Background

- DPIRD commissioned a life cycle assessment (LCA) for sheep production in WA in 2021.
- This aligns with other DPIRD initiatives, including organisational carbon neutrality over the next decade for the Katanning Research Facility (KRF)
- An LCA provides a systematic assessment tool that delivers quantified results that can be used to benchmark performance.
- The LCA will further assist in understanding and identifying current impacts and provide a baseline for assessing future progress.
- DPIRD is conducting industry wide LCAs (horticulture, grains, sheep and beef) as part of its commitment to industry and to inform the State Government’s Climate Policy.
Overview of the Western Australian Sheep Industry structure

The WA sheep industry has a production base of 13.6 million sheep in 2020. The LCA included all major sheep production regions of WA including the;

- Central and South Wheat Belt (CSWB),
- North and East Wheat Belt (NEWB) and
- South West Coastal (SWC) regions as defined by ABARES.

Pastoral sheep were not included due to the small proportion of the state flock (~80,000 head)
Objectives

1. Complete an LCA focused on greenhouse gas emissions (carbon footprint) for the WA sheep industry.

2. Identify carbon impact hotspots associated with the WA sheep industry.

3. Explore improvement options for production in Western Australia, allowing the Department to understand and potentially set targets to reduce impacts over time.

Methodology

• The LCA examined the farm production system, up to the point at which product is ready to be transported from the farm (i.e. to the farm gate).

• The farm system boundary included farm services (purchased feed, diesel/ petrol, fertiliser, electricity, administration, and other purchased inputs) including emissions from both pre-farm and on-farm sources, and the livestock system and associated livestock emissions.

• As a multi-functional system, the reference flows included ‘one kilogram of sheep meat measured as liveweight’ and ‘one kilogram of greasy wool’.

• GHG emissions and carbon storage results from land use, direct land use change and land use change were not included in the assessment, partly due to difficulties in attributing these emissions to sheep compared to other land uses such as cattle or cropping.
Sheep System Boundaries for LCA

**UPSTREAM** (Pre-farm emissions)

**Scope 3 emissions**
- Emissions from purchased livestock
- Emissions from the production of feed
  - Grain
  - Hay
  - Silage
  - Fodder
  - Supplements
- Emissions from fertiliser and other chemicals
- Emissions from the extraction of fossil fuels for electricity and fuel

**ON-FARM**

**Scope 1 emissions**
- Livestock emissions
  - Enteric methane
  - Manure emissions including nitrous oxide and methane
- Diesel emissions
- Petrol emissions
- Emissions from on-farm feed production

**Scope 2 emissions**
- Grid-supplied electricity emissions

**DOWNSTREAM** (Post-farm emissions)

**Scope 3 emissions**
- Transport emissions
- Meat processing
- Retail
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>2005</th>
<th>2020</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lamb marking rate</td>
<td>%</td>
<td>82.7%</td>
<td>87.6%</td>
</tr>
<tr>
<td>Sheep mortality rate</td>
<td>%</td>
<td>5.0%</td>
<td>4.5%</td>
</tr>
<tr>
<td>Breeding ewe culling rate</td>
<td>%</td>
<td>13%</td>
<td>12%</td>
</tr>
<tr>
<td>Clean wool yield</td>
<td>%</td>
<td>59.0</td>
<td>59.9</td>
</tr>
<tr>
<td>Sales per ewe joined</td>
<td>no.</td>
<td>0.74</td>
<td>0.79</td>
</tr>
<tr>
<td>Ewe mature weight</td>
<td>kg</td>
<td>54</td>
<td>60</td>
</tr>
<tr>
<td>Lamb sale weight</td>
<td>kg</td>
<td>43</td>
<td>45</td>
</tr>
<tr>
<td>Greasy wool sales per DSE</td>
<td>kg</td>
<td>5.4</td>
<td>4.6</td>
</tr>
<tr>
<td>Live weight sales per DSE</td>
<td>kg</td>
<td>18.8</td>
<td>20.4</td>
</tr>
<tr>
<td>Protein production per DSE</td>
<td>kg</td>
<td>6.9</td>
<td>6.6</td>
</tr>
<tr>
<td>Greasy wool sales per breeding ewe</td>
<td>kg</td>
<td>10.0</td>
<td>8.9</td>
</tr>
<tr>
<td>Live weight sales per breeding ewe</td>
<td>kg</td>
<td>34.6</td>
<td>39.3</td>
</tr>
<tr>
<td>Protein production per breeding ewe</td>
<td>kg</td>
<td>12.7</td>
<td>12.8</td>
</tr>
</tbody>
</table>
WA Sheep population

Region | proportion of flock
--- | ---
CSWB | 72%
NEWB | 16%
SWC | 12%
Total Emissions

Total emissions declined 37% from FY 2005 to FY 2020. 5,873,332 t CO$_2$-e in FY 2005 to 3,681,703 t CO$_2$-e in FY 2020, mainly due to the decline of the sheep flock over that time.

![Chart showing total emissions declining from FY 2005 to FY 2020.](chart_image)

**Global Warming Potential (GWP$_{100}$) values relative to CO$_2$**

<table>
<thead>
<tr>
<th>Greenhouse Gas</th>
<th>Chemical Formula</th>
<th>5th Assessment Report (AR5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon Dioxide</td>
<td>CO$_2$</td>
<td>1</td>
</tr>
<tr>
<td>Methane</td>
<td>CH$_4$</td>
<td>28</td>
</tr>
<tr>
<td>Nitrous Oxide</td>
<td>N$_2$O</td>
<td>265</td>
</tr>
</tbody>
</table>
Liveweight Emission Intensity

9% increase in GHG emission intensity for the WA sheep industry from FY 2005 (7.4 kg CO$_2$-e kg LW$^{-1}$) to 8.2 kg CO$_2$-e kg LW$^{-1}$ in FY 2020
Greasy Wool Emission Intensity

- CSWB
- NEWB
- SWC
- Western Australia

Emission Intensity (kg CO₂-e/kg greasy wool)

- Carbon Dioxide
- Nitrous Oxide
- Methane

Years:
- 2005
- 2020

Western Australia
Enteric methane emissions from sheep dominated the emissions profile for the WA sheep industry in both FY 2005 (85%) and FY 2020 (79%).

From FY 2005 to FY 2020 there was a significant increase in impacts from carbon dioxide (6-12%) which was related to an increase in the use of purchased inputs such as diesel, fertilizer and supplementary feed.
Productivity

- Flock productivity and breeding objectives have changed in the WA sheep industry over the past 15 years. Most notable is a substantial shift from wool to lamb production.

- No meaningful change in protein output from the flock between 2005 to 2020. There were multiple drivers for this: lamb marking rates improved and turnoff weight of lambs increased but wool cut per head decreased, counteracting any improvement in overall productivity.

- Declining wool production led to a higher proportion of the impacts being allocated to sheep meat.

- The reduction in wool cut was related to:
  - a reduction in wether numbers, which declined 37% of the total WA flock.
  - lower fibre diameter, and therefore lower wool cut from 20.5um in 2005 to 19.2um in 2020.
  - increase in lamb marking rate from 82.7 to 87.6% contributed to lower wool cut from breeding ewes.

- The increase in liveweight production was demonstrated by sheep and lamb carcase weight. Hot standard carcase weight (HSCW) increased 8% in lambs, and 22% in sheep.
Comparison of GHG of this study to the National Inventory

- Total enteric methane emissions for FY 2005 were 9.9% higher here than reported in the NGGI in FY 2005.
- Total enteric methane emissions for FY 2020 were 10.1% higher than that reported in the NGGI for FY2019 (Figure 8) (AGEIS, 2020).
- This study reported higher emissions due to the flock inventory and key productivity parameters differing from the NGGI assumptions.
- Ewe, ram and lamb liveweight and lamb liveweight gain in this study were all higher than what is used in the NGGI.
Conclusions on LCA

• This study reported an increase in emission intensity, which was contrary to what the industry aims to achieve.

• The most notable trend was associated with intensification of the production system.

• There was a noticeable shift from wool to meat production from FY 2005 to FY 2020 but overall resulted in no meaningful change in protein production.

• This shift from wool to meat production may somewhat explain the increase in production intensity as meat production is expected to require greater amounts of purchased inputs than wool production.

• 132% increase in impacts from carbon dioxide from FY 2005 to FY 2020 related to purchased fuel and other inputs. In FY 2005 carbon dioxide accounted for 6% of the impacts compared to 12% in FY 2020. This explained 72% the increase in emission intensity between the years.

• There was an increasing use of diesel and fertiliser and supplementary feed purchases for sheep when expressed on a per head or stocking rate basis.
Stocking rate and profitability per DSE vs per Hectare

The North East Wheatbelt region was the best performing region in both FY 2005 and FY 2020 in terms of GHG emissions.

- Emission intensity of 6.9 kg CO2-e /kg LW and 22.6 kg CO2-e /kg GW in FY 2005 and 7.2 kg CO2-e per kg LW and 24.1 kg CO2-e /kg GW in FY 2020
- This region produced the largest amount of wool, liveweight and protein per DSE. However, it has lower per hectare productivity and lower overall sheep numbers (16%).

The South West Central region was the worst performing region in both FY 2005 and FY 2020 in terms of GHG emissions.

- Emission intensity of 7.9 kg CO2-e per kg LW and 25.9 kg CO2-e /kg GW in FY 2005 and 8.7 kg CO2-e per kg LW and 28.8 kg CO2-e /kg GW in FY 2020.
- This region produced the smallest amount of wool and protein per DSE. However, it has highest productivity per hectare but carries a small proportion of the state flock (12%).

Measures of profitability for producers may not be a useful indicator of GHG efficiency due to a focus on emissions per kilogram of product and the dual production of wool and meat in the same system.
Scenario Modelling

- Eight scenarios were modelled to understand some of the impacts of changing flock structure and productivity.

- Two scenarios were analysed to demonstrate the potential impact of the use of anti-methanogenic feed additives in the WA sheep flock compared to FY 2020.

- Note: Use of anti-methanogenic additives at a level great enough to make an impact on emissions may not occur until at least 2030.

- Six scenarios were analysed to demonstrate the potential impacts of different productivity increases on emission intensity (kg CO$_2$-e /kg LW and kg CO$_2$-e /kg GW) compared to emission intensity in the FY 2020 in this study.

- Productivity increases of any magnitude in lamb marking rate, lamb turn off weight or wool production per breeding ewe have the impact of reducing emission intensity.

- The greatest impact on emission intensity was achieved in scenario five with a 20% increase in lamb marking rate, 20% increase in lamb turn off weight and 10% increase in wool production per breeding ewe.
Anti-methanogenic Feed Additives

The first scenario assumes the anti-methanogenic additive is:

- 35% effective with
- 50% adoption within the WA flock for
- 33% of the year, representing the time for feeding during the annual feed gap.

5.8% reduction in enteric methane emissions and total emissions by 4.5%

The second scenario assumes;

- an efficacy of 35%, with
- 100% of the WA flock adopting this technology for
- 33% of the year.

11.6% reduction in enteric methane emissions and total emissions by 9.1%

Note: Use of anti-methanogenic additives at a level great enough to make an impact on emissions may not occur until at least 2030.
<table>
<thead>
<tr>
<th>Productivity improvement scenarios</th>
<th>FY 2020</th>
<th>Scenario 1</th>
<th>Scenario 2</th>
<th>Scenario 3</th>
<th>Scenario 4*</th>
<th>Scenario 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lamb marking rate (%)</td>
<td>88</td>
<td>90 (2.5%)</td>
<td>92 (5%)</td>
<td>96 (10%)</td>
<td>96 (10%)</td>
<td>105 (20%)</td>
</tr>
<tr>
<td>Lamb turnoff weight (kg)</td>
<td>45</td>
<td>47 (5%)</td>
<td>49 (10%)</td>
<td>49 (10%)</td>
<td>49 (10%)</td>
<td>54 (20%)</td>
</tr>
<tr>
<td>Wool production/ ewe (kg)</td>
<td>8.9</td>
<td>9.2 (3%)</td>
<td>9.2 (3%)</td>
<td>9.3 (5%)</td>
<td>9.8 (10%)</td>
<td>9.8 (10%)</td>
</tr>
<tr>
<td>Emission Intensity (kg CO₂-e /kg LW)</td>
<td>8.2</td>
<td>8.1</td>
<td>8.0</td>
<td>7.9</td>
<td>7.7</td>
<td>7.7</td>
</tr>
<tr>
<td>Emission Intensity (kg CO₂-e /kg GW)</td>
<td>27.2</td>
<td>26.7</td>
<td>26.6</td>
<td>26.3</td>
<td>25.7</td>
<td>25.5</td>
</tr>
<tr>
<td>Carbon Dioxide (CO₂)</td>
<td>11.8%</td>
<td>11.6%</td>
<td>11.4%</td>
<td>11.4%</td>
<td>11.4%</td>
<td>11.0%</td>
</tr>
<tr>
<td>Nitrous Oxide (N₂O)</td>
<td>8.5%</td>
<td>8.5%</td>
<td>8.5%</td>
<td>8.5%</td>
<td>8.5%</td>
<td>9.0%</td>
</tr>
<tr>
<td>Methane (CH₄)</td>
<td>79.5%</td>
<td>79.6%</td>
<td>79.8%</td>
<td>79.9%</td>
<td>79.9%</td>
<td>80.0%</td>
</tr>
</tbody>
</table>

*scenario 4 also included the impact of increase wether sale weights 3% to 55kg liveweight
Scenario 6: Merino wethers sold as lambs

- Another scenario was conducted which investigated the impact of the wethers sold in the self-replacing flock being sold as lambs.

- Compared to FY 2020 this scenario resulted in a 5% increase in emission intensity, because live weight production was lower and additional inputs were required to meet the weight specifications for a lamb carcase at an earlier age (Table 11).

- These results were governed by the assumptions used. If it was possible to achieve heavy lamb weights, similar to live-export weights then it may be possible to reduce emission intensity while shifting from live export to lambs.

- However, this would require feeding lambs for a longer period over summer and into autumn to achieve these weights before reaching hogget ages.

<table>
<thead>
<tr>
<th>Wethers are sold as lambs scenario</th>
<th>Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emission Intensity (kg CO$_2$-e /kg LW)</td>
<td>8.6</td>
</tr>
<tr>
<td>Emission Intensity (kg CO$_2$-e /kg GW)</td>
<td>28.6</td>
</tr>
<tr>
<td>Carbon Dioxide (CO$_2$)</td>
<td>11.9%</td>
</tr>
<tr>
<td>Nitrous Oxide (N$_2$O)</td>
<td>8.5%</td>
</tr>
<tr>
<td>Methane (CH$_4$)</td>
<td>79.3%</td>
</tr>
</tbody>
</table>
Recommendations

1. Promote the benefits of increased flock productivity from both a profitability and emissions reduction standpoint. This would be assisted by education on the importance and benefits of emission reduction at the farm level.

2. Identify options for collection of improved data to more accurately identify trends in emissions over time, and to identify the impact of inter-annual variability.

3. Supporting research to develop feeding technologies and improved in-field efficacy of anti-methanogenic feed additives.

4. Supporting work on adoption strategies to assist producers to utilise anti-methanogenic feed additives and pastures.

5. Conduct a survey of soil and vegetation management to augment the analysis here with further insight around soil and vegetation carbon changes, and the impact this has on the livestock carbon account.

6. Implementing the carbon neutral strategy at KRF to act as a demonstration site for industry and planning extension and communication activities to maximise the benefit of this activity.

7. Develop industry wide pathways to emission reduction and investigate a broad suite of carbon storage options for different regions and production systems in WA.

8. Aligning analysis presented here with research in the grains sector to maximise benefits from mixed enterprises.

9. To maintain currency and to monitor progress, we recommend updating the analysis on a two-yearly basis to ensure positive (or negative) changes are identified.
Thank you
Visit dpird.wa.gov.au

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