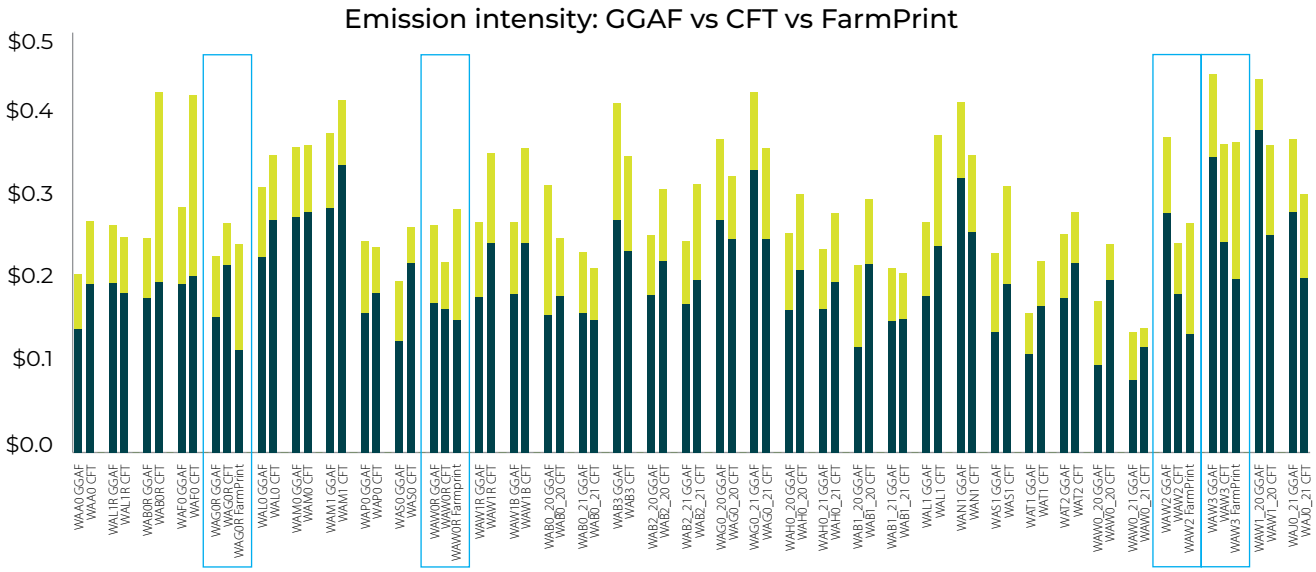

Figure 19: Comparison between calculators of GHG emissions intensity results for each farm enterprise. Note that the data sets circled in blue include results from the CSIRO FarmPrint calculator.

Appendix B: References

Pilot Consultants

Larissa Taylor
Savoir Consulting, ESG, Sustainability, Food and Agribusiness
CBH WOA DPIRD Carbon Neutral Grain Pilot Designer
laramarc@iinet.net.au
0413 076 665

Ben White
BM White Consulting
ben@bmwhite.com.au
@1800weevil
0407 941 923

Richard Brake
Richard Brake Consulting
richard@richardbrakeconsulting.com.au
0458 416 602

Project Presentations

Two key pilot project workshop presentations from 24th March 2022:

- **Why Decarbonise Western Australian Agriculture: A Clear-Eyed View**
  Overview Results: Presentation #1
  Carbon Neutral Grain Pilot Workshop, 24 March 2022, Larissa Taylor
- **Measuring Farm Baseline GHG Emissions for Western Australian Cropping**
  Detailed Data Review: Presentation #2
  Ground-truthing Three GHG Calculators × 36 Farm-Cropping Years (2020 and 2021)
  Carbon Neutral Grain Pilot, 24 March 2022, Ben White & Richard Brake

Supporting presentations:

- Larissa Taylor, Savoir Consulting – Market View on Global Energy Transition & Implications for Agriculture
- Liz O'Leary, Head Macquarie Agriculture and Natural Assets, Video Interview
- Australian GHG Emissions – Implications for Agriculture
  Carbon Neutral Grain Pilot, 24 March 2022, Professor Richard Eckard
- Australian GHG Emissions – Univ Melb PICCC Grains-GAF v10.4
  Carbon Neutral Grain Pilot, 24 March 2022, Professor Richard Eckard
- FlintPro/CSIRO FarmPrint
  Carbon Neutral Grain Pilot, 24 March 2022, Rob Waterworth
- Cool Farm Tool & Cool Soils initiative, Charles Sturt University
  Carbon Neutral Grain Pilot, 24 March 2022, Cassandra Schefe

Lawrence, J., B., F. Chiew Mackey, M.J. Costello, K. Hennessy, N. Lansbury, U.B. Nidumolu, G. Pecl, L. Rickards, N. Tapper, A. Woodward, and A. Wreford. 2022. "Australasia." In *Climate Change 2022: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*, edited by D.C. Roberts H.-O. Pörtner, M. Tignor, E.S. Poloczanska, K. Mintenbeck, A. Alegría, M. Craig, S. Langsdorf, S. Löschke, V. Möller, A. Okem, B. Rama. Cambridge University Press.

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