Department of Primary Industries and Regional Development
GOVERNMENT OF WESTERN AUSTRALIA

Protect
Grow
Innovate

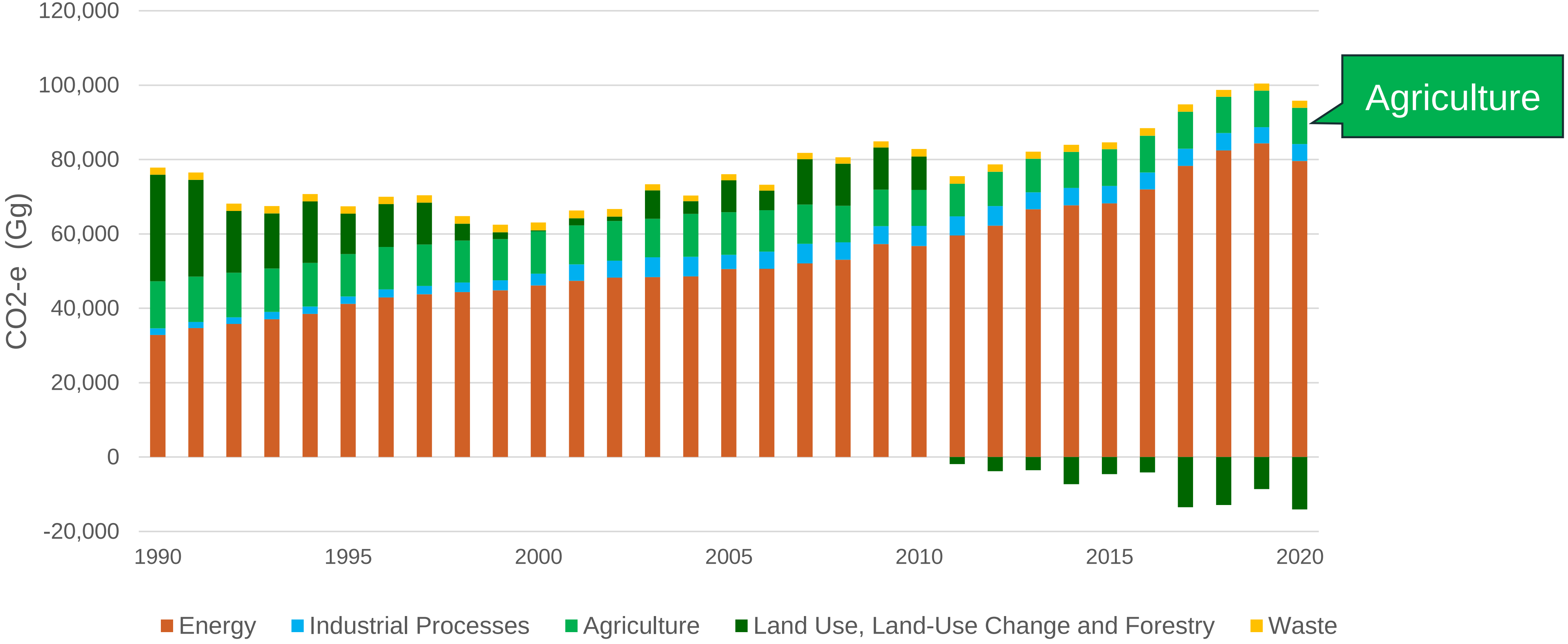
Grains and the road to Carbon Neutral

Mandy Curnow
DPIRD

December 2023

Background

WA agriculture sector has emissions of 9.63Mt CO_2e – 10% of state reported emissions to IPCC (Intergovernmental Panel on Climate Change)



However, this isn't the only method of reporting - it is important to understand the difference between what the State reported emissions are and what industry has to report.

Methods for GHG accounting

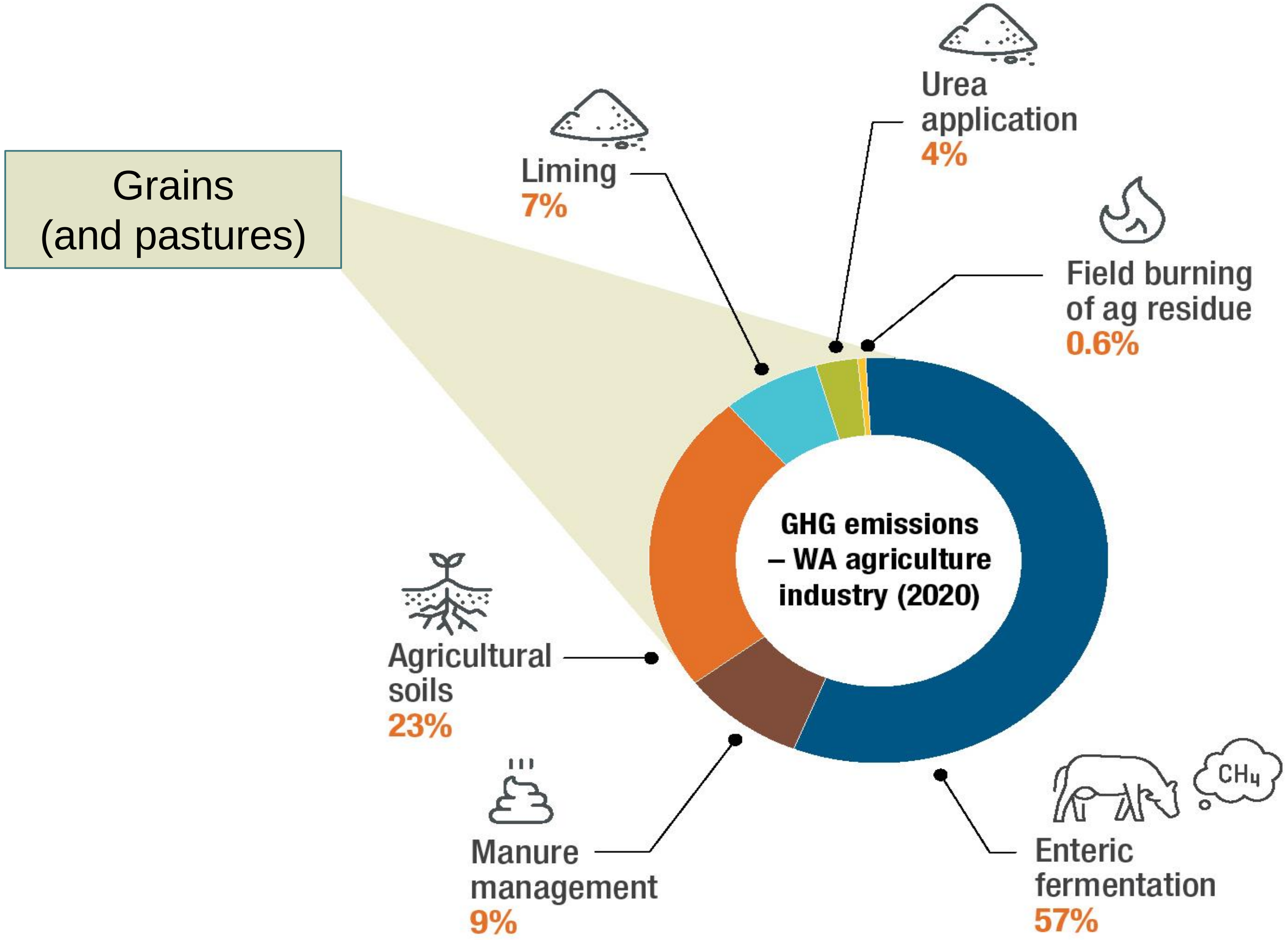
Depends who's asking the question?

1. Government and international reporting to IPCC
   - reporting uses the international protocol with a sector for Agriculture (National GHG Inventory)
   - Rigid reporting framework to ensure no gaps or double counting by countries
   - The Land Use Sector covers sequestration

2. Farm businesses to understand their emissions profile
   - want to know their total emissions and their product's emissions intensity (carbon account)
   - includes all emissions to the farmgate and can include sequestration
   - Can do this at an industry level too – useful for planning R&D

3. Consumers and retailers on product's carbon status
   - want to know a product's emissions intensity and carbon neutral status
   - Includes all emissions up to the supermarket shelf

National GHG Inventory Accounting - Agriculture Sector



Agricultural Soils Emissions (N_2O)

- Emissions from ‘agricultural soils’ comprise:
  - direct soil emissions: microbial nitrification and denitrification of fertiliser and manure nitrogen that remains in agricultural soils.
  - indirect soil emissions: nitrogen removed from agricultural soils via volatilisation, leaching, runoff, or harvest of crop biomass.

Lime Emissions (CO_2)

- Emissions from liming account for the field-based loss of CO_2 fixed during the manufacturing process and released during the dissolution process.

Urea Emissions (CO_2)

- Urea ($CO(NH_2)_2$) is manufactured by reacting ammonia (NH_3) and carbon dioxide (CO_2) at high pressure and temperature. The CO_2 fixed during the manufacture is released during dissolution in the field and is accounted for in ‘Urea application’.

Accounting for Agriculture Industry or business Emissions

Pre-Farm Inputs: Fertilisers, Chemicals, Transport *20%*

+

Agriculture Sector: on-farm emissions *71%*

+ +

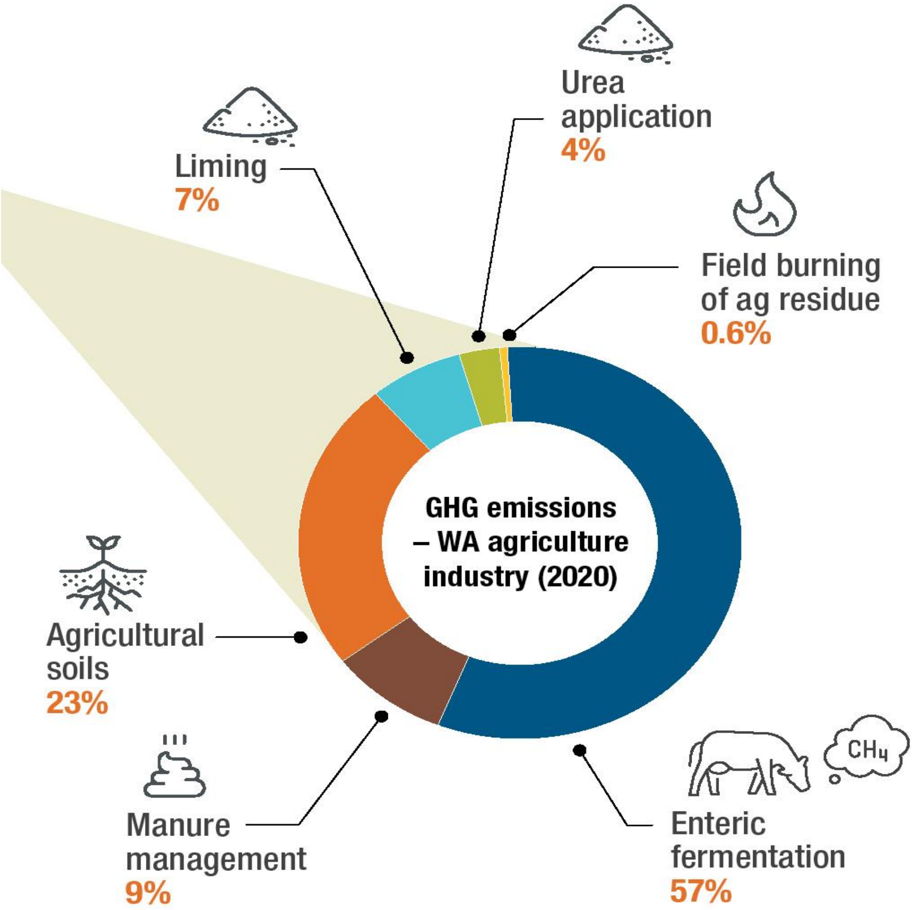
Energy: on-farm Electricity *1.7%*

Energy: Machinery fuel *5.6%*

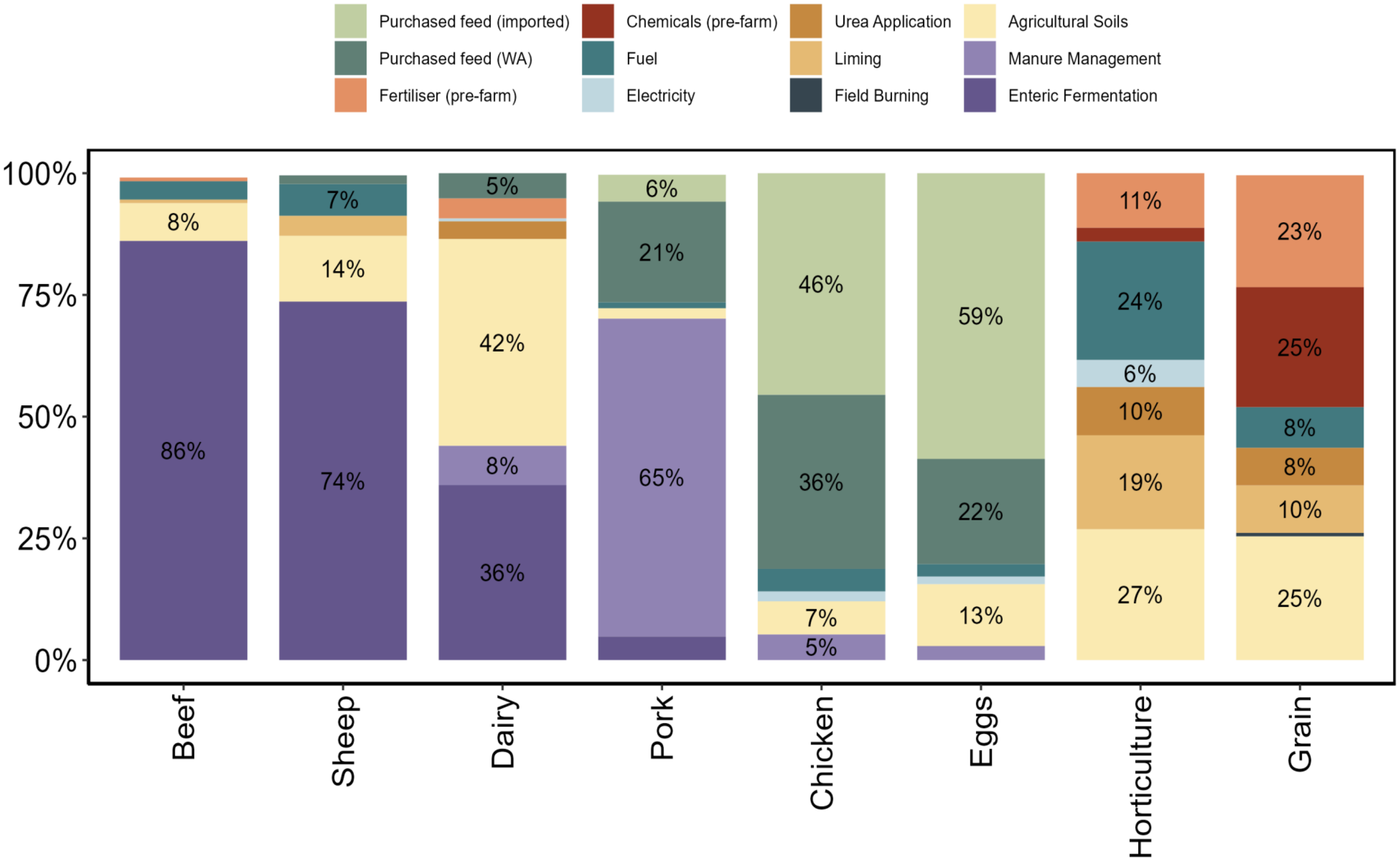
-/+

Land Use, Land Use Change & Forestry

National GHG Inventory Accounting - Agriculture Sector



Emissions by Industry: 2020



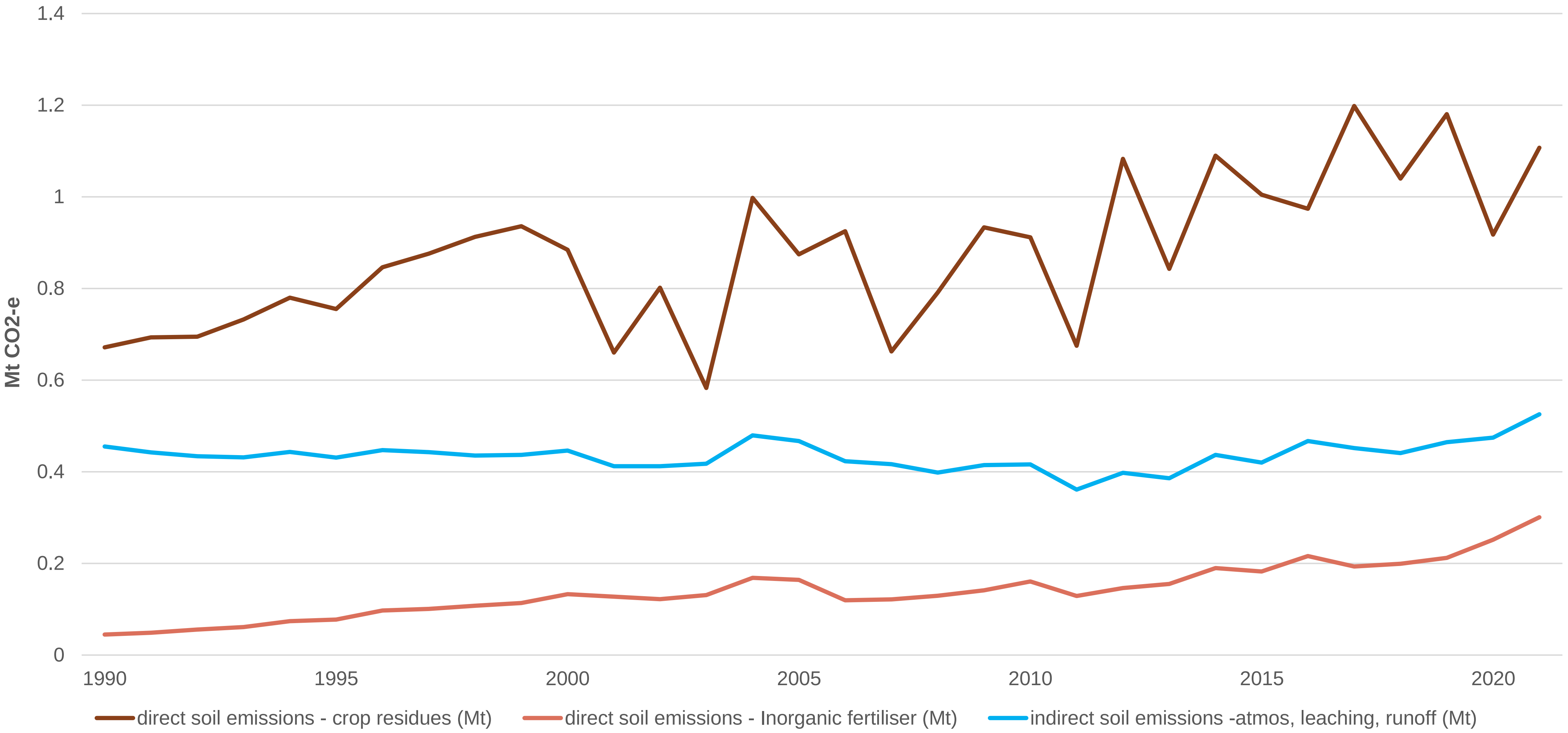
Farm and Industry Carbon Accounting

- Fertiliser emissions on farm (as total emissions) come from:
  - direct emissions from fertiliser use
  - pre-farm emissions from fertiliser use
- Nitrogen fertiliser use is a key factor – the good thing is more efficient N use is good for production, emissions and profitability
- Change in National Inventory for N leaching will make ~6% lower emissions in 2024
- Energy use is 9% of Grain’s emissions
  - Nearly all from diesel
- Herbicide and fertiliser (pre farm) - comes from energy inputs for processing, packaging, transport). Herbicide emissions could be closer to 15% rather than 25%

Factors affecting N_2O emissions

- Soil N (NO_3) – when NO_3 exceeds the capacity of crop to take up, increased N_2O emissions is more likely
- Increasing soil temperature – more emissions
- Soil moisture – more emissions
- Saturation – Water Filled Pore Space (WFPS) - Peak N_2O emissions occurs at around 70% water filled pore space
- Soil pH - More N_2 than N_2O in alkaline soils
- Compaction
- Organic matter - Soils with elevated levels of labile C, have the potential to produce higher levels of N_2O than those with little labile organic C
- The availability of ammonium and nitrate are key determinants of how much N_2O a particular soil will produce.
- Because the nitrification process relies on a good availability of oxygen, in wetter or more compact soils, the anaerobic conditions suitable for denitrification become more prevalent.

Sources of N_2O



Nitrogen 4Rs

1. **Right Product –** N_2O emissions are less where ammonium (NH_4^+) is the dominant N form and its rate of conversion to NO_3^- in the soil is slowed. Nitrification inhibitors can slow the conversion of NH_4^+ to NO_3^-
2. **Right Rate** – optimum N fertiliser rate – cost, yield and emissions.
3. **Right Time** –Match fertiliser application to crop demand.
4. **Right Place** – Placing the fertiliser in the active root zone.

Increasing N Use Efficiency is a win-win

Legumes in the rotation

- Replacing canola with lupins consistently reduces rotational emissions
- 1 million ha of grain legumes have been replaced by canola in WA since 1999 which equates to an increase of 45 million units of nitrogen fertiliser per annum.
- With lupins in rotation, the emissions intensity of the cereals is reduced by upto 23% for the first cereal, and by upto 16% for the second cereal.
- The minimum price premium for low emission cereals needs to be over AUD20/t to stimulate replacement of canola with lupins in cropping rotations.
- Pulses suited to other soil types (e.g. loamy and clay soils) may offer higher gross margins whilst still delivering emission reductions.

Green Fertilisers

- Gains in technology to economically decarbonize fertilizer production from the Haber-Bosch process, which produces more CO_2 than any other chemical-making reaction.
- Green ammonia technology uses renewable energy – this is the critical path for lowering emissions
- To produce green fertilizers, the hydrogen needed to make ammonia will come from water using electrolysis based on renewable electricity. After extracting the hydrogen to create green ammonia, all other processes will remain the same.
- Emerging technology to produce N fertiliser on-farm using small local production units
  - n2applied.com - runs machines placed on farms. Using nitrogen from the air, organic material and renewable energy to produce fertiliser.
  - ReMo Energy - designed small production plant with an electrolyzer, using conventional components at lower cost than conventional ammonia plant architectures.
  - Yara – Pilbara - reduce fertilizer production emissions from nitrous oxide (N_2O) by more than 90 percent.
  - Nitricity is developing a non-thermal plasma reactor that uses air, water, and renewable electricity to produce nitrogen fertilizer – currently in use on large scale irrigated strawberry farms in USA

Industry growth will impact emissions

- Production in all commodities is forecast by industry to maintain or grow (except for sheep)
- WA ag emissions will grow due to industry growth
- Goal is how to decrease emissions, **without** constraining productivity and growth

Predicted growth in industries and their predicted emissions

Industry	2020 (t CO_2 e)	predicted expansion of industry	Emissions due to Expansion 2035 (t CO_2 e)
Beef	4,642,479	9.2%	429,416
Sheep	3,206,125	-8.6%	-276,741
Broadacre Crops	**4,285,149**	**67.5%**	**+2,893,970**
Dairy	601,218	0%	0
Pork	361,647	25.0%	90,412
Horticulture	99,199	7.8%	7,707
Chicken meat	322,557	26.9%	86,719
Eggs	136,230	26.9%	36,620

Grains will become the largest emitting industry by 2035

DPIRD Emissions Priorities

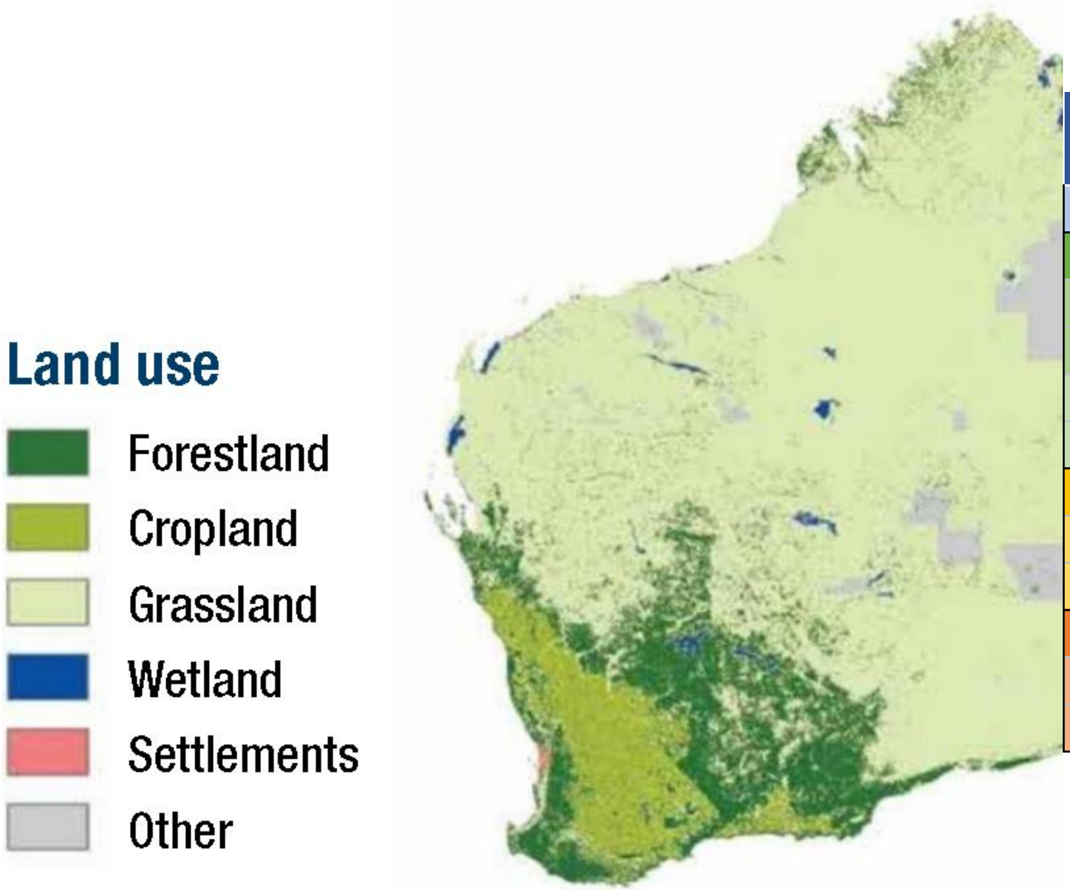
Focus is verifying emissions from WA broadacre grain production, identifying the key drivers to reduce emissions.

1. Completing a detailed analysis of emissions from broadacre systems using DPIRD designed specialised modelling which will include the contribution of legumes, application of lime, and livestock and crop management practices which reduce synthetic fertiliser use.
2. Confirm the emissions of current and new fertilisers and effect on productivity and identify ways to limit losses (leaching and run-off). This will also add value to existing projects examining nitrogen cycling in WA cropping systems.
3. Document emissions intensity for grains to support ongoing market access. The result will also inform the National Greenhouse Gas Inventory (NGGI), improving the methodology for the WA context.
4. Providing a clear understanding of the complexity of the farming system and its effect on emissions.

The other side of the Ledger - sequestration

- Farm, industry and product accounting allows the inclusion of sequestration on the balance sheet.
- Not just carbon credits – insetting and balance accounting is an opportunity.
- Vegetation is the focus, soil carbon is a long way off – expensive and risky to use in reporting.
- It is currently difficult to get any detail on WA's sequestration rates.

LULUCF - a variable carbon sink beast



Sector	2020 (Mton CO2e)	2021 (Mton CO2e)
LULUCFs	-9.80	-14.00
Forest Land	-10.66	-15.72
Forest Land remaining Forest Land	-2.46	-3.85
Land converted to Forest Land	-8.20	-11.87
Regrowth on deforested land	-1.42	-1.72
Plantation and Natural regeneration	-6.11	-9.32
Cropland	0.58	1.48
Cropland remaining Cropland	-0.22	0.71
Land converted to Cropland	0.80	0.77
Grassland	-0.07	-0.01
Land converted to Grassland	2.69	2.74
Grassland remaining Grassland	-2.76	-2.75

mainly veg

mainly soils

Technical issues on sequestration

To transition to net zero emissions, an accurate estimation of carbon sequestration across WA is required.

Carbon capture in vegetation and soils could currently be either underestimated or overestimated due to a lack of accurate data regarding ‘grassland’ and ‘forests remaining forests’ categories on agricultural land.

This limits the State’s capacity to accurately offset its carbon emissions – both in the agricultural industries but also for hard-to-abate sectors like mining.

At the farm level, better accounting methods are required to monitor carbon sequestration dynamics more accurately for insetting purposes.

How will carbon sequestration change with the change in climate?

What’s really happening in soils?

Soil C

- The amount of carbon in soil can be thought of as a ‘leaking bucket that constantly needs topping up’.
- The size of the bucket represents the total amount of carbon the soil could potentially hold. Factors such as clay content, soil depth and soil density will affect the size of the bucket. For example, the size of the soil carbon bucket will be smaller for sand than it is for clay soil.
- Management practices can’t influence the size of the bucket
- It is the balance between the amount of plant biomass produced, and the rate of decomposition that determines net changes to soil carbon

(from Baldock)

How to lose soil carbon

- Wet and warm seasons
- Sandy soils
- Management
  - Increase erosion
  - Increase the decomposition of soil organic matter through
    - fallowing,
    - cultivation,
    - stubble burning or removal and
    - overgrazing

Or

Reduce loss by reducing tillage, minimising stubble burning, minimising periods of fallow, reducing erosion and avoiding overgrazing.

Conclusions

- Accounting isn't perfect and we need to make it better. It's what we have, get your head around it
- Producers need a handle on their benchmarks and others in a similar system
- Think in emissions intensity – kgCO_2e per kg of grain – it's a benchmark of efficiency
- Understand the impacts of changes to the system – fallow, lime application, rotations, fuel, fertiliser and chemical use
- DPIRD and others are working to improve the emissions calculations inputs
- Principle – reduce emissions first then look to sequestration on-farm to offset own emissions, only consider Carbon Farming if lots left over and not wanting to expand operations.

Thank you

dpird.wa.gov.au

Important disclaimer

The Chief Executive Officer of the Department of Primary Industries and Regional Development and the State of Western Australia accept no liability whatsoever by reason of negligence or otherwise arising from the use or release of this information or any part of it.

Copyright © State of Western Australia (Department of Primary Industries and Regional Development), 2023.

Farm/Industry System Boundary