Pathways to Zero Net Emissions: Stocktake Paper

2025

Acknowledgement of Country

Zero Net Emissions Agriculture CRC acknowledges the Traditional Custodians of the lands across Australia, where we live, work and learn.

We pay deep respect to Elders past and present and extend that respect to all First Nations people who have cared for Country for tens of thousands of years.

We honour their enduring connection to Country and knowledge passed down through generations.

Zero Net Emissions Agriculture CRC is committed to genuine Indigenous inclusion and will actively build respectful relationships with First Nations people, grounded in listening, learning and trust.

These relationships will bring together scientific insight and Indigenous wisdom to foster cultural awareness and understanding, to build a more sustainable future.

Together, we will shape a lower-emissions future for Australian agriculture.

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Acknowledgement of Contributions

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Glossary

Absolute Reductions - Total decrease in greenhouse gas emissions over a set period (usually annually). Required by most science-based target frameworks for net-zero alignment.

ACCU (Australian Carbon Credit Unit) - A unit issued under Australian Government schemes for verified emissions reductions, such as soil carbon sequestration or vegetation projects.

Carbon Neutral - A state where net CO_2 emissions from an activity, company, product, or service are zero, achieved by measuring emissions, reducing them, and purchasing carbon credits to offset the remainder. Often used in corporate claims and product labelling.

Carbon Markets - Systems for trading carbon credits, which represent verified emissions reductions.

Regulated (Compliance) Carbon Markets - Markets that trade credits created under approved methodologies and tracked in registries administered by government.

Voluntary Carbon Markets - Markets established by independent organisations, with credits certified by registries like Verra Gold Standard or Athian.

Carbon Sequestration - The process of capturing and storing atmospheric CO_2 in soils, trees, or other biomass, helping to offset greenhouse gas emissions.

Emission Scopes - Definitions of greenhouse gas emissions based on where the emissions occur and the level of control or influence the organisation has over them. Emissions are defined as Scope 1 (direct emission), Scope 2 (indirect emissions from purchased energy) and Scope 3 (all other indirect emissions occurring upstream and downstream in the supply chain).

Greenhouse Gas (GHG) - Gases that trap heat in the atmosphere, including carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O). Agriculture produces GHGs through livestock, fertiliser use, energy consumption, and land management.

Insetting - Interventions within a company's value chain designed to generate GHG reductions and carbon storage, creating positive impacts for communities and ecosystems. Insetting can occur at the business, supply chain, or 'Supply Shed' level.

Intensity Reductions - Decrease in emissions per unit of output (e.g., per kg of beef or litre of milk), even if total production increases. Often used in supply-chain reporting to show efficiency gains.

Net Zero Emissions - A state where all greenhouse gas emissions produced are balanced by an equivalent amount of emissions removal (e.g., sequestration in soils or trees), resulting in no net impact on the atmosphere.

Offsetting - A carbon market structure where one party generates a carbon credit and another purchases it to compensate for their own emissions. Projects are outside the buyer's value chain.

Paris Agreement - A legally binding international treaty on climate change adopted in 2015, establishing a universal framework for countries to commit to climate action under Nationally Determined Contributions (NDCs).

Science Based Targets initiative (SBTi) - A global initiative that sets a common, science-based framework for companies to align greenhouse gas reduction targets with climate science, specifically the Paris Agreement goal of limiting warming to 1.5°C or well below 2.0°C.

Supply Shed - A group of suppliers in a defined market providing equivalent goods or services within a company's supply chain.

Executive summary

Australian agriculture is at the forefront of the nation's climate response, with farmers and land managers already experiencing the impacts of climate change through shifting seasons, extreme weather, and challenges to productivity and resilience.

The sector is embracing a wide range of strategies and technologies to reduce emissions, improve efficiency, and unlock new business opportunities.

The Australian Government's *Net Zero Plan* sets an ambitious national target: a 43% reduction in emissions by 2030 and a 62–70% reduction in emissions below 2005 levels by 2035. *The Agriculture and Land Sector Plan* is central to this effort, recognising agriculture's critical role in achieving these national targets and forecasting a 28% reduction in agriculture emissions by 2050.

Many farmers and producers are already taking action, adopting innovative practices, and exploring carbon markets, which not only reduce emissions but also deliver productivity gains, resilience, and economic benefits.

Companies across agricultural value chains are setting Science Based Targets initiative (SBTi) targets, driving further change and requiring suppliers to align with science-based frameworks.

The bulk of emissions reduction work must occur before the farm gate, raising important questions about which strategies to adopt and how costs will be shared between supply chains and carbon markets.

Participation in carbon markets offers direct financial benefits and supports both economic and environmental resilience, while ongoing research and development will deliver further solutions in the medium to long term. Early adoption of climate-smart interventions positions Australian agriculture as a leader in climate action, ready to meet national and global expectations.

Zero Net Emissions Agriculture Cooperative Research Centre (ZNE-Ag CRC) is driving innovation for a low-emissions future by advancing practical, scalable solutions that enable producers and land managers to reduce emissions, enhance productivity, and protect natural resources.

This publication provides a comprehensive overview of the current opportunities, and practical pathways for reducing greenhouse gas emissions in Australian agriculture. It is designed to inform farmers, producers, industry stakeholders, and policymakers about the strategies, technologies, market mechanisms, and policy frameworks available now to support the sector's transition to a low-emissions and resilient future.

1. Introduction

This report provides Australian farmers and livestock producers with a clear, practical overview of the many opportunities available now to reduce emissions on-farm.

It recognises these opportunities within the broader global context, acknowledging the pressures and expectations of international supply chains and evolving emissions reporting requirements.

The report explores both the emerging opportunities and challenges in emissions reduction, including the role of carbon markets and key considerations for participation. It profiles the growing ecosystem of companies and service providers supporting emissions reduction, through education, technology, certification, and market access, and offers a curated summary of useful products and services.

To help producers navigate this rapidly changing landscape, the report explains essential terminology and includes real-world case studies.

Finally, it builds on existing public resources by compiling practical recommendations and links across sectors and industries, supporting informed decision-making and action.

2. Global context

Efforts within Australia to reduce agricultural emissions need to align with global policies and frameworks for reporting, claiming and crediting. The global context affects how corporations, supply chains and financial institutions engage with farm businesses.

Opportunities and challenges

The key opportunities for Australian farmers and livestock producers include:

- participating in carbon credit markets
- ability to charge commodity premiums
- using branding to build customer loyalty.

The challenges they face to do this, include:

- a complex global climate policy
- market access can be used as a ‘stick’ not a ‘carrot’
- issues around data sharing and privacy
- assessing the credibility of the different carbon market schemes
- permanence requirements for soil carbon
- difficulty in measuring at a high enough accuracy
- the costs of project development and measurement
- conflicting scientific views relating to methodologies and protocols
- lack of methodologies and protocols.

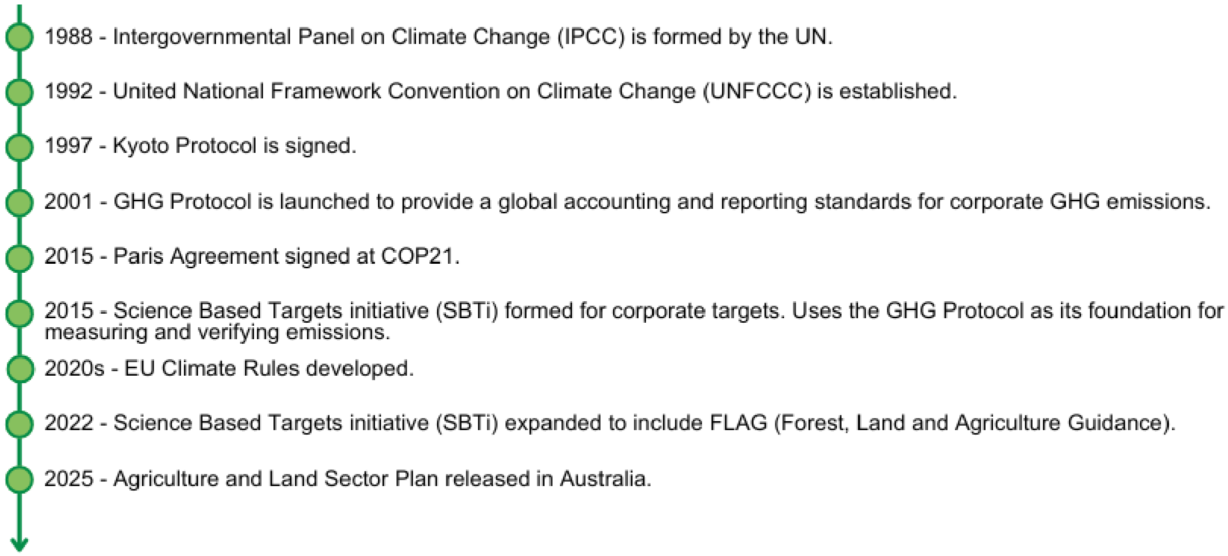


Figure 1: *A brief history of global climate policy. EU = European Union; GHG = greenhouse gas; UN = United Nations*

The Paris Agreement (2015)

The Paris Agreement is a legally binding international treaty on climate change. It was adopted by 195 Parties at the UN Climate Change Conference (COP21) in Paris, France, on 12 December 2015.

The agreement fundamentally reshaped the approach to emissions reduction by influencing key elements of global carbon markets. It introduced a universal framework for which most countries committed to climate action under Nationally Determined Contributions (NDCs). Unlike the Kyoto Protocol before it, which applied binding targets only to developed countries, the Paris Agreement created a global system in which both developed and developing nations pledged to reduce emissions, opening the door for far broader participation in carbon markets.

A central feature of the Paris Agreement is Article 6, which established the rules for international cooperation. In particular:

- Article 6.2 allows countries to trade emissions reductions through Internationally Transferred Mitigation Outcomes (ITMOs) and using those ITMOs towards their NDCs.
- Article 6.4 creates a new global crediting mechanism under UN oversight designed to generate high-integrity credits.

These mechanisms are still being operationalised, but they are expected to boost transparency and comparability across markets.

Science Based Targets initiative (SBTi)

The SBTi was established to solve the problem of inconsistent or 'greenwashed' corporate targets by setting a common, science-based framework. The aim is to help companies align greenhouse gas reduction targets with climate science, specifically the Paris Agreement goal of limiting warming to 1.5°C or well below 2.0°C.

Institutional investors are increasingly requiring SBTi-aligned targets as part of environmental, social and governance (ESG) screening. Several significant international agri-food companies have committed to SBTi targets and therefore need their suppliers to assist them in achieving those targets.

An Australian example is Woolworths, which has committed to reducing its absolute Scope 1 and Scope 2 emissions by 63% by 2030 and absolute Scope 3 emissions by 19% by 2030. In 2024, Woolworths announced a FLAG (Forest, Land and Agriculture Guidance) target to reduce its absolute Scope 3 agricultural emissions by 39.4% by 2033, relative to a 2023 baseline.

In 2023, PwC estimated that 75% of Scope 3 emissions for a supermarket chain come from enteric methane from cattle in its supply chain. A company such as Woolworths will therefore depend on its producers and farmers reducing their Scope 1 emissions to meet its own Scope 3 targets.

FLAG targets are specific targets for supply-chain companies that need to address emissions and removals from land use change and land management. The targets mandate emissions reduction goals and often include a zero-deforestation commitment by 2025.

Mandatory climate disclosures

In 2025, the *Treasury Laws Amendment (Financial Market Infrastructure and Other Measures) Bill 2024* (Cth) came into effect. Under the Bill, many large Australian businesses must prepare annual sustainability reports, covering climate-related financial disclosures and including mandatory reporting of Scope 3 emissions.

Even if a medium-sized agricultural business does not itself meet the legislative thresholds for preparing an annual sustainability report, there are 'cascade effects' because larger businesses (processors, wholesalers, supermarkets, financiers, etc.) will require data from their suppliers.

3. Terminology

Net zero emissions vs carbon neutral

Net zero emissions

Net zero emissions refers to a state where all greenhouse gas emissions produced (across carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) etc.) are balanced by an equivalent amount of emissions removal (e.g. sequestration in soils or trees).

Meeting international frameworks for emissions reduction in livestock systems means achieving a balance whereby substantial reductions in enteric CH_4 and other greenhouse gases are implemented, and any residual emissions are neutralised through verified removal or offset so that the overall net impact is zero.

Carbon neutral

In comparison, carbon neutral means the net CO_2 emissions from an activity, company, product or service are zero. This is achieved by measuring CO_2 emissions, reducing them where possible and purchasing carbon credits to offset the remainder.

Carbon neutral is often used in corporate claims, product labelling or events (“carbon neutral beef”, “carbon neutral operations”). It is typically CO_2-focused, although some standards allow conversion of other gases into CO_2-equivalent (CO_2-e).

Regulated vs voluntary carbon markets

Regulated (Compliance) Carbon Markets

Regulated or compliance carbon markets are Government-administered and have associated legislation approved by the government. Credits are typically created under government-approved methodologies and tracked in official registries.

In Australia, the government administers two schemes:

- The ACCU scheme which issues ACCUs
- The Safeguard mechanism which issues Safeguard Mechanism Credit Units (SMCs).

The legislation guiding these schemes include:

- *Australian National Registry of Emissions Units Act 2011* (ANREU Act)
- *Australian National Registry of Emission Units Regulations 2011* (ANREU Regulations)
- *Carbon Credits (Carbon Farming Initiative) Act 2011*
- *Carbon Credits (Carbon Farming Initiative) Rule 2015*
- *National Greenhouse and Energy Reporting Act 2007*
- *Corporations Act 2001 (Corporations Act).*

Voluntary Carbon Markets

In comparison, voluntary markets have been established by independent organisations. Credits are certified by registries (e.g., Verra VCS, Gold Standard, Athian) which develop their own methodologies or protocols.

Biogenic carbon cycle

In sustainably managed grazing systems, carbon flows in a closed repeating cycle – referred to as the biogenic cycle.

Plants absorb CO_2 through photosynthesis and produce carbohydrates, which are consumed by the animal. In ruminants, enteric CH_4 is then released back to the atmosphere. If total emissions are kept constant, there is a cycle of new emissions entering into the system and being drawn out of the system and, therefore, no additional warming. However the atmosphere doesn't differentiate between sources of CH_4, which means reducing emissions has a positive impact of the climate.

Methane is a more potent greenhouse gas than $CO_{2,}$ trapping significantly more heat per molecule, but it has a much shorter lifespan in the atmosphere. If the amount of CH_4 going into the atmosphere is reduced, even if that would normally be part of the biogenic cycle, the colling impact is significant. Therefore, $CH_{4,}$ reduction or avoidance is important and priorities by government through specific methane targets.

Scope 1, 2 and 3 emissions

Scope 1 emissions

Scope 1 emissions are emissions released on farm or directly controlled by the agricultural enterprise. Some examples include:

- livestock – enteric CH_4 from cattle, and manure management emissions (CH_4, N_2O)
- fuel and energy use – emissions from farm machinery, tractors, irrigation pumps and on-site generators
- fertiliser application – N_2O from synthetic and organic fertilisers applied directly to soils
- on-farm processing – emissions from boilers, dryers or other combustion processes run by the farm.

Scope 2 emissions

Scope 2 emissions are indirect emissions arising from the purchased energy (electricity or gas) that the agricultural operation consumes, so are generated elsewhere.

Scope 3 emissions

Scope 3 emissions are the largest and most complex category in agriculture, covering emissions not owned or directly controlled by the producer, but occurring upstream and downstream in the supply chain.

Upstream (inputs) include emissions:

- from fertiliser, feed and chemical manufacturing
- from the transport of feed and inputs to the farm
- embedded in machinery and infrastructure.

Downstream (products) include emissions:

- from transport of cattle to processors
- from processing and packaging of meat/dairy
- from cold-chain storage and distribution to retailers
- from consumer use (e.g. cooking) and disposal of waste
- embedded in capital goods such as tractors, barns or feedlot infrastructure
- from land use change, such as deforestation or conversion of land linked to feed production (soy, corn).

An example of these emissions for a cotton farm is shown in Figure 2.

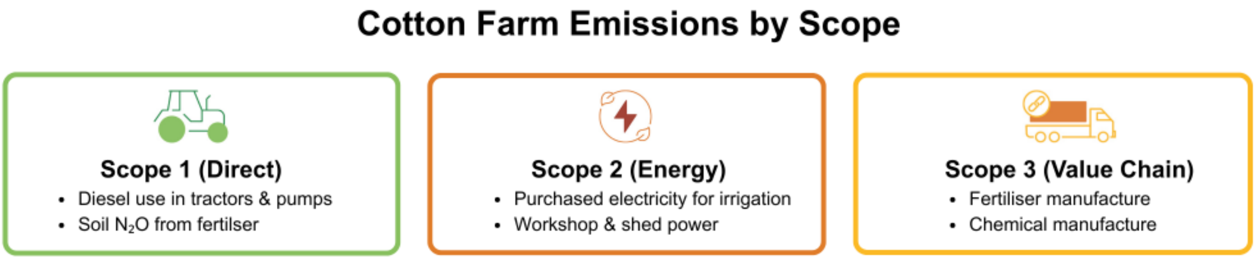


Figure 2: Comparison of scope 1, 2 and 3 emissions in a cotton business.

Offsetting vs insetting

The concept of offsetting is well understood as a carbon market structure that involves one party generating a credit and being paid by one external party. Insetting is a newer concept and is more layered because it can refer to insetting within a business, a supply chain or a Supply Shed.

Offsetting

Offsetting involves one party generating a carbon credit and another party purchasing those carbon credits. The projects are outside the buyer's value chain and are used to offset, or to compensate for emissions. For example, when an airline offers a passenger the option to fly carbon neutral and the airline pays an independent party to plant trees to generate the credits used to offset the airline emissions.

Insetting

The International Platform for Insetting (IPI) defines insetting projects as: Interventions along a company's value chain that are designed to generate GHG emissions reductions and carbon storage, and at the same time create positive impacts for communities, landscapes and ecosystems. An example of **business level insetting** is when a farming business completes their own carbon footprint assessment, then they undertake a management activity, such as planting trees, assess the CO_2 sequestered, then reduce their carbon account by that number.

An example of **supply chain insetting** is when a supermarket chain pays a premium for a product that is 'carbon neutral' and then sells that product to consumers with carbon neutral branding certified by Climate Active.

An example of **Supply Shed insetting** is when a global dairy company establishes a project boundary with farmers and processors and those parties share the cost of an intervention, such as feed additives, and all three parties co-claim the reduction in their reporting. Insetting is becoming more prominent in agricultural value chains because of pressures to prove reductions through direct sourcing channels.

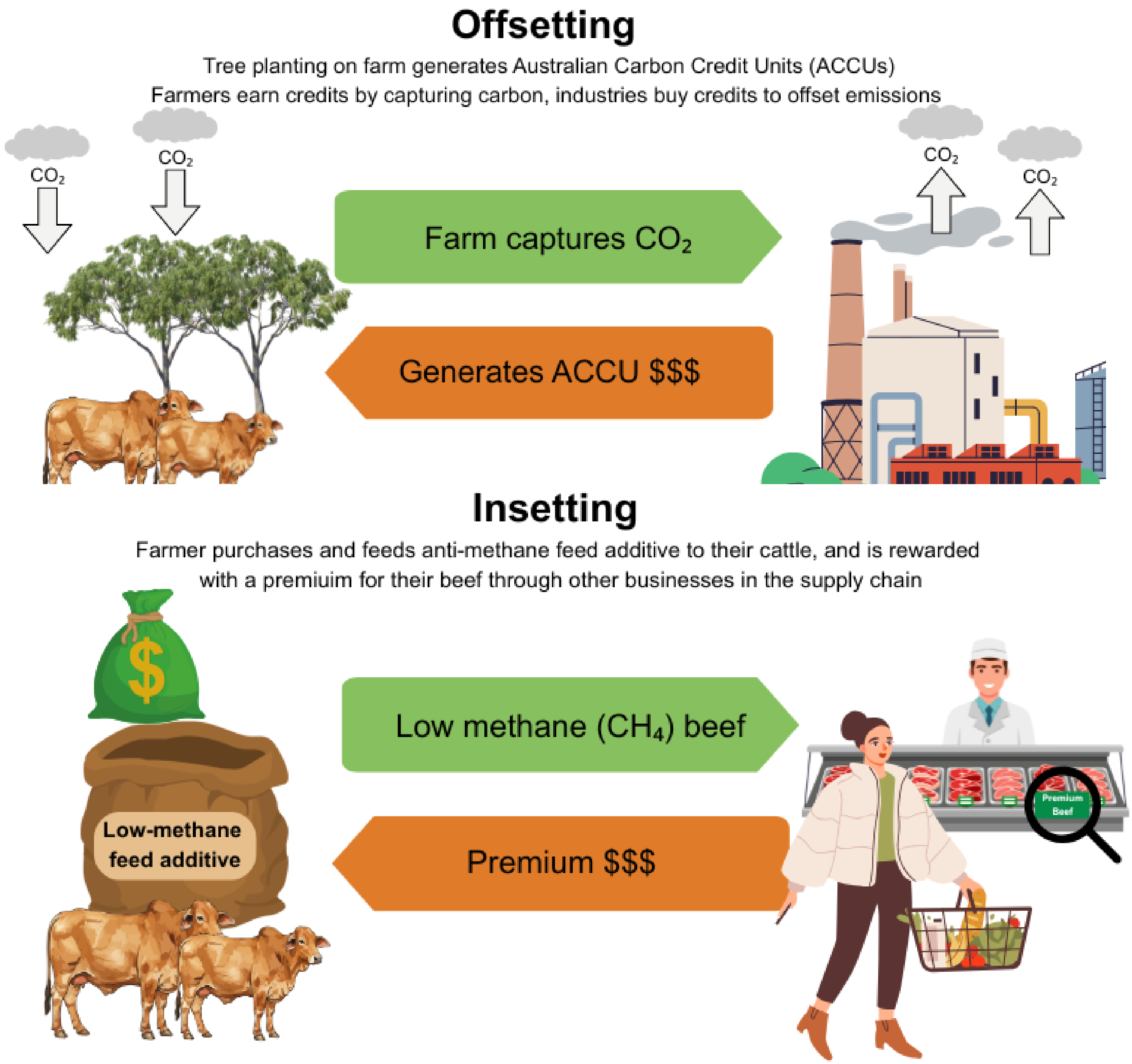


Figure 3: *Offsetting (top) versus insetting (bottom) representing product-based insetting with premiums.*

Supply Shed

Supply Shed has been broadly defined as a group of suppliers in a specifically defined market (e.g., at a national or sub-national level) providing functionally equivalent goods or services (commodities) that can be demonstrated to be within the company's supply chain (Value Change Initiative, 2024).

The Supply Shed approach enables co-investment and co-claiming of GHG reduction projects. Compared to offset programs, which generate exclusive reduction claims, Supply Shed inset programs present opportunities for multiple parties to share in the investment claims to Scope 3 reduction. (The Climate Source, 2023)

The Value Change Initiative (VCI) is a collaborative platform focused on decarbonising corporate supply chains. It brings together companies, NGOs, and technical experts to tackle one of the biggest challenges in climate action: how to measure, report, and reduce Scope 3 (value chain) emissions in a credible and practical way. They have been responsible for developing guidance around Supply Sheds and associated eligibility of companies participating in projects as depicted in Figure 4.

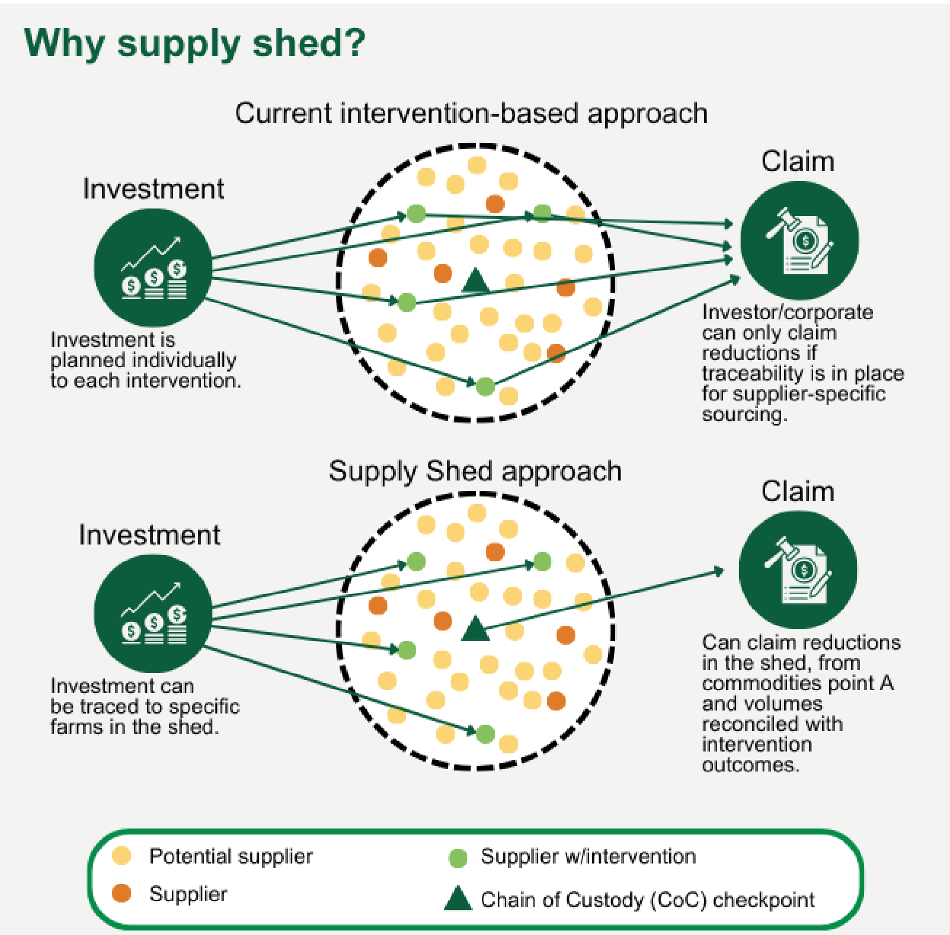


Figure 4: *The supply shed concept as depicted by the Value Change Initiative in Achieving Net Zero Through Value Chain Mitigation Interventions: Exploring Accounting, Monitoring & Assurance in Food and Agriculture*

(https://valuechangeinitiative.com/resource/achieving-net-zero-through-value-chain-mitigation-interventions-exploring-accounting-monitoring-assurance-in-food-and-agriculture/)

ZNE-Ag CRC Project 4030: Demonstrating an Insetting Business Model in the Beef Value Chain

This project will develop industry-agreed approaches for cost-sharing and co-claiming of mitigation benefits along the supply chain (i.e. insetting business models).

In agricultural value chains, it is typically the primary producer who needs to undertake activities to reduce emissions. This benefits downstream actors in the value chain. This project seeks to reduce institutional barriers to the uptake of decarbonisation strategies across industries by bringing together a team of experts and industry leaders in a facilitated policy-industry roundtable. This work will generate a proof-of-concept and a white paper to propose next steps in policy development for the Australian Government.

Absolute reduction vs intensity reduction

Absolute Reductions

Absolute reductions refers to the total decrease in emissions across a set time period (usually annually). For example, when fertiliser use is decreased and the total emissions produced from a farm are subsequently reduced and reported. Absolute reductions are required by most science-based target frameworks (SBTi) for net-zero alignment.

Intensity Reductions

In comparison, intensity reductions refer to the decrease in emissions per unit of output (e.g. per kg beef liveweight or per litre of milk) even if herd size (and total emissions) grows. For example, when methane per kg of beef decreases 20% due to better feed efficiency. This form of reduction is often used in supply-chain reporting because it shows efficiency gains, however, reduced intensity will not reduce total warming impact if production expands.

Reduction vs removal

Reduction (or avoidance)

Reduction represents avoided or reduced emissions compared with a baseline scenario. It does not remove carbon already in the atmosphere but slows down additional warming. Examples: feed additives reducing enteric CH_4, renewable energy replacing coal, and avoided deforestation.

Removal

Removal represents the physical removal of CO_2 (or CH_4 converted to CO_2-e) from the atmosphere and its durable storage. This is critical for net zero because it counterbalances residual, hard-to-abate emissions. Examples: soil carbon sequestration, afforestation/reforestation, direct air capture.

4. Methods and Calculators

Carbon accounting methods and calculators

Carbon accounting methods and calculators underpin NDCs, mandatory climate disclosures, SBTi reporting and carbon markets. Consequently, significant effort is needed at country-level to develop appropriate methods and calculators.

A whole farm carbon audit needs to comply with the following guidelines:

1. The methodology used should be consistent with that approved by the Intergovernmental Panel on Climate Change (IPCC) and the Australian National Greenhouse Gas Inventory (NGGI), with adjustments made only where these are required to be more specific to the farm rather than a state or country. For example, the NGGI uses the proportion of land area per state to determine indirect N_2O from nitrate leaching, but at a farm boundary this would be either the property does or does not receive enough rainfall to leach.

2. The methodology should align with:

   - the Climate Active “Draft Guideline: Land and Agricultural Emissions”
   - SBTi FLAG guidance
   - ISO 14040 standard – Environmental management — Life cycle assessment — Principles and framework
   - ISO 14067 standard – Greenhouse gases — Carbon footprint of products — Requirements and guidelines for quantification
   - ISO 14021:2016 standard – Environmental labels and declarations — Self-declared environmental claims (Type II environmental labelling) for self-declared environmental claims if the audit is self-declared
   - the Ecoinvent or AusLCI database for farm scope 3 emissions factors.

3. The calculation should be conducted within a pre-farm to farm gate Life Cycle Assessment framework (ISO 14040), with the boundary representing the whole of farming enterprise (all activities within the ABN) – for example, if there are separate physical properties within the farm enterprise, movement of product between the properties needs to be included as scope 1 emissions. This applies to agistment properties if they are part of the business unit.

4. The greenhouse gas balance must be calculated on an annual timestep, but with the annual change in soil and tree carbon sequestration calculated based on a 10-year running mean, to minimise rainfall variability influences.

5. The audit should include:

    - **Scope 1 emissions:** all direct greenhouse gas emissions (CO_2, CH_4, N_2O) from within the farming enterprise. The audit can also include the annual net change in soil and tree carbon within the property boundary but based on a 10-year rolling mean.
    - **Scope 2 emissions:** indirect emissions from the generation of purchased electricity from a fossil fuel origin onto the farm. This is included as the farmer now has choice to generate or buy renewable energy.
    - **Scope 3 emissions:** include all pre-farm embedded emissions associated with the purchase of products for the farm (e.g. lime, steers, urea, herbicides). Some selected post-farm emissions are also included where these are deemed to be under the control of the farmer's choice (e.g. freight operators, waste treatment destinations). Scope 3 emissions should be included in a carbon neutral product audit, as these emissions are essential to producing that product, but not all Scope 3 emissions are needed in a carbon neutral property audit, only those that are essential to the management of the property.

6. For a corporate company, ensure alignment with:

    - GHG Protocol Corporate Value Chain (Scope 3) Accounting and Reporting Standard
    - ASRS 2 climate-related financial disclosures, including all 15 GHG Protocol Scope 3 categories.

7. **Allocation:** where more than one product is produced, a protein-based allocation (livestock) or mass-based allocation (lint vs seed) should be applied to apportion the emissions between the products. Before applying the allocation, ensure that the proportion used is acknowledged between the industries (e.g. 15% of dairy farm emissions can be allocated to red-meat production, but *only if* the bull calves are sold to a beef producer).

8. **Carbon credits sold:** carbon credits generated within but sold out of the boundaries of the audit must be debited to the final balance. Likewise, carbon credits generated and retained within the boundaries of the audit (i.e. an inset) are credited once off and retired. In other words, the final net emissions position should be increased by the number of carbon credits sold or decreased by the number of carbon credits retained within the boundary. This is to avoid double counting of carbon offsets sold outside of the boundary, where clearly the intention of the new owner is to use these against their own balance.

The final calculation

The net carbon position of the farm enterprise or the product from the farm is a summation of the emissions minus the annual change in soil and tree carbon for that annual timestep.

The **carbon account/audit** is the same as net emissions (NE = t CO_2-e/business unit) and includes:

- all greenhouse gases from the boundary of the farm enterprise
- the annual change in soil and tree carbon
- adjusted for the carbon offsets bought or sold (note SBTi only allows purchased offsets for the intractable residual emissions).

The **carbon footprint** or emissions intensity (EI = t CO_2-e/t product) uses the same calculation as above, but the dominator is the unit of product produced. It should include all scope 3 emissions (pre-farm and some post-farm greenhouse gases), as these are essential for the product produced.

Net zero is calculated as zero t CO_2e/denominator (being either the business enterprise or the product).

Table 1: *Tools to calculate your emissions*

Name	Custodian
Greenhouse Accounting Frameworks	Primary Industries Climate Challenges Centre (PICCC), University of Melbourne
MLA Carbon Calculator	Meat and Livestock Australia
Australian Dairy Carbon Calculator	Dairy Australia
Environmental Accounting Platform	Agricultural Innovation Australia
Ruminati | Agricultural Emissions Tracking	Ruminati
Carbon Footprint Calculator | Measure Water & Biodiversity – Cool Farm Tools	Cool Farm Alliance
SOCRATES Web (Soil Organic Carbon Reserves and Transformations in EcoSystems)	Queensland University of Technology
Full Carbon Accounting Model (FullCAM) – DCCEEW	Department of Climate Change, Energy, the Environment and Water

Greenhouse gas emissions

In Australia, the Greenhouse Accounting Framework (GAF) tools are the basis of many calculators including the AIA Environmental Accounting Platform and Ruminati as outlined in the above table of calculators, GAF is fully aligned with the Australian National Greenhouse Gas Inventory (NGGI).

Soil carbon

For the purposes of a farm-based carbon audit, soil carbon should ideally be measured in situ by an accredited service provider, using the sampling methodology originally developed under the Soil Carbon Research Program (SCaRP) and prescribed under the Australian Government method in *Carbon Credits (Carbon Farming Initiative – Estimation of Soil Organic Carbon Sequestration Using Measurement and Models) Methodology Determination 2021*.

Specifically:

- Soil organic carbon ideally should be measured in the top 30 cm (minimum) using the dry combustion method after removing plant residues and root material carbonates (where present).
- Wet chemistry methods, such as the Walkley-Black, are discouraged due to the high degree of variability in using these methods.
- New laboratory methods using spectroscopic analysis can be considered if they are validated against the CSIRO or state department spectral libraries developed from SCaRP. In situ spectroscopic analysis or remote sensing is not currently valid.
- Note that a single soil sampling event is insufficient to derive an annual timestep change in soil organic carbon. Normally, a minimum of two soil sampling dates are required, at least 5 years apart.
- If soil samples are not available, using a simulation model (e.g. FullCAM, SOCRATES, DayCent, Roth-C, SGS model) is potentially acceptable, on the condition that this has been validated in the peer-reviewed literature for the situation in which it is being used. The model must be validated for the local soil and farming system, ideally including at least 20 years of in situ management history and run using climate data from the Bureau of Meteorology.
- Ideally, a combination of measurement and modelling (as per the ACCU method) is required to validate the history and trajectory of the change in soil organic carbon over time, with a detailed analysis of the soil profile providing associated chemical and physical properties used in the simulation. A time series of soil organic carbon analyses could be used if coupled with the above modelling protocol.

Tree carbon

For the farm tree carbon audit, a very similar approach should be taken to soil sampling, where direct measurement by an accredited service provider would be the highest standard applied.

This can be coupled with modelling using a peer-reviewed tree growth model, demonstrated to apply to the Australian context (e.g. FullCAM, 3PG), with the same validation and review requirements as the soil carbon method. While the Greenhouse Accounting Framework (GAF) calculators provide a lookup table version of the FullCAM model, they do not comply with the process outlined above and so should be used as a general indicator only.

ZNE-Ag CRC Project 3020: Farm Systems GHG Evaluation

This project will apply biophysical modelling, life-cycle analysis and economics to provide whole-farm system assessments. This is crucial information for industries to understand the 'systems fit' of new technologies.

Component technologies to reduce greenhouse gas emissions in agriculture must be assessed in a whole-system context to evaluate emissions reduction potential and impacts on production, profit and risk. New and emerging technologies developed by ZNE-Ag CRC (under research programs 1 and 2) need to be assessed in this context. Technology packages that will be implemented on demonstration farms also require this assessment to ensure that the best options are selected.

5. The ecosystem for achieving net zero

The opportunities identified included participating in carbon credit markets, commodity premiums and branding. The document also identifies the methods and calculators that underpin these opportunities. There are many service providers and participants in the ecosystem needed to generate a carbon credit, or a claim. This is represented in Figure 5.

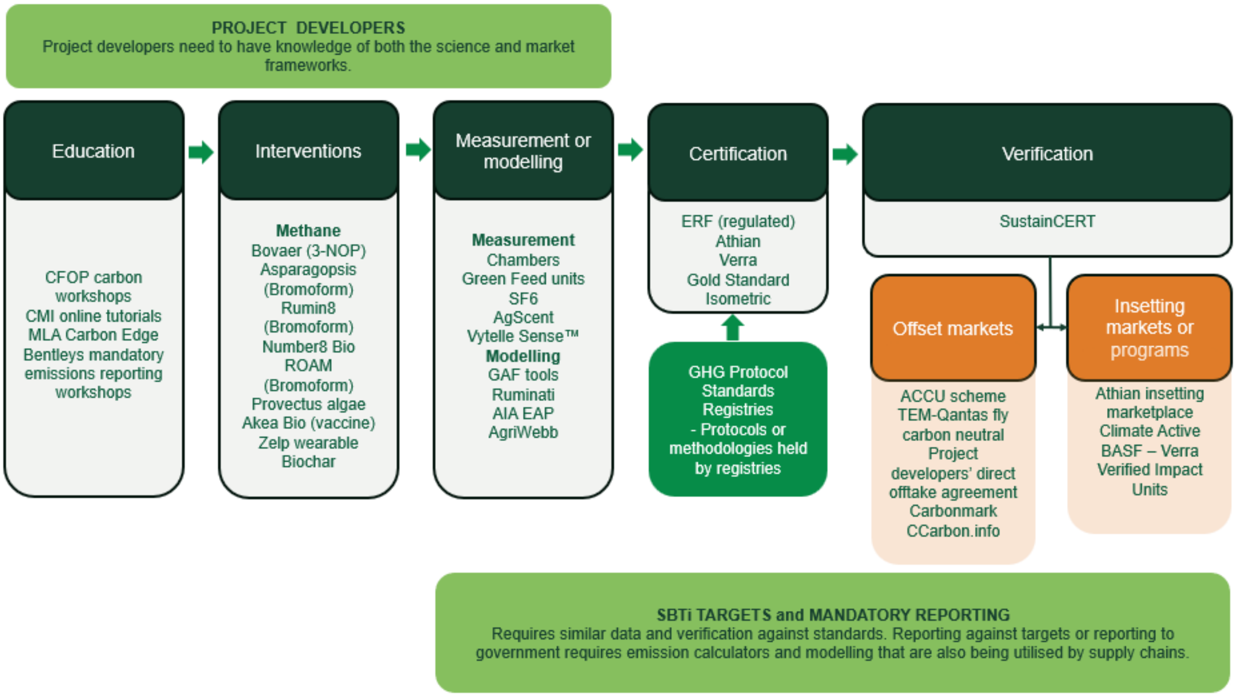


Figure 5: *The ecosystem of providers and stages to generate a claim or participate in carbon market*

6. Reducing emissions from cropping

Greenhouse gas emissions from cropping are dominated by emissions associated with nitrogen fertiliser, including both the energy required to produce the fertiliser (a Scope 3 emission for farmers, as these emissions are produced off farm) and N_2O emissions from fertiliser volatilisation.

For Australian cereals, for instance, 22.5% of emissions are from fertiliser production and 15.1% are from N_2O emissions on farm (labelled 'fertiliser scope 1' in Figure 6. The emissions profile is broadly similar for cotton (Figure 6B). Given this emissions profile, it is not surprising that the most substantial reductions in emissions are likely to be achieved by adopting low-emissions fertilisers or inhibitor-coated fertilisers and changing the method of production of fertilisers.

In the short term, strategies to reduce emissions intensity (in this case, N_2O g/t product) are the most attractive because they can also improve productivity. Increasing yields for the same amount of fertiliser can be achieved with precise timing and depth of application of fertiliser, for example.

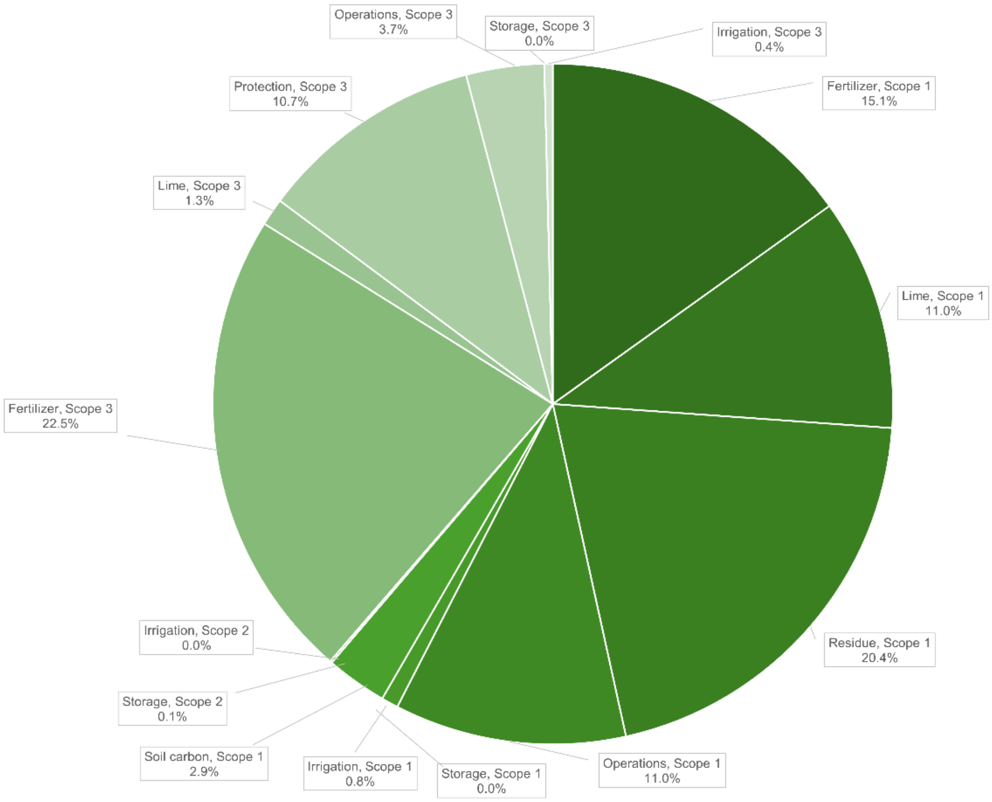
Enhanced-Efficiency Fertilisers (EEFs)

Several companies offer coated fertiliser products, with the fertiliser coating slowing the release of nitrogen and reducing N_2O emissions. These fertilisers are often called Enhanced Efficiency Fertilisers (EEFs). For example, an EEF has been shown to reduce N_2O emissions by 60% or more when applied to a wheat crop (Ma et al., 2023).

It should be noted that EEFs can also reduce emissions in mixed farming and intensive grazing systems. In one study, N_2O emissions were reduced by 56% using an EEF relative to a control when applied to a southern Australian pasture (Suter et al., 2020).

The challenge with these products is that they have not been shown to convincingly improve plant growth, although the ZNE-Ag CRC project 'Fertiliser Evaluation Framework' may address this.

A



B

Figure 6A: *Emissions from cropping systems: cereals;*
Figure 6B*. cotton. Source: A, Sevenster et al. (2022);*

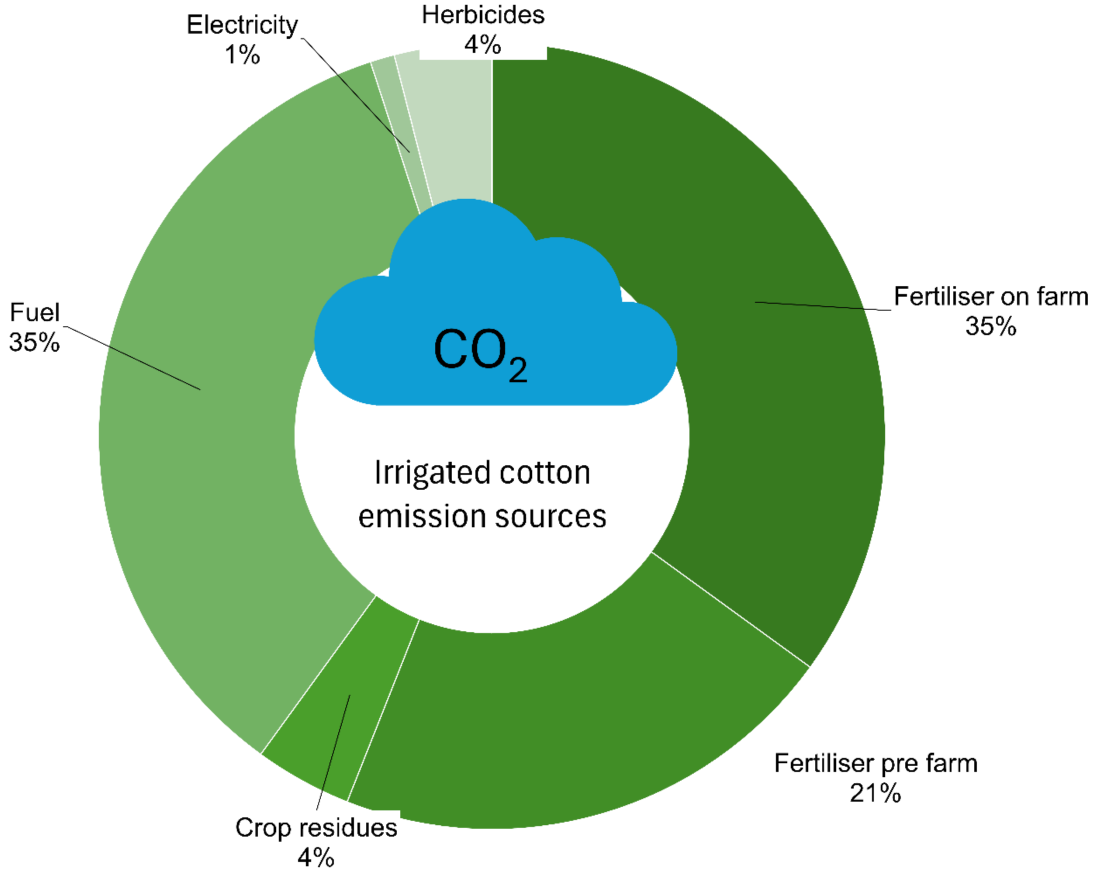


Figure 7: *Irrigated Cotton. Ekonomou A, Eckard RJ. (2024) University of Melbourne C-GAF based on the Australian National Greenhouse Gas Inventory methodology*

ZNE-Ag CRC Project 1050: Fertiliser Evaluation Framework

This project is expected to become the benchmark for evaluating Enhanced Efficiency Fertilisers (EEFs), supplying data to carbon calculators and national standards.

The project will co-design a Plant Nutrition Solutions Strategy, an EEF evaluation framework and associated investment principles. The evaluation framework will set out a cost-effective, national approach to evaluating EEF product performance and greenhouse gas emissions, and will be co-designed and co-developed by CRC industry and research partners.

The framework will principally consider N_2O reductions and, to a lesser extent, soil carbon benefits and Life Cycle Assessments (LCAs). The project will also include initial testing of products, which will be evaluated for their N_2O emissions and effects on plant growth and yields.

Other strategies available

Other options to reduce emissions from cropping include using legumes in rotation, growing cover crops and reducing fallows (Table 2).

Of all these options, and given Figure 6A, the on-farm strategy that would result in the greatest reduction in emissions would be to use fertilisers that reduce N_2O emissions (e.g. slow-release and coated products).

***Table 2:** Summary of management options to avoid greenhouse gas emissions or to sequester carbon in a grain farming system. Source: Badgery et al. (2024) Reducing GHG emissions in cropping systems – responding to drivers for change, GRDC report.*

Management strategy	Avoidance	Sequestration	Comments
N fertiliser efficiency	Yes	Possible	Applying N fertiliser efficiently (e.g. variable rate, split applications, not in waterlogged conditions) to optimise crop yield and replace N removal. Excess N fertiliser above crop removal rates increases the risk of N losses and N_2O production, higher fertiliser (balanced for NPKS) may lead to higher soil C.
N fertiliser coating	Yes	No	Using enhanced efficiency fertilisers (EEFs; e.g. N inhibitors) can reduce N_2O emissions by up to 80% but generally do not increase yield to offset the higher price.
N fertiliser production	Yes	No	Green ammonia can reduce Scope 3 emissions from production. Possible modular production available on-farm.
Lime use efficiency	Yes	No	Lime neutralises acid soils but also omits CO_2. Improve the efficiency of lime by using precision application. Consider lime alternatives.
Legumes in rotation	Possible	Possible	Legume N may reduce N fertiliser needs and the emissions associated with production. Higher N may also be associated with higher soil C.
Biochar	Yes	Yes	Biochar can neutralise soil acidity, reducing the use of lime. It also has a negative priming effect that can stimulate additional soil C storage.

Management strategy	Avoidance	Sequestration	Comments
			Currently it is not viable in extensive grain production systems.
Increasing pasture phases	Yes	Yes	Soil C often continues to decrease with cropping, but pasture phases increase soil C and N, and increase mineralisation of N for subsequent crops.
Cover crops and reducing fallows	Uncertain	Uncertain	Legume cover crops may supply additional N to subsequent crops but also increase the N fertiliser needs in the short-term as N is used from fallows. Cover crops and reducing fallows may increase soil C in some situations.
Revegetation with trees	No	Yes	Revegetation with trees can sequester C but removes land used for cropping from production.

Methodologies or protocols currently available to claim or generate credits

There are a limited number of carbon credit generating methodologies available for Australian farmers. Table 3 and Table 4 identify options that are available.

Table 3: *Methodologies available to cropping businesses to generate Australian Carbon Credit Units (ACCUS).*

Category	ACCU Methodology	Current Status	# of issued ACCUs
Land and Soil	Estimating soil organic carbon sequestration using measurement and models method (2021)		307,852

Category	ACCU Methodology	Current Status	# of issued ACCUs
Vegetation	Environmental plantings, forestry or management of native forests.	8,301,112	8,301,112

Table 4: *Previously available methods for cropping businesses to generate Australian Carbon Credit Units (ACCUS).*

Category	ACCU Methodology	Current Status	# of issued ACCUs
Fertiliser & Nitrous Oxide Reduction	Fertiliser in irrigated cotton^	Expired 30 Sep 2025	0

^ As of July 1, 2025, the Australian Government's outreach material states "There are no projects registered under the [Reducing greenhouse gas emissions from fertiliser in irrigated cotton] method".

Table 5: *Voluntary market methodologies available to cropping enterprises.*

Enterprise	Methodology
Soil Carbon Sequestration & Cropping Practices	VM0042 – Methodology for Improved Agricultural Land Management (IALM)
	Isometric - Enhanced Weathering in Agriculture (used by Carbonaught)
	Climate Action Reserve - US Soil Enrichment Protocol Version 1.1
Fertilizer & Nitrous Oxide Reduction	VM0022 – Quantifying N_2O emissions reductions in agricultural systems
Agroforestry & Cropland–Forest Integration	VM0047 – Afforestation, Reforestation, and Revegetation (ARR)

Case Study

EU biodiesel market access

Sector: WA Canola Farm

Partners: Elders

The canola for EU biodiesel is a high-value market, with a significant premium over other markets available to Australian canola exports. However, to access this market, an agricultural enterprise's carbon footprint must be below a certain value.

In 2015, CSIRO was commissioned to determine the carbon footprint of canola grown in each state. The carbon footprint for Western Australian (WA) and South Australia (SA) was found to be substantially below the EU threshold. This opened the EU biodiesel market to WA and SA producers, in EU decision 2017/2356 (European Union, 2014)

The price premium for canola entering the biodiesel market ranges from $20 to $40. Given the amount exported by WA producers into this market (70% of all exports) since the EU decision was made, demonstrating a low-carbon footprint to gain access to a high-value market has resulted in approximately $432 million of extra returns for WA canola growers.

7. Reducing emissions from livestock

Most greenhouse gas emissions from grazing cattle and sheep businesses are from methane, as a result of enteric fermentation in the rumen.

Methane emissions have a high potency and short lifetime relative to carbon dioxide. This means that reducing methane emissions has significant climate benefits in the short-term. This is critical to slowing warming and making Paris aligned targets achievable (IPCC 2023).

Figure 8 and Figure 9 compare the typical emissions profile of a grazing enterprise versus a dairy enterprise. In the grazing profile, note the exact contributions can vary by ±10% for methane and by about ±5% for nitrous oxide and carbon dioxide.

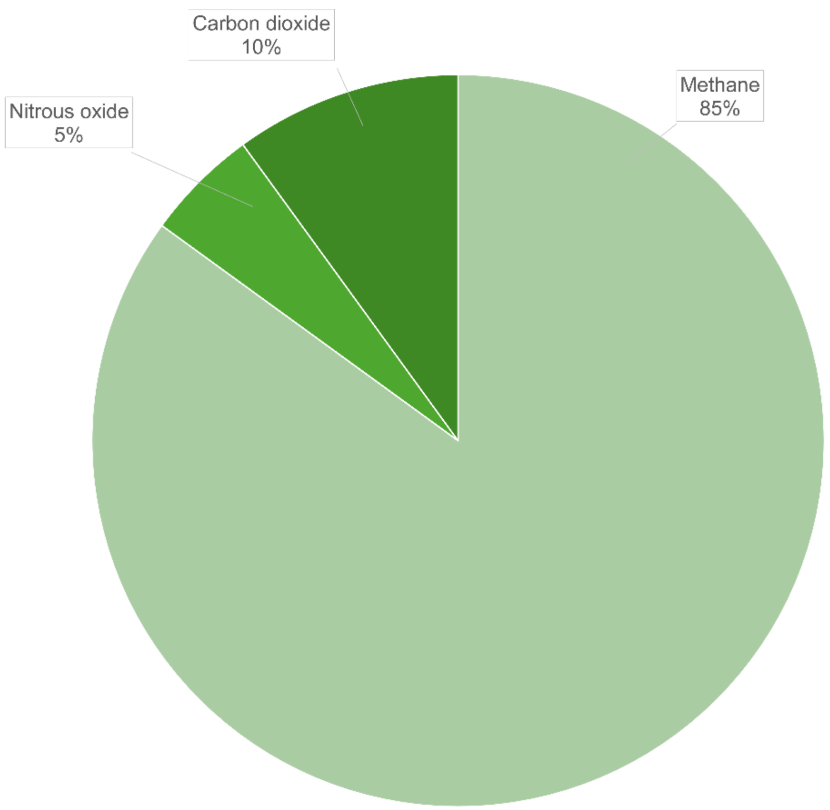


***Figure 8:** Typical grazing business emissions profile. Source: reproduced from Wiedemann et al. (2015; 2016). From Futurebeef*

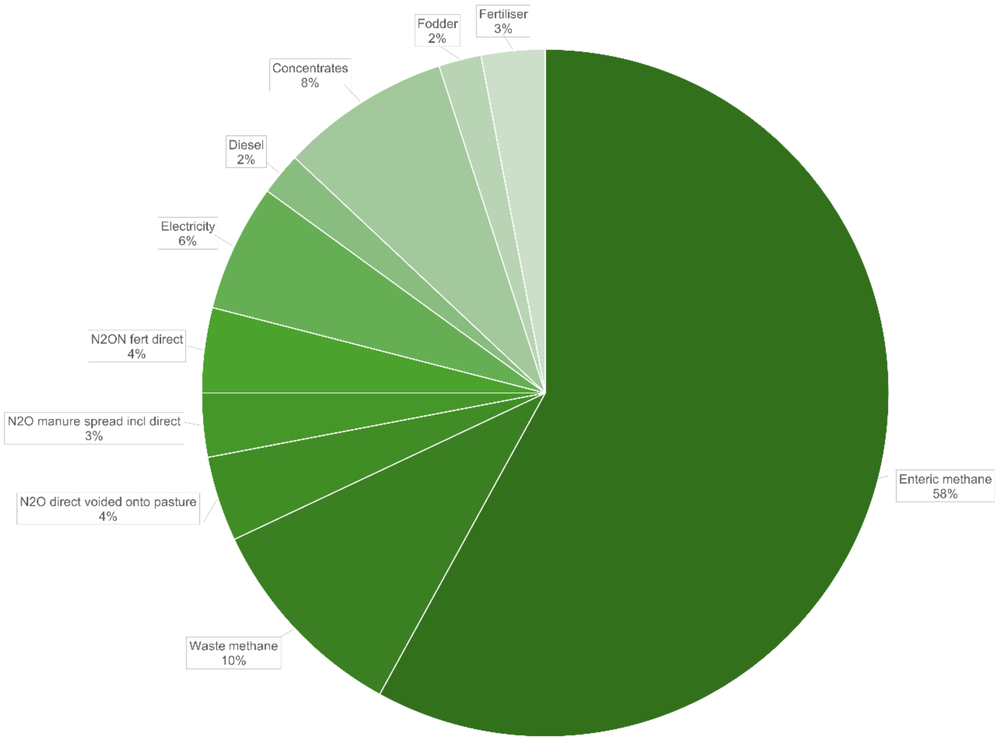


Figure 9: *Typical dairy business emissions profile: there are fewer emissions from CH4, and more from N2O as a result of using nitrogen fertiliser on pastures. Source: reproduced from Dairy Australia, (2023). From. [Dairy farm emissions.]*

Strategies Available

There are several strategies available to livestock producers that are known to reduce the amount of methane and other gasses entering the atmosphere through avoidance or interventions that reduce emissions.

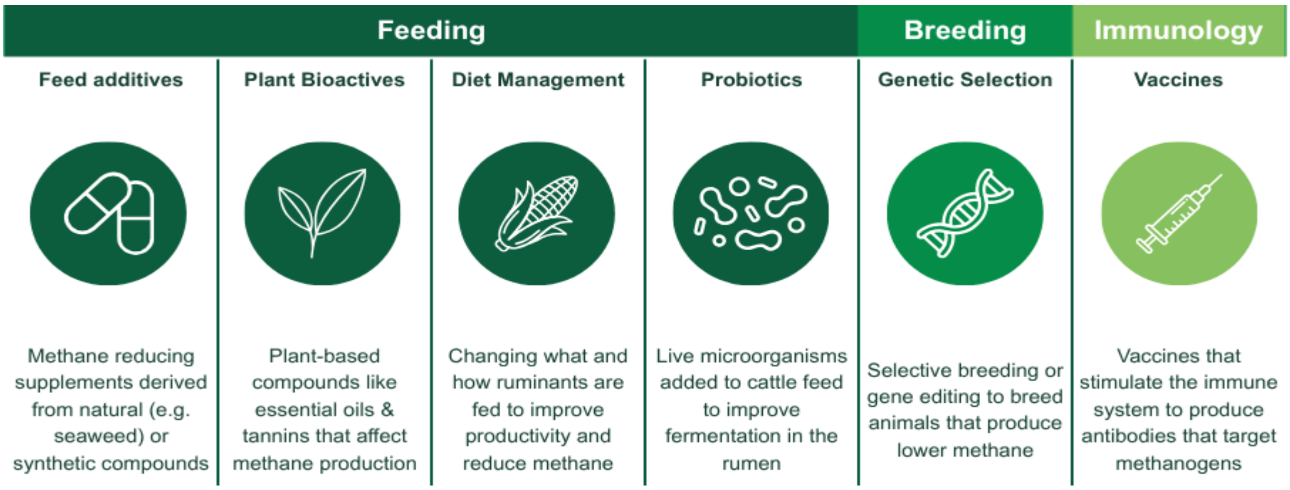


Figure 10: *Snapshot of enteric methane reduction strategies available to livestock producers (Spark Climate Solutions, 2025)*

Reduction Strategies

Emissions reductions occur when a livestock system emits less methane or nitrous oxide than it did before, due to a change in practice within the system.

Reducing methane intensity (CH_4 g/kg beef or lamb)

In the short term, reducing methane intensity is the most attractive pathway for reducing emissions from beef and lamb. This is because most strategies to reduce methane intensity can improve profit.

Improving weaning rates results in more beef produced per cow, diluting the cow's methane production over more kg of beef. Improving weaning rates can be achieved with better nutrition, particularly for heifers, and selection on estimated breeding values (EBVs) or genomic breeding values (GBVs) for traits such as days to calving, heifer puberty, pregnant or not 4 months after calving (P4M) in beef cattle and weaning rate in sheep.

Reaching target market weights at an earlier age. The less time an animal requires to reach market weights, the less methane it will produce. Earlier turnoff times can be achieved by selection for weight EBVs or GBVs, and better nutrition.

Breeding and Genetics

Breeding and genetics is considered an extremely promising, long-term solution.

Genetic selection for cattle and sheep with lower methane emissions should be possible in the next couple of years. For Australian dairy cattle, a sustainability index is already in place which allows dairy farmers to breed herds with reduced methane emissions. However, the rate of reduction in methane is predicted to be fairly slow, reflecting the low number of cows with actual methane records in the data set behind this index (https://www.datagene.com.au/wp-content/uploads/2023/11/fact-sheet-34-Sustainability-index.pdf). In beef cattle, preliminary genomic breeding values have been derived for Angus cattle, but these are not yet accurate enough to deploy (Hayes et al. 2016).

Large MLA projects and a recently launched ZNE-Ag CRC project will expand the number of cattle and sheep measured to the tens of thousands, at which point genomic breeding values for methane emissions will be ready to deploy. These genomic breeding values will be part of an index that weigh methane along with other traits to improve profit while decreasing emissions.

Moderate mature cow weight

Monitoring cow weight is important, as it has a distinct influence on emission intensity and the total enteric fermentation emissions of an enterprise. Moderate-sized cows are recommended because they are more efficient, requiring less energy for maintenance than very large cows, and are less prone to dystocia than small cows. Selecting moderate-sized cows as a target, rather than small cows, can result in a 6% reduction in emissions intensity and helps avoid issues related to dystocia.

Case Study

Improving efficiency and resilience on a Bega Valley dairy farm

Sector: Dairy

Partners: Bega

A 174-hectare dairy in the Bega Valley milks 380 Friesian cows, producing about 2.8 million litres of milk annually. Operating on a pasture and forage system with supplementary irrigation, the farm has focused on growing more of its own feed and on protecting biodiversity by fencing 49 hectares of remnant vegetation and managing 12 hectares of tree plantations.

Through participation in the Bega Better Farms Program, the farmer identified practical ways to improve productivity while lowering emissions. Growing and using more homegrown feed (9.46 tonnes per hectare, above the regional average) reduced reliance on imported feed and cut methane emissions per litre of milk. Smarter nitrogen management helped limit fertiliser-related emissions and reduce costs, while the farm's tree plantations and vegetation provided valuable carbon storage and biodiversity benefits. Together, these actions improved efficiency, reduced the farm's net emissions to below the regional average, and strengthened its environmental credentials.

Low-emissions pastures and forages

You can plant pastures and forages that reduce emissions, such as Leucaena, Brassicas, Biserrula, and Desmanthus. These plants contain compounds that reduce livestock methane production and increase livestock productivity. This could result in a 20–40% reduction in emissions, depending on the species grazed.

Enteric Methane (CH_4) direct reduction

Some of the products that can be used for direct reduction include:

- Bovaer® 3-NOP (3-nitrooxypropanol) – reduces enteric methane by inhibiting methanogenesis.
- Red seaweed (Asparagopsis spp.) – has several bioactive compounds but the dominant compound is *Bromoform CHBr3* which is a rumen modifier that suppresses methane production.
- Other natural additives – tannins, saponins, Agolin™ or Mootral™ (essential oils), Polygain (sugar cane extract).
- High-fat or oil supplements – reduce hydrogen availability for methane formation.
- Improved feed digestibility – higher- quality forage reduces methane per unit of output.
- Biochar
- Zelp wearables.

Emerging direct interventions still in development include:

- Vaccines.
- Bolus or slow-release rumen devices are being developed by companies such as Ruminant Biotech, ROAM and the ZNE-Ag CRC (Project 2030).
- Probiotics with proven methane reduction.

Avoidance Strategies

Avoided emissions occur when an intervention prevents emissions that would have occurred in a counterfactual (baseline) scenario. This is typically associated with manure and fertiliser management.

Manure Management and Waste Handling

- Anaerobic digestion – capture methane from manure to generate biogas.
- Covered lagoons / impermeable covers – prevent methane escape.
- Solid-liquid separation – reduces anaerobic decomposition.
- Composting – aerobic treatment to reduce methane formation.
- Manure drying and pelleting – lowers microbial activity and CH_4 production.

Nutrient and Fertiliser Management

- Precision fertilisation of pastures – reduces N_2O emissions by aligning nutrient supply with plant uptake.
- Use of nitrification inhibitors – prevents N_2O formation in soils.
- Optimized manure application (timing, incorporation into soil) – avoids nitrous oxide hotspots.

Systems Avoidance

- Improved feed storage (silage covers, reduced spoilage) – avoids emissions from decomposition.
- Breeding for lower-yield manure systems (e.g., selection for animals with more efficient nutrient utilisation).

GHG removals in livestock systems

GHG removals are related to carbon dioxide being removed from the atmosphere due to activities that drive sequestration in soil or vegetation. In grazing livestock systems, the rate of sequestration can be driven by changes in land or grazing management.

Pasture & Forage Improvements

- Legume integration (e.g., clovers, leucaena, desmanthus) reduce N fertilizer needs and can lower methane intensity. Recent work in Australia has shown increased soil carbon sequestration, improved intensity through improved productivity and small direct methane reductions from desmanthus (Agrimix, 2025 pers comm).

Grazing pastures or forage with higher digestibility has been shown to reduce total GHG emissions compared to grazing low digestibility forages (FAO, 2013)
Grazing forage crops with secondary compounds (e.g., condensed tannins in some legumes) reduce total emissions.
Technologies in development such as Biolumic utilise UV light to develop a low-emissions pasture with increased productivity gains.

Commercial Readiness of Interventions for Enteric Methane

There has been significant investment globally to develop interventions for direct methane reduction due to the critical nature of this gas on warming. Product development is being led by global animal health companies such as DSM with their product Bovaer™ and Future Feed, with their research on Asparagopsis. There are several start-up companies also developing solutions with funding from venture capital.

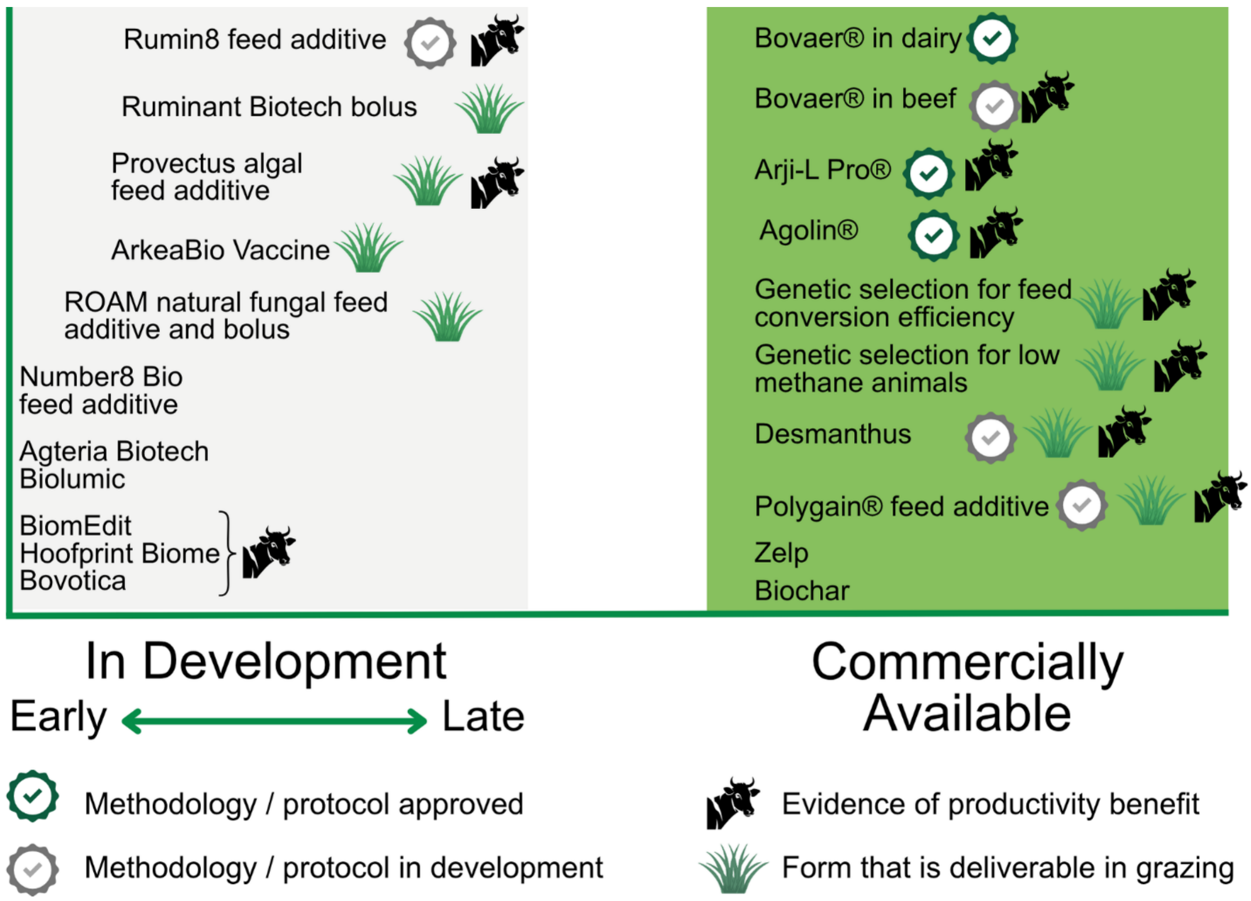


Figure 11: *Stage of development, application to grazing, evidence of productivity benefit and ability to create credits for carbon markets or verify claims using an approved methodology or protocol.*

Recent analysis completed by Spark Climate Solutions as part of their Livestock Enteric Methane Mitigation Roadmap (2025) identifies various strategies and considers the subsequent impacts, potential trade-offs and consumer acceptance.

	Feed Additives				Plant Bioactives		Diet	Probiotics	Breeding	Immunology
	Ionophores	3-NOP	Haloform-based Inhibitors	Nitrates	Essential Oils	Tannins and Saponins	Diet Management	Probiotics	Genetic Selection	Vaccinnes
Consumer acceptance	Medium risk	Medium risk	Medium risk	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk
Mitigation Potential	Low <20%	Moderate 20-50%	Moderate 20-50%	Moderate 20-50%	Low <20%	Low <20%	Low <20%	Low <20%	Moderate 20-50%	Unknown
Upstream/ Downstream Impact	Neutral	Potential Trade-offs	Potential Trade-offs	Potential Trade-offs	Unknown	Beneficial	Potential Trade-offs	Unknown	Unknown	Unknown
Pasture Applicability	Medium risk	Medium risk	Medium risk	Limited	Medium risk	Medium risk	Medium risk	Medium risk	Low risk	Low risk
Productivity	Low risk	Neutral	Negative	Neutral	Neutral	Neutral	Low risk	Low risk	Neutral	Unknown
Cost Feasibility	Low risk	High cost structure	High cost structure	Medium risk	High cost structure	Medium risk	Low risk	Low risk	Low risk	Medium risk
Timeline	Available	Available	Ready by 2030	Available	Available	Available	Available	Available	Ready by 2030	Long-term

Figure 12: *Evaluation of solutions by Spark Climate Solutions (2025).*

Methodologies or Protocols Currently Available to claim or generate credits

There are a limited number of carbon credit generating methodologies available for Australian livestock producers. The following tables identify options that are available.

Table 6: *Currently available methods for livestock businesses to generate Australian Carbon Credit Units* ***(ACCUS).***

Category	ACCU Methodology	# of issued ACCUs
Enteric Methane and Manure	Manure Management (combined)	1,259.179
Land and Soil	Estimating soil organic carbon sequestration using measurement and models method (2021)	307,852
Vegetation	Environmental plantings, forestry or management of native forests	8,301,112
Savanna Burning	Savanna fire management method 2018	14,666,212

***Table 7:** Previously available methods for livestock businesses to generate Australian Carbon Credit Units (ACCUS).*

Category	ACCU Methodology	Status	# of issued ACCUs
Expired or under review	Beef Cattle Herd Methodology	No new projects and under review	998,577
	Human Induced Regeneration	Expired on 30 September 2023	48,265,593
	Avoided Clearing	Expired on 31 March 2025	535,629
	Avoided deforestation	Expired February 2023	29,862,496
	Reducing Greenhouse Gas Emissions by Feeding Dietary Additives to Milking Cows Method 2013	Expired (date not published)	0
	Reducing Greenhouse Gas Emissions by Feeding Nitrates to Beef Cattle) Method 2014	Expired on 30 September 2024	0

***Table 8:** Examples of currently available voluntary market methods for livestock businesses.*

	Methodology or Protocol
Enteric Methane and Manure	Athian – Alternative Manure Management
	Athian – Digester Cap and Flare
	Athian - Bovaer
	Athian – AjiPro®-L
	Athian - Rumensin
	Verra - VM0041 Methodology for the Reduction of Enteric Methane Emissions from Ruminants

	Methodology or Protocol
	Verra - VM0033 Methodology for Reducing GHG Emissions from Manure Management Systems
	Gold Standard - Reducing Methane Emissions from Enteric Fermentation in Beef Cattle through Application of Feed Supplements
Land and Soil	The Regenerative Standard - Regenerative Soil Organic Carbon Methodology for Rangeland, Grassland, Agricultural, and Conservation Lands V2.0
	Verra - VM0042 Methodology for Improved Agricultural Land Management (IALM)
	Verra - VM0026 Methodology for Sustainable Grassland Management
Afforestation and Agroforestry	Verra – VM0047 Afforestation, Reforestation, and Revegetation (ARR)

Case Study

Reducing emissions through moderate cow size

Sector: Livestock

Partners: Elders

An Elders study examined how altering cow size can help reduce methane emissions in a southern mixed-farming beef herd of 270 British-bred cows. The herd, which turns off weaners at five to six months without supplementary feeding, had an average cow weight of 650 kilograms and produced about 1,232 tonnes of carbon dioxide equivalent per year, with an emissions intensity of 12.4 kilograms of carbon dioxide equivalent per kilogram of live weight.

Reducing the average cow weight to 600 kilograms lowered total emissions to 1,140 tonnes of carbon dioxide equivalent and emissions intensity to 11.7 kilograms of carbon dioxide equivalent per kilogram of liveweight – a 6% reduction. This could be achieved by selecting moderate-framed cows or crossbreeding with smaller-framed breeds. Moderate-sized cows are more efficient, needing less feed for maintenance, and this case study shows they can help lower emissions without affecting herd performance.

8. Reducing emissions from horticulture

Horticulture has quite a different emissions profile from other agricultural industries, with a greater proportion of emissions coming from CO_2 as a result of energy in diesel and use of irrigation pumps.

The example in Figure 11 for potato production shows that approximately half of all emissions are associated with CO_2 production, and the rest with N_2O production.

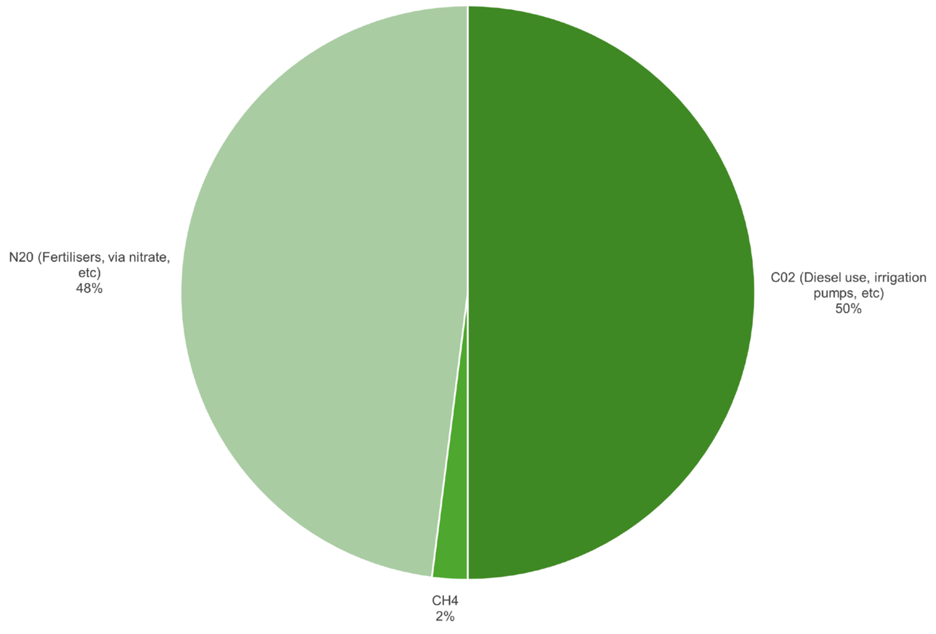


Figure 11: *Emissions profile for potato production. Source: Norton (2008), Enhancing environmental sustainability in the processing potato industry, University of Tasmania.*

Given this profile, there is considerable potential to reduce emissions through technologies that lower energy usage, such as solar-powered irrigation pumps and more efficient or even battery-powered tractors.

For orchards, there is the opportunity to sequester considerable amounts of carbon in the growing trees, however there are currently no approved methodologies that allow carbon credits to be generated for orchards.

9. Sector-agnostic options

Tree planting

Regardless of the type of agricultural operation, there is an opportunity to reduce net emissions by planting trees. This strategy can also be considered on land that is unproductive for farming. Tree planting is one of the most straightforward strategies to reduce net emissions from a farm, as CO_2 is sequestered in the trees as they grow (Doran-Browne et al., 2017).

As well as sequestering carbon, the co-benefits of trees include providing shelter and shade for livestock, offering protection for species that prey on agricultural pests, and maintaining or improving biodiversity (Meyer et al., 2025).

Options include reforestation (restoration of previously forested land back to forest); planting to enhance biodiversity on land that is marginal for agriculture and agroforestry, which can provide income from timber harvested and have co-benefits for livestock production; and afforestation (the establishment of new forest in an area that was not forested or has not been forested for a significant period).

Several factors affect how much carbon tree plantings will sequester, including:

- the age of the trees
- local rainfall and soil type, and other factors that affect site productivity
- the species of tree planted
- the design of the tree plantings.

Younger, rapidly growing trees will sequester more CO_2, particularly in higher rainfall areas. The amount sequestered in such systems can be substantial. For example, a recent study found that in high-productivity livestock systems in Victoria (14–18 DSE/ha), tree planting scenarios covering 4.8%, 5.2% and 11.6% of three case study farms reduced net farm emissions by 20%, 23% and 33%, respectively, over 30 years (Meyer et al., 2025).

The type of planting design (e.g. blocks, rows, size of alleyways) can affect the amount of CO_2 sequestered and the performance of livestock/crops produced alongside these systems. The Steak 'n Wood project, run by Queensland DPI, is currently assessing the impact on emissions and productivity of different agroforestry tree planting configurations. See Steak 'n Wood for findings to date and updates.

Farmers can generate ACCUs by planting trees under the Reforestation and Afforestation Method. This requires planting seeds or seedlings to establish a permanent forest on grazed, cropped or fallow land, and undertaking field measurements of the planted trees.

Other cross-sector options

Other cross-sector options for reducing emissions include reducing reliance on fossil fuels, for example by using solar or wind to power irrigation pumps. Depending on the emissions profile of the sector, this can have either a large impact on emissions (e.g. horticulture) or a modest impact (e.g. grazing cattle and sheep).

Risks and considerations

- While carbon farming has many co-benefits, it is also essential to consider the trade-offs and risks. The following is an extract from the Carbon Farming Outreach Program.
- **Location:** some locations are much more suitable for sequestering carbon than others. Rainfall, soil type, temperature and land management history all affect how much carbon can be sequestered, either in trees or in soil.
- **Compatibility with agricultural production:** establishing trees on farms may reduce the land available for agricultural production, but carefully positioned plantings can complement agricultural production.
- **Biodiversity impacts:** which trees to plant and their location and layout should consider impacts on biodiversity. Some states (e.g. NSW) offer biodiversity credits for tree plantings that improve biodiversity.
- **Permanence of carbon storage:** storing carbon in vegetation and soil requires ongoing management. Fire, drought or management changes could lead to losses of stored carbon. Managing this risk in carbon markets requires a long-term – many decades – commitment to maintain carbon stores and restore any losses, with implications for land, financial and succession planning.
- **Legal considerations:** legal aspects of participating in carbon markets may include land use agreements, complying with legislation and contracts.
- **Financial factors:** carbon farming can provide an additional source of income from the sale of ACCUs and on-farm productivity gains. Carbon market participation involves costs in addition to those incurred in investing in new equipment and changing practices. Other costs may include obtaining legal and financial advice; estimating emissions reductions and carbon storage; and monitoring, reporting and auditing. The time commitments involved also need to be considered. There is likely to be a lag between paying the initial costs and earning revenue from the sale of ACCUs. This is particularly so for carbon storage activities, where building carbon levels in vegetation and soils takes time and can be subject to variability. Where carbon farming is conducted without participating in the ACCU scheme, the costs of making new purchases and changing practices need to be weighed up against benefits such as improved production.

Case Study

Environmental Plantings

Sector: QLD Beef

Partners: NAB, Fitzroy Basin Association

Planting trees on a Queensland beef property

A Central Queensland beef property, operating over 17,500 hectares, created a 38-hectare native tree corridor with 17 local species to increase grass and tree cover, biodiversity and carbon storage. The property also registered a soil carbon project, adopted rotational grazing and wet-season spelling, and planted legumes. They measured baseline soil carbon and vegetation cover using remote sensing, and the farm participated in Meat and Livestock Australia's Environmental Credentials Platform and a NAB Green Loan to support investment. This work was a collaboration with the Fitzroy Basin Association.

Benefits included increased soil carbon, improved drought resilience, and recognition of sustainable credentials. Initial challenges to tree survival were addressed through better planning, tree guards, and mulching. The project shows how tree planting and careful management can reduce net emissions, boost productivity, improve drought resilience, and earn credibility with financiers.

10. Conclusion

This Paper has highlighted the sector's progress and the breadth of practical opportunities currently available to Australian farmers and land managers. From innovative on-farm practices and emerging technologies to participation in carbon markets and alignment with global frameworks such as the Science Based Targets initiative (SBTi) and the Paris Agreement.

Achieving zero net emissions will require coordinated action across the entire value chain.

Farmers and land managers are already adopting climate-smart interventions that not only reduce emissions but also enhance productivity, resilience, and market access.

The evolving policy landscape, including mandatory climate disclosures and supply chain expectations, underscores the importance of robust measurement, transparent reporting, and credible certification.

While challenges remain, such as data complexity, cost-sharing, and the need for high-integrity methodologies, the sector's collaborative approach, supported by research, industry partnerships, and government programs, is driving continuous improvement.

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