Strategies for productivity, profitability, and greenhouse gas mitigation - a Western Australian perspective

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Abstract

This paper presents new estimates of greenhouse gas (GHG) emissions from six of Western Australia's (WA) agricultural industries, including pre-farm emissions from the manufacture of inputs such as fertilisers, chemicals and purchased feed. Total on-farm and pre-farm emissions are estimated to have been about 14.5–15.2 megatonnes of carbon dioxide equivalents (Mt CO_2e) per annum (p.a.) from 2019-20 to 2021-22. Emissions originated largely in the beef (5.3–5.6 Mt CO_2e p.a.), grains (4.4–5.1 Mt CO_2e p.a.) and sheep (3.8–4.0 Mt CO_2e p.a.) industries. Methane from enteric fermentation accounted for about 45 % of estimated total emissions, with some indication that this share may be decreasing over time through lower livestock numbers and increasing grain production. As grain yields increase, pre-farm emissions will be increasingly important to the WA agriculture sector's mitigation efforts. WA studies suggest that strategies exist that can improve the efficiency and profitability of agricultural businesses while delivering mitigation co-benefits.

Keywords

Greenhouse gas emissions, mitigation, profitability, productivity, carbon dioxide, methane, nitrous oxide

Introduction

Many agrifood businesses in Western Australia (WA) are striving to improve their understanding of greenhouse gas (GHG) emissions and potential mitigation strategies that align with profitability objectives. The WA Department of Primary Industries and Regional Development (DPIRD) is actively working to improve our understanding of the GHG footprint of the state's diverse agricultural industries to inform business decision-making and government investment. The modelling presented in this paper builds on previous analyses of WA agriculture's GHG emissions to produce consolidated estimates of cradle-to-farm gate emissions for six major agricultural industries.

While the annual National Inventory (NI) Report (DCCEEW 2024) accounts for most emission sources at the national and state level, the NI attributes only a subset of on-farm emissions to agriculture, and only a further subset can be attributed to individual industries. Emissions from on-farm fuel combustion and pre-farm emissions from the production processes for inputs such as fertilisers and chemicals are largely not accounted for by the NI, as they mainly occur overseas and thus are outside its scope. As a result, the NI does not describe agriculture's emissions from a supply chain perspective and is generally not appropriate as a point of comparison for individual agricultural businesses.

Curnow et al. (2022) presented estimates for WA agricultural emissions in 2019-20 but did not estimate total emissions from cradle to farm gate for each industry. d'Abbadie and Machon (2024) modelled cradle-to-farm gate emissions (excluding carbon sequestration) for the WA grains industry. Other studies have assessed GHG emissions from a life cycle perspective for WA industries such as beef (Wiedemann et al. 2023) and sheep (Wiedemann et al. 2022).

There are indications that finance markets and supply chains increasingly will expect certified carbon accounts for agrifood businesses and products. This could pose a risk to businesses that do not act in time, either through missed opportunities or a direct loss (e.g. loss of market access). WA growers have already responded to the increasing sustainability requirements of the European Union (EU) canola market with remarkable success, with exports to the EU worth almost $1.9 billion in 2021-22 (Maharjan et al. 2023).

This study aims to inform strategies for productivity improvements and GHG mitigation for businesses by presenting estimates of the total emissions of six major agricultural industries in WA from cradle to farm gate. Together, these industries make up most of WA agriculture's total emissions.

Methods

Six industries were considered: pastoral beef, feedlot beef, sheep, dairy, pork and grains. GHG sources from cradle to farm gate were modelled for each industry. For GHG sources captured in the agriculture sector of the NI, each industry's emissions were generally estimated in line with the latest NI Report (DCCEEW 2024), reflecting the latest changes to emission factors. Where the NI does not provide estimates by industry (e.g. use of urea and lime), allocations were informed by Curnow et al. (2022) and d'Abbadie and Machon (2024). Pasture-related emissions were allocated based on herd sizes (dry sheep equivalents) and geographical distribution. As beef herd numbers in the ABS survey data (which underpins the NI estimates) are likely underreported (Fordyce et al. 2020), estimates for the pastoral beef herd instead build on a simple projection of the 2018-19 beef cattle herd inventory from Wiedemann et al. (2023). As it is not feasible to disaggregate NI data for land use-related changes in carbon stocks, these have not been included.

The NI does not estimate WA agriculture's emissions from pre-farm sources, such as the manufacture of fertilisers, chemicals and imported feed, nor from fuel and electricity use. Therefore, these emission sources were modelled based on relevant literature. For the grains industry, the modelling follows the methodology of d'Abbadie and Machon (2024), with updated emission factors to align with DCCEEW (2024). For pork, emissions were modelled based on Copley et al. (2024), ratioed to the size of the WA industry. Modelling of energy (electricity and fuel) and purchased feed emissions for dairy was based on Gollnow et al. (2014). For sheep, estimated energy emissions as well as purchased feed volumes were based on Wiedemann et al (2016), scaled to the WA flock. For feedlot cattle, feed intake was calculated as per the NI. Emission factors derived from the AusLCI database (ALCAS 2024) were then applied to purchased feed estimates for sheep and feedlot cattle. Feedlot energy use was modelled based on Wiedemann et al. (2017). For pastoral beef, energy emissions were estimated from ABARES (2024) survey data. Pre-farm emissions from fertilisers and lime for dairy, sheep and beef were modelled following Lopez et al. (2023) and Lopez et al. (2024), with estimates of each industry's application of urea and other fertilisers derived from the NI.

There is a high degree of uncertainty for emissions estimates for agriculture. For instance, DCCEEW (2024) indicates uncertainties in the order of 25 % for enteric fermentation, 37–55 % for manure management and 56 % for agricultural soils and liming. The estimates provided here must be revised as new data and research become available and more accurate emission factors are documented for WA conditions.

Results

Emissions vary from year to year, reflecting changes in herd numbers, yields and activities. Total emissions across the six industries are estimated to have been about 14.5 Mt CO_2e in 2019-20, 15.2 Mt CO2e in 2020-21 and 15.0 Mt CO_2e in 2021-22. Beef, sheep and grains make up more than 90 % of the total.

The estimated emissions and sources for each industry are shown in Figure 1. The estimates reflect the diversity of production systems across the different industries. While enteric fermentation is a major source of emissions across beef, sheep and dairy, there are differences in the proportions of other sources, such as purchased feed and fertilisers. For the pork industry, manure management and purchased feed are the major emissions sources, whereas for grains, pre-farm emissions make up about half of total emissions. As these are aggregate estimates, they may not reflect the relative emission sources of an individual farming operation, and mixed farming operations will form a hybrid of the different industries shown in Figure 1.

Methane from enteric fermentation is a major component of total emissions (about 45 %) and thus a critical mitigation challenge. The estimates presented in Figure 1 also show a significant increase in grains industry emissions from 4.4 Mt CO_2e in 2019-2020 to 5.1 Mt CO_2e in 2021-22. It is conceivable that this change is due to the annual variability of grain production, e.g. the record harvest in 2021-22, rather than any longer-term trend. However, an increase over time would be in line with long-term growth expectations expressed by the grains industry (d'Abbadie and Machon 2024). If the increase is sustained, there are important implications for GHG mitigation strategies, as pre-farm emissions from the manufacture of inputs are a much larger component of the GHG footprint of the grains industry than is the case for the extensive livestock industries. Consequently, mitigating pre-farm emissions would become increasingly important in reducing the overall GHG footprint of the sector.

It is important to note that total emissions are not always an appropriate metric for assessing the successful implementation of GHG mitigation strategies. While governments typically report only emissions that occur on their territory, consumers and corporations who purchase agricultural products will want to know the emissions intensity from a supply chain perspective, i.e. the quantity of GHG emitted per unit of product. Agricultural businesses that produce more outputs from fewer inputs are likely to be both more profitable and have a lower emissions intensity than their competitors. This may provide a further competitive advantage as consumers and corporations increasingly demand lower emissions-intensity products.

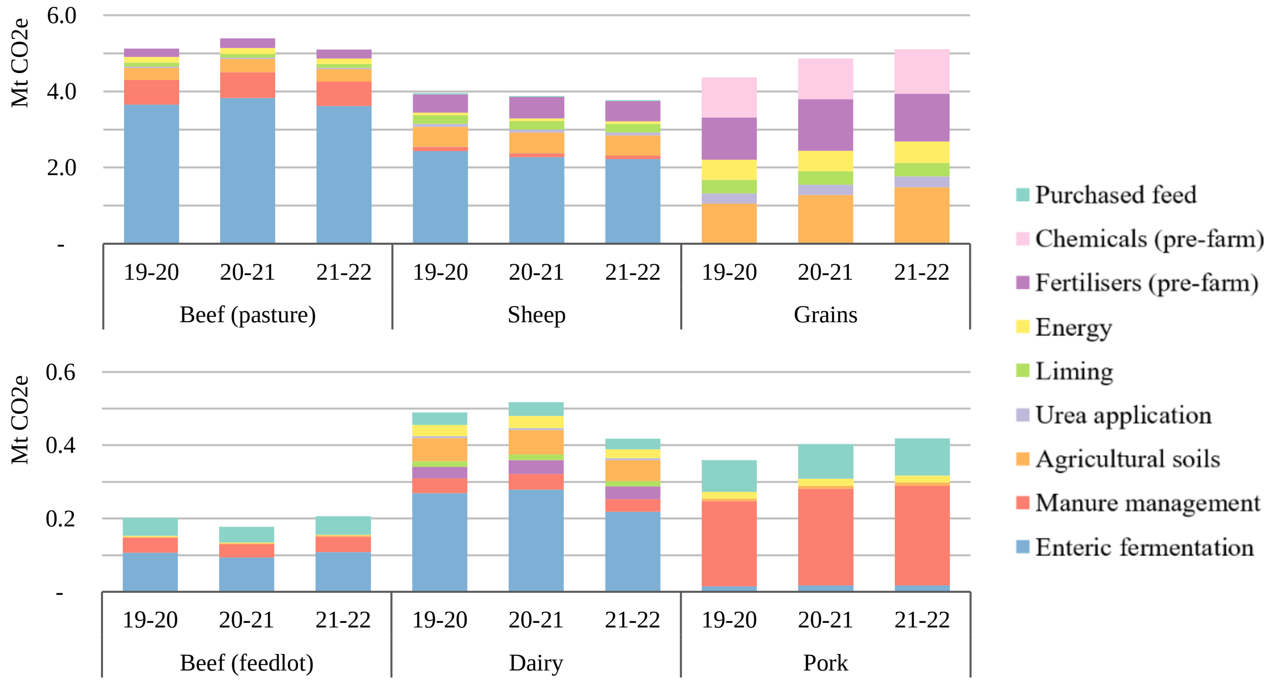

Figure 1: Annual GHG emissions by industry (megatonnes of carbon dioxide equivalents, Mt CO_2e). Note the difference in scale between the two panels, reflecting the smaller size of the feedlot, dairy and pork industries.

The diversity of sources of emissions for each industry means that there is no single pathway for a sector as diverse as WA agriculture to lower its GHG footprint. Rather, businesses within each industry may draw on several complementary mitigation strategies that align with their profitability objectives. However, it is generally true that improvements to production efficiencies will benefit both profitability and emissions intensity. Even if the impacts are moderate to small, the impacts are may lead to a multiplier effect that could enable further improvements over time (Kingwell 2023).

Recent WA studies have addressed the profitability and mitigation potentials of improved management practices for nitrogen application, drawing on median rainfall expectations through the season (d’Abbadie et al. 2023a). Improved management may also be applied to other inputs, such as chemicals, to improve profitability and mitigate GHG emissions. The use of legumes in rotations to reduce the nitrogen needs of the following crops has had mixed results in WA, depending on soil types and rainfall patterns. As a mitigation strategy, lupins are only aligned with profitability in the usual regions of lupin production, though mitigation benefits would apply across the WA grainbelt (Kharel et al. 2022, d’Abbadie et al. 2023b). A study of Tolga Farm, Kulin has shown that it is possible to capitalise from an efficient low-emissions mixed farming system. Tolga Farm is currently selling low emission barley at a premium and the performance of the farm showcases the economic benefits of a drought-resilient, low-input system (Plunkett et al. 2023).

For pastoral beef and sheep, mitigation strategies for methane from enteric fermentation include improved animal management, genetic selection for low-emissions animals, dietary supplementation and improved forage quality and composition. DPIRD’s Katanning Research Station is currently demonstrating mitigation strategies for WA broadacre farmers (Wiedemann et al. 2020). This includes assessing feed types such as lupins, biserrula and saltbush to understand the unique feed systems used in WA. Any mitigation achieved by the WA grains industry will also lower the emissions intensity of livestock industries that use WA grains for feed. However, while some of the strategies mentioned above may help to mitigate GHG from intensive livestock production, strategies that address emissions associated with manure management and housing systems will hold the greatest potential for emissions reduction in those industries (Copley et al. 2024).

Conclusion

Agricultural businesses increasingly seek to understand and mitigate the emissions associated with their products. To provide context for WA agricultural businesses, pre-farm and on-farm GHG sources for six agricultural industries in WA were modelled for 2019-20, 2020-21 and 2021-22. Total emissions were estimated to be about 14.5–15.2 Mt CO_2e per annum, with substantial differences between the industries. However, total emissions at the industry level should not be the only indicator for businesses seeking to evaluate strategies for profitability and GHG mitigation, as their marginal effect on global warming will ultimately depend on the changes in emissions intensity of the business' products. If more output is generated from fewer inputs, the emissions intensity of the product will improve even if total emissions are unchanged. By improving their productivity and efficiency, WA agricultural businesses are taking the first steps towards more profitable and sustainable production systems.

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