Policy Brief

Making low-carbon agriculture verifiable: Reducing the cost of measuring on-farm emissions in Queensland

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About the Hub

The Queensland Decarbonisation Hub brings together knowledge, people and innovation to co-create solutions to accelerate Queensland's clean growth future. We connect Queensland universities, industry, communities, First Nations people and government to build and share the knowledge needed to reduce emissions. The Hub's vision is for Queensland to become a leading decarbonised economy in which communities, industry and the environment thrive.

About this policy brief

In 2024, the Queensland Decarbonisation Hub initiated a funded research stream, inviting proposals for research that could contribute to understanding and supporting Queensland's decarbonisation transition. The Hub's Advisory Committee, which brings together representatives from industry and other sectors, helped inform the selection process by identifying areas where research could add value to emerging policy and practice. Eight projects were selected across a diverse range of topics, including the research featured in this brief.

Each project has produced a detailed technical report, which is undergoing review prior to publication. Alongside these reports, the Hub has worked with the research teams to consider a different question: what does the research mean for policy and practice?

This question was explored through a series of workshops and the Hub's Research Showcase, where researchers presented their findings to an audience drawn from government, industry, research and the wider community. These policy briefs build on that process. They are intended as short, accessible companions to the technical reports, highlighting the findings that matter most beyond the research itself and the questions and opportunities they raise for Queensland and Australia more broadly.

About this research

Much of the discussion about agricultural decarbonisation focuses on identifying new ways to reduce emissions. This research addresses a different challenge: how to verify those reductions in a way that is both scientifically robust and commercially practical. While a range of farming practices are already known to reduce nitrous oxide emissions, widespread adoption has been constrained by the cost and complexity of demonstrating that these reductions have occurred under commercial farming conditions.

The study shows that this barrier can be substantially reduced by combining targeted field measurements with modelling and existing scientific datasets. Rather than relying on intensive field monitoring, the approach provides a practical pathway to maintaining confidence in emissions estimates while significantly reducing the cost of verification. This approach has implications well beyond research, supporting more practical Measurement, Reporting and Verification (MRV) systems for agricultural producers, supply chains and governments.

The significance of this work extends beyond emissions accounting. As export markets increasingly seek evidence of low-carbon production, credible and affordable verification will become an important part of maintaining the competitiveness of Queensland's agricultural industries. The research shows that innovation is not only about developing new technologies; it is also about improving the evidence needed to support their adoption.

Dr Liz Young

Research Director, Queensland Decarbonisation Hub

From the Showcase Session Facilitator

One of the key challenges in implementing on-farm monitoring and the promotion of greenhouse gas emission mitigation actions is the cost and complexity of doing this at a property scale. This project provides some important work that verifies that such on-farm measurements, supported by modelling, may make monitoring of carbon and nitrous oxide emissions more viable at a farm scale, leading to greater adoption of mitigation practices as well as confidence in the use of this data for reporting at both a property and industry scale.

Chris Norman

CEO, NRM Regions Queensland

1. Why this research matters

Agricultural industries are under increasing pressure to demonstrate and reduce greenhouse gas (GHG) emissions derived from their production processes. Export markets, food manufacturers and supply chains are increasingly seeking evidence that agricultural products are produced with lower carbon footprints. For Queensland's agri-food sector, this creates both a challenge and an opportunity.

Nitrous oxide (N_2O) emissions from fertilised soils make one of the largest contributions to the carbon footprint of cropping systems. Scientific research has identified a range of farming practices that can reduce these emissions. However, adoption remains limited because N_2O emissions are highly variable and reductions are difficult to verify. Current evaluation approaches rely heavily on fixed emission factors that only reflect changes in fertiliser nitrogen (N) input amounts, unless costly high-frequency measurements are employed. This creates a critical gap: emissions claims that lack adaptability and credibility, or emission reductions that are too expensive to validate.

This project examined how N_2O emissions can be measured more efficiently while maintaining scientific confidence in reported emission reductions. The aim was to develop practical approaches that reduce verification costs and support wider adoption of emission mitigation practices across Queensland.

2. Key findings

Datasets of N_2O emissions from 20 high-frequency GHG monitoring trials were collated, representing 102 site-season-treatment combinations across Australian cropping systems. Most treatment-related N_2O emission differences occurred within approximately 100 days after fertiliser application and were strongly associated with rainfall or irrigation events.

The study found that conventional gas sampling schedules and linear interpolation approaches require more than 30 sampling events per season to reliably quantify N_2O reduction. This level of monitoring is often too costly for large-scale implementation.

By combining strategically timed field measurements with process-based modelling and data-driven approaches, seasonal N_2O emission reduction could be estimated with similar accuracy using approximately 15–20 sampling events per season. This represents a substantial reduction in monitoring effort while maintaining confidence in emission reduction estimates.

Evidence from Australian studies also indicates that proven mitigation practices, including enhanced efficiency fertilisers and improved fertiliser management, could reduce direct N_2O emissions by approximately 50% collectively across the Queensland’s cropping industries.

3. Why the findings matter in practice

The findings provide a pathway to substantially reduce the cost of verifying on-farm N_2O emission reduction. By combining strategically targeted field measurements with modelling and existing scientific evidence, robust estimates of emission reduction can be achieved with significantly fewer monitoring events than conventional approaches. This improves the feasibility of Measurement, Reporting and Verification (MRV) frameworks for commercial farming operations.

Lower verification costs remove a key barrier to the adoption of proven on-farm emission reduction strategies. Farming practices such as enhanced efficiency fertilisers and improved fertiliser management have demonstrated substantial N_2O mitigation potential, but widespread uptake has been constrained by the often-high verification costs under real farming conditions. More practical and cost-effective verification approaches allow producers, supply chains and governments to implement and evaluate these mitigation strategies with greater confidence.

At a broader scale, cost-effective verification strategies can support the transition towards low-carbon agricultural production across Queensland. Verified reductions in product carbon footprint can support product differentiation and enhance the market access of Queensland's export-oriented agri-food industries, as global markets increasingly seek evidence of sustainable production systems.

4. Who should pay attention

Government and policy agencies could take advantage of the findings as these promote decarbonisation practices and enhance market access for agricultural industries in Australia.

Agricultural industries and producer groups could leverage this work to identify lower-cost pathways to verify emission reductions and demonstrate sustainability credentials to customers and supply chains.

Food manufacturers, processors and exporters can use the study to better verify reductions in product carbon footprint, supporting supply-chain decarbonisation commitments and product differentiation in global markets.

Carbon reduction strategy developers and methodology designers can use the findings to provide evidence that support the development of scalable verification approaches for agricultural emissions reduction projects.

Researchers and technology providers can take advantage of the project approach to combine field monitoring with modelling and digital technologies to improve agricultural emissions accounting.

5. What could happen next

The low-cost verification approach developed through this project could be tested and refined through commercial-scale demonstration projects across Australia's major cropping industries. These demonstrations would help evaluate how optimised measurement strategies can be integrated into emission reduction methodologies, supply-chain reporting systems and product carbon footprint assessments under real farming conditions. Continued expansion of the N_2O database established through this project would further improve verification accuracy and extend applicability across different regions, commodities and mitigation practices.

Over the longer term, Australia could build a low-cost MRV framework for N_2O emission reduction that combines targeted field measurements, process-based modelling and existing scientific datasets. This would provide producers, government agencies and supply chains with credible evidence of emission reductions, supporting wider adoption of mitigation practices and low-carbon commodity processes. Scaling such low-carbon agricultural production can help advance decarbonisation and enhance the market access of the agricultural industries in Queensland.

6. Points to note

The findings of this study are based primarily on cropping systems and focus on direct N_2O emissions from fertilised soils. Application to other agricultural systems and a broader range of mitigation strategies requires further investigation.

Estimated mitigation potentials are derived from published Australian research and represent technical potential under suitable conditions. Actual outcomes will depend on management practices, climate, soil conditions and adoption rates.

While modelling and targeted sampling can substantially reduce monitoring costs, strategic high-frequency monitoring sites remain important for ongoing validation and improvement of verification frameworks.

7. Contact

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