

Alternative land use and diversification opportunities in the grazing lands of Queensland

Evaluation of environmental markets and renewable energy projects as diversification opportunities for grazing properties

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Summary

The global commitment to address climate change is resulting in the largest and most rapid economic transformation since the industrial revolution. Agriculture is a key focus for emissions reductions given the sector is responsible for 16.9% or 21 MtCO₂-e (in 2021-22) of Queensland's GHG emissions with 78.3% of these agricultural GHG emissions due to enteric fermentation in ruminant livestock. A key component of Australia's strategy to reduce GHG emissions and transition to cleaner sources of energy has been the implementation of the Australian Carbon Credit Unit Scheme (ACCU Scheme) to incentivise adoption of new practices or technologies to reduce emissions or store carbon by generating additional income streams. Similar to carbon credits, other environmental markets or co-benefit schemes are emerging and create opportunities for eligible landholders to earn regular income through generating and selling credits. Government policy to increase renewable energy generation also creates opportunities for landholders close to transmission infrastructure to generate income from hosting renewable energy projects.

Grazing industries, particularly beef cattle, make an important contribution to the Queensland economy. In 2022-23 the Queensland farm-gate value of the beef cattle industry was \$6 billion while sheep and wool contributed \$100 million. However, Queensland's variable rainfall, especially long periods of drought, is one of the biggest challenges for grazing land managers and climate change is likely to exacerbate this variability. In addition to climate challenges, the Queensland beef and sheep industries are also confronted by variable commodity prices and by pressures on long-term financial performance and viability resulting from (1) an ongoing disconnect between asset values and returns, (2) high debt levels and (3) a declining trend in terms of trade. Furthermore, the managers of grazing businesses face an increasing administrative and regulatory burden associated with environmental, social and governance (ESG) requirements. Therefore, to remain in production, and to build resilience, beef and sheep properties need to be profitable and to build equity

Income diversification is one strategy that can be considered by grazing businesses to improve business resilience by smoothing income over time, while still allowing reasonable profit. With current policy settings encouraging the development of (1) environmental market and (2) renewable energy projects on agricultural land, there are opportunities to consider the effects of diversification into these alternative land uses on the profitability and future viability of grazing businesses. However, an important point to note in terms of income diversification from engaging in environmental markets is that carbon and ecosystem services credit issuance are closely linked to rainfall, as is grazing livestock production. Thus, these income streams likely share the same vulnerability to drought and climate variability. The hosting of renewable energy projects is more likely to provide true income diversification due to the independence of the income streams from climate variability and agricultural markets.

This review presents an overview of the opportunities and challenges for landholders from engaging in these diversification opportunities. While there are opportunities, there are also risks and challenges. Furthermore, it appears likely the benefits will be biased towards eligible landholders in specific locations.

Key challenges and risks of engaging in environmental markets include:

- Intermittent and uncertain credit issuance and income for newer ACCU Scheme methods.
- Current lack of suitable ACCU Scheme methods while older methods sunset and new methods are yet to be released.
- Limited ability to engage in credit stacking opportunities, which would improve the attractiveness of projects, due to additionality and leakage clauses. The development of the Integrated Farm and Land Management ACCU Scheme method and the federal Government Nature Repair Market may overcome some of the existing barriers.
- Credits generated and sold off-farm cannot be used to demonstrate farm climate and nature credentials (balances) as part of future market access and ESG reporting requirements. This may lead to negative consequences for future profitability of the agricultural business.
- Potential negative implications for taxation and land value, and consequences for engagement with financial lenders (banks) who have tended to regard carbon contracts as an encumbrance and a financial liability, rather than a source of income.

Key challenges and risks associated with hosting renewable energy projects include:

- Potential negative financial and economic implications of renewable energy projects for land classification and taxation.
- Risks associated with landholder liability for decommissioning the renewable energy assets at the end of their useful life.

There is a significant lack of independent information about the analysis of choices available to Queensland extensive livestock producers. It was concluded that a lack of understanding of the effects of engaging in alternative land use options is likely deterring participation. There is also a risk that perverse outcomes could occur in terms of property profitability, permanent land use change out of agriculture in productive regions, and wider effects on supply chains and the economy.

There is an urgent need for comprehensive, farm-level analysis to understand the trade-offs and opportunities for landholders and thereby support adoption of practices that enable net zero emissions targets, and other sustainability and biodiversity obligations, to be met. As carbon and environmental market opportunities continue to evolve, new opportunities (methods and markets) should be examined as they arise. It is expected that there will be large variation across Queensland bioregions in the opportunities available and the profitability of implementing carbon and environmental projects, or hosting renewable energy projects. Therefore, analysis should be conducted to encompass this variability. Such analysis should include the effects on agricultural production, farm profitability, indebtedness, future land values, and the impact on farm risk of these diversification opportunities. A key aspect should be investigating the potential impact on future price of agricultural products due to selling carbon credits off-farm (engaging in carbon markets) rather than retaining carbon for farm balances and market access. The short-term nature of any benefit from carbon sequestration, should be considered.

In addition to a better understanding of the risks and benefits for landholders, it is clear that the implications of land use change for commodity markets and rural communities also need consideration and further research and analysis. The insights from appropriate analysis will allow landholders to make informed decisions and policy makers to implement strategies that facilitate desired engagement with these opportunities while potentially avoiding perverse outcomes from land use change.

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1. Introduction

The objective of this report was to review the potential for alternative land uses to provide a diversification of income streams which could complement existing production systems in the grazing lands of Queensland. Environmental markets and opportunities to host renewable energy projects, were the focus of this review. Opportunities and challenges to widespread adoption of such alternative land use options were identified and recommendations made for further research and analysis.

1.1 The policy framework and emergence of environmental markets and renewable energy targets

The global commitment to address climate change is resulting in the largest and most rapid economic transformation since the industrial revolution (Australian Government, DCCEEW 2024a). International obligations under the Paris Agreement have guided Australian and Queensland Government policy to reduce greenhouse gas (GHG) emissions. Under the Paris Agreement and the *Climate Change Act 2022*, Australia is committed to a 43% reduction in GHG emissions by 2030 and net zero by 2050 (from 2005 levels), (Australian Government 2022, 2023). Additionally, the Australia Government joined the Global Methane Pledge in October 2022, which commits to reduce global methane emissions across all sectors by at least 30% below 2020 levels by 2030 (Commonwealth of Australia 2022).

At the State level, the Queensland Government's *Clean Economy Jobs Act 2024* has legislated emissions reduction targets of 30% by 30 June 2030, 75% by 30 June 2035, and net zero by 30 June 2050 (from 2005 levels), (Queensland Government 2024a). This Queensland legislation requires the development of sector emissions reduction plans to support the achievement of targets, with 'Agriculture and Land' being one of the six sectors identified, mirroring the Australian Government policy and process (Australian Government, DCCEEW 2024a; Queensland Government 2024b).

Agriculture is a key focus for emissions reductions given the sector is responsible for 16.9% or 21 MtCO₂-e (in 2021-22) of Queensland's GHG emissions (Queensland Government 2024d). As 78.3% of these agricultural GHG emissions are due to enteric fermentation in ruminant livestock (cattle, sheep, goats), targeting emissions reduction in the livestock sector is seen as critical. In contrast, Queensland's collective land use, land-use change and forestry emissions have been on a declining trajectory since 2006 with net emissions of -15.9 Mt CO₂-e in 2021-22 (Queensland Government 2024d). Sequestration of carbon in forest land (-11 Mt CO₂-e) and grassland (-5.4 Mt CO₂-e) were the largest contributors to the removal of emissions and this was associated with reduced land clearing, expanding forest regrowth and improved savanna fire management (Australian Government, DCCEEW 2024b).

A key component of Australia's strategy to reduce GHG emissions and transition to cleaner sources of energy has been the implementation of the Emissions Reduction Fund (ERF) now known as the Australian Carbon Credit Unit Scheme (ACCU Scheme). The scheme allows participants, including landowners and farmers, who adopt approved methods to earn Australian Carbon Credit Units (ACCUs), (Australian Government, CER 2024a). The objective is to incentivise adoption of new practices or technologies to reduce emissions or store carbon by generating additional income streams. The Safeguard Mechanism is a crucial component of the ACCU Scheme in it that creates demand for ACCUs by requiring large emitters to take corrective measures, such as acquiring and surrendering ACCUs, to offset emissions exceeding the set baseline (Australian Government, CER 2024b).

Amendments to the *Corporations Act 2001* and related legislation will require mandatory climate reporting according to Australian Sustainability Reporting Standards for annual periods beginning 1 January 2025 for large entities meeting thresholds for consolidated revenue, value of consolidated assets and/or number of employees, with a phase in of smaller entities over a period of 3 years (ASIC 2024). Small to medium-sized entities (meeting no more than one of these thresholds: \$50 million consolidated revenue, \$25 million EOFY consolidated gross assets, 100 EOFY employees) are currently exempt from reporting. However, most agricultural businesses will operate in supply chains where their customers will be required to request emissions data for their Scope 3 emissions (upstream and downstream indirect emissions) reporting (Australian Government, CER 2024c). Additionally, many multi-national supply chain companies have set targets towards carbon neutrality by 2050, often informed by the Science Based Targets Initiative (SBTi; Science Based Targets Initiative 2024). It is expected that these supply chain demands will drive the

eventual implementation of emissions-reducing strategies by agricultural producers, in order for them to remain competitive. That is, it appears that Queensland livestock producers will soon have to implement an appropriately detailed and comprehensive record keeping and report generating process to meet the requirements of supplying products to corporations captured by the *Corporations Act 2001*.

However, it is recognised that there are considerable real-world barriers that will make it difficult to achieve major emissions reductions and net zero by 2050 in the Australian agriculture and land sectors (Climate Change Authority 2024). In particular, CSIRO modelling for the 'Sector Pathways Review 2024' (Climate Change Authority 2024) has indicated that enteric emissions from ruminant livestock were likely to remain high until ca. 2035 and that greater investment in research was required to produce technological breakthroughs. Even assuming that technological breakthroughs could be made, via methane-reducing supplements to livestock, it was concluded that emissions would still only reduce modestly by 2050 (i.e. a ca. 20% decrease on current levels).

It is estimated that ca. 60% of Australia's enteric methane emissions are produced by cattle in pasture-based production systems (Climate Change Authority 2024). The scientific literature supports the conclusions of the Climate Change Authority (2024), particularly highlighting the difficulty in reducing emissions on extensive beef cattle properties in northern Australia where cattle graze largely low quality tropical/subtropical pastures under low stocking density in large paddocks (relative to southern Australia). A number of research papers have demonstrated that major reductions in emissions on extensive beef cattle properties will be difficult to achieve without a technological breakthrough, or land use change, and without incurring production losses (Almeida *et al.* 2023; Bilotto *et al.* 2023; Wiedemann *et al.* 2024). For instance, there is currently no practical/feasible mechanism to deliver methane-inhibiting feed supplements (e.g. *Asparagopsis* and 3-NOP) to cattle in extensive rangeland systems. Currently available, pasture-based forage solutions applicable to northern Australia are also limited. While the leguminous browse tree, *Leucaena* spp., has been shown in to reduce methane emissions in grazing cattle in a number of studies (reviewed by Black *et al.* 2021) the shrubby legume, *Desmanthus* spp., has not resulted in methane reduction *in vivo* under either high quality, pen-fed diets or under grazing conditions (Suybeng *et al.* 2021; Australian Government, DCCEEW 2024g).

Even if a research breakthrough occurs, a major obstacle to uptake of enteric-methane reducing technologies is the likely high cost of administering these initiatives (Climate Change Authority 2024) and the effect this may have on the viability of beef cattle enterprises, given the already low to moderate returns for the median beef cattle enterprise across northern Australia (Bowen and Chudleigh 2021a; ABARES 2024c). For instance, the average farm cash income for specialist beef farms in Australia in 2023-24 is estimated to have decreased by around 66% to \$65,000 per farm which is 60% below the average in real terms for the 10 years to 2022-23 (ABARES 2024c). The lack of evidence, to-date, of consistent, substantial positive effects on animal productivity resulting from enteric methane inhibition will mean that the additional cost of methane reduction will be difficult for extensive beef cattle businesses to absorb unless financial incentives are provided or a price premium for 'climate friendly' products eventuates.

Community sentiment research in Australia found that cost is the primary driver of red meat consumption with health and environmental concerns less significant (MLA 2023). Market research has indicated that 1 in 4 consumers would be willing to pay 15% more for carbon neutral beef, reducing to 1 in 5 when the price premium was set at 30% (Wiedemann *et al.* 2022). However, premiums for carbon neutral beef brands currently on the market in Australia are yet to be realised (Condon 2022), a situation which is also reflected worldwide (Goodwin 2023). Given the current inflationary pressures, and sustained high red meat prices, it is difficult to envisage a widespread willingness to pay a price premium for carbon neutral beef products in Australia or our key export markets (Goodwin 2023). More recent consumer research conducted by Coles supports these conclusions, indicating that 38% of consumers believe enough is being done for climate change and only 2% wanted a meat product that was more sustainable and ethical (Condon 2024).

In addition to climate change policy, complementary initiatives that focus on additional sustainability or biodiversity objectives are also under development at a Commonwealth and State level and are aimed at meeting Australia's obligations towards key international frameworks to which Australia is a signatory i.e., Sustainable Development Goals (UNDESA 2024) and Kunming-Montreal Global Biodiversity Framework (UNEP 2022). The major initiatives relevant to Queensland grazing businesses include:

- The Commonwealth Government's Agriculture Biodiversity Stewardship Package, including development of a Platform for Land and Nature Repair and the Australian Farm Biodiversity Certification Scheme (Australian Government, DCCEEW 2024c).
- The Commonwealth *Nature Repair Act 2023* (Australian Government 2024), which came into effect in December 2023 and establishes the framework for a legislated, national, voluntary biodiversity market anticipated to open in 2025.
- The Queensland Government's Land Restoration Fund (LRF), which incentivises private investment to deliver biodiversity and other sustainability co-benefits to carbon (Queensland Government 2024e). The LRF facilitates certification of premium carbon credits from carbon farming products that produce ACCUs and are administered by the Clean Energy Regulator (CER).
- The Reef Credit Scheme, which is administered by not-for profit company, Eco-Markets Australia. The Reef Credit Scheme works in a similar way to carbon credits but is targeted at farmers and landholders in Reef regions who take actions to reduce nutrient or sediment run-off flowing to the reef (Queensland Government 2024f).

Similar to carbon credits, these other environmental markets or co-benefit schemes create opportunities for eligible landholders to earn regular income through generating and selling credits.

1.2 The value of grazing industries, challenges and opportunities

More than 80% of Queensland's total area of 173 million ha is used for grazing livestock on lands extending from humid tropical areas to arid western rangelands (QLUMP 2022). Most extensive grazing enterprises occur on native pastures. Introduced (sown) pastures constitute less than 10% of the total grazing area and occur on the more fertile land types (McIvor 2005; QLUMP 2022). Grazing industries, particularly beef cattle, make an important contribution to the Queensland economy. In 2022-23 the Queensland farm-gate value of the beef cattle industry was \$6 billion while sheep and wool contributed \$100 million (ABS 2024).

In 2022-23, Queensland accounted for 22% of the income generated by Australia's red meat and livestock industry and accounted for 44.5% of the national beef cattle herd (MLA 2024). Although Australia holds a relatively small share of the global cattle and sheep inventory (1.9% of global cattle and 5.8% of global sheep flock in 2022), Australia plays a key role in the global supply of red meat (MLA 2024). In the calendar year 2023, Australia was the second largest beef exporter and the world's largest sheep meat and goat meat exporter (MLA 2024). Approximately of 78% of beef and sheep meat produced in Australia is exported (ABARES 2024a).

Over the past 20 years, total global consumption of animal protein, including red meat, has been steadily increasing at an average annual rate of 1.0% for beef and 1.9% for sheep meat (MLA 2024). Despite global efforts to lower meat intake for environmental or other reasons, animal protein is likely to continue to make a critical nutritional contribution to global human health (Ederer and Leroy 2023; Leroy *et al.* 2023; Polkinghorne *et al.* 2023) as the human population continues to increase towards a predicted peak of 10.3 billion in the mid-2080s, up from 8.2 billion in 2024 (United Nations 2024).

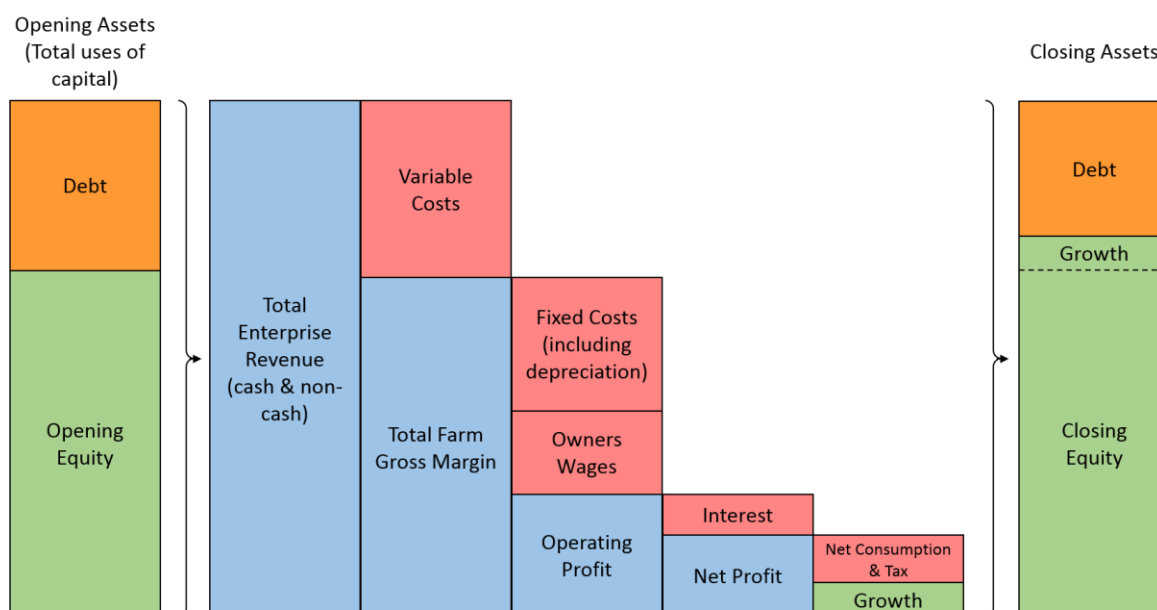
Queensland's variable rainfall, especially long periods of drought, is one of the biggest challenges for grazing land managers. As well as the potential for causing degradation of the grazing resource and impacting animal welfare, drought has a severe impact on business viability, is a regular occurrence, and provides the context for many of the production and investment decisions made by managers of grazing enterprises. Climate change is expected to result in increased severity and impact of droughts in Queensland in addition to an overall decrease in annual precipitation (2-3% lower by 2050) and warmer temperatures (1.4-1.9°C greater by 2050), (Queensland Government 2022a). Accordingly, the number of heat stress days and heatwaves for beef cattle in Queensland are also expected to increase by 2050. For example, at Biloela in central Queensland, the number of heat stress days and heatwave events are expected to increase by 16.2% and 100%, respectively, by the 2050s compared to the 1994-2023 average (Climate Services for Agriculture 2024).

In addition to climate challenges, the Queensland beef and sheep industries are also confronted by variable commodity prices and by pressures on long-term financial performance and viability resulting from (1) an ongoing disconnect between asset values and returns, (2) high debt levels and (3) a declining trend in terms

of trade (ABARES 2019). Furthermore, the managers of grazing businesses face an increasing administrative and regulatory burden associated with environmental, social and governance (ESG) requirements.

Therefore, to remain in production, and to build resilience, beef and sheep properties need to be profitable and to build equity (Figure 1; Bowen and Chudleigh 2021b). Building resilience usually means investments must be made and alternative management strategies considered. To make profitable management decisions, graziers need to be able to appropriately assess the impact of different strategies on profitability, the associated risks, and the period of time before benefits can be expected. The effects of such alternative management strategies are best assessed using property-level, regionally relevant models that determine whole-of-property productivity and profitability (Malcolm 2000, Malcolm *et al.* 2005; Bowen and Chudleigh 2021a).

Figure 1 The link between profit and growth in equity



Income diversification is one strategy that can be considered by grazing businesses to improve resilience through smoothing income over time whilst maintaining average profitability. With current policy settings encouraging the development of (1) environmental market and (2) renewable energy projects on agricultural land, there are opportunities to consider the effects of diversification into these alternative land uses on the profitability and future viability of grazing businesses.

1.3 The impact of diverse streams of income on farm viability and risk

During the 20th century, agricultural production globally has become increasingly specialised, intensified and mechanised with the focussed use of resources leading to economies of scale and other competitive advantages for farmers (Bowman and Zilberman 2013; Roest *et al.* 2018). However, it has been argued that such specialisation has weakened the economic resilience of farms due to a high dependence on commodity markets which have become more volatile over time over time as markets have become deregulated (Hansson *et al.* 2010; Roest *et al.* 2018.)

Mixed farming (e.g. wheat and sheep enterprises) and diversification of enterprise types (e.g. addition of goats to a traditional beef production enterprise) are forms of agricultural diversification that have long been viewed as a strategy to reduce exposure to climate and market risks. Diversification can also include non-agricultural income streams from alternative land uses (e.g. carbon farming), agritourism, contractor income, off-farm employment income and off-farm investment income (Hansson *et al.* 2010; Ollenburg and Buckley 2007; Currey *et al.* 2024).

Diversifying sources of income can have the effect of smoothing income over time through reducing risks from climate and market variability, and therefore can improve business resilience (Roest *et al.* 2018; Tocker

et al. 2022). However, the effectiveness of diversification in reducing risk and maintaining satisfactory profit depends on the correlations between yields and prices of the various activities, complementarities between enterprises, and the ability of the farmer to manage the various systems (Tocker *et al.* 2022). Tocker *et al.* (2022) demonstrated the principle that specialisation in one commodity (i.e., prime lamb production in south-west Victoria) has the potential to generate higher profits than a diversified system although having higher exposure to price risk. Therefore, farmer attitude to risk will influence the decision to diversify. If higher profits are sought, and the associated higher risk is acceptable, then specialisation and focussing on a single enterprise may be the best option (Tocker *et al.* 2022).

There is indication that economic diversification, including into non-agricultural land uses and income streams, is increasingly being adopted by primary producers in the grazing lands of Australia and on farms internationally (Medhurst and Segrave 2007; Currey *et al.* 2024). Furthermore, there is evidence of a positive impact of non-agricultural diversification on the financial performance of family farms, internationally (Salvioni *et al.* 2020). An example of the potential economic benefits of diversifying into the non-agricultural land use of carbon farming, was conducted for the mulga lands of Queensland (Bowen *et al.* 2022). This latter analysis demonstrated that the profitability of the existing enterprise/s is a key factor in the attractiveness of such a diversification. The analysis showed that partial conversion of a beef enterprise to carbon farming improved the property-level returns and viability of the property. Where an unprofitable enterprise was in place (e.g. beef production in the mulga lands), the opportunity costs of investing in carbon farming were low and provided greater incentive for diversification into this alternative land use. The widespread adoption of carbon farming in the low-productivity mulga lands of Queensland and New South Wales is the result of this phenomenon (Baumber *et al.* 2020). An additional feature of beef cattle properties in the mulga lands is the reliance on off-farm income for business survival (Bowen *et al.* 2022), which has been broadly identified as an important strategy in inherently low-productivity regions (Johnston *et al.* 1990; Fargher *et al.* 2003).

However, an important point to note in terms of income diversification from engaging in environmental markets is that carbon and ecosystem services credit issuance are all close linked to rainfall, as is grazing livestock production. Thus, these income streams likely all share the same vulnerability to climate variability. The hosting of renewable energy projects is more likely to provide true income diversification due to the independence of the income streams from climate-related variables.

Regardless, it will be important to appropriately assess the potential effects of diversification on profitability, riskiness and indebtedness of the overall business. The decision about whether to diversify will not only depend upon economic considerations of financial pressures or the desire for growth and profit but will also depend upon the attributes of the property, the knowledge, skills, goals and lifestyle preferences of the management team and upon family relationships and inheritance issues for family businesses (Medhurst and Segrave 2007; Currey *et al.* 2024). Building knowledge and skills in assessing the potential impacts of diversification into environmental markets on farm viability in Australia could be a critical role for an independent third party.

2. Land use diversification opportunities for grazing land managers

Examples of a change of land use to non-agricultural, for all or part of the farm, include carbon farming and other environmental markets, and hosting coal seam gas wells or renewable energy projects. Many of these opportunities will only be available to land managers in specific locations.

2.1 Environmental markets and ecosystem opportunities for grazing business

Environmental markets, such as carbon or ecosystems service markets, provide a framework for landholders to invest in sustainable practices while gaining economic benefits. Environmental markets facilitate the trade of environmental assets or ecosystems services including carbon credits, water rights and biodiversity offsets.

2.1.1 Credit schemes

This section provides a summary of credit schemes relevant to grazing properties in Queensland.

2.1.1.1 Australian Carbon Credit Unit (ACCU) Scheme

The Commonwealth Government's voluntary ACCU Scheme, formerly known as the ERF, allows landowners and farmers to undertake projects that avoid the release of GHG emissions or remove and sequester carbon from the atmosphere, using approved methods to earn ACCUs. Each ACCU issued represents one tonne of carbon dioxide equivalent (t CO₂-e) net abatement (through either emissions reductions or carbon sequestration) achieved by an eligible offset project. The objective is to incentivise adoption of new practices or technologies to reduce emissions or store carbon by generating additional income streams. The ACCU Scheme is administered by the Clean Energy Regulator (CER). The *Carbon Credits (Carbon Farming Initiative) Act 2011* sets out the rules established for the ACCU Scheme (Australian government 2020).

ACCUs can be used to generate an additional source of income for landholders, or they can be retained and surrendered to offset farm emissions. The voluntary market allows any government or private entity to trade and/or surrender ACCUs to meet emission reduction commitments they place upon themselves. Therefore, ACCUs can be sold to private sector buyers or to the Australian Government. The Australian Government historically purchased ACCUs through carbon abatement contracts and will continue to do so through the Powering the Regions Fund (Australian Government, DCCEE 2024f). The Australian Government's purchasing of ACCUs has been via reverse auction in accordance with a mandate that seeks lowest cost emissions abatement. To-date, the Australian Government has been the biggest purchaser of ACCUs, capturing ca. 90% of ACCU sales between 2014-2023 (CER 2024; Milne *et al.* 2024). Purchased ACCUs are surrendered by the Australian Government to offset its own emissions.

Under the Safeguard Mechanism, the private demand for ACCUs is expected to grow significantly. In addition to compliance buyers, the volume of new voluntary buyers is expected to increase with the objective of meeting corporate climate commitments or making ethical investments (Milne *et al.* 2024). ACCUs are generally only tradeable in Australia but, as international markets grow, there is potential that arrangements will be made for trade in ACCUs on a global scale.

2.1.1.1.1 Available methods

Currently available methods under the ACCU Scheme, with relevance to grazing businesses, include methods within the following categories:

- (1) Agriculture
 - a. Beef cattle herd management method (sunsets 1 October 2025)
 - b. Estimating sequestration of carbon in soil using default values method (sunsets on 1 October 2025)
 - c. Estimation of soil organic carbon sequestration using measurements and models method

(2) Vegetation management

- a. Avoided clearing of native regrowth (AC) method (sunsets on 1 April 2025)
- b. Designated verified carbon standard projects method (sunsets 1 April 2025)
- c. Plantation forestry method
- d. Reforestation and afforestation 2.0 method (sunsets 1 October 2025)
- e. Savanna fire management – 2018 emissions avoidance method
- f. Savanna fire management – 2018 sequestration and emissions avoidance method
- g. Tidal restoration of blue carbon ecosystems

2.1.1.1.2 Methods in development

- (1) Integrated farm and land management (IFLM) method
- (2) Reforestation by environmental or mallee plantings method
- (3) New savanna fire management methods.

2.1.1.1.3 Methods under review

- (1) Beef cattle herd management method

2.1.1.1.4 ACCU Scheme project register and ACCU generation

Projects listed in the ACCU Scheme project register (data downloaded 29/11/2024) for Australia and Queensland are summarised under method type in Table 1 and Table 2, respectively. It is important to note that when a method expires, existing project proponents may continue their projects under those methods for the remainder of their crediting period. Alternatively, projects within expired methods may be transferred to a new or updated method.

Of the ca. 13,150 businesses involved in grazing enterprises in Queensland (ABS 2022), 3.7% have registered ACCU Scheme projects on grazing land (491 projects; Table 2), although some businesses have more than one registered project making the participation rate of the sector even lower. Without mapping the project areas provided in the ACCU Scheme register, it is not possible to obtain a total area of land under ACCU Scheme projects in Queensland. Regardless, it is evident that the current level of engagement in ACCU Scheme projects by available landholders in Queensland is low.

Table 1 Number of ACCU Scheme projects by method type in Australia with relevance to agriculture (Australian Government, CER 2024d; as at 29/11/2024)

Project type	Total registered	Number of ACCUs issued	Number of projects with ACCUs issued
Agricultural methods	752	2,493,634	30
Beef cattle herd management (methodology determination 2015)	14	953,241	3
Estimation of soil organic carbon sequestration using measurement and models (methodology determination 2021)	529	289,280	16
Measurement of soil carbon sequestration in agricultural systems (methodology determination 2018) - <i>closed</i>	142	0	0
Sequestering carbon in soils in grazing systems (Methodology determination 2014) - <i>closed</i>	37	0	0
Methods relating to animal effluent management	30	1,251,113	11
Vegetation methods	1,179	84,210,320	421
Avoided deforestation (methodology determination 2013) - <i>closed</i>	3	527,774	2
Avoided deforestation 1.1 (methodology determination 2015) - <i>closed</i>	61	28,763,550	59
Avoided clearing of native regrowth (methodology determination 2015)	16	530,772	11
Human-induced regeneration of a permanent even-aged native forest 1.1 (methodology determination 2013) - <i>closed</i>	529	46,236,311	262
Native forest from managed regrowth (methodology determination 2013) - <i>closed</i>	50	3,201,672	22
Reforestation and afforestation (methodology determination 2013) - <i>closed</i>	3	123,477	2
Reforestation and afforestation 1.2 (methodology determination 2013) - <i>closed</i>	9	130,660	6
Reforestation and afforestation 2.0 (methodology 2015)	5	0	0
Measurement based methods for new farm forestry plantations (methodology determination 2014) - <i>closed</i>	3	409,017	1
Reforestation by environmental or mallee plantings – FullCAM (methodology determination 2014) - <i>closed</i>	287	2,884,775	28
Plantation forestry (methodology determination 2017) - <i>closed</i>	34	388,537	15
Plantation forestry (methodology determination 2022)	126	32,718	5
Quantifying carbon sequestration by permanent environmental plantings of native species using the CFI reforestation modelling tool (methodology determination 2012) - <i>closed</i>	47	41,658	5
Quantifying carbon sequestration by permanent mallee plantings using the reforestation modelling tool (methodology determination 2013) - <i>closed</i>	1	0	0
Designated verified carbon standards projects (methodology determination 2015)	3	939,399	3
Tidal restoration of blue carbon ecosystems (methodology determination 2022)	2	0	0
Savanna burning and Savanna fire management	101	14,566,854	71
Emissions abatement through savanna fire management (methodology determination 2015) - <i>closed</i>	72	13,211,844	57
Savanna fire management – emissions avoidance (methodology determination 2018)	11	164,479	4
Savanna fire management - sequestration and emissions avoidance (methodology determination 2018)	4	19,414	1
Reduction of greenhouse gas emissions through early dry season savanna burning 1.1 (methodology determination 2013) - <i>closed</i>	14	1,171,117	9
Australia total – methods applicable to grazing businesses (excludes effluent management)	2,002	100,019,695	511
Australian total – all methods (including those not shown in table)	2,416	154,426,699	691

Notes: Register data as at COB 27/10/2024. Grey shading indicates open methods with relevance to livestock grazing systems.

Table 2 Number of ACCU Scheme projects by method type in Queensland with relevance to agriculture (Australian Government, CER 2024d; as at 29/11/2024)

Project type	Total registered	Number of ACCUs issued	Number of projects with ACCUs issued
Agricultural methods	166	1,656,132	16
Beef cattle herd management (methodology determination 2015)	10	953,241	3
Estimation of soil organic carbon sequestration using measurement and models (methodology determination 2021)	120	269,971	10
Measurement of soil carbon sequestration in agricultural systems (methodology determination 2018) - <i>closed</i>	25	0	0
Sequestering carbon in soils in grazing systems (Methodology determination 2014) - <i>closed</i>	5	0	0
Methods relating to animal effluent management	6	432,920	3
Vegetation methods	281	23,016,983	144
Avoided clearing of native regrowth (methodology determination 2015)	16	530,772	11
Human-induced regeneration of a permanent even-aged native forest 1.1 (methodology determination 2013) - <i>closed</i>	183	19,210,324	105
Native forest from managed regrowth (methodology determination 2013) - <i>closed</i>	50	3,201,672	22
Reforestation and afforestation 1.2 (methodology determination 2013) - <i>closed</i>	1	30,191	1
Reforestation by environmental or mallee plantings – FullCAM (methodology determination 2014) - <i>closed</i>	23	17,081	2
Plantation forestry (methodology determination 2017) - <i>closed</i>	2	0	0
Plantation forestry (methodology determination 2022)	1	0	0
Quantifying carbon sequestration by permanent environmental plantings of native species using the CFI reforestation modelling tool (methodology determination 2012) - <i>closed</i>	4	26,943	3
Tidal restoration of blue carbon ecosystems (methodology determination 2022)	1	0	0
Savanna burning and Savanna fire management	50	4,487,622	40
Emissions abatement through savanna fire management (methodology determination 2015) - <i>closed</i>	37	4,037,517	32
Savanna fire management – emissions avoidance (methodology determination 2018)	1	0	0
Savanna fire management - sequestration and emissions avoidance (methodology determination 2018)	3	19,414	1
Reduction of greenhouse gas emissions through early dry season savanna burning 1.1 (methodology determination 2013) - <i>closed</i>	9	430,691	7
Queensland total – methods applicable to grazing businesses (excludes effluent management)	491	28,727,817	197
Queensland total – all methods (including those not shown in table)	603	42,363,178	248

Note: ACCU Scheme register data as at COB 27/10/2024. Data included for those projects registered across a number of states and/or territories including Queensland. Grey shading indicates open methods with relevance to livestock grazing systems.

2.1.1.2 Queensland Land Restoration Fund (LRF)

The Queensland Land Restoration Fund is governed by the Commonwealth *Carbon Credits (Carbon Farming Initiative) Act 2011* (Australian Government 2020). The Queensland Government's LRF works by purchasing premium carbon credits from carbon farming projects that produce ACCUs plus demonstrated additional environmental, economic, social and First Nations co-benefits (Queensland Government 2024e). The LRF Trust is a commercial contracts project that delivers carbon credits with co-benefits through investment rounds to ensure a self-sustaining fund. All LRF projects must be registered with the ACCU Scheme under an ACCU Scheme method and must generate ACCUs.

The LRF pays for co-benefits in the overall sum offered to landholders. Therefore, the LRF may pay more for the ACCUs generated from carbon farming projects than the Australian Government which has been required by legislation to purchase lowest cost abatement. The LRF may choose to trade the ACCUs purchased to enable further funding for carbon farming projects, or to surrender them to support the Queensland Government's emission reduction targets (Queensland Government 2024e).

The co-benefit model followed by the LRF uses third-party verification of (1) environmental co-benefits via the Accounting for Nature Framework, and (2) First Nations benefits using the Aboriginal Carbon Foundation's standard (Queensland Government 2023b). The LRF attributes multiple co-benefits based on overall ecosystem condition, using a weighted set of indicators such as species richness, function, etc., which are benchmarked against a reference ecosystem. Unlike the concept of 'stacking' in which credits are assigned to specific land parcels or separate projects, the LRF operates on the premise that improving the ecosystem condition delivers a range of co-benefits. The LRF applies a 'financial viability' rule which requires project proponents to demonstrate to the investment board that the projects wouldn't be financially viable without the co-benefits. Therefore, the price per ACCU (including co-benefits) takes into consideration the cost of generating the ACCUs plus the co-benefits, and the benefits to the state that the project will deliver.

Three investment rounds have been made to-date with a total of 19 projects currently contracted after selection for investment for the independent LRF Investment Panel:

- Round 1
 - opened 28/2/2020, closed 15/04/2020,
 - 12 contracted projects (as of 28/11/2024)
 - average of 7 contracted co-benefits per project
 - 984,150 contracted ACCUs
 - median contracted price per ACCU with co-benefits \$61.73
 - project duration ranged from 5 to 16 years with 9 of the 12 projects being 16 or 16 years in duration
 - Four of the 12 projects were based on the Vegetation methods AC and/or Human-induced regeneration (HIR),
- Round 2
 - opened 02/08/2021, closed 08/10/2021
 - 7 contracted projects (as of 28/11/2024)
 - Average of 6 contracted co-benefits per project
 - 164,213 contracted ACCUs
 - median contracted price per ACCU with co-benefits \$71.16
 - project duration ranged from 5 to 16 years; three projects utilising native regrowth Vegetation methods (AC) were 5 years in duration with a fourth project (HIR) being 10 years in duration
- Round 3
 - opened 13/04/2023, closed 16/06/23
 - no information yet available to indicate outcomes.
- Future investment rounds
 - details and timelines for future investment rounds are not yet available.

Projects contracted in Rounds 1 and 2 were based on ACCU Scheme methods which were either regrowth-related Vegetation projects (AC and/or HIR), environmental plantings, soil carbon sequestration or savanna fire management. The regrowth-related Vegetation projects tended to be shorter in duration than other projects, i.e. 5 or 10 years for seven of the eight projects based on a Vegetation method. Co-benefit categories for those 19 projects currently contracted in Rounds 1 and 2, in order of the most to least numerous (popular) include:

- 1) Threatened ecosystems: 18 projects
- 2) Threatened wildlife: 18 projects
- 3) Native vegetation: 17 projects
- 4) Employment and skills: 16 projects

- 5) Great Barrier Reef: 12 projects
- 6) Community resilience: 10 projects
- 7) Diversity and human rights: 9 projects
- 8) First Nation's participation: 7 projects
- 9) Wetlands: 6 projects
- 10) First Nation's location: 6 projects
- 11) Coastal systems: 4 projects
- 12) Soil health: 2 projects.

2.1.1.3 Reef Credit Scheme

The Reef Credit Scheme delivers water quality benefits for the Great Barrier Reef and works in a similar way to carbon credits (Queensland Government 2023c). Farmers and landholders in Reef regions (catchments) can earn additional, regular income through generating and selling Reef Credits by taking actions on their land to reduce nutrient or sediment run-off flowing to the Reef. The Queensland Government committed \$10 million to initiate the Reef Credit Market and awarded brokers, Palladium and Greencollar, contracts to establish Reef Credit projects on grazing and sugarcane properties and to secure potential buyers for the Reef Credits generated.

A Reef Credit represents a quantifiable amount of pollutant prevented from entering the Great Barrier Reef catchment. Projects operating under the Reef Credit Scheme must use an approved Reef Credit Methodology to quantify pollutant reductions. It is possible to undertake other ecosystem services projects, including carbon, biodiversity and renewable energy projects, over the same area of land (i.e. 'stacking'), subject to the requirements set out in the Reef Credit Standard. However, the Reef Credit Standard (Version 3.2, p. 8) states that "Reef Credits may only be issued for pollutant reduction that is additional to that already paid for." Thus, if the same activity (e.g. reducing stocking rates) results in both pollutant reductions (Reef Credits) and carbon sequestration (ACCUs), stacking would likely be disqualified due to non-additionality.

The Reef Credit Scheme is managed by independent, not-for-profit company, Eco-Markets Australia. All Reef Credit projects must be registered with Eco-Markets Australia to earn Reef Credits. Currently (03/12/2024), 13 projects are registered in the Reef Credit project database, with 54,997 credits issued and 40,773 credits retired (Eco-Markets 2024). However, this data is not a complete listing of all registered projects, as it is voluntary for account holders to publicly list their projects.

There are currently four approved methods to undertake Reef Credit Projects that provide verifiable pollutant reductions (Eco-markets 2024):

- (1) DIN Method (developed by GreenCollar Group Ltd). The Method for Accounting Reduction in Nutrient Run-off through Managed Fertiliser Application Version 1.1 quantifies the reduction in Dissolved Inorganic Nitrogen (DIN) lost from agricultural land through improved soil and nutrient management practices within catchments of the Great Barrier Reef World Heritage Area. Eligible agricultural enterprise include (but are not limited to) sugarcane, bananas, grains and fodder.
- (2) Gully Method (developed by GreenCollar Group Ltd). The Method for Accounting for Reduction in Sediment Run-off through Gully Rehabilitation Version 1.4 describes the approach to achieve and quantify reductions in fine sediment from rural landscapes through gully rehabilitation within the catchments of the Great Barrier Reef World Heritage Area.
- (3) Wastewater Methods (developed by GreenCollar Group Ltd and RegenAqua Pty Ltd). The Method for Accounting for Nutrient Reduction in Municipal Wastewater Treatment Plants through Managed Bioremediation Operations Version 1.3 describes the approach to achieve and quantify the reduction in DIN in wastewater discharged from a site or facility through managed algal bioremediation solutions, with catchments of the Great Barrier Reef World Heritage Area.
- (4) Grazing Land Management (GLM) Method (developed by GreenCollar, Verterra Ecological Engineering and AgriProve). This method is designed to account for fine sediment savings through improved grazing land management practices. The GLM method is based on a refined sediment delivery model, the Revised Universal Soil Loss Equation (RUSLE).

New methodologies may be developed for any practice change or ecosystem repair activities that are able to reduce or remove pollutants entering the Great Barrier Reef. Methodologies must comply with the Reef Credit Standard requirements and Methodology Approvals Procedure. A new method currently under development includes:

- (1) Constructed Wetlands. This method is currently being reviewed for approval to utilise constructed wetlands to prevent dissolved inorganic nitrogen from entering waterways in the Great Barrier Reef catchment.

2.1.1.4 NaturePlus™

NaturePlus is a biodiversity credit scheme, developed by GreenCollar, that applies the Accounting for Nature framework to generate a stand-alone NaturePlus credit (NaturePlus 2024). Each NaturePlus credit represents 1 ha of measured and verified active restoration or conservation of habitat or species. To-date, 20 projects (in Australia and internationally) have been registered. Two of these projects have been validated, both in the mulga lands bioregion of NSW, and have been issued a combined total of 60,435 credits. These credits are a stand-alone credit but there is potential for them to be stacked with other environmental service projects.

2.1.1.5 Cassowary Credit Scheme – in development

The Cassowary Credit Scheme is a voluntary biodiversity credit scheme designed to generate an income for landholders who restore, protect and improve rainforest habitat (Eco-Markets 2024). The scheme was designed by Terrain NRM for Australia's Wet Tropics region and is currently under assessment by Eco-Markets Australia for administration. Landholders or managers must use an approved methodology for projects ranging from rainforest reforestation on cleared or heavily disturbed land to weed control to improve the condition of existing vegetation. The scheme will measure change in terms of outcomes. Cassowary Credits will be awarded for a quantified improvement in rainforest habitat (vegetation) condition earned by landholders. The credits will be available for purchase by investors but cannot be used as offsets to meet conservation and restoration commitments in a compliance market. The Cassowary Credits are stand-alone credit but there is a potential for these to be stacked with other projects.

2.1.1.6 Australian Nature Repair Market – in development

The *Nature Repair Act 2023* came into effect in December 2023 and established a framework for a legislated, national, voluntary biodiversity market (Australian Government, 2024; Australian Government, DCCEEW 2024d). The Act allows Australian landholders to be issued with tradeable biodiversity certificates as part of a Nature Repair Market which would operate in parallel to the carbon market so that landholders can receive certificates from carbon projects that create biodiversity. The CER will regulate the market to help align carbon and biodiversity markets.

The concept of the Nature Repair Market is that carbon credits and biodiversity certificates can be generated from the same project area, i.e. 'stacked'. However, concerns have been raised by some stakeholders during the consultation process, regarding the need to ensure carbon and biodiversity projects are 'additional' and do not enable 'double dipping' where landholders earn income for biodiversity benefits from both 'premium ACCUs' and biodiversity certificates for the same project (Climate Change Authority 2023).

The Nature Repair Market was anticipated to open in 2025. However, negotiations in the Federal parliament to pass environmental reforms that would enable this market to develop further have currently stalled (November 2024).

The development of methods (the legislative instruments) that set out how projects will operate are still under development. The following potential methods have been identified (Australian Government, DCCEEW 2024d):

- Enhancing remnant vegetation – protection and enhancement of existing native vegetation,
- Replanting native forest and woodland ecosystem – environmental restoration,
- Native forest – protect, restore and manage native forests,
- Invasive pest management – control of specific feral pests or weeds,

- Permanent protection – protect and control biodiversity
- Rangelands – manage and enhance habitat in the arid and semi-arid areas of Australia.

2.1.2 Carbon farming and co-benefits

As the federal government purchases ACCUs is in accordance with a mandate that seeks lowest cost emissions abatement, there has historically been no formal recognition or valuation of co-benefits. Compliance buyers also demand low-cost ACCUs. However, the voluntary carbon market is increasingly showing an interest in ACCUs with co-benefits, which attract price premiums (Milne *et al.* 2024).

The federal government Agriculture Biodiversity Stewardship Package has facilitated two pilot schemes that involve co-benefits, and produced a labelled ACCU product (Australian Government, DCCEE 2024c):

- Carbon + Biodiversity Pilots – new native vegetation plantings delivering both biodiversity improvement and carbon abatement.
- Enhanced Remnant Vegetation Pilots – remnant native vegetation is protected and improved through management activities such as installing fencing, weeding, pest control, or supplementary planting.

Additionally, the Queensland Government, LRF results in a labelled premium ACCU which includes demonstrated additional environmental, economic, social and First Nations co-benefits (Queensland Government 2024e).

Of note is a comment made in an industry webinar ('Biodiversity in Agriculture', hosted by Landcare; 06/11/24) by a central Queensland landholder participant in the federal government Enhanced Remnant Vegetation Pilot. The landholder indicated that the project didn't make them any income but covered the costs of doing the work to improve biodiversity. The landholder indicated that they had learnt the importance of doing a cost-benefit analysis prior to signing up to any long-term projects and that such an assessment should incorporate the effect of the project on agricultural productivity. A greater financial and economic incentive to participate in these markets may be required to attract future participants.

2.1.3 Stacking offsets in Queensland

The Queensland Environmental Offsets Policy allows landholders in Queensland to participate in offset stacking where two different types of offsets are delivered on the same area of land, either simultaneously or at different points in time (The State of Queensland, DES 2019). The policy states that an environmental offset may be 'stacked' on top of an existing carbon offset, but only to the extent that actions implemented to deliver the environmental offset are additional to those implemented to deliver the carbon offset, such that the environmental offset results in additional environmental outcomes. Therefore, offset stacking must abide by the Commonwealth *Carbon Credits (Carbon Farming Initiative) Act 2011* which mandates that all projects must meet (1) a 'newness requirement' where the project has not begun to be implemented, and (2) a 'regulatory additionality requirement' (Australian Government 2020).

The State of Queensland, DES (2019) identifies that offset stacking could be acceptable where:

- An environmental offset is delivered on top of an existing carbon offset.
- The management actions undertaken to deliver the environmental offset are separate from and additional to the management actions undertaken to deliver the carbon offset.
- Additionality can be transparently accounted for and demonstrated.
- The delivery of one type of offset does not lead to any perverse outcome for the other type of offset with regard to its intended outcome.

The following practices have been identified as generally not acceptable:

- Delivering a carbon offset on top of an existing environmental offset.
- Attributing one management action to the delivery of two different offsets simultaneously.

- Implementing management actions for which additionality cannot be transparently accounted for or demonstrated.
- Delivering one type of offset that in any way hinders the success of the other in delivering its intended outcome.

Requests to stack Queensland environmental offsets (e.g. produced via the Reef Credit Scheme) on carbon offsets are assessed by the Department of Environment and Science on a case-by-case basis (The State of Queensland, DES 2019). Where the principles of 'offset stacking' cannot be upheld, landholders may still be able to participate in more than one offset market by developing projects on separate areas of land that do not overlap spatially.

Offset stacking is seen as desirable due to the potential to maximise environmental outcomes and landholder income while minimising administrative burden and overhead costs of establishing and maintaining offset projects. However, due to additionality and leakage clauses associated with the legislation and methods there are currently limited opportunities to 'stack' projects and therefore reduce overhead and administration costs. Additionally, at present, separate reporting and costs are required for the two independent projects even when the criteria are met to allow 'stacking', i.e. to generate credits on the same area of land. Therefore, there is currently limited potential or financial incentive for stacking to occur on Queensland's grazing lands, even when criteria are met (GreenCollar 2022).

The developing Australian Nature Repair Market is intended to allow carbon credits and biodiversity certificates to be generated from the same project area, i.e. 'stacked'. However, the methods and how the projects will operate are still not clear. Additionally, the proposed IFLM method is still under development but is anticipated to combine activities under several existing and expired ACCU Scheme methods into a single method which is anticipated to facilitate stacking of credits on a single land area/property. The potential crediting of carbon stored from managed regeneration and plantings of native forest in addition to improvements to soil are the initial activities identified (Australian Government, DCCEE 2024e). However, it has been flagged that additional project activities, abatement estimates and carbon pools could be considered for inclusion in the method over time following its initial opening.

2.1.4 Support for landholders to estimate current business GHG emissions and assess alternative management strategies and carbon farming opportunities

In order to consider the opportunities and risks of engaging in carbon projects, and the potential impact on market access and ESG reporting for their livestock production enterprise, producers need to first have an understanding of their farm carbon account and carbon footprint of production. Carbon accounting is the process used to estimate the GHG emissions and sequestration associated with an enterprise. A brief summary of the key metrics and the requirements for developing a carbon account (audit) and a carbon footprint, is given in Appendix 1. Carbon accounting for beef cattle and sheep enterprises.

There has been a proliferation of Government and private providers offering whole-farm carbon baselining services (Table 3). A number of these also offer an assessment of sustainability, biodiversity and natural capital assets. Other than Government and bank-funded baselining services, there appears to be some level of charge to access the tools and/or to receive support from an advisor.

Table 3 Carbon emissions baseline and GHG abatement service providers for Queensland grazing businesses

Service provider and/or tool	Services offered	Free to producers or charge for service	Agricultural sectors	Location of existing activities
AgCarE	A tool to conduct an initial audit of sustainable production, carbon balance and biodiversity assets. Includes identification of carbon farming opportunities and environmental and biodiversity credit market opportunities. Determines a value of the natural capital assets on the property to assist with branding opportunities and access to commodity markets and finance. https://www.agcare.org.au/	Charge; subsidised for AgForce members	Beef, sheep, goats (coming soon), grains, cane, forestry	Qld
Agricultural Innovation Australia	An environmental accounting platform for Australian agriculture, fisheries and forestry. Enables carbon footprint calculation at commodity, enterprise and whole of business level. https://www.aiaeap.com/	Charge; access via subscription	Agriculture, fisheries, forestry	Australia-wide
Australian Wagyu Association (AWA): 2-year partnership with Ruminati from November 2023	AWA members provided free access to the Ruminati PRIME platform to generate personalised emissions estimates for the farm business. Users can model the impact of methane and CO ₂ -e abatement options, set and measure against individual emissions reduction targets, and create tailor-made, future-facing emissions reductions plans. Several baselining and technical workshops provided. https://www.wagyu.org.au/new-partnership-takes-first-steps-toward-baselining-australias-wagyu-sector	Free; Ruminati PRIME platform made available at no direct cost to AWA members	Wagyu beef association members	Australia-wide
Bentleys (ESG & carbon accounting services)	Advice on carbon farm management and carbon accounting practices, including (1) measuring carbon emissions and establishing a baseline, (2) understanding asset values impacts from carbon-related projects and markets, and (3) practical strategies to meet regulatory or and/or supply chain pressures. Complementary carbon accounting information sessions provided. https://www.bentleys.com.au/services/esg-carbon-accounting/	Charge for advice; free information sessions	All agri-business	Australia and NZ
Commonwealth Bank of Australia (CBA): partnership with Ruminati	Staged programme from July 2024 making Ruminati Prime available on an opt-in basis to agribusiness customers around Australia. Objective is to calculate baseline emissions and to model changes in farming practices to lower carbon emissions. https://www.commbank.com.au/articles/newsroom/2024/05/commbank-beef2024-ruminati.html	Free; Ruminati PRIME platform made available at no cost to CBA agribusiness customers	Livestock and mixed farming	Australia-wide
Commonwealth Department of Climate Change, Energy, the Environment and Water (DCCEEW Carbon Outreach	Training package and grants to advisors to deliver training. Package provides information to help farmers and land managers make decisions about reducing emissions and storing carbon. Training to occur from July 2024. Carbon Farming Outreach Program - DCCEEW	Free	All enterprises	Australia-wide
Elders	Carbon farming service: assist producers to participate in carbon farming or to inset against other business emissions to move towards carbon neutrality. https://elders.com.au/our-services/agriculture-services/carbon-farming/	Charge: upfront fee-for-service	All enterprises	Australia-wide

GAF tools	Greenhouse Accounting Frameworks (GAF) tools developed by the University of Melbourne to align with the National Greenhouse gas inventory to predict magnitude and sources of GHGs emitted from a farm and a product at the farm gate. Scope 1 emissions, (e.g. methane and nitrous oxide), Scope 2 (e.g. electricity), and Scope 3 (pre-farm embedded emissions such as urea manufacture) are included. Scope 3 emissions are essential to the carbon footprint (emissions intensity) but not to the farm boundary.	Free	Dairy, sheep and beef, cropping, feedlot, sugar, cotton, horticulture, pork, buffalo, deer, poultry, rice	Australia-wide
IntegrityAg	Full-cycle carbon services and natural capital and carbon markets. Includes baselining, net emissions reduction, science-based target setting, emission reduction plans, insetting, offsetting, reporting and certification. https://integrityag.net.au/#:-:text=Full%2DCycle%20Carbon%20Services,Baselining	Charge	Sheep and cattle, pigs and poultry, dairy, broadacre cropping, horticulture, land managers and investors	Australia and international projects
LOOC-C	A tool developed by CSIRO to quickly assess GHG abatement options for a specific land area. Covers ACCU Scheme soil carbon and vegetation methods, and the beef cattle herd management method. The tool also estimates the possible co-benefits as part of the LRF https://looc-c.farm/	Free	Livestock grazing enterprises/ land	Australia-wide
Map of Ag	GHG Interactive Scenario Planning Tool: models changes to farm inputs and outputs, and determines impact on emissions. Can be used at an individual farm or producer group level to provide accurate and reliable carbon footprint and scope 3 emissions data. https://mapof.ag/#info	Charge	Livestock, cropping and mixed enterprises	Australia and international projects
McDonalds: partnership with Ruminati to conduct carbon baselining project 'Townsville to Tassie'	Carbon baselining project commencing in November 2023 with producer hubs along the east coast of Australia. Consultant/advisor support provided to run workshops and one-on-one assistance to use the Ruminati platform. Baselining data provided to McDonalds as part of the program. https://ruminati.com.au/in-the-news/	Free to producers in selected hubs along the east coast of Australia	Beef	Eastern states of Australia
MLA Carbon Calculator	Meat and Livestock Australia have digitised the Sheep and Beef Greenhouse Accounting Framework (SB-GAF), (and also the Grains Accounting Framework) developed by the University of Melbourne and the Primary Industries for Climate Challenges Centre. The calculator enables the calculation of GHG produced at the property level. The calculator enables the calculation of total enterprise GHG emissions as well as emissions intensity per product produced (e.g. beef, sheepmeat). MLA request collection data which is aggregated to report on emissions profiles of users and the industry. https://carbon-calculator.mla.com.au/	Free	Beef and sheep, grains	Australia-wide
MLA Carbon Edge training program	A 2-day carbon training program providing participants with an understanding of (1) their carbon account and emissions intensity, and how to change on-farm activities to reduce emissions while improving productivity, (2)	Charge	Livestock grazing enterprises	Australia-wide

	opportunities and risks associated with generating carbon credits and their use to benefit livestock businesses, (3) supply chain drivers and how to future proof market access, (4) how to develop a carbon action plan.			
Mort & Co Predictor Plus	Management software for beef grazing businesses with outputs including GHG emissions and forecasting scope 1 livestock emissions. Includes opportunity to modify inputs to understand the impact of management decisions and operational costs. When combined with Mort & Co's manure testing laboratory, Predictor Plus provides a Resource Use Certificate which validates the sustainability credentials of a grazing business. https://mortco.com.au/predictor/	Charge	Beef cattle	Australia
Nutrien Ag solutions	Farm Emissions Profile service: a team of sustainable agriculture specialists available to use government and industry-approved models to determine your farm emissions profile, emissions reduction options and market opportunities with link provided to supply chain partners. https://www.nutrienagsolutions.com.au/sustainability/farm-emissions-profile	Charge	Cropping, livestock, mixed enterprises	Australia-wide
Qld DPI Carbon outreach	50 carbon outreach workshops or engagement days/events held across commodities and regions	Free	Livestock and extensive grazing (28 events), horticulture (17 events), broadacre cropping (5 events)	Qld
Rabobank	Offering a nation-wide suite of 'Carbon farming' and 'Carbon Neutral Agriculture' workshops across regional Australia, including North Qld (latest promoted as presented by Stephen Wiedemann) to assist producers to measure their carbon missions footprint and determine options for lowering emissions or engaging in carbon markets. https://www.rabobank.com.au/insights/2022/20221014-rabobank-nqld-carbon-workshop	Free to Rabobank customers	All enterprises	Australia-wide
Ruminati	Online emissions calculators. Ruminati BASE is the standard emissions baseline calculator with an estimate of property Scope 1, 2 and 3 emissions along with an estimate of total and net emissions, and sequestration. Ruminati PRIME gives the added ability to model the impact of abatement options, set and measure against individual emissions targets and create emissions reduction plans. Can elect to share on-farm emissions data with selected organisations that require the data for their supply chains. Integrations on the Ruminati PRIME platform are available for Agriwebb (pre-fills farm data), SB-GAF, AuctionsPlus. https://ruminati.com.au/	Free to access Ruminati BASE; Charge to access Ruminati PRIME	Grazing livestock, dairy, feedlot, processor	Australia-wide
Sustell (DSM-firmenich)	Platform to conduct full life cycle assessment for farms. Calculates footprint per kg of product for animal protein production, up and until the farm gate. Assists in complying with upcoming sustainability regulations and best practice as	Charge	Poultry, swine, ruminants, aquaculture	Building a database across countries

unlocking additional market and business opportunities.
<https://www.dsm.com/anh/products-and-services/services/sustell.html>

ACCU, Australian carbon credit unit; GHG, greenhouse gas

2.1.5 Support for landholders to assess natural capital assets and to identify opportunities to engage in environmental offset and biodiversity credit markets

Natural capital accounting and assessments are gaining momentum as a way for landholders and land managers to quantify the value of natural resources including soil, water and biodiversity on their properties. A number of guides, tools and programs are available to assist landholders to assess natural capital assets (Table 4). A number of these also assess carbon balance and carbon market opportunities. These programs and tools are promoted as a way to provide information that can be used to inform decisions on-farm, or to be shared with an end-user such as a bank, retailer or processor at the discretion of the user.

Table 4 Natural capital accounting service providers for Queensland grazing businesses

Service provider and/or tool	Services offered	Free to producers or charge for service	Agricultural sectors	Location of existing activities
AgCarE	A tool to conduct an initial audit of sustainable production, carbon balance and biodiversity assets. Includes identification of carbon farming opportunities and environmental offset and biodiversity credit market opportunities. Determines a value of the natural capital assets on the property to assist with branding opportunities and access to commodity markets and finance. https://www.agcare.org.au/	Charge; subsidised for AgForce members	Beef, sheep, goats (coming soon), grains, cane, forestry	Qld
Farming for the Future	A program delivering Natural Capital Accounts valued at \$35,000, in partnership with the National Farmers Federation. Participating producers need to commit 2-3 days over 12 months and to provide at least 5 years of financial and operational (production) records. The first stage of participation involves preparing a detailed property ap, analysing satellite information and independent field observations by an ecologist. The second stage involves collection of detailed financial and operational data from business records by a professional farm advisor. Data is used to identify relationships between different types of natural capital and farm business performance. The objective is to create an anonymous Natural Capital Benchmarking platform. https://farmingforthefuture.org.au/	Free in this pilot stage	Livestock operations between 600-5,000 ha	Pilot program in NSW, Vic, SA, and southern WA. Other farms around Australia will be eligible in later stages.
IntegrityAg	Full-cycle carbon services and natural capital and carbon markets. Includes baselining, net emissions reduction, science-based target setting, emission reduction plans, inseting, offsetting, reporting and certification. A Nature Disclosures and Environmental Assessment service is also available including service offerings of: (1) Life Cycle Assessment, (2) Energy and Water Footprinting, (3) Product Environmental Footprint and Environmental Product Declarations certification (for products entering the EU), (4) Company disclosures and environmental reporting.	Charge	Sheep and cattle, pigs and poultry, dairy, broadacre cropping, horticulture, land managers and investors	Australia and international projects

<https://integrityag.net.au/#:~:text=Full%2DCycle%20Carbon%20Services,Baselining>

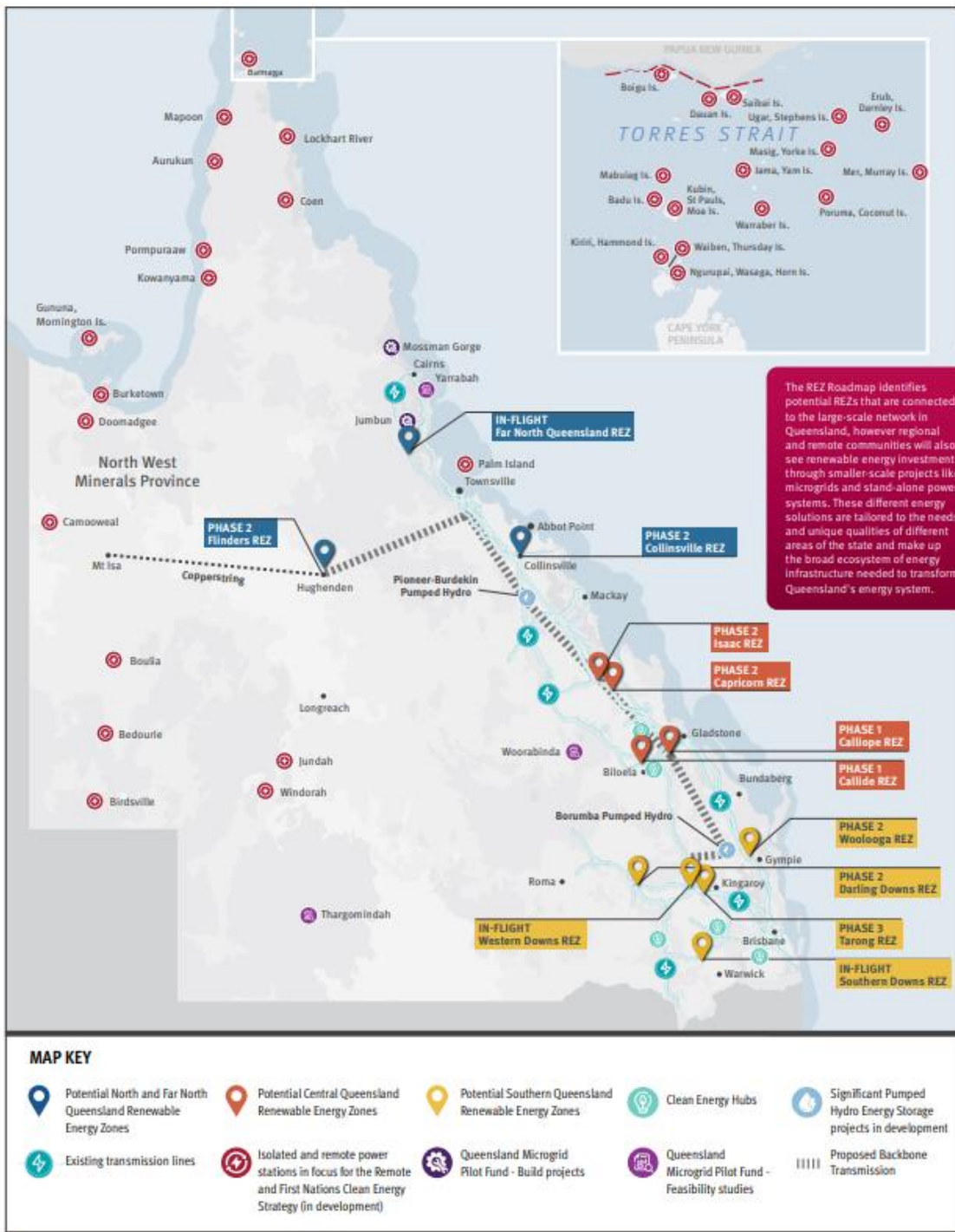
LOOC-B	A biodiversity co-benefits calculator developed by CSIRO. A rapid assessment solution offering a consistent and standardised approach for monitoring how biodiversity has changed over time and anticipating how different management strategies (e.g. carbon farming) influence the availability and quality of the surrounding habitat. Estimates are produced for two biodiversity indicators: habitat condition and biodiversity persistence. The analysis is most robust for environments with higher natural tree cover. Additional indicators such as habitat connectivity and threatened species will be added in future versions of the tool.	Currently not available for commercial use. Commercial release is anticipated in coming months	All enterprises but most robust where there is high natural tree cover	Australia-wide
MLA Environmental Credentials	A tool for producers to compile and collate environmental and sustainability data to demonstrate sustainable practices to the supply chain. Content is based around 5 themes: drought resilience, biodiversity, ground cover, tree cover, and carbon balance. The platform utilises the MLA carbon calculator and the Cibo Labs remote sensing platform, self-guided learning modules and self-assessment checklists. https://www.mla.com.au/extension-training-and-tools/environmental-credentials-platform/	Low to no cost	Beef	Australia-wide
The Natural Capital Handbook	A step-by-step guide developed by CSIRO on how to measure and incorporate natural assets such as clean air, water, soil and living things into financial books. The handbook aligns with existing corporate financial reporting equivalents to identify environmental loss and gains. https://www.csiro.au/en/research/natural-environment/natural-resources/Natural-capital-accounting/Handbook	Free	All	Australia-wide

2.2 Renewable energy project opportunities for grazing business

2.2.1 Current status and location of renewable energy power plants in Queensland

The Queensland Government has legislated targets to generate 50% renewable energy by 2030, 70% by 2032, and 80% by 2035, by connecting 22 gigawatts (GW) of new wind and solar generation between 2022 and 2035 (Queensland Government 2022b, 2023a, 2024c). The Queensland Government has outlined 12 potential Renewable Energy Zone (REZ) locations within three regions of (1) Southern Queensland, (2) Central Queensland, and (3) North and Far North Queensland (Figure 2).

Figure 2 Potential Renewable Energy Zone (REZ) locations in the Queensland SuperGrid (Queensland Government 2024g; https://www.epw.qld.gov.au/__data/assets/pdf_file/0020/49241/rez-roadmap-a3-poster.pdf)



Developments within the REZs are supported by regional plans which are statutory, long-term strategic documents that guide decision-making and investment for state and local governments (Queensland Government 2024h). These regional plans identify Priority Agricultural Areas (PAAs) which contain strategic clusters of the most significant agricultural production areas with designated Priority Agricultural Land Uses (PALU; e.g. broadacre cropping, horticulture, intensive animal husbandry, plantation forestry and terrestrial aquaculture). Any non-agricultural resource activity seeking to operate in these areas will not be supported unless they can co-exist with the PALUs for mutual benefit and without compromising the PALU's current or future ability to operate. The PAAs and PALUs are defined terms under the *Regional Planning Interests Act 2014* (Queensland Government 2024i) and the *Planning Act 2016* (Queensland Government 2024j). Two of the most recently updated regional plans, North Queensland Regional Plan March 2020 and Wide Bay

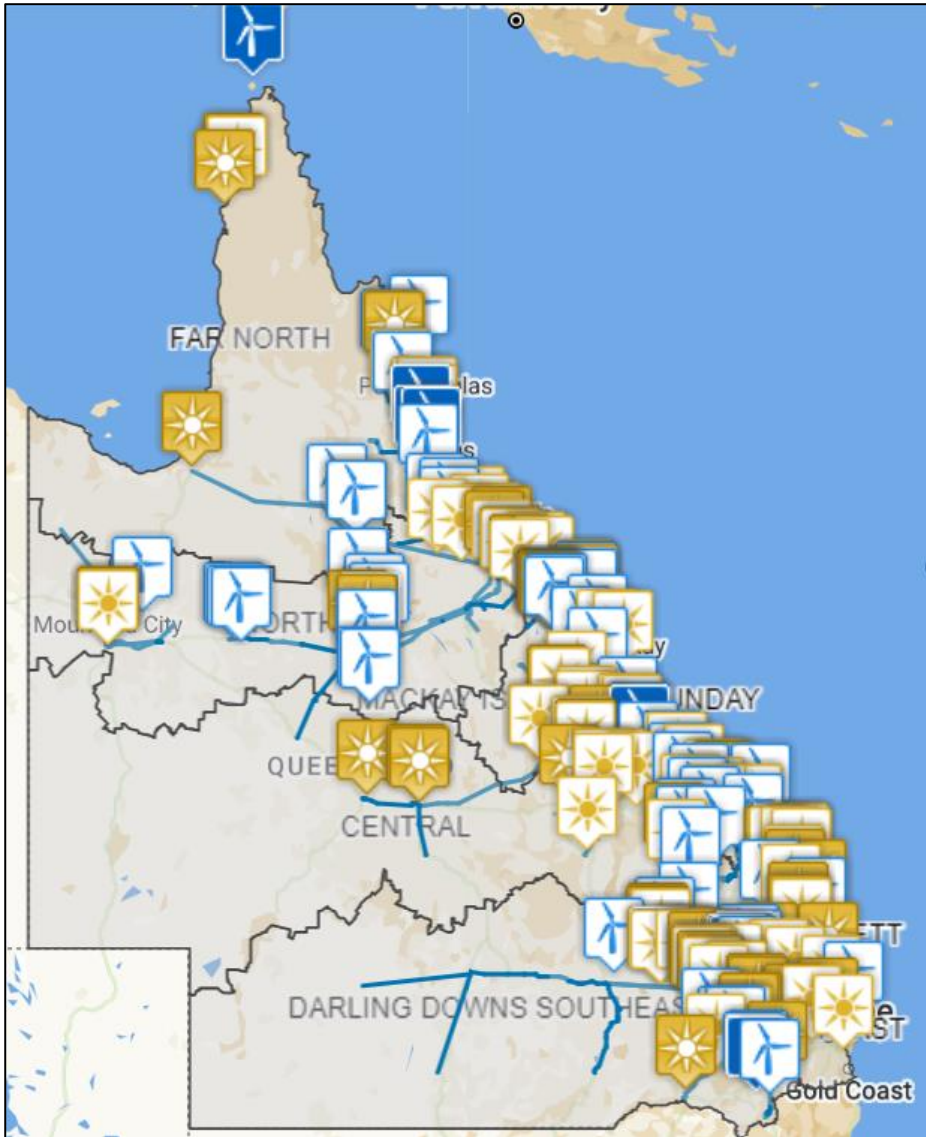
Burnett Regional Plan 2023, state that establishment of renewable energy systems for off-grid or site-specific uses may be supported within PAAs, where they directly support on-site agricultural production and processing activities (Queensland Government 2024h).

The current number and generation capacity of existing, proposed and under construction solar and wind power plants in Queensland are summarised in Table 5 with the location of these power plants shown in Figure 3. It is evident that the total generation capacity of plants of all status (70.2 GW) significantly exceeds the 22 GW by 2035 target. However, it is important to note that not all proposed and publicly announced generating facilities will proceed to construction. Regardless, the distribution of proposed power plants indicates the regions where landholders may have an opportunity to engage in hosting renewable energy projects as an income diversification exercise.

Table 5 Number of existing, under construction and proposed solar and wind power plants in Queensland (Queensland Government 2024k; downloaded 13 November 2024; <https://electricity-generation-map.epw.qld.gov.au/>)

Status	Solar power plants		Wind power plants		Total	
	Number of power plants	Capacity (MW)	Number of power plants	Capacity (MW)	Number	Capacity (MW)
Existing	46	3,359	9	2,399	55	5,758
Under construction	7	983	2	506	9	1,489
Proposed	81	20,519	56	42,424	137	62,943
<i>Total (all status)</i>	<i>134</i>	<i>24,861</i>	<i>67</i>	<i>45,339</i>	<i>201</i>	<i>70,200</i>

Figure 3 Location of 201 existing, under construction and proposed solar and wind power plants in Queensland. Coloured boxes signify power plants either existing or under construction (solar = yellow, wind = blue) while white boxes signify proposed power plants. The regional Ergon distribution network is identified as blue lines (Queensland Government 2024k; downloaded 13 November 2024; <https://electricity-generation-map.epw.qld.gov.au/>)



2.2.2 Considerations for landholders

Queensland Farmers' Federation (2023) estimated that to achieve a 25 GW renewable energy generation target by 2035, 40,200 ha of land would be required for solar farms (assuming 4ha/MW) and 540,000 ha of land for wind turbines (assuming 200 ha / wind turbine). Opportunities to host these projects will likely occur relatively close to the backbone transmission network or the regional distribution network. Freehold land is considered the most appropriate tenure for renewable energy projects. However, leaseholders can apply to convert their lease to freehold for a conversion price if the land meets certain conditions. Alternatively, landholders can apply under the *Land Act 1994* (Queensland Government 2024l) to have an additional purpose of renewable energy added to the purpose of the least.

Developers usually approach landholders with a request to consider hosting a project. However, landholders can approach developers to register their interest. It is important to note that, unlike gas and resources developments, there is no obligation for landholders to negotiate or sign a renewable energy agreement (Queensland Farmers' Federation 2023).

Wind turbines and solar arrays are typically located on cleared land previously used for grazing or crop production. A solar array consumes most of the land that it resides on, with limited opportunities for co-located farming activities due to the current lack of incentives to motivate solar power plant developers to prioritise agrivoltaics over profit-optimising arrays (Feuerbacher *et al.* 2022; Brent *et al.* 2023; Bowen 2024). In contrast, wind farms require a relatively small proportion of the productive land to host the turbine and provide access roads, transmission line easements, electrical substations, transformers and meteorological masts. Regardless, there is usually significant disruption to the normal management activities on and around the land during the construction phase of renewable energy assets (Australian Government, AEIC 2024). Additionally, ongoing access to the assets is required by the project operator for the life of the project. Landholders will likely need to remove any livestock and/or cease farming activities in the paddocks affected by the project development during the construction phase. Furthermore, additional areas of farming land may be required by the project proponents during the operating and maintenance phases of the project if major components of the assets need to be replaced. An important consideration for landholders is whether the remainder of the property will be viable once the project site is excluded from agricultural production.

The Australian Government, AEIC (2024) indicates that host landholders for solar farms and associated batteries are generally compensated by a fixed annual amount per hectare. The land is leased to the proponent via a long-term lease agreement for the anticipated life of the solar farm (usually 25 years with an option for renewal) similar to a commercial lease. Host landholders for wind farms are compensated under similar agreements but are generally paid a fixed amount per turbine per year for the life of the wind farm. The fee paid to the landholder may be either a flat annual fee per turbine or a fee based on the generating capacity of the turbine. A fee based on the generating capacity of the turbine (currently ca. 5-7 MW) accommodates for rapid advances in technology and the likelihood that the number of turbines that are required to be installed on a project area will be less than the original number intended for installation at the time of entering in to the agreement. As rapid technological advances may also result in the energy output capacity per hectare for solar farms being substantially greater than at the time of entering into the lease agreement, it is recommended that contemporary agreements have provision to adjust fees in the event of a turbine or solar panel capacity increase and/or a reduction in number of hosted assets (Australian Government, AEIC 2024). Landholders that host transmission lines and other ancillary assets (e.g. electrical substations, batteries, project offices etc.) may also be paid for the easement, and disturbance to the property and farming practices.

Individual payment arrangements are negotiated between the developer and the landholder, but it is recommended that payments commence no later than the start of project construction and cease no earlier than the completion of decommissioning and restoration of the landholder's property (Australian Government, AEIC 2024). It is common for a developer to propose more renewable projects or assets than will be finally approved or installed. Consequently, this may result in landholders 'missing out' on hosting assets or hosting less assets than originally expected, potentially reducing the income and profitability of the project for the landholder.

The addition of energy infrastructure to a rural property is likely to cause an increase in property council rates, land taxes, insurances and other levies. The land may also be reclassified from primary production use land to industrial use land and may increase the valuation of property. These financial impacts may be considerable for the landholder. Unless there is a specific agreement between the parties, the landholder is generally liable for payment of such fees/costs and any increases in property outgoings due to the project (Australian Government, AEIC 2024). Income tax implications for the landholder should also be considered before committing to host a renewable energy project.

Another key point to note is that project operators/owners may change many times during the life of the project, putting at risk any long-term funding arrangements to cover the costs of decommissioning. It is recommended that landholders ensure that commercial agreements clearly set out the responsibilities for securing and maintain the funding required to pay for decommissioning of the assets at the end of their useful life. In the event of a default by the project owner, the liability for decommissioning may ultimately rest with the landholder who generally does not have ownership of the project's assets and may be unable to recover the costs of any decommissioning assets from selling the assets remaining on the property. Decommissioning costs are expected to be considerable. For example, it has been estimated that the cost to

decommission a turbine (\geq \$600,000) could be equal to or greater than the total income generated for the landholder over a 25-year operating period (\$250,000 - \$750,000), (Australian Government, AEIC 2024).

2.2.3 Sources of information for landholders

It is essential that landholders obtain sound legal, financial and other professional advice before signing any agreement with a renewable energy proponent. It is important to note that the terms of an initial agreement (for the purpose of surveys and investigations) may legally bind the landholder to accept the terms of a later lease or easement agreement.

Useful sources of information for landholders considering hosting renewable energy projects:

- The Australian Government, Australian Energy Infrastructure Commissioner provides a list of observations and recommendations for host landholders and developers of renewable energy projects. Available at <https://www.aeic.gov.au/observations-and-recommendations/chapter-1-host-landowner-negotiations#-recommendations> (Australian Government, AEIC 2024).
- Queensland Renewable Energy Landholder Toolkit. Available at https://www.qff.org.au/wp-content/uploads/2023/07/QFF-Renewable-Energy-Toolkit-June23_web.pdf (Queensland Farmers' Federation 2023).
- Farm Powered – opportunities for regional communities in the renewable energy boom. Available at https://farmersforclimateaction.org.au/wp-content/uploads/2022/10/FARM_POWERED_FINAL.pdf (Stark *et al.* 2022).
- Queensland Solar Farm Guidelines – practical guidance for communities, landowners and project proponents. Available at https://www.epw.qld.gov.au/_data/assets/pdf_file/0012/16122/solar-farm-guidelines-communities.pdf (Queensland Government 2018).

3. General discussion

Demographic trends suggest that livestock productivity must increase substantially to meet the demands of an exponentially increasing, and more affluent, global human population who demand high quality red meat protein (FAO 2003; Struik *et al.* 2014; Harrison *et al.* 2021). The need to sustainably increase or intensify livestock production while concurrently reducing GHG emissions appear to be conflicting goals, given the strong link between productivity and GHG emissions (Bilotto *et al.* 2023). As such, it has been predicted that global livestock methane emissions will grow by another 30% by 2050 under current policies (Reisinger *et al.* 2021).

The Queensland Government's emissions reduction target of at least 30% below 2005 levels (191.9 Mt CO₂-e) by 2030 has been achieved 8 years ahead of schedule with total emissions in 2022 (124.1 Mt CO₂-e) being 35% below 2005 levels (Queensland Government 2024d). This reduction was primarily due to the large decline in emissions attributed to the land use, land-use change and forestry sector which declined from 66.2 Mt CO₂-e in 2005 to -15.9 Mt CO₂-e in 2022. The capacity to continue the conversion of land to forest in Australia has been modelled by CSIRO in a net zero to 2050 scenario (Climate Change Authority 2024). The Australia-wide land sink was projected to increase through to 2050 with an additional 3 million ha of land converted to forest to provide a carbon sink of 129 Mt CO₂-e. However, the modelling indicated that by 2050, residual agricultural emissions are likely to remain for Australia under even the most ambitious scenarios (ca. 71-73 Mt CO₂-e) with residual emissions from enteric fermentation in the range of 26-46 Mt CO₂-e by 2050.

The current lack of available and cost-effective technologies, particularly those applicable to extensively grazed livestock, is a major impediment to GHG emissions reduction. CSIRO modelling indicates that enteric methane emissions from ruminant livestock in Australia are likely to reduce only modestly by 2050 even assuming technological breakthroughs can be made (Climate Change Authority 2024). Mandatory climate reporting, beginning in Australia from 1 January 2025, is expected to create supply chain demands that will drive the eventual implementation of emissions-reducing strategies by agricultural producers, including extensive livestock enterprises, in order for them to remain competitive.

The creation of the carbon market opportunities through the ACCU Scheme is a key strategy to encourage GHG abatement in Australia. However, with only 491 registered projects in Queensland relevant to grazing land or enterprises, and a total of 13,150 grazing businesses, the level of engagement in carbon markets has been low for the sector. Impediments to participation are likely to include a lack of suitable and economically attractive methods, and uncertainty about future requirements for carbon to be retained as a farm asset to maintain market access for farm products.

It is predicted that without adaptations to climate change, livestock production and profitability across many Australian regions will decline primarily due to a decreased pasture growing season and compounding cascading extreme weather events (Henry *et al.* 2018; Bilotto *et al.* 2023). Therefore, it appears apparent that livestock producers in Australia will face substantial future challenges requiring GHG mitigation and climate change adaptation as well as adoption of strategies that enable profitability and business resilience.

3.1 Environmental market opportunities and challenges for landholders

Research has indicated that individual landholders engaging in carbon projects in Queensland were motivated to adopt carbon farming primarily for the perceived economic benefits (Baumber *et al.* 2022; Jassim *et al.* 2022). As such, it is important that landholders have access to sound technical, economic and financial analysis to indicate the potential outcomes of engaging in such markets. While there is potential for engagement in environmental markets to provide a diversified income and improve the viability of grazing businesses, there are also risks that need to be considered and appropriately evaluated. A farm business that dedicates resources to a diversified activity will not then have those resources available for alternative uses (Hansson *et al.* 2010). Therefore, a property-level economic analysis that appropriately considers the opportunity cost of the alternative land uses is required to understand the economic consequences for the business. A consideration of the environmental and social implications of diversification will also be important. As commodity prices, market conditions and carbon targets continue to evolve, the economic consequences of engaging in alternative land use options for landholders will need regular evaluation to

inform and support landholder decision-making. Additionally, the industry-level and wider economic and social implications of land-use change out of agricultural production is poorly understood.

It is evident that the majority of ACCUs to-date have been produced using now closed, or soon to expire, methods. In particular, the AC/Avoided deforestation (AD), HIR and Native forest from managed regrowth (NFMR) methods have produced 51% of Australia's total ACCUs (54% of Queensland's) and 79% of Australia ACCUs from methods applicable to grazing livestock businesses (80% of Queensland's), (Table 1, Table 2). Furthermore, the majority of ACCUs have been generated from two of these Vegetation methods (AC and HIR) with these projects concentrated in the mulga lands of Queensland and New South Wales.

Up to a third of the mulga lands bioregion of south-west Queensland and western New South Wales; 7 million ha) has transitioned from extensive grazing to carbon farming in less than a decade (Jassim *et al.* 2022). Negative social impacts in rural communities where these projects are being undertaken have been identified and result from destocking of properties, increase in landholder absenteeism, non-active land management, and inequitable distribution of benefits (wealth) within the community (Baumber *et al.* 2022; Jassim *et al.* 2022).

The dominance of the low-productivity mulga lands in the generation of ACCUs to-date demonstrates the favourable ratio of carbon income to opportunity cost, i.e. the small amount of profit foregone per unit land area from existing land management (Baumber *et al.* 2020; Bowen *et al.* 2022). However, changing market and price signals may alter the economic attractiveness of engaging in carbon markets for more highly productive grazing lands of Queensland.

The closure of key Vegetation methods has left Queensland landholders with a lack of suitable methods applicable to grazing lands, reducing options for participation in the carbon market. The proposed IFLM method is still under development but is anticipated to enable crediting of carbon stored from managed regeneration and plantings of native forest and improvements to soil (Australian government, DCCEEW 2024e).

Agricultural methods have underperformed to-date, with Agriculture methods accounting for 28% of project registrations in Queensland but representing only 4% of total ACCU issuance (Table 2). While the Estimation of soil organic carbon sequestration using measurement and models method has 120 project registrations, only 10 have been issued with ACCUs which combined constitute only 0.6% of Queensland's total ACCU issuance.

The Beef cattle herd management method accounts for 2.3% of Queensland's ACCU issuance but these have been issued to only 3 of the 10 registered projects under this method (Table 2). These projects are held by large beef cattle operations with scale: AACo, Consolidated Pastoral Company and Paraway Pastoral. It has been identified previously (e.g., Bray *et al.* 2016) that a large scale of operation (e.g. > 50,000 cattle) would be required to cover the costs of implementation and to make the Beef cattle herd management method feasible for property managers. An additional consideration is that reducing emissions intensity as is required for the Beef cattle herd management method will generally result in greater enterprise/property emissions if grazing capacity is fully utilised, i.e. if animal numbers are not reduced (Almeida *et al.* 2023).

The Savanna burning and Savanna fire management methods are restricted in applicability to the northern savannas of Australia with > 600 m annual rainfall. In Queensland there are 50 registered projects, all found in the Cape York Peninsula region with 40 of these projects issued ACCUs constituting 10.6% of Queensland's total ACCU supply (Table 2).

Concerns have been raised that environmental market mechanisms may reward past poor environmental stewardship while providing no benefit for landholders who have historically implemented environmentally beneficial practices (Cotton and Witt 2024). Furthermore, significant concerns have been raised about administrative and governance failings in Australia's carbon credit scheme.

Both the HIR and AD methods have come under scrutiny due to concerns over the additionality and permanence of carbon abatement credited (Merzian *et al.* 2021; Macintosh *et al.* 2022a,b; Macintosh *et al.* 2024). Macintosh *et al.* (2024) identified that most HIR projects are non-compliant with key regulatory requirements that are essential to project integrity and have had minimal impact on woody vegetation cover in credited areas. These concerns have resulted in the retirement of the HIR method, which had generated by far the greatest proportion of ACCUs on the market, and a number of others that had had uptake. The

current lack of Vegetation methods in the ACCU Scheme has significantly reduced market opportunities for landholders.

Additionally, concerns have been raised about the integrity of soil carbon ACCU Scheme methods, with recent research indicating that soil organic carbon credits issued in 2023 were largely attributable to above-average rainfall rather than project interventions (Mitchell *et al.* 2024). More-over, these soil carbon gains were not sustained when rainfall returned to average, raising concerns about the additionality of the sequestration, beyond natural climatic variability. Recommendations to increase the minimum measurement period to at least 5 years and to increase the number of soil samples required (Mitchell *et al.* 2024) will likely decrease the financial attractiveness of soil carbon methods for landholders. The lack of evidence from research to-date, to indicate that grazing management directly influences soil carbon, limits the application of the soil carbon method for extensive grazing properties (McDonald *et al.* 2023; Henry *et al.* 2024). However, (1) converting from cropping to permanent pasture, or (2) sowing more productive grasses or legumes in existing grass pastures have been found to more consistently increase carbon stocks (Henry *et al.* 2024). These latter activities may provide opportunities for landholders with the proviso that there are soil and climate constraints to the quantity of soil carbon that can be sequestered and maintained over time (Mitchell *et al.* 2024).

The emergence of natural capital markets, and development of methodologies and frameworks to allow greater opportunity for payment of co-benefits and method stacking, is likely to improve the economic incentive for landholders to engage in environmental markets. Due to additionality and leakage clauses associated with the legislation and methods there are currently limited opportunities to 'stack' projects and therefore reduce overhead and administration costs. While there is opportunity to establish multiple distinct projects, each with distinct income streams, these will each have an administrative and cost burden. Therefore, it is possibly more economically efficient for landholders to scale the most profitable environmental market method/credit source rather than to diversify by establishing multiple projects. The developing co-benefits markets, including the LRF and the Australian Biodiversity Stewardship Package, provide more opportunities to increase the economic efficiency of engaging in environmental markets.

When a farm manager is considering diversifying their income streams through selling credits to carbon and environmental markets, it will also be important to consider the potential requirement for these credits to be retained as a farm asset to maintain market access for farm products. If credits have been sold off-farm they cannot be used to demonstrate farm climate and nature credentials (balances) as part of future market access and ESG reporting requirements. It has been estimated that even with optimistic assumptions about the ability of future methane mitigation technologies and herd management strategies to reduce emissions, that only relatively small proportion of emissions will be abated (e.g. a maximum 25% remissions reduction in Western Australian beef herds at full adoption; Wiedemann *et al.* 2024). This indicates that any carbon sequestration on-farm may need to be retained to improve property carbon balance and maintain future competitiveness for livestock products in the market. A key issue is that land-based carbon sequestration only provides a temporary, short-term benefit to emissions balances with sequestration rapidly decreasing as trees mature, a principle clearly demonstrated by Jigsaw Farms in western Victoria which was only able to maintain carbon neutral status for ca. 6 years (2011-2016) following tree planting on 19% of the farm (Brown 2024). The relative benefits of selling sequestered carbon or retaining it for short-term market access credentials will have to be evaluated by landholders. While carbon sequestration methods rely on a finite accumulating stock, emissions avoidance methods can be utilised up until the point that market access requirements come into force.

Other important considerations for landholders when engaging in environmental markets include implications for taxation and land value, as well as potential negative consequences from financial lenders (banks) who have tended to regard carbon contracts as an encumbrance and a financial liability, rather than a source of income (Jassim *et al.* 2022).

The medium to long term (i.e. 30-year) economic consequences for landholders from engaging in carbon projects are largely unknown. The uncertainty surrounding opportunity costs, impacts on production and future land values, and uncertainty about future market access requirements, are a deterrent to landholder participation. There is an urgent need for comprehensive, farm-level analysis to understand the trade-offs and opportunities for landholders and thereby support adoption of practices that enable net zero emissions targets, and other sustainability and biodiversity obligations, to be met. As carbon market opportunities continue to evolve, new opportunities (methods and markets) should be examined as they arise. It is

expected that there will be large variation across Queensland bioregions in the profitability of implementing carbon and environmental projects. Therefore, analysis should be conducted to encompass this variability.

3.2 Renewable energy project opportunities and challenges for host landholders

Queensland Farmers' Federation (2023) estimated that to achieve a 25 GW renewable energy generation target by 2035, 40,200 ha of land would be required for solar farms (assuming 4ha/MW) and 540,000 ha of land for wind turbines (assuming 200 ha / wind turbine). Opportunities to host these projects will likely occur relatively close to the backbone transmission network or the regional distribution network.

Cleared land previously used for grazing or crop production are typically the target sites for renewable energy developments of wind turbines and solar arrays. While there is limited opportunity or economic incentive for co-locating farming activities with solar arrays, wind farms require a smaller proportion of productive land and co-existence with agriculture can more readily occur (Feuerbacher *et al.* 2022; Brent *et al.* 2023; Australian Government, AEIC 2024; Bowen 2024). An important consideration for landholders is whether the remainder of the property will be viable once the project site is excluded from agricultural production.

While there are opportunities for landholders with the optimal combination of location and landscape attributes to realise considerable economic benefits, there are also associated risks. To minimise these risks and avoid negative outcomes landholders must seek sound legal, financial and other professional advice before undertaking any agreement with a renewable energy proponent (Australian Government, AEIC 2024). Financial and economic implications of renewable energy projects for land classification and taxation should be considered. Additionally, in the event of default by the project owner, the liability for decommissioning may ultimately rest with the landholder. The costs of decommissioning of infrastructure are estimated to in some cases exceed the total income generated for landholders over the 25-year operating period of renewable energy projects (Australian Government, AEIC 2024). Professional advice is essential to ensure agreements clearly set out the responsibilities for securing and maintaining the funding required to pay for decommissioning of the assets at the end of their useful life.

3.3 General comments - risks associated with diversification and land use change

It is evident that non-agricultural land uses, such as environmental market projects or renewable energy projects, are generally competitive with agriculture. Some land use options, such as Vegetation ACCU Scheme projects, and hosting solar energy plants, effectively result in land use change out of agriculture and livestock production. Analysts have highlighted the possibility that recent reforms to the Safeguard Mechanism will incentivise the purchasing of carbon offsets resulting in rapid and potentially undesirable land use changes (Deane *et al.* 2023). Combined with the increasing pace of renewable energy installations, these alternative land uses have the potential to add to the growing pressures on the land and water resources that provide food, fibre, biodiversity and cultural value (Climate Change Authority 2024).

Negative outcomes from diversification into non-agricultural land uses could include reduced agricultural production, financial risks to farmers, and other social and economic impacts on rural communities where carbon farming or renewable energy projects are concentrated (Milne *et al.* 2024). As such, it has been identified that achieving a balance between competing land uses will be important to avoid unintended consequences and to earn social license. For example, stakeholders have highlighted that it will be important that carbon sequestration projects also achieve other benefits such as biodiversity, social and cultural benefits (Climate Change Authority 2024). While there appear to be opportunities for landholders to realise considerable economic benefits from land use diversification in the right circumstances, these benefits are unevenly distributed across and within regions. This inequitable distribution of wealth can create divisions within communities and society more broadly (Australian Government, AEIC 2024; Milne *et al.* 2024).

At the producer level, diversifying sources of income can have the effect of smoothing income over time through reducing risks from climate and market variability, and therefore can improve business resilience (Roest *et al.* 2018; Tocker *et al.* 2022). However, an important point to note in terms of income

diversification from engaging in environmental markets is that carbon and ecosystem services credit issuance are closely linked to rainfall, as is grazing livestock production. Thus, these income streams likely share the same vulnerability to drought and climate variability. The hosting of renewable energy projects is more likely to provide true income diversification due to the independence of the income streams from climate-related variables.

The profitability of the existing enterprise, and therefore the opportunity cost of making a change in land use, will be a key determinant of whether diversification is attractive to the landholder. To better inform decision making it will be important to appropriately assess the potential effects of diversification on profitability, riskiness and indebtedness of the overall business. The decision about whether to diversify will not only depend upon considerations of financial pressures or the desire for growth and profit, but will also depend upon the attributes of the property, the attitude to risk, knowledge, skills, goals and lifestyle preferences of the management team and upon family relationships and inheritance issues for family businesses (Medhurst and Segrave 2007; Currey *et al.* 2024).

4. Proposed research to better understand opportunities and challenges for diversification of income streams

To understand the effect on property profitability and risk, of engaging in either environmental markets and/or renewable energy projects, economic and financial analysis to understand the impacts at the property level are required. A sound analysis of these strategies must incorporate (1) any additional capital and labour required, (2) the effect on livestock herd structure and performance, (3) the implementation phase, (4) the timing of costs and benefits, (5) the economic life of the investment, and (6) the assessment of the financial impacts and risks associated with each change in management (Malcolm 2000, Malcolm *et al.* 2005; Bowen and Chudleigh 2021a). The analysis should be conducted over a sufficient time period, e.g. 10-30 years, to understand the medium- to long-term effects of the change in management of the property.

It is recommended that such analysis should be based on the experiences of real property managers and their available choices, requiring extensive consultation with the managers of grazing businesses across a range of regions and who have been engaged in at least one of the diversification options of interest.

Producer data and experience should be combined with any available research data to indicate the impact of the diversification options over time, on livestock productivity, including effects on safe stocking rates (property carrying capacity), individual liveweight gain, mortality and reproductive performance.

Whole-farm models representing relevant regions of interest should be developed, including the livestock herd structure and performance in the 'base property', before and after implementation of the various strategies of interest.

To understand the risk aspects of these income diversification strategies, the analysis should apply Monte Carlo simulation to understand the possible scenarios and the probability they will occur. The software package @RISK is one package that could be used for this task (Lumivero 2024). This risk analysis should incorporate climate variability and climate change scenarios, price and product yield variability, and correlations between price, yields and seasons. A key aspect should be investigating the potential impact on future product price due to selling carbon credits off-farm (engaging in carbon markets) rather than retaining carbon for farm balances and market access. The short-term nature of benefits due to sequestration activities should also be incorporated.

In addition to a better understanding of the risks and benefits for landholders, it is clear that the implications of land use change for commodity markets and rural communities also need consideration and further research and analysis at the industry level.

5. Conclusions and recommendations

There is potential for alternative land uses to provide a diversification of income streams for landholders, which could complement existing production systems in the grazing lands of Queensland. Environmental markets and opportunities to host renewable energy projects, were the focus of this review. It was concluded that a lack of understanding of the effects of engaging in alternative land use options is likely deterring participation. There is also a risk that perverse outcomes could occur in terms of property profitability, permanent land use change out of agriculture in productive regions, and wider effects on supply chains and the economy.

As the decision to engage in environmental markets or alternative land use opportunities is made by the farm manager, there is an urgent need for comprehensive, farm-level economic analysis to understand the trade-offs and opportunities for landholders and thereby support adoption of practices that enable net zero emissions targets, and other sustainability and biodiversity obligations, to be met. As carbon market opportunities continue to evolve, new opportunities (methods and markets) should be examined as they arise. It is expected that there will be large variation across Queensland bioregions in the opportunities available and the profitability of implementing carbon and environmental projects, or hosting renewable energy projects. Therefore, analysis should be conducted to encompass this variability. Such analysis should include the opportunity costs, effects on agricultural production, profitability, indebtedness, future land values, and the riskiness of these diversification opportunities. A key aspect should be investigating the potential impact on future price of agricultural products due to selling carbon credits off-farm (engaging in carbon markets) rather than retaining carbon for farm balances and market access. The short-term nature of any benefit from carbon sequestration, should be considered.

In addition to a better understanding of the risks and benefits for landholders, it is clear that the implications of land use change for commodity markets and rural communities also need consideration and further research and analysis. The insights from appropriate economic analysis will allow landholders to make informed decisions and policy makers to implement strategies that facilitate desired engagement with these opportunities while avoiding perverse outcomes from land use change.

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7. Glossary of terms and abbreviations

Table 6 Glossary of terms and abbreviations

Abbreviation/Term	Definition
ACCU	Australian Carbon Credit Unit. An ACCU is a unit issued to a person by the Clean Energy Regulator. Each ACCU issued represents one tonne of carbon dioxide equivalent (t CO ₂ -e) net abatement (through either emissions reductions or carbon sequestration) achieved by an eligible offset project. ACCUs may be sold to generate income, either to the Australian Government through a carbon abatement contract or to companies and other private buyers in the secondary market.
ACCU Scheme	Australian Carbon Credit Unit Scheme, formerly known as the Emissions reduction fund (ERF). The Scheme provides incentives for a range of organisations and individuals to adopt new practices and technologies to reduce their emissions or store carbon.
Carbon account / audit	Equivalent to a net emissions calculation (NE = t CO ₂ -e / business unit) and includes: (1) all GHG produced within the boundary of the farm enterprise, (2) Annual changes in soil and tree carbon, and (3) Adjustments for carbon offsets bought or sold (note, SBTi only allows purchased offsets for the intractable residual emissions).
Carbon accounting	The process used to quantify greenhouse gas (GHG) emissions from an enterprise.
Carbon footprint	Equivalent to an emissions intensity calculation (EI = t CO ₂ -e / t product). The process of quantifying GHG emissions emitted directly or indirectly by an individual, company or product (i.e. the sum of Scope 1, 2 and 3 emissions). A carbon footprint is more commonly used for products (i.e. beef) than enterprises, but it can be applied at either scale. Several standards exist to define a carbon footprint, such as ISO 14067.
Carbon neutrality	The sum of GHG emissions is completely offset by equivalent carbon sequestration. This may be achieved within an enterprise or by purchasing carbon credits.
Carbon sequestration	The process whereby carbon dioxide is removed from the atmosphere and stored in carbon sinks such as soil and vegetation.
Carbon sink	A reservoir that absorbs carbon dioxide from the atmosphere. Natural carbon sinks include, plants, soils and the ocean.
Carbon stocks	A carbon stock refers to the quantity of carbon that has been sequestered from the atmosphere and is stored in a carbon sink.
CER	Clean Energy Regulator. The CER was established by the <i>Clean Energy Regulator Act 2011</i> and is a non-corporate Commonwealth entity which administers schemes legislated by the Australian Government for measuring, managing, reducing or offsetting Australia's carbon emissions.
CO ₂ -e	Carbon dioxide equivalent. Unit used to compare emissions from different GHGs based on their global warming potential (GWP) over a specified time period, typically 100 years (GWP ₁₀₀)
Discounting	The process of adjusting expected future costs and benefits to values at a common point in time (typically the present) to account for the time preference of money. With discounting, a stream of funds occurring at different time periods in the future is reduced to a single figure by summing their present value equivalents to arrive at a net present value (NPV). Note that discounting is not carried out to account for inflation. Discounting would still be applicable in periods of nil inflation.
Discount rate	The interest rate used to determine the present value of a future value by discounting. This helps determine if the future cash flows from a project or

	investment will be worth more than the capital outlay needed to fund the project or investment in the present.
Economic analysis	Economic analysis usually focusses on profit as the true measure of economic performance or how efficiently resources are applied. The calculation of profit includes non-cash items like opportunity costs, unpaid labour, depreciation and change in the value of livestock or crop inventory. NPV and amortised NPV are both measures of profit.
EI	Emissions Intensity. Emissions intensity values are based on the net emissions relative to the output (e.g. per kg beef, sheep meat or greasy wool). Emissions intensity values allow for comparison and benchmarking between farms of different sizes. They are the standard unit for a carbon footprint.
Enteric methane	Methane produced through enteric fermentation where plant material is broken down in the rumen. Enteric methane is the by-product of this process and is expelled by the animal through belching.
EOFY	End of Financial Year.
ERF	Emissions Reduction Fund. An Australian Government program, established in 2014, to incentivise Australian businesses to reduce the amount of GHGs they create and to undertake activities that store carbon. This scheme is now known as the Australian Carbon Credit Unit (ACCU) Scheme.
ESG	Environmental, Social and Governance. A holistic framework that measures the sustainable and ethical behaviour of a business. Australia introduced mandatory ESG reporting requirements for large businesses, commencing 1 January 2025. The legislation requires large Australian corporations and asset managers to make mandatory climate-related financial disclosures in their annual reports at the end of each financial year.
Financial analysis	Financial analysis focusses on cash flow and the determination of whether all business and family cash costs can be met. Financial analysis can also include analysis of debt servicing capacity.
Forest cover	In ACCU Scheme Vegetation methods, 'forest cover' is defined as having 20% crown cover at a tree height of at least 2 m, across an area of at least 0.2 ha.
FullCAM	Full Carbon Accounting Model. A calculation tool for modelling Australia's greenhouse gas emissions from the land sector. FullCAM is used in Australia's National Greenhouse Gas Accounts for the land use, land use change and forestry sectors. Results from modelling are used to produce the annual totals for Australia's National Inventory Reports. FullCAM is also used to generate abatement estimates for methods under the ACCU Scheme.
GHGs	Greenhouse Gases. Gases that absorb and emit radiant energy and that are reported under the National Greenhouse and Energy Reporting scheme. GHGs include carbon dioxide (CO ₂), methane (CH ₄), nitrous oxide (N ₂ O), sulphur hexafluoride (SF ₆) and specified kinds of hydro fluorocarbons and perfluorocarbons. GHG emissions are measured as kilotonnes of carbon dioxide equivalence (CO ₂ -e).
Gold standard	A voluntary international GHG standard that provides methodologies to ensure projects that reduced carbon emissions feature the highest level of integrity in line with the Paris Climate Agreement and the Sustainable Development Goals.
Gross margin	The gross income received from an activity less the variable costs incurred. Gross margins are only the first step in determining the effect of a management decision on farm or business profitability. To determine the value of a potential strategy to the 'whole farm' or business, a more complete

	economic analysis is required in the form of a marginal analysis that considers the effect of alternative strategies at the property or business level.
GW	Gigawatt. A unit of power equal to one billion watts or 1,000 MW.
GWP	Global Warming Potential. A measure of cumulative radiative forcing, which aims to quantify the long-term contribution of a greenhouse gas to global warming. Each GHG has a specified GWP value, and this is relative to a specified time period (typically 100 years, but values are also available for 20-year and 500-year time horizons). The 100-year time horizon is abbreviated as GWP ₁₀₀ .
IPCC	Intergovernmental Panel on Climate Change. An intergovernmental body of the United Nations. Its objective is to provide policy-makers with regular scientific assessments on climate change, its implications and potential future risks, as well as to propose adaptation and mitigation options.
IRR	Internal Rate of Return. This is the discount rate at which the present value of income from a project equals the present value of total expenditure (capital and annual costs) on the project, i.e., the break-even discount rate. This indicates the maximum interest that a project can pay for the resources used if the project is to recover its investment expenses and still just break even. IRR can be expressed as either the return on the total investment or the return on the extra capital.
LGA	Local Government Area. These state-defined areas are used by the Australian Bureau of Statistics in the collation and dissemination of official statistics.
LRF	Land Restoration Fund. A Queensland Government program to encourage private investment which delivers biodiversity and other sustainability co-benefits to carbon offsets.
Marginal	Extra or added. Principle of marginality in economics emphasises the importance of evaluating the changes for extra effects, not the average level of performance.
MW	Megawatt. A unit of power equal to one million watts or 0.001 GW.
n/a	Not applicable
n/c	Not able to be calculated
NE	Net Emissions. Total GHG emissions minus carbon sequestration
Net profit	This is the reward to the farmers own capital. Net profit equals operating profit less the returns to outside capital. The returns to lenders of fixed capital (interest, rent, leases) are deducted from Operating profit in the calculation of Net profit. It is available to the owner of the business to pay taxes or to provide living expenses (consumption) or it can be used to reduce debt. Net profit minus income tax minus personal consumption (above operators allowance if it has already been deducted from operating profit) = change in equity.
Net zero	Calculated as zero t CO ₂ -e / denominator, where the denominator is either the business enterprise or the product.
NGGI	National GHG inventory. The NGGI accounts for and estimates Australia's GHG emissions.
NIR	National Inventory Report. The annual report released by the Australian Government with results from the NGGI and the methods used to determine those emissions.
NPV	Net Present Value. Refers to the net returns (income minus costs) over the life of an investment, expressed in present day terms. A discounted cash-flow allows future cash-flows (costs and income) to be discounted back to an NPV so that investments over varying time periods can be compared. The

	investment with the highest NPV is usually preferred. NPV is calculated at a rate of return (usually 5-7%) which is taken as the real opportunity cost of funds to the producer.
NRM region	Natural Resource Management region. NRM regions across Australia are based on catchments or bioregions. The boundaries of NRM regions are managed by the Australian Government and used for statistical reporting and allocation and reporting of environmental investment programs.
Operating profit	The return to total capital (equivalent to total assets) invested after the variable and overhead (fixed) costs involved in earning the revenue have been deducted. Operating profit represents the reward to all of the owners of the capital tied up in the enterprise. Operating profit equals gross margin (total receipts minus variable costs) minus overheads. When operating profit is expressed as a percentage return to total capital it indicates the efficiency of the use of all of the capital invested in the farm enterprise. In the Dynama spreadsheet (within the Breedcow and Dynama (BCD) software package) the 'return on total non-cash assets' is equivalent to the operating profit. Both calculations are identical and are adjusted for the annual change in livestock inventory and the annual cash surplus or deficit.
Opportunity cost	The benefit foregone by using a scarce resource for one purpose instead of its next best alternative use.
Payback period	The number of years it takes for the cumulative present value to become positive. Other things being equal, the shorter the payback period, the more appealing the investment.
Peak deficit	This is an estimate of the peak deficit in cash flow caused by the implementation of the management strategy. It assumes interest is paid on the deficit and is compounded for each additional year that the deficit continues into the investment period. It is a rough estimate of the impact of the investment on the overdraft if funds for the development are not borrowed but sourced from the cash flow of the business.
PMAV	Property Map of Assessable Vegetation. This is a property-scale map that shows the boundaries of vegetation categories on a property, defined and administered by the Queensland Government.
Radiative forcing	A concept used to quantify a change to the balance of energy flowing through the earth's atmosphere. Radiative forcing is defined as the difference between incoming solar radiation and outgoing infrared radiation (i.e. net radiative flux) at the top of the atmosphere caused by external drivers of climate change. This concept enables the climatic effects of various changes to the planet to be approximately compared.
Rate of return on total capital	An estimate of how profitable a business is relative to its total capital (or total assets). It is the operating profit expressed as a percentage of the average of the total capital employed for the period under review (usually a year). In the Dynama spreadsheet (within the Breedcow and Dynama (BCD) software) the 'percentage return on total non-cash assets' can be taken as equivalent to the rate of return on total capital but only for steady-state base cattle herds before implementing a change in management.
REZ	Renewable Energy Zone. REZs are the equivalent of modern-day power stations. They combine (1) new energy infrastructure, including generators such as solar and wind farms, (2) storage such as batteries and pumped hydro, and (3) high-voltage transmission infrastructure.
Safe carrying capacity	A safe carrying capacity for a property is defined as a strategic, i.e., long-term (e.g., 20-30 years) estimate of livestock numbers that can be carried without any decrease in pasture condition and without accelerated soil erosion.
Safe stocking rate	A safe stocking rate is a short-term, tactical (seasonal or annual) stocking rate based on seasonal forage budgeting principles and safe utilisation rates

	of pasture. A safe stocking rate may be higher or lower than the long-term safe carrying capacity due to seasonal variability in rainfall.
SB-GAF	Sheep and Beef GHG Accounting Framework tool which can be used to generate a carbon account. Developed by the University of Melbourne to align with the National Greenhouse Gas Inventory to predict the magnitude and sources of GHGs emitted from a farm and a product at the farm gate.
SBTi	Science Based Targets Initiative. A corporate climate action organisation.
Scope 1 emissions	Direct GHG emissions from sources that are owned or controlled by a company.
Scope 2 emissions	GHG emissions from the generation of purchased electricity consumed by a company.
Scope 3 emissions	GHG emissions that are the consequence of the activities of the company but occur from sources not owned or controlled by the company. Examples include emissions from purchased supplements, and use of services. These emissions can relate to the supply chain prior to the business (i.e. purchased cattle) or after the business in the supply chain (i.e. meat processing).
Variable costs	These costs change according to the size of an activity. The essential characteristic of a variable cost is that it changes proportionately to changes in business size (or to change in components of the business).

8. Appendix 1. Carbon accounting for beef cattle and sheep enterprises

In order to consider opportunities and risks of engaging in carbon projects, and the potential impact on market access and ESG reporting for their livestock production enterprise, producers need to first have an understanding of their farm carbon account and carbon footprint of production. Carbon accounting is the process used to estimate the GHG emissions and sequestration associated with an enterprise. As it is difficult and expensive to measure actual emissions on-farm, standard calculations are applied to estimate net emissions (NE) from the property (business) and the carbon footprint (emissions intensity; EI) of products.

A carbon account (or audit) is equivalent to the NE of the business unit (t CO₂-e / business unit) and includes:

- All GHG produced which is essential to the management of business unit, including Scope 1 and 2 emissions and those Scope 3 emissions essential to the management of the property.
- The annual change in soil and tree carbon, based on a 10-year rolling mean.
- Adjustments for carbon offsets bought or sold (note that the SBTi only allows purchased offsets for the intractable residual emissions (Science Based Targets Initiative 2024)).

A carbon footprint or emissions intensity (EI) (t CO₂-e / t product) uses the same calculations as for a carbon audit except the denominator is the unit of product produced rather than the business unit. Additionally, the carbon footprint includes all Scope 3 emissions (pre-farm GHG and some post farm) as these are essential for the product produced. MLA-funded 'Life Cycle Assessments' conducted in 2019 indicated an average emissions intensity for beef production (from farm to processor) across the beef industry of 12.6 kg CO₂-e / kg liveweight (for the 5 years to 2015), (Wiedemann *et al.* 2019). Wiedemann and Dunn (2021) provide an expected range for emissions intensity (excluding sequestration) of 9-18 kg CO₂-e / kg liveweight gain for beef breeding, growing and finishing, and 5-9 kg CO₂-e / kg liveweight gain for beef cattle traded excluding scope 3 livestock emissions. The Australian Government provides an estimate of Australian cattle emissions intensity expressed per animal (i.e., per head) and calculated according to FAOSTAT methodology used in international trade forums: 1.83 t CO₂-e / head (5 year average, 2017-2021), (ABARES 2024b).

The net carbon position of the farm enterprise, or product from the farm, is therefore a summation of the GHG emissions minus the annual change in soil or tree carbon sequestered for that annual time-step. There are number of farm-based, GHG emissions tools available that estimate emissions for grazing properties (Table 3), the most widely accepted being the GHG Accounting Framework calculators (e.g., SB-GAF tool for sheep and beef) developed by the University of Melbourne (2023). Carbon sequestration is not estimated using the SB-GAF tool and must be estimated separately as part of a farm-based carbon audit. Soil carbon should ideally be measured in situ, using approved protocol but a combination of measurement and modelling (e.g. using FullCAM) is acceptable using approved models and approaches. Tree carbon is ideally measured directly by an accredited auditor but, as for soil carbon, direct measurements can be coupled with modelling using a peer-reviewed tree growth model, applicable to the Australian context (e.g. FullCAM).

To ensure that farm carbon audits have integrity and comply with international standards and frameworks, they must comply with Australian and international carbon accounting standards. As detailed by Eckard (2024), a whole-farm carbon audit must comply with the following guidelines:

- 1) The methodology should be consistent with the IPCC-approved, Australian National Greenhouse Gas Inventory (NGGI) methodology, only making adjustments where these are required to be more specific to the farm.
- 2) The methodology used should align with:
 - a. The Climate Active 'Draft Guideline: Land and Agricultural Emissions',
 - b. The Science Based Targets initiative (SBTi) FLAG Guidance
 - c. The ISO 14040 Life Cycle Assessment framework, and

- d. The ISO 14067 standard – Carbon footprint of products
 - e. Where the audit is self-declared, it should align with ISO 14021:2016 standard for Self-declared environmental claims.
 - f. Farm Scope 3 emissions factors should be aligned with the Ecoinvent or AusLCI database.
- 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).
- 4) The GHG balance must be calculated on an annual timestep, but with annual change in soil and tree carbon sequestration calculated on a 10-year running mean, to minimise rainfall variability influences.
- 5) The audit should include:
- a. Scope 1 emissions. All direct GHG emissions (CO₂, CH₄, N₂O) 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.
 - b. Scope 2 emissions. Electricity purchased from a fossil fuel origin onto the farm.
 - c. Scope 3 emissions. Include all pre-farm embedded emissions associated with the purchase of products on to 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”.
 - i. Scope 3 should be included in a *carbon neutral product audit*, as these emissions are essential to producing the product.
 - ii. Not all Scope 3 emissions are needed in a *carbon neutral property audit*, only those that are essential to the management of the property.
 - iii. Corporate companies must 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.
 - d. Allocation. Where more than one product is produced, a protein-based allocation (livestock) or mass-based (lint vs seed) should be applied to apportion the emissions between products. The proportion allocation should be acknowledged/accepted by the industries, e.g. 15% of dairy farm emissions can be allocated to red meat production if bull calves are sold to a beef producer.
 - e. Carbon credits sold. 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 of the audit. Carbon credits generated and retained within the boundaries of the audit (i.e. an ‘inset’) are credited once and then retired.