CARBON AND CO-BENEFITS

A GUIDE FOR AUSTRALIAN GRAIN GROWERS

2025

GrainGrowers

CONTENTS

GrainGrowers

Disclaimer

The professional analysis and advice in this report has been prepared by GrainGrowers for the exclusive use of the party or parties to whom it is addressed (the addressee) and for the purposes specified in it. This report is supplied in good faith and reflects the knowledge, expertise and experience of the consultants involved. The report must not be published, quoted or disseminated to any other party without GrainGrowers' prior written consent. GrainGrowers accepts no responsibility whatsoever for any loss occasioned by any person acting or refraining from action as a result of reliance on the report, other than the addressee. In conducting the analysis in this report GrainGrowers has endeavoured to use what it considers is the best information available at the date of publication, including information supplied by the addressee. Unless stated otherwise, GrainGrowers does not warrant the accuracy of any forecast or prediction in the report. Although GrainGrowers exercises reasonable care when making forecasts or predictions, factors in the process, such as future market behaviour, are inherently uncertain and cannot be forecast or predicted reliably. GrainGrowers shall not be liable in respect of any claim arising out of the failure of a client investment to perform to the advantage of the client or to the advantage of the client to the degree suggested or assumed in any advice or forecast given by GrainGrowers.

Cover image - *Paddocks of gold* – Kate Payne, NSW

Contact us

Level 19, 1 Market Street
Sydney NSW 2000

PO Box Q1355 Queen
Victoria Building NSW 1230

(02) 9286 2000

www.graingrowers.com.au

DESIGNED AND PRINTED IN AUSTRALIA

Ripening under a clear starry night - Georgie Hamilton, NSW

INTRODUCTION

With greenhouse gas (GHG) emissions and climate change at the forefront of global agricultural and commercial priorities, understanding the key concepts related to 'carbon' has become increasingly important. This rising awareness has prompted requests from growers for a comprehensive guide to these topics.

GrainGrowers has created this guide to outline the concepts of carbon farming so growers can make the decisions that work best for their enterprise.

Other resources available to growers include GrainGrowers' publications Carbon Calculators Compared and Carbon and Cropping. At the back of this guide, there is a glossary of key terms and a QR code for useful resources.

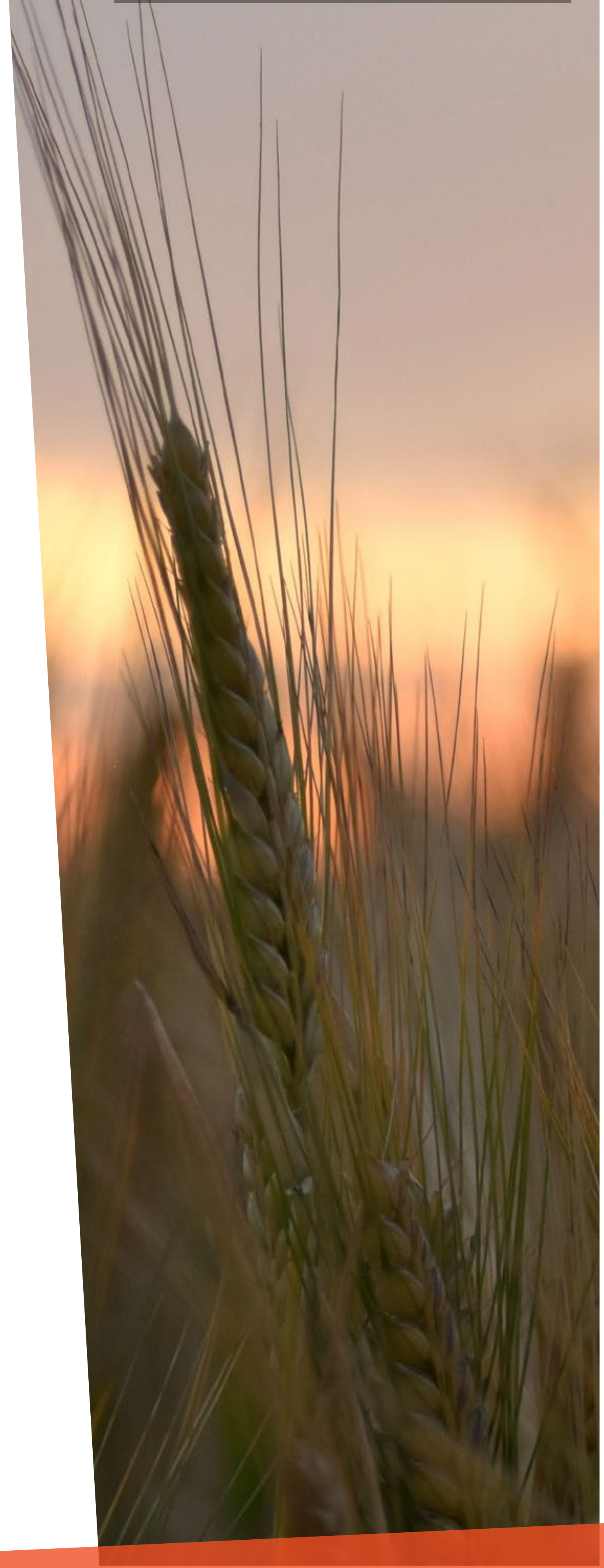
What this guide does not provide

Legal advice: While this guide outlines regulatory requirements, it does not substitute for legal advice. Specific legal considerations should be discussed with qualified professionals.

Financial advice: The information provided is for general information purposes only and does not constitute financial advice. Consulting a qualified financial advisor before making any investment or financial decisions related to the ACCU Scheme is recommended. The information provided is based on current understanding and may change over time.

Detailed methodologies: It does not delve into the specifics of every carbon farming methodology or the exact certification requirements for carbon neutral and net zero. Growers will need to consult official guidelines and possibly experts for methodology selection.

Guarantees of success: Carbon farming, like any farming venture, is not without risks or challenges. Success depends on factors such as project design, implementation, progress evaluation and compliance.



Golden glow just peeking through - Tamara Ward, WA

CARBON FARMING

What is carbon farming?

Carbon farming is an inclusive term for the deliberate practices used to avoid greenhouse gas (GHG) emissions or store carbon in soil and vegetation

Carbon farming is also known as low emissions farming or low emissions agriculture.

The main goal of avoiding GHG emissions and storing (or sequestering) carbon is to help slow climate change by reducing the buildup of GHGs that cause global warming.

This is how the practices work.

Avoiding emissions

When the release of GHG gases like carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O), are avoided, the volume of heat-trapping gases in the atmosphere reduces. GHGs are a major cause of global warming, so fewer emissions mean less added heat.

Overuse of fertiliser (particularly when combined with wet and warm soils), livestock urine and dung, burning residue and the use of diesel fuel are all on-farm sources of GHG emissions. In cropping, some activities that help with the avoidance of GHG emissions include:

- Refraining from burning stubble.
- Changing how fertiliser is used e.g. adopting variable rate technology.
- Using renewable electricity to power infrastructure and machinery.

Storing or sequestering carbon

Plants naturally absorb CO_2 from the atmosphere as they grow and some of that carbon gets stored in trees and other vegetation. Under the right conditions and over time, carbon can be stored in the soil.

By increasing storage, carbon in the form of CO_2 is kept out of the atmosphere. Trees, vegetation, oceans and soils that store carbon are called carbon sinks. Some carbon farming activities that help with carbon sequestration in cropping include:

- Planting trees.
- Agroforestry.
- Creating conditions to let vegetation regenerate.

Carbon farming can involve one or two practices, or it can be part of an integrated plan that simultaneously optimises the avoidance of GHG emissions and the absorption and storage of carbon.

The type of carbon farming activity that is right for a farming operation will depend on several factors, including location, climate conditions, property type, and management goals.

What about low-till and no-till?

Low-till and no-till farming is an agricultural practice that minimises soil disturbance by avoiding traditional ploughing (tilling). Instead of turning the soil over to prepare for seeding, growers plant seeds directly into the soil, leaving previous crop residue on the surface.

Australian growers began experimenting with low-till and no-till in the early 1960s. Drought and dust storms drove the need for change, but forward-thinking growers seeking new practices, along with the development of modern pesticides, provided the solutions.

Today, low-till and no-till is the dominant practice on approximately 85% of Australian cropping operations. Its known benefits are moisture conservation and the prevention of soil erosion caused by wind and water.

No-till and low-till is also recognised as an important carbon farming practice. With ploughing bypassed, no-till farming helps avoid GHG emissions from diesel use in tractors, and from the soil itself.

Emissions avoidance

On-farm GHG emissions sources in Australian grain production

There are six main sources of GHG emissions produced on-farm in Australian grain production. Each on-farm source, the main GHG emitted, and their relative percentages are illustrated in Figure 1.

On-farm sources of GHG emissions in grain production

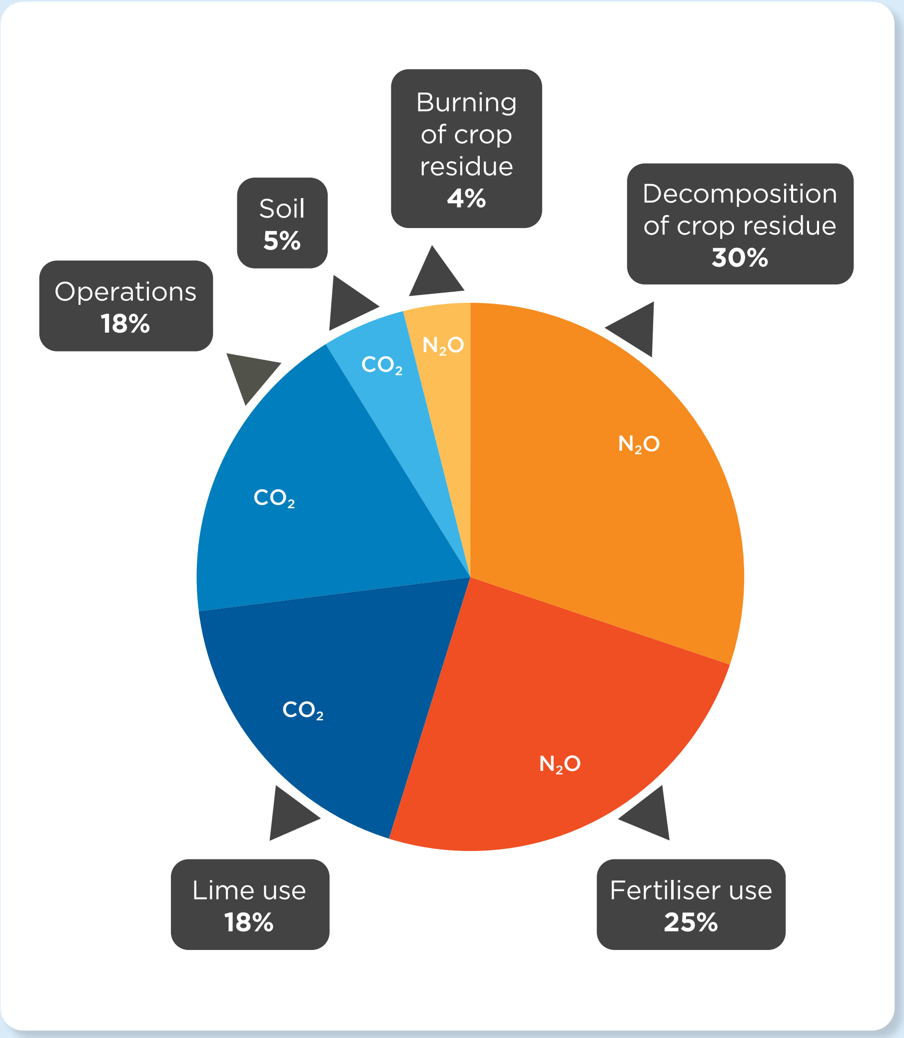


Figure 1. On-Farm Sources of GHG Emissions in Australian Grain Production. Source: Sevenster M., Bell L., Anderson B., Jamali H., Horan H., Simmons A., Cowie A., Hochman Z. (2022) Australian Grains Baseline and Mitigation Assessment. Main Report. CSIRO, Australia

It is important to note that the figures have been calculated at a national level, and the source proportions for an operation or region will vary according to the location, climatic conditions, season and agricultural practice.

On-farm sources of GHG emissions

Decomposition of crop residue - 30%

Decomposing crop residue, or stubble, produces GHG emissions as the soil microbes break down the residue in the paddock. Most emissions are in the form of nitrous oxide (N_2O).

Burning crop residue - 4%

GHG emissions are the product of the combustion process that takes place during burning. Nearly all of the GHG emissions produced are in the form of carbon dioxide (CO_2). Methane (CH_4) is often also produced due to inefficient combustion.

Fertiliser use - 25%

Nitrogen plays a key role in plant growth,and crops often respond positively to higher soil nitrogen levels in the form of nitrogen fertiliser. However, when nitrogen-based fertiliser is applied in excessive amounts or at the wrong times, it can lead to a buildup of nitrogen compounds. Soil microbes break down the excess nitrogen compounds and release nitrous oxide (N_2O).

Lime use - 18%

Soil acidity constrains crop production in Australia. Liming is an ameliorative practice that reduces soil acidity to make land arable. When the lime (calcium carbonate) dissolves, it can release bicarbonate which evolves into the GHG CO_2. The net effect of lime on GHG emissions depends on the specific soil and management practices.

Operations

The GHG emissions from diesel combustion is predominantly in the form of CO_2. Methane (CH_4) may also be present depending on the specific engine and its combustion efficiency.

Soil

Soil can emit GHG emissions due to microbial and chemical processes, particularly when it is disturbed. Most GHG emissions from soil are in the form of CO_2.Tillage can increase CO_2 emissions. The amount of CO_2 emitted depends on soil type, moisture content, agricultural practices, and environmental factors.

Harvest golden hour - Nicole Fragar, NSW

Retaining crop residue or stubble is good practice

While retaining crop residue, or stubble, does lead to GHG emissions, it also provides important benefits that are well known to many growers. Stubble acts as ground cover, protecting soil from wind and water erosion by reducing wind speed at the surface and minimising runoff. Keeping crop stubble can enhance soil moisture by reducing evaporation and boosting rainfall infiltration. It can also support nutrient recycling by very gradually increasing soil organic carbon and microbial biomass. Additionally, retaining stubble can lead to savings on fuel and labour.

On balance, it is considered good practice to retain stubble, despite the emission of GHGs during its decomposition.

The 4Rs of fertiliser use

The 4Rs – Right Source, Right Rate, Right Time, and Right Place, represent a framework for precise fertiliser management that avoids emissions and optimises yield.

Right source: The correct type of fertiliser to match the crops' nutrient needs is selected, such as selecting urea or ammonium nitrate for nitrogen, or specific forms of phosphate or potash based on soil conditions.

Right rate: The precise amount of each nutrient based on crop requirements and soil nutrient levels is applied to support growth and avoid emissions from overapplication.

Right time: The fertiliser is applied when crops can best absorb nutrients, like timing nitrogen applications to critical growth stages and adjusting timing for phosphorus and potassium as needed.

Right place: Fertilisers are applied where crops can easily access them to minimise waste thus avoiding emissions whilst preventing nutrient runoff or leaching.

Canola Glow - Eloise Bagshaw, WA

	On-farm source of emissions	% of on-farm emissions	Main GHG	How the GHG is emitted
	Decomposition of crop residue	30%	N_2O	When soil microbes break down crop residue over time
	Fertiliser use	25%	N_2O	When soil microbes break down excess nitrogen compounds in fertiliser
	Burning of crop residue	4%	N_2O	When crop residue is burnt, it is a combustion reaction
	Lime use	18%	CO_2	The chemical reaction that takes place when lime dissolves in water
	Operations	18%	CO_2	When diesel fuel is burnt, it is a combustion reaction
	Soil	5%	CO_2	When microbial and chemical processes are stimulated, particularly when it is disturbed by agricultural practices

Table 1. Summary of GHG emissions

Carbon sequestration

Carbon sequestration on farm can be a way for agriculture to contribute to climate change mitigation by capturing and storing atmospheric carbon in plant biomass and soil. Through practices like tree planting, natural regeneration, cover cropping, crop grazing and agroforestry, growers can increase carbon storage and improve soil health. These methods not only help reduce GHG concentrations but can also contribute to sustainable land use.

The most appropriate method, or combination of methods, for a grain growing operation to achieve carbon sequestration depends on a range of factors including business strategy, farm type, location, environmental conditions, implementation costs and resources available for maintenance.

Environmental tree planting

Trees absorb CO_2 from the atmosphere and store carbon in their branches, stems, leaves, bark and roots. As they grow, the carbon is stored as wood. Planting trees can be used to help reduce net on-farm GHG emissions. Several factors influence the amount of carbon trees sequester, including tree age, tree species and planting design. Tree growth and carbon sequestration also varies with climate, rainfall, and general site productivity.

Carbon sequestration generally peaks about 10 years after planting and then slows, reaching negligible amounts about 20 years after planting. The harvested timber offers stored carbon in the form of wood products. Well managed trees may provide extra income if harvested following appropriate approval processes.

Good planning for strategic planting of trees ensures they become an asset not a liability.

Natural regeneration of native vegetation

Natural regeneration means allowing or assisting the bush to grow back by itself. It is generally regarded as the most economical way to expand patches of native vegetation and improve their condition which helps them to sequester carbon more effectively. This approach can be especially beneficial in marginal or degraded areas, as it leverages natural ecological processes to restore biodiversity, stabilise soils, and improve water infiltration, thus enhancing carbon storage with minimal intervention.

Natural regeneration can occur in healthy bushland after a bushfire or an ecological burn. In degraded areas, growers can actively promote natural regeneration through assisted natural regeneration. This typically involves protecting and managing existing native trees and shrubs from loss or damage by fire, land clearing, grazing or excessive invasive species and weeds.

Agroforestry

Agroforestry is a land management system that involves the practice of growing trees, shrubs and crops in interacting combinations. With multiple plant species having roots in the ground year-round, plants can continue to draw carbon from the atmosphere. In systems such as silvopasture (trees with pasture) or alley cropping (trees with crops in between), trees act as carbon sinks while also improving soil quality.

There is some research to suggest that agroforestry may offer higher potential to sequester carbon because of their perceived ability for greater capture and utilisation of light, nutrients, and water than single-species crop or pasture systems. The rate and amount of carbon sequestered in agroforestry systems largely depends on environmental conditions and system management.

A pause in harvest after rain - Georgie Hamilton, NSW

Carbon sequestration and soil

Australia's soils are unique and highly complex, shaped by ancient geological processes, variable climates, and distinctive ecosystems. Acknowledging this complexity is essential, especially when it comes to the topic of sequestration of carbon in soil.

The carbon storage potential of soil depends on factors such as soil type, soil depth and climate, all of which vary across Australia's agricultural land. For example, soils in wetter, cooler regions typically have higher soil carbon levels (and variability) than those in hot, dry climates. Sandy soils can hold less carbon than clay soils, and even less in lower rainfall areas.

Rainfall dependency

In Australia, rainfall largely determines soil carbon changes in stable management systems. Unless there is a significant management shift—such as switching from conventional farming to permanent pasture in high-rainfall areas—most yearly soil carbon fluctuations are driven by rainfall. In mixed cropping systems, these changes can be substantial and unpredictable. With rainfall variability in Australia being 23% higher than the global average, efforts to build significant levels of soil carbon with long term stability may prove to be disappointing.

Slow to build, fast to deplete

Increases in soil carbon content may be subtle and slow, require annual management to realise potential productivity gains and may be sensitive to seasonal conditions. Measurements over several decades may be needed to define accurately the effects of management treatments on soil carbon. This is largely due to the high spatial and temporal variability of soil.

Depletion of soil carbon can be fast. It is driven by several factors that are not unfamiliar to Australian growers.

Carbon depletion in soil

Erosion

Soil erosion from wind or water can be intensified by deforestation, overgrazing, and lack of ground cover, leaving soil vulnerable to carbon loss.

Drought

Extended hot and/or dry periods reduce plant growth lowering carbon inputs to the soil. Drought also slows down microbial activity, which can make it harder for soil to retain existing carbon.

Flooding and waterlogging

Excessive water can cause soil erosion, remove organic matter, and disrupt soil structure, making it difficult for soil to store carbon.

Bushfires

Fire rapidly consumes plant material directly releasing carbon into the atmosphere and reducing the amount of organic material that contributes to soil carbon.

Stable soil carbon at the best possible level is critical for soil health and resilience. However, building soil carbon is generally a slow process whilst losing soil carbon can happen quickly. It is for this reason that maintaining and enhancing existing soil carbon is an important priority in soil carbon management.

Fields of gold - Kasie Guest, WA

Protect, maintain and enhance soil carbon

Targeted interventions to increase the physical protection of soil organic carbon can improve soil condition over time and support soil health. Best-practice approaches will differ depending on location, degree of degradation, soil type, past and present land use, and desired soil health improvement.

In cropping systems, there are multiple strategies to help protect existing soil carbon. When selecting a practice, it is important to consider the goals of the operation and ensure that the method is economically and environmentally sound. Maintaining good groundcover to control erosion is a common feature of many of these activities.

Just some of the strategies include:

- Minimising tillage.
- Retaining stubble.
- Managing fertiliser inputs to optimise plant growth.
- Identifying degraded soils (e.g. scalded or eroded areas) and changing practice or land use.

Intervention to protect, maintain and enhance soil carbon can be an important investment in an operation's future soil health and security.

Carbon neutral and net zero

Carbon neutral and net zero are often used interchangeably. Whilst both ideas involve balancing emitted greenhouse gases (GHGs) with avoided or removed emissions, the distinguishing factors between the two claims are:

- The use of offsets.
- The reduction and elimination of GHG emissions.

Carbon neutral

Balancing GHG emissions with offsetting practices

A business can claim carbon neutrality by measuring its GHG emissions and then offsetting the balance through purchasing carbon credits or through other financed projects outside of its value chain. A business can claim carbon neutrality without reducing its own emissions.

An agricultural operation can achieve carbon neutrality by taking this approach.

However, more typically, carbon neutral agriculture is a targeted farming practice that balances carbon emissions with carbon sequestration and storage. Growers seek to reduce CO_2 emissions and offset any outstanding emissions through absorption and storage practices such as planting trees, restoring wetlands, and effective soil management.

Carbon credits might also be purchased to offset any remaining emissions.

Carbon neutral certification

The Climate Active certification is a voluntary Australian government program recognising businesses that achieve carbon neutrality. For some growers, this certification can offer a pathway to demonstrate environmental stewardship while addressing climate change.

Demonstrating and maintaining carbon neutrality is a complex, ongoing task.

It bears marking that the capacity for soils and vegetation to sequester carbon is finite and there are specific maximum levels of carbon storage that can be achieved for any farming system.

Expert advice is required for the establishment and continuance of a carbon neutral operation. To navigate these challenges, growers should engage with expert advisors, leverage available government support, and integrate certification efforts into broader sustainability strategies.

Key elements of climate active certification

Achieving certification involves detailed reporting and adhereing to rigorous standards

Carbon accounting

Growers calculate their GHG emissions, including from machinery, fertilisers, crop residues, and land-use changes.

Emissions avoidance

Measures such as improving energy efficiency, adopting renewable energy, optimising fertiliser use, and incorporating sustainable farming practices help minimise emissions.

Offsetting remaining emissions

Growers purchase accredited carbon offsets to balance any emissions that cannot be reduced.

Climate Active: Key areas of ongoing maintenance

Once accredited, growers must be transparent and vigilant with record keeping related to the growing operation and the management of offsets. Regular audits are required to maintain the accreditation. Other considerations include the operational budget to maintain the accreditation and regular evaluations of risks to the accreditation along with the development of mitigation strategies.

Evaluating and adopting emissions avoidance innovations

- Continuously explore and evaluate new technologies or practices, such as precision agriculture, renewable energy, and low-emission fertilisers.

Monitoring and measuring emissions

- Regularly track GHG emissions including fuel use, fertiliser applications, soil management, and energy consumption.
- Update data annually to reflect changes in farm operations or external factors like fuel price shifts or weather variability.

Offset management

- Purchase carbon offsets to balance residual emissions. As markets fluctuate, securing high-quality, certified offsets that align with Climate Active standards can become complex.
- Diversify offset sources to mitigate risks from price spikes or reduced availability in specific projects.

Compliance with certification standards

- Submit annual reports to demonstrate adherence to Climate Active criteria.
- Undergo regular audits, ensuring all data and documentation are accurate and complete.

Financial and operational costs

- It is important to set aside resources to manage recurring expenses like auditing, reporting, and purchasing offsets.
- Consideration must be given to balancing investments in emissions avoidance activities with overall farm profitability.

Resilience to external factors

- Accredited growers must be prepared for shifts in consumer deman for carbon-neutral products, which could affect profitability.
- Changes in rainfall, temperature, or extreme weather events may necessitate adjustments in farming practices, potentially impacting GHG emissions profiles.

Net zero

Cutting emissions to as close to zero as possible.

Net zero marks the end of human induced GHG emissions. Net zero is the internationally agreed upon goal for mitigating climate change in the second half of the 21st century. The path required to achieve net zero is sometimes referred to as decarbonisation.

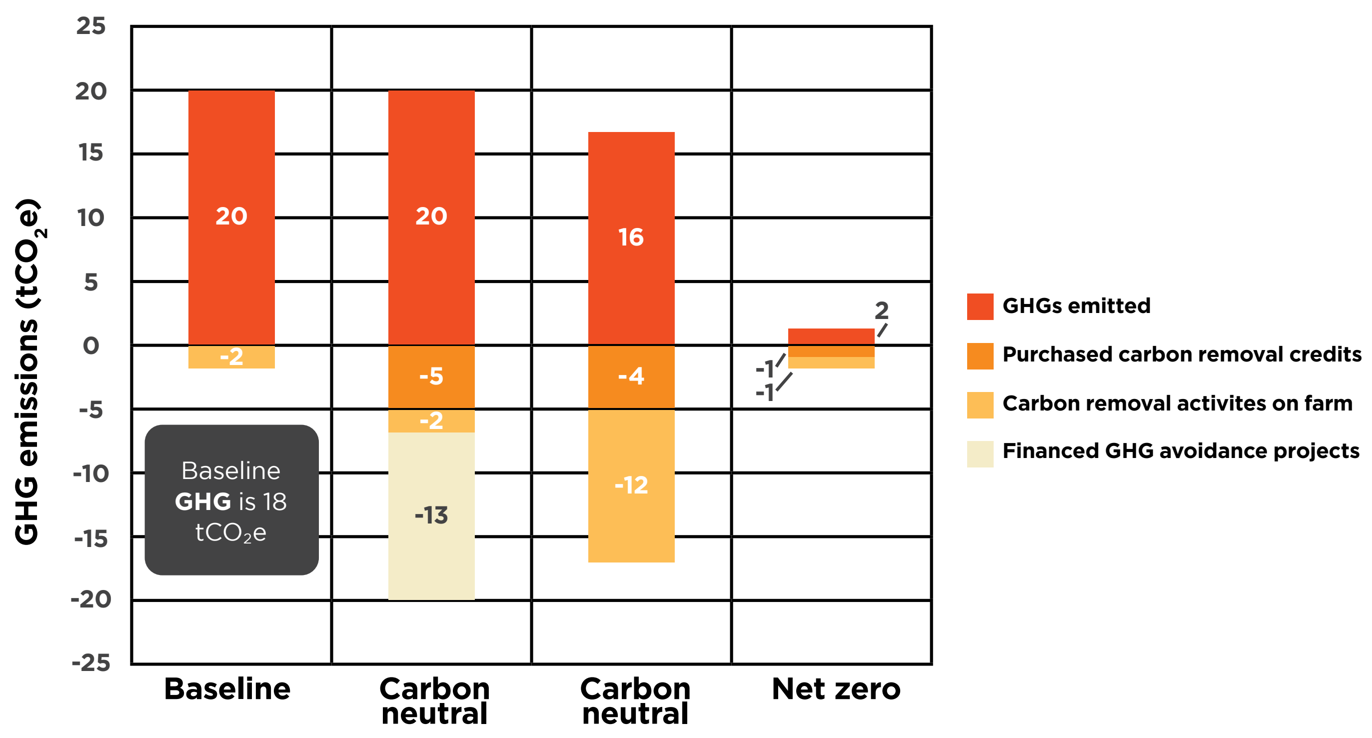
To achieve net zero, GHG emissions must be actively minimised, and any remaining emissions can be offset only through carbon removal activities or carbon removal credits.

To limit global warming to 1.5°C, as outlined in the Paris Agreement, GHG emissions must be reduced by 45 per cent by 2030 and net zero achieved by 2050.

Net zero was officially defined in late 2021 by the Science Based Targets initiative's (SBTi) Corporate Net Zero Standard. According to the standard, achieving net zero requires reducing at least 90 per cent of emissions, with the remaining 10 per cent offset through permanent removals by the target year.

See Figure 2 for an illustration of the differences between baseline, carbon neutral and net zero.

Illustration of carbon neutral* and net zero scenarios



carbon neutral in this case includes all GHGs

Figure 2. Scenarios for a mixed farming enterprise from net emitter to carbon neutral and net zero.

Baseline

The net GHG emissions baseline result of 18 tCO_2e is made up of 20 tCO_2e emitted from the farm minus 2 tCO_2e removed through sequestration and storage activity. The operation is regarded as a net emitter.

Carbon neutrality using purchased offsets

The operation has achieved carbon neutrality because the net GHG emissions baseline (18 tCO_2e) has been offset by the purchase of carbon removal credits and the financing of GHG avoidance projects outside of the value chain. The operation has achieved carbon neutrality without reducing its GHG emissions or increasing carbon removal activities on farm.

Carbon neutrality using carbon farming principles and purchased offsets

The operation has achieved carbon neutrality using a combination of carbon farming principles - reducing emissions and increasing carbon removal activities on farm - and the purchase of carbon removal credits.

Net zero

The operation is at net zero because it has reduced its emissions by 90 per cent and offset the remaining 10 per cent using a combination of on farm carbon removal activities and the purchase of carbon removal credits.

Net zero certification

While a globally recognised certification for achieving net zero does not yet exist, there are programs that support the goal of achieving and verifying net zero status for businesses, including farms.

Crop inspection before the storm - Sarah McCaskie, NSW

Recognised certifications and standards supporting net zero goals

Science Based Targets initiative (SBTi)

Offers a Net Zero Standard, which aligns with global climate goals to achieve near-zero emissions by 2050 or earlier.

Focuses on deep decarbonisation across value chains, emphasising absolute emission reductions.

Zero Carbon Certification Scheme (Australia)

Run by the International Living Future Institute, this program certifies products, buildings, and organisations that achieve net zero outcomes through renewable energy use and emissions elimination.

B Corp Certification

While not specifically net zero, B Corp must meet rigorous environmental standards and are encouraged to eliminate emissions wherever possible as part of their sustainability commitments.

Net zero in grain growing operations

A known net zero grain growing operation does not exist anywhere in the world.

To achieve net zero, a grain growing operation must:

Transition to renewable energy
Switching to solar, wind, or bioenergy to power farm operations.

Adopt a full suite of practices to avoid emissions
Using no-till methods, optimising fertiliser type and use and planting carbon-sequestering crops.

Circular farming
Recycling waste and minimising external inputs.

Carbon sequestration
Achieving soil carbon storage to completely offset all emissions through on-going tree planting, regeneration of native vegetation or agroforestry.

Key considerations

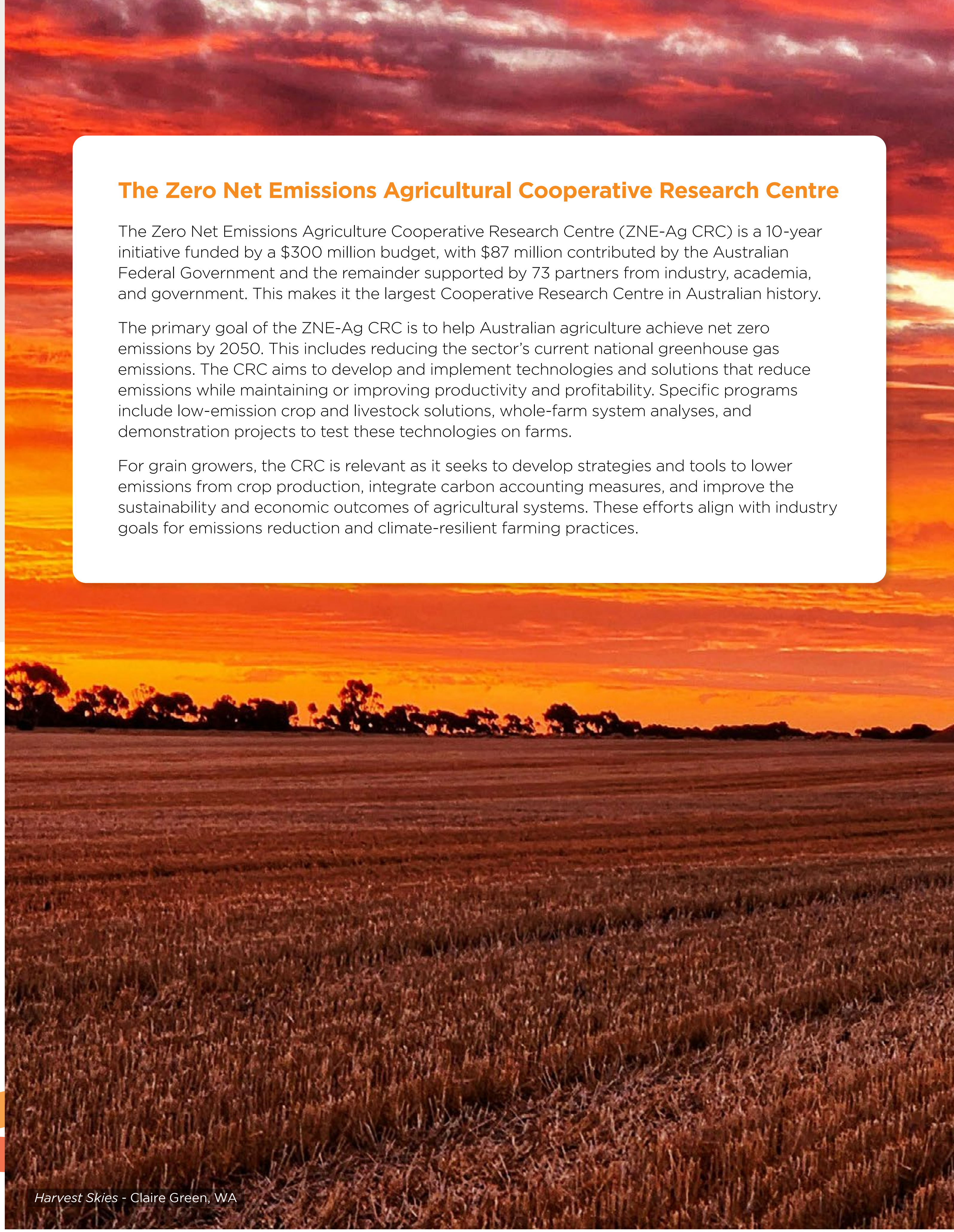
- **Certification availability:** Certification schemes avoid using Net Zero as an explicit term; instead, they support strategies under broader frameworks that aim to achieve carbon neutrality or net zero.
- **Costs and complexity:** Achieving net zero is resource-intensive, requiring substantial investments in technology, infrastructure, and ongoing maintenance.
- **Transparency:** Robust monitoring, reporting, and verification are crucial to ensure claims are credible and withstand scrutiny.

The Zero Net Emissions Agricultural Cooperative Research Centre

The Zero Net Emissions Agriculture Cooperative Research Centre (ZNE-Ag CRC) is a 10-year initiative funded by a $300 million budget, with $87 million contributed by the Australian Federal Government and the remainder supported by 73 partners from industry, academia, and government. This makes it the largest Cooperative Research Centre in Australian history.

The primary goal of the ZNE-Ag CRC is to help Australian agriculture achieve net zero emissions by 2050. This includes reducing the sector's current national greenhouse gas emissions. The CRC aims to develop and implement technologies and solutions that reduce emissions while maintaining or improving productivity and profitability. Specific programs include low-emission crop and livestock solutions, whole-farm system analyses, and demonstration projects to test these technologies on farms.

For grain growers, the CRC is relevant as it seeks to develop strategies and tools to lower emissions from crop production, integrate carbon accounting measures, and improve the sustainability and economic outcomes of agricultural systems. These efforts align with industry goals for emissions reduction and climate-resilient farming practices.



Harvest Skies - Claire Green, WA

CARBON FARMING CO-BENEFITS

Co-benefits of carbon farming practices

Whether the carbon farming practice involves on-farm emissions avoidance or carbon sequestration, the adoption of many of the practices also deliver some valuable co-benefits to the cropping operation.

The impact of the co-benefit will depend on practice type and the specifics of the farming operation, such as location, climate, enterprise type and more.

Some types of possible co-benefits related to soil health, crop health, environmental health and reduction of inputs are explained below.

The possible co-benefits of some carbon farming practices are summarised in Table 2 and Table 3.

Carbon farming can generate income by creating carbon credits

Carbon farming activities can be used to create Australian Carbon Credit Units (ACCUs).

To generate carbon credits, projects must be new and additional to existing on-farm activities. There are rules around how to create ACCUs, and it is important to check the rules with the Clean Energy Regulator before starting any activity that aims to generate ACCUs.

It is important to be aware that many growers adopt carbon farming practices for the co-benefits and do not participate in the Australian Carbon Credit Unit Scheme.

What is biodiversity and why is it important?

Biodiversity — short for biological diversity — is the variety of all living things and their interactions. Biodiversity changes over time as extinction occurs and new species evolve. The benefits of biodiversity to humans are sometimes called ecosystem services. Any loss or deterioration in the condition of biodiversity can compromise all these systems and affect human wellbeing.

Soil health

Building, maintaining and protecting soil carbon is at the heart of achieving optimum soil health. Soil carbon and soil organic matter are key drivers and indicator of soil health. Soils with good levels of soil carbon and soil organic matter typically possess:

- A structure that allows the movement of water, nutrients, oxygen and microorganisms.
- Good water holding capacity.
- Low levels of soil erosion.
- The right balance of nutrients.
- A diverse range of microorganisms, insects and earthworms.

A healthy soil will have all aspects functioning well to promote optimal plant growth.

Environmental health

Carbon farming can be beneficial for the health of the environment because it can help to:

- Mitigate climate change by sequestering carbon.
- Slow the rate of global warming by avoiding GHG emissions.
- Repair, maintain and protect biodiversity.

Crop health

Healthy soils can strengthen plant growth, health and productivity because:

- Microorganisms, insects and earthworms cycle and provide plant nutrients.
- The structure holds moisture for plant uptake and erosion prevention.
- The structure allows enough oxygen is present for root growth.
- The structure allows nutrients and water to be easily taken up by plants.
- Well-nourished plants are less vulnerable to pests and disease.
- Beneficial microorganisms cover plant roots, protecting them from disease causing microbes.

Productivity

Carbon farming can help boost productivity through:

- Reduction in input costs.
- Reduction in fuel use.
- Reduction in labour cost.
- Improved resilience against drought.
- Improved protection against soil erosion.
- Enhanced soil fertility to support stronger plant growth.

Pretty in yellow - Chelsea Gordon, NSW

Table 2. Carbon farming practice, impact on GHG emissions and co-benefits

Carbon farming practice	Impact on GHG emissions		Co-benefits														
			Soil health							Crop health			Environ-mental health	Productivity		
	Emissions avoidance	Protect, maintain & enhance soil carbon	Protection against soil erosion	Soil moisture conservation	Enhanced soil organic matter	Protection against soil sealing	Enhanced water infiltration	Soil nutrient conservation	Enhanced soil biodiversity	Enhanced nutrient uptake	Enhanced water uptake	Increased resilience against pest and disease pressures	Enhanced habitat biodiversity	Reduced labour	Reduced fuel use	Reduced cost
Low or no-till	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X
Retain stubble	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X
The 4Rs	X	X			X			X		X	X					X
Variable rate application of fertiliser	X	X						X		X	X					X
Electric motors powered by renewable energy	X													X	X	

Table 3. Carbon farming practice, impact on carbon sequestration and co-benefits

Carbon farming practice	Impact on carbon sequestration and soil carbon		Co-benefits														
			Soil health							Crop health			Environ-mental health	Reduction of inputs		
	Carbon sequestration	Protect, maintain & enhance soil carbon	Protection against soil erosion	Soil moisture conservation	Enhanced soil organic matter	Protection against soil sealing	Enhanced water infiltration	Soil nutrient conservation	Enhanced soil biodiversity	Enhanced nutrient uptake	Enhanced water uptake	Increased resilience against pest and disease pressures	Enhanced habitat biodiversity	Reduced labour	Reduced fuel use	Reduced cost
Environmental tree planting	X	X	X	X	X	X	X	X	X			X	X			
Natural regeneration of native vegetation	X	X	X	X	X	X	X	X	X			X	X			
Agroforestry	X	X	X	X	X	X	X	X	X			X	X			

Overall co-benefits of carbon farming

Whilst carbon farming involves implementing practices that aim to avoid GHG emissions and/or increase carbon sequestration, carbon farming can also help to deliver long-term benefits for the resilience, productivity, and profitability of a grain growing business.

Financial resilience

Carbon farming can be profitable as a distinct activity. Reducing inputs and improving productivity may be outcomes of carbon farming that could contribute to the financial resilience of an operation.

Carbon farming may generate financial benefits in the form of ACCUs.

Sustainable agriculture

Carbon farming encourages practices that aim to be sustainable over the long term, helping to maintain agricultural productivity while supporting the health of natural resources.

Soil resilience

Many carbon farming practices play an important role in enhancing soil structure and stability, often leading to healthier, more resilient, and productive soils.

Building long-term value

Carbon farming has the potential to support high-quality agricultural production and build long-term value across the agricultural supply chain. Evidence of carbon farming practices may help enhance the sustainability profile of a cropping operation. Establishing a carbon baseline and showing progress over time may help to improve the operation's marketability, especially for customers who prioritise sustainability.

Climate resilience

Healthy soils with sound levels of organic matter are generally better able to endure extreme weather conditions, like droughts and heavy rainfall, which can help make farms more resilient in the face of such events.

Enhanced biodiversity

Integrating trees through agroforestry or establishing habitat corridors can help support on-farm biodiversity. This can help with natural pest control, pollination services, and overall ecosystem resilience.

GETTING STARTED WITH CARBON FARMING

To successfully manage carbon on a cropping enterprise, the sources of GHG emissions and the sinks of carbon on the property must be understood.

Growers can take steps towards carbon farming by adopting the most suitable carbon farming methods.

Start by establishing a carbon baseline

A carbon baseline gives a clear picture of current net GHG emissions.

Net GHG emissions = GHGs emitted - GHGs sequestered and stored

- Net GHG emissions can be measured using free online carbon calculators.
- The calculators can differ in terms of whether they are for general agriculture or a particular commodity group.
- The Agriculture Innovation Australia Environmental Accounting Platform is a good place to start.
- Some calculators might share data with other parties. Make sure the terms and conditions of the calculator are understood before information is entered.

Identify key sources of emissions

The calculator outputs will identify the main sources of emissions e.g. burning diesel, fertiliser use, residue decomposition etc.

Explore management options for lowering GHG emissions.

With a clear baseline, options to reduce emissions and increase carbon storage can be modelled on the carbon calculator.

Ensure that the baseline inputs and the results of the calculation are saved.

Adopt a carbon farming practice

Keep comprehensive records of all aspects of the adopted practice so that inputs are ready for the recalculation.

Recalculate GHG emissions

The impact of the adopted practice on net GHG emissions is measured by conducting a recalculation. Use the new inputs from the practice change records and use the same tool used to calculate the baseline.

Track progress over time

A baseline, a carbon calculator, and excellent record keeping means that the impact of any adopted practice on net GHG emissions can be measured over time. Progress can be tracked, and strategies can be adjusted as necessary. Refer to GrainGrowers' Carbon Calculators Compared report for a more detailed explanation of GHG emissions, key sources in cropping and using carbon calculators.

CONCLUSION

As climate change continues to unfold in the early 21st century, adaptation will be central to Australia's strategy for maintaining food security, self-sufficiency, and vibrant rural communities, while sustaining its globally significant agricultural exports. Significant efforts are needed to help Australian society adjust to the changing conditions, as well as to future shifts that may now be unavoidable. Proactive adaptation is not only prudent but also likely to bring national benefits and a competitive edge under most projected climate scenarios.

Moreover, many of the adaptations developed in Australia are expected to play a crucial role in helping other countries stabilise food production and mitigate the more severe impacts of climate change. Australia's past contributions and current expertise position it well to offer solutions to this global challenge.

This guide has highlighted how adopting farming practices that avoid emissions, sequester, and store carbon not only contribute to global climate goals and enhance farm profitability. Throughout this journey, growers have the opportunity to:

Enhance global reputation

By implementing sustainable farming practices, Australian growers demonstrate their commitment to environmental responsibility and sustainability.

This enhances their reputation among consumers, stakeholders, and industry peers who increasingly prioritise ethical and environmentally conscious products.

Boost productivity and resilience

Practices such as no-till farming, cover cropping, and agroforestry improve soil health, increase water retention, and reduce erosion. These enhancements contribute to higher crop yields, improved resilience to climate variability, and reduced dependency on external inputs. Enhanced productivity not only ensures stable production but also positions growers competitively in fluctuating market conditions, strengthening long-term viability.

Future-proof agriculture

Embracing sustainable practices prepares growers for future regulatory frameworks and evolving market demands.

Proactively managing environmental impacts builds resilience against regulatory uncertainties and potential market disruptions related to climate change and sustainability.

Fields of Gold - Kathi McDonald, WA

GLOSSARY OF KEY TERMS

Listed in alphabetical order, the key terms used in this report are defined below.

Australian Carbon Credit Unit (ACCU)
An ACCU is a type of carbon credit issued by the Australian Government through the Clean Energy Regulator (CER). One ACCU represents the avoidance and storage of one tonne of carbon dioxide equivalent (tCO_2e) through eligible carbon projects as part of the ACCU Scheme.

ACCU scheme
The ACCU scheme is the system through which ACCU projects are registered and carbon credits are issued.

Agroforestry
Agroforestry is the practice of growing trees along with crops on the same piece of land. This approach helps produce both tree and crop products while also protecting and maintaining important resources like the environment and natural habitats. Unlike traditional farming or forestry, which focus only on one type of plant, agroforestry looks at how trees and crops can work together.

Baseline
A baseline is a fixed point of reference that is used for comparison purposes. The baseline represents the 'business-as-usual' scenario, where the net GHG emissions without intervention is recorded. A baseline GHG number is needed to calculate the amount of GHG emissions reduced or stored through the implementation of GHG emission reduction or carbon storage activities.

Carbon
Carbon (chemical symbol C) is a chemical element, like hydrogen, oxygen, nitrogen. Or iron. Carbon is a very abundant element. It exists in pure or nearly pure forms but can also combine with other elements to form molecules. It can exist in solid, liquid or gaseous forms. These carbon-based molecules are the basic building blocks of humans, animals, plants, trees and soils.

Carbon farming
Carbon farming involves strategies to absorb and store carbon in soil and vegetation and/or avoid greenhouse gas emissions. Practices include planting forests, native species revegetation, and agroforestry, and emissions avoidance methods like efficient use of fertiliser and sourcing solar power.

Carbon footprint
A carbon footprint is the total GHG emissions caused directly and indirectly by an individual, organisation, event or product. Its calculation considers all other GHGs like methane (CH_4) and nitrous oxide (N_2O) in addition to carbon dioxide. The word carbon in carbon footprint is used as a shorthand word to mean all GHGs.

Carbon offset
Using carbon offsets is a way to compensate for generating GHG emissions. Buying ACCUs helps offset GHG emissions by supporting verified projects that reduce GHG emissions or store an equivalent amount of CO_2. This is a common practice for entities looking to mitigate their environmental impact and meet sustainability goals.

Carbon neutral
For an operation to be carbon neutral, it must balance the amount of CO_2 it puts into the atmosphere with the amount of CO_2 it takes away. Any remaining emissions can be 'cancelled out' by purchasing carbon offsets.

Being GHG neutral requires an operation to balance all its GHG emissions, not just CO_2, with an equivalent quantity of emissions.

The term carbon neutral can be ambiguous because carbon may be used as shorthand for all GHGs.

Carbon sequestration
While soil and vegetation can interact with various gases, carbon sequestration primarily refers to the process of capturing and storing carbon dioxide (CO_2) for at least 100 years. Plants absorb CO_2 from the atmosphere during photosynthesis and store it as carbon in their biomass (roots, stems, leaves) and in the soil when organic matter decomposes. Soil organic matter and vegetation, especially trees, can store carbon for long periods, making them crucial in mitigating climate change.

While other gases like methane (CH_4) and nitrous oxide (N_2O) are involved in soil and vegetation processes, carbon dioxide (CO_2), is the main gas stored through the process of carbon sequestration.

Carbon sink
A carbon sink is any process, activity or mechanism which removes a greenhouse gas, from the atmosphere. The soil, vegetation or the ocean are carbon sinks.

Carbon source
A carbon source refers to any process or activity that releases a greenhouse gas, into the atmosphere.

Climate change
Climate change refers to the long-term shift in global weather patterns primarily due to the rise in GHG emissions in the earth's atmosphere. Climate change is characterised by rising temperatures, rising sea levels, ocean acidification, more severe and more frequent droughts and extreme weather events. Ecosystems and human societies are all adversely affected.

Crop residue
Crop residue is the straw and crown of plants left on the soil surface after harvest. It also includes straw and chaff discharged from the harvester. It is also known as 'stubble'.

Greenhouse gases (GHGs)
Greenhouse gases (GHGs) are atmospheric gases that trap the sun's heat leading to global warming and climate change. GHGs include carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and some synthetic gases. The burning of fossil fuels – coal, oil and gas – is by far the largest contributor to global climate change, accounting for over 75 per cent of global GHG emissions and nearly 90 per cent of all CO_2 emissions. Enteric emissions from ruminants such as cattle and sheep are the main global source of CH_4, whilst the production and inefficient use of fertiliser accounts for 75 per cent of N_2O emissions (see Figure 3).

Not all GHGs have the same impact or long-term effect, and each survives in the atmosphere for different amounts of time. The most significant of these for grain growers is N_2O which is 265 times more effective at trapping the sun's heat than CO_2. (see Figure 4).

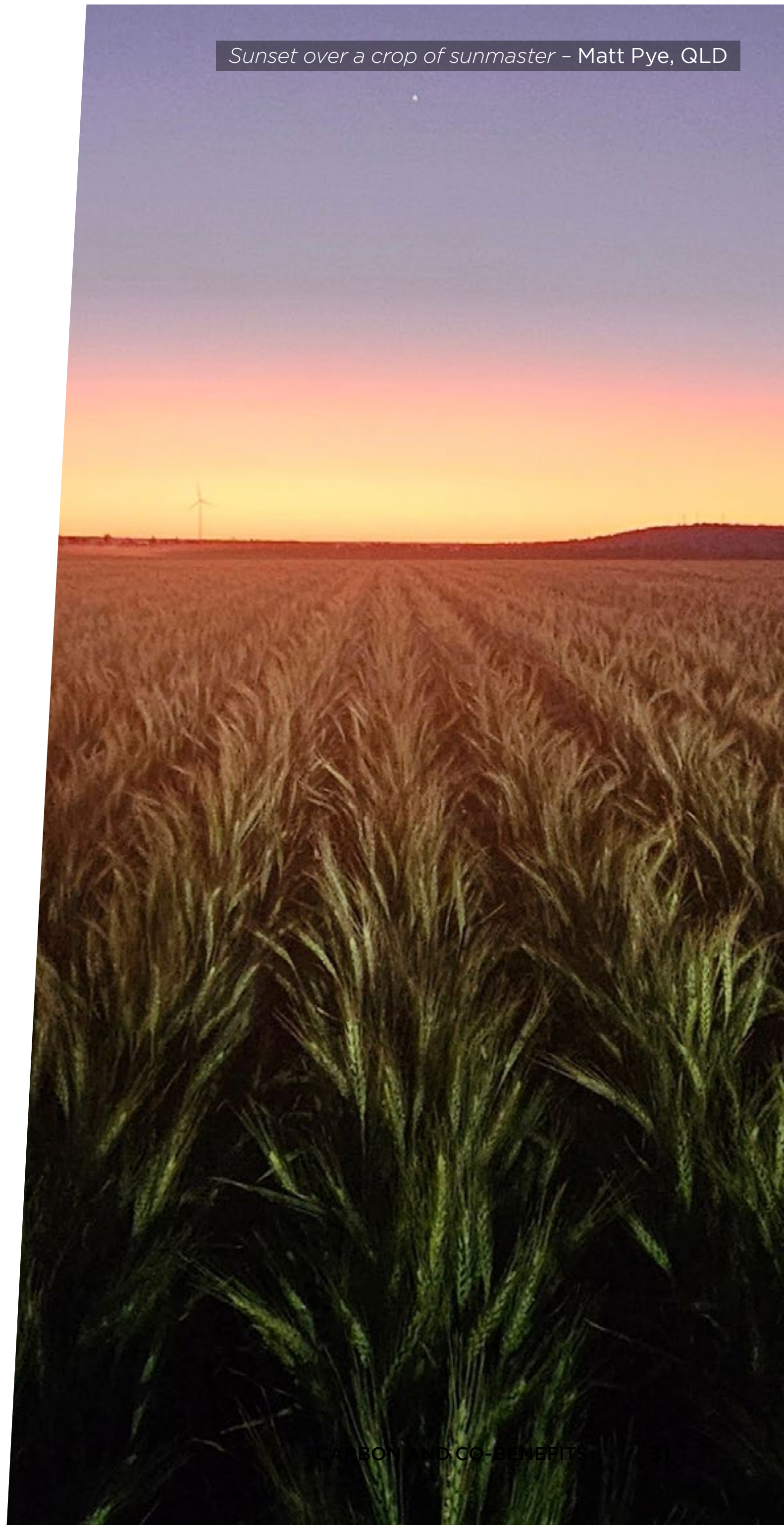

Sunset over a crop of sunmaster – Matt Pye, QLD

Figure 3. Main global and cropping sources of common GHG emissions.

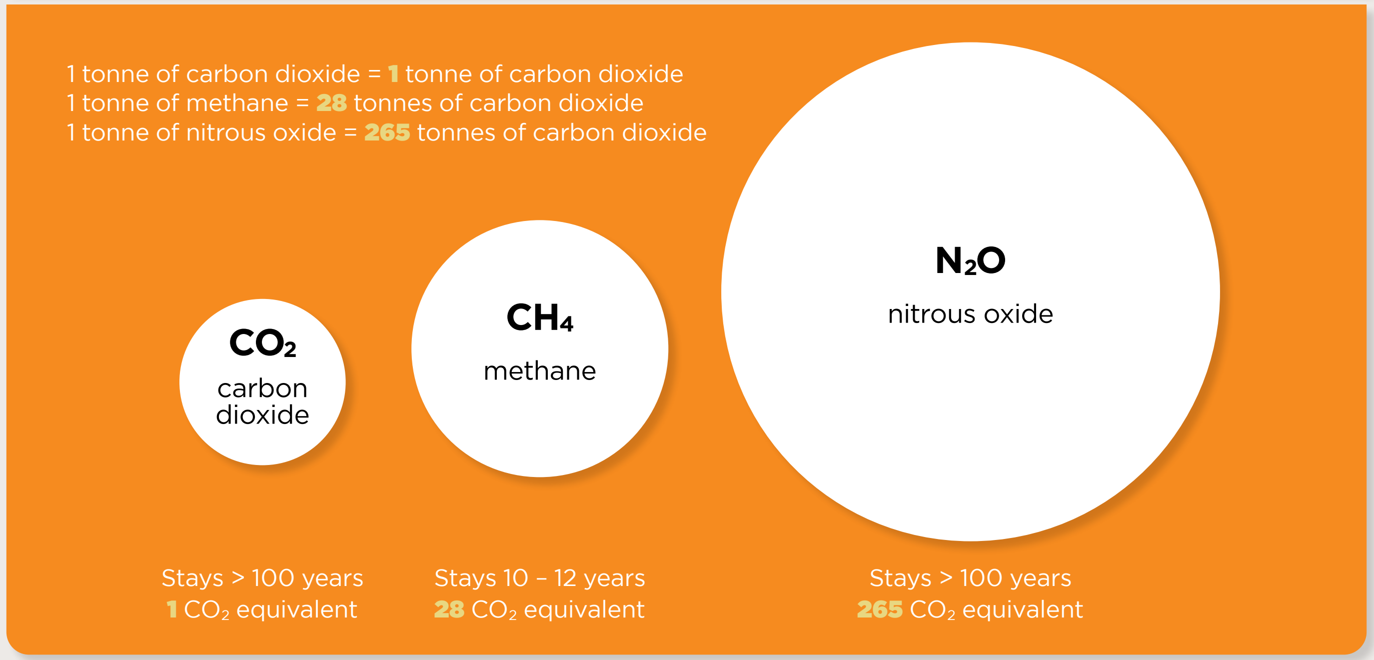
GHG emissions and sources

GHG	Main global source	Cropping sources
CO_2 carbon dioxide		• Tillage • Liming • Residue decomposition • Burning crop residue • Burning fuel
CH_4 methane		• Residue decomposition • Burning crop residue
N_2O nitrous oxide		• Fertiliser inefficiency • Residue decomposition

Source: Sevenster M., Bell L., Anderson B., Jamali H., Horan H., Simmons A., Cowie A., Hochman Z. (2022) Australian Grains Baseline and Mitigation Assessment. Main Report. CSIRO, Australia

Figure 4. Common cropping GHG emissions, their potency and atmospheric lifetime.

GHG potencies and CO_2 equivalents (CO_2e)



Net zero
Net zero is the internationally agreed upon goal for mitigating climate change in the second half of the 21st century. The Intergovernmental Panel on Climate Change (IPCC) determined the need for (CO_2) net zero by 2050 to remain consistent with the Paris Agreement's target of 1.5°C. Entities may also aim to account for all emissions, not just CO_2, then the term will be net zero GHG.

Organic matter or soil organic matter
Organic matter is the lifeblood of fertile, productive soil. Without it, agricultural production is not sustainable. Organic matter is any living or dead animal and plant material. It includes living plant roots and animals, plant and animal remains at various stages of decomposition, and microorganisms and their excretions. On farms the main sources of organic matter are plant litter (plant roots, stubble, leaves, mulch) and animal manures. Earthworms and microorganisms decompose these materials. The process of decomposition releases nutrients which can be taken up by plant roots. The product of decomposition is humus, a black crumbly material resistant to further decomposition. A complex chemical substance, humus stores plant nutrients, holds moisture and improves soil structure.

The Paris Agreement
The Paris Agreement is an international treaty adopted in 2015 during the United Nations Conference of the Parties (COP21) in Paris. It aims to address climate change by limiting global warming to well below 2°C above pre-industrial levels, with efforts to limit the increase to 1.5°C.

Pre-industrial levels refer to the climate conditions before the widespread industrialisation that began in the mid-18th century. These levels are used as a benchmark to measure how much human activities have altered the earth's climate, particularly in terms of GHG concentrations and global temperatures.

Science Based Targets initiative (SBTi)
The Science Based Targets initiative (SBTi) is a corporate climate action organisation that enables companies and financial institutions worldwide to play their part in combating the climate crisis. SBTi develops standards, tools and guidance which allow companies to set GHG emissions reduction targets in line with what is needed to limit global warming and reach net zero by 2050 at the latest. Many global agricultural companies use the SBTi standards to set their sustainability goals.

Spatial variability of soil
This refers to the natural differences in soil properties across a paddock or landscape. This means that factors like soil texture, nutrient levels, organic matter, moisture, and pH can vary significantly from one area to another, even within a single farm. These differences can be influenced by factors like past erosion, crop history, and underlying geology.

Temporal variability of soil
This refers to the changes in soil properties over time, often due to seasonal cycles, weather events, and farming practices. Soil moisture, temperature, nutrient availability, and organic matter can fluctuate daily, seasonally, or annually. For example, soil moisture levels can change rapidly after rainfall, and nutrient levels might vary depending on the timing of fertilizer application or crop growth stages.

Water infiltration
Water infiltration refers to the process by which water enters the soil from the surface. It occurs when precipitation, irrigation, or runoff seeps into the soil, moving downward through the soil profile. Effective infiltration is critical for grain growing, as it helps recharge soil moisture, supports plant root growth, and reduces runoff and erosion. Infiltration rates can be influenced by factors such as soil texture, structure, organic matter, and compaction. Proper management of water infiltration can improve crop yield by ensuring plants have adequate access to water while minimising water wastage.

Key references

Barton, L., Murphy, D.V. and Butterbach-Bahl, K. (2013). Influence of crop rotation and liming on greenhouse gas emissions from a semi-arid soil. Agriculture, Ecosystems & Environment, 167, pp.23–32.

Coelli, R. (2021). Natural Resource Management and Drought Resilience Survey of farm practices. [online] doi: https://doi.org/10.25814/99n0-7q92.

Gjerek M, Morgan A, Gore-Brown N, Womersley G. (2021). Diesel Use in NSW Agriculture and Opportunities to Support Net Zero Emissions. Sydney: Australian Alliance for Energy Productivity for NSW Department of Primary Industries.

Haile, S.G., Fraisse, C.W., Nair, V.D. and Nair, R.P-K. (2009). Greenhouse Gas Mitigation in Forest and Agricultural Lands: Carbon Sequestration.

Kharel S et al. (2024) Liming acidic soils creates profits, land use options but often more emissions. Crop & Pasture Science 75.

Llewellyn, R. and Ousman, J. (2014) Adoption of precision agriculture-related practices: status, opportunities and the role of farm advisers. Available at : https://grdc.com.au/__data/assets/pdf_file/0024/208653/adoption-of-precision-agriculturalrelated-practices-status-opportunities-and-the-role-of-farm-advisers-2014.pdf.[Accessed 27 Nov 2024]

Love, G. (2005) Impacts of climate variability on regional Australia. In 'Outlook 2005. Conference proceedings, climate session papers'. (Eds R Nelson, G Love) pp. 10–19. (Australian Bureau and Resource Economics: Canberra, ACT, Australia).

Meyer, R., Cullen, B.R. and Eckard, R.J. (2016). Modelling the influence of soil carbon on net greenhouse gas emissions from grazed pastures. Animal Production Science, 56(3), p.585.

Meyer R.S., Eckard R.J., Cullen B.R., Johnson I.M. (2015) Modelling to assess the sequestration and productivity benefits of soil carbon in grazing systems. Agriculture, Ecosystems and Environment 213, 272-280.

Orgill, S. (2020). Soil organic matter in cropping systems. Soil and Water R&D Unit, Wagga Wagga Agricultural Institute.

Read, A., Rollan, J., Creed, C., and Fell, J. (2023). ABARES Insights: Sustainability and agri-environmental indicators – international comparisons, Issue 2.

Riverineplains.org.au. (2018). Maintaining profitable farming systems with retained stubble in the Riverine Plains region. [online] Available at: https://riverineplains.org.au/projects/maintaining-profitable-farming-systems-with-retained-stubble-in-the-riverine-plains-region [Accessed 27 Nov. 2024].

Sevenster M., Bell L., Anderson B., Jamali H., Horan H., Simmons A., Cowie A., Hochman Z. (2022). Australian Grains Baseline and Mitigation Assessment. Main Report. CSIRO, Australia.

RESOURCES

For more carbon resources, related links and information about the certifications references in this document scan the QR code below, or visit graingrowers.com.au.

Big red - Kate Payne, NSW

Stay in touch with GrainGrowers

Please visit us online or email
if you would like to hear more!

1800 620 519
enquiry@graingrowers.com.au
www.graingrowers.com.au

@GrainGrowersLtd
@GrainGrowers
@GrainGrowers
@GrainGrowers

Grain Growers

DESIGNED
AND PRINTED
IN AUSTRALIA