Agriculture's impact on climate: the science, not the headlines

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https://www.oxfordmartin.ox.ac.uk/pollutants


Achieving Net Zero – The role of land
What it takes to stop global warming

- Net Zero emissions of carbon dioxide
- Net Zero **additional warming** due to other emissions
  - this is not the same as Net Zero emissions of all greenhouse gases

Conclusions of the 2018 IPCC Special Report on 1.5°C
Methane and nitrous oxide dominate agricultural emissions

CO₂ – lasts 100s to 1000s of years in the atmosphere

Methane – lasts about a decade

Nitrous Oxide – lasts about a century

Figure: Edward Hornsby
How does methane affect temperature?

- Rising methane emissions cause warming: lots of warming.
- Gently falling methane emissions cause no further warming.
- Rapidly falling methane emissions cause cooling.

https://www.oxfordmartin.ox.ac.uk/publications/net-zero-for-agriculture/
A problem with current accounting metrics

- All three profiles are equated with ongoing CO₂ emissions, all of which cause warming.

https://www.oxfordmartin.ox.ac.uk/publications/net-zero-for-agriculture/
Can we do better?

<table>
<thead>
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<th>Annual CH₄ emissions</th>
<th>Total equivalent CO₂ emissions</th>
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<tr>
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<td>Using GWP₁₀₀</td>
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<tr>
<td>WARMING</td>
<td>1 tCH₄/y</td>
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<td></td>
<td>30 years</td>
<td>33 tCO₂/y for 30y</td>
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<tr>
<td>STABLE</td>
<td>1 tCH₄/y</td>
<td>798 tCO₂-e</td>
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<td>10 years</td>
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<tr>
<td>COOLING</td>
<td>1 tCH₄/y</td>
<td>693 tCO₂-e</td>
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<td>30 years</td>
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https://www.oxfordmartin.ox.ac.uk/publications/net-zero-for-agriculture/
The CCC recommendation for Net Zero

• Target of net zero emissions for all GHGs by 2050

• Defined using existing guidelines for CO₂-equivalence (GWP\textsubscript{100})

• Report notes that this would lead to the UK contributing towards cooling because ongoing methane emissions are ‘offset’ by removals defined with CO₂-e

Source: The CCC Net Zero Report
https://www.theccc.org.uk
What does this mean for UK agriculture?

• **Traditional “CO₂-equivalent” emissions:**
  • Undervalue new or increasing methane sources (good for Irish farmers and fracking operators)
  • Overvalue long-established or declining methane sources (bad for most UK livestock farmers)

• **“CO₂-warming-equivalent” emissions:**
  • Can be used to estimate warming accurately
  • Helpful for estimating temperature outcome from applying a policy

• **Thought experiment:**
  What if the UK reduces its agricultural methane emissions to zero by 2050?
Thought experiment: What if the UK reduces its agricultural methane emissions to zero by 2050?

• It would have the same impact on global temperatures as:
  • the removal of about 2 billion tonnes of CO2,
  • which is about 5 years of current UK CO2 emissions from all sources,
  • which is £50 billion at an ETS price of £25/tCO2.
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• Reducing emissions from livestock is needed; there is a genuine debate about:
  • how much by
  • how to do it (reduced herd, efficiencies, farm management, technologies...)
  • what replaces the livestock (environmental impact of the replacements, offshoring of emissions)
  • consequences for land use, biodiversity, water, food supply...
Extra slides
In summary

• CO$_2$ emissions must get to at least net zero to stop global warming
• The more other gases can be reduced, the lower the peak temperature will be
• Short-lived gases like methane should be reduced, but do not need to reach zero emissions
• Reducing emissions from livestock is needed; there is a genuine debate about:
  • how much by
  • how to do it (reduced herd, efficiencies, farm management, technologies...)
  • what replaces the livestock (offshoring of emissions, environmental impact of the replacements)
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In summary

- If limiting global warming is the goal, mitigation options should be evaluated in terms of **reductions in temperature**
  - this would make the evaluation measure consistent with the Paris Agreement temperature target
  - conventional CO$_2$-equivalent (CO2-e) emissions do not align with temperature
  - CO$_2$-warming-equivalent (CO2-we) emissions do
Can we do better?

- **GWP\(_{100}\)**: 28 times your methane emissions this year gives your “CO\(_2\)-equivalent” emissions.

- **GWP\(^*\)**: 112 times your methane emissions this year minus 105 times your methane emissions 20 years ago gives your “CO\(_2\)-warming-equivalent” emissions.
Thought experiment: What if UK agriculture goes to zero emissions by 2040?

Cumulative total CO$_2$-we (dash) tracks modelled warming (shaded) because of the high fraction of methane.
Thought experiment: What if UK agriculture goes to zero emissions by 2040?

• Agriculture’s contribution to global warming would be reversed to **below 1990 levels** even before zero is reached
• because the methane-induced cooling is greater than the nitrous oxide and CO$_2$-induced warming
A (slightly) more realistic scenario for UK agriculture

UK agriculture’s contribution to global warming reversed back to 1990 levels by mid-century

- \( N_2O \) emissions reduced 15% (efficiency)
- \( CH_4 \) emissions reduced 25% (efficiency + reduced herd)

Figure by Edward Hornsby
Agricultural greenhouse gas emissions are dominated by: **methane** (CH$_4$) and **nitrous oxide** (N$_2$O)

Figures from OurWorldInData.org, data from FAO.
Equivalent drivers of climate change

A closed power station

A gently declining (10% over 30 years) herd of cattle
Motivation

• A country (or a sector) has a target of reducing CO$_2$e to zero by 2050, from a 2020 level of 100 MtCO$_2$e
• What would the effect on global mean surface temperature be if:
  • all their emissions were CO$_2$?
  • all their emissions were CH$_4$?

CO$_2$e = CO$_2$ equivalent emissions, calculated using standard GWP$_{100}$ methodology
Different impacts from CO$_2$ and CH$_4$ emissions

Why do the same CO$_2$e emissions give such different outcomes?

Figure: Lynch et al, Agriculture’s contribution to climate change and role in mitigation is distinct from predominantly fossil CO2-emitting sectors (in press)
How methane differs from CO$_2$

In the atmosphere:
CO$_2$ lasts 100s to 1000s of years
Nitrous oxide lasts about a century
Methane lasts about a decade

i.e. For \textit{methane}, removals are large already

Compared to CO$_2$, relatively small emissions reductions needed to stabilise methane levels

Overall framing by Dr. John Sterman, MIT Sloan