



A Wolf Called Opportunity

Colette Glazik, 2022 Scholar
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Scholar contact details

Colette Glazik

0400 001 385

Coletteglazik@gmail.com

Coletteglazik.com.au

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NUFFIELD AUSTRALIA Contact Details

Nuffield Australia

Telephone: 0456 916 506

Email: enquiries@nuffield.com.au

Address: 38 Walker Drive, Worongary, QLD 4213

Executive Summary

This document provides an overview of local and international attention to greenhouse gases (GHGs) and agriculture, focusing on how emissions affect agricultural systems and how the sector contributes to and is impacted by global GHG levels. It examines the key policy drivers—both governmental and industry-led—that are shaping national and international strategies for reducing emissions in agriculture.

A particular focus is given to the methodologies used to calculate emissions from ruminant livestock. I have found the current approaches often fail to accurately reflect the true dynamics of biogenic methane in grazing-based systems leading to an overstatement of emissions associated with these animals. This has important implications for how grazing livestock are represented in climate policy and sustainability reporting, and many far-reaching implications affecting farmers' ability to achieve economic viability.

These considerations raise the role of carbon markets in agriculture—how they operate, their practical impact (if that is less or more emissions), and whether they offer a viable path for supporting farmers to adopt more sustainable practices while remaining economically viable. By unpacking these interconnected issues, this research summary highlights both the challenges and opportunities facing agriculture in a carbon-constrained future.

Keywords: carbon, greenhouse gases, methane, livestock, wool, ruminant, agriculture, textile industry

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Foreword

In 2021, I was farming sheep for wool and meat alongside my parents, Rae and Lindsay Young, for decades they had run a low-input operation with a strong focus on revegetation and farming in a way that respect with the surrounding environment. That same year, a brand we supplied wool to asked us to complete a carbon footprint assessment of our farm, to measure the footprint of their wool garments. I expected the audit would highlight and validate their low impact methods of farming. However, as a ruminant-based operation, our main emission was methane, and despite operating in a low input way, with revegetation work, we were still net emitters.

What surprised me was that, according to the audit, the most efficient way to become carbon neutral—without reducing production—was to replace our diverse native plantings and fenced-off ecosystems with monoculture plantations of pine or blue gums. This would maximise carbon sequestration but at the cost of valuable biodiversity and ecosystem health.

As a trained lawyer with experience working in government, this realisation pushed me to look deeper into the scientific, legal and policy frameworks shaping these carbon targets. I wanted to understand how this policy ecosystem worked, and where it was failing sheep farmers, the wool industry, and the broader environment.

My research further exposed how the problem wasn't just with implementation—it was with the entire framing of the issue. Despite political rhetoric about supporting agriculture, I came to see that Australian policy is falling short. Worse still, current approaches risk increasing emissions and contributing to climate instability, all while asking farmers to take on disproportionate risk in unproven carbon markets.

The title of this report, *A Wolf Called Opportunity*, reflects that tension. In literature, the wolf has been a symbol of both transformation and threat. While agriculture is often sold the promise of opportunity—through carbon markets, sustainability-linked products, and climate-smart branding—the reality is far more complex. Much of this "opportunity" is fragile, poorly quantified, and in some cases, actively damaging to the long-term viability of farming businesses.

Guided by advice from my Nuffield mentor, James Walker, I looked beyond wool and sheep farming to explore broader environmental markets, policy ecosystems, and financial mechanisms that could shape agriculture's future. This journey took me across the world to many farming operations and associated businesses, from a sturgeon farm on the Black River in Uruguay to seaweed operations in Israel and Tasmania, a chopstick factory in Japan, Tesco's head office in London, to a regenerative cacao farm in Costa Rica. I attended a sustainable finance summit in Sydney and had conversations about sustainability-linked finance in London. I witnessed the second-hand clothing trade in Papua New Guinea, spoke with policy leaders and carbon brokers, and visited many well-regarded international research institutions across the world. These encounters gave me global insight into both the complexity and the potential of carbon and nature-based solutions, and also what

could be lost if we don't address the problem of climate change at local and global level.

The full scope of my research is necessarily constrained in this report. I have kept the focus narrowed to carbon – creating carbon neutral products and participation in carbon markets – and the policy drivers impacting Australian ruminant farmers. The information presented reflects the questions I've asked, the concerns I've uncovered, and some of the ideas I've explored in relation to carbon—always with the intent of understanding where the real value lies for farmers, and how we ensure that value is not only environmental, but also economic and enduring.

Table 1. Travel itinerary

Travel date	Location	Key visits (not all listed)
Week 1-4 3 – 28 March 2022	United Kingdom	• Bristol Port • The Palace of Westminster • The Goat shed • Condimentum • Thatchers Cider Company • Frogmary Green Farm • Lye Cross Farm • Fernhill Farm • Norwich Research Park • Houghton Estate • Holkham Estate • John Kirkpatrick, Tesco • Jo Dawson, HD Dawson • Curtis wool direct • Richard Davies, Hainsworth • British Wool • Leslie Prior (due to covid this meeting was held online) • Andrew Balmford, University of Cambridge (due to covid this meeting was held online) • Oliver Chedgely • Chris Taylor • Rob Howe – Vet Partners
Week 5 28 March – 1 April 2022	Ireland:	• Tommy Boland • Teagusc • University College of Dublin
May 2022	Sydney, Australia:	Kanganews Sustainable Debt Conference
June 2022	Tasmania	True South Seafoods – Factory Tour
Week 6-8 June 19 - 5 July, 2022	Costa Rica:	• IFAMA conference – presented on NGIN panel • Dos-Pinos • INCAE Business School

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		• Centro Agronomico Tropical de Investigacion y Ensenanza (CAITE) • IICA • Nortico • Hacienda Retes – sheep farm and cattle dairy
Week 8-12 12 August – 5 September 2022	Chile, Uruguay & Argentina	• Isidora Molina Perez de Castro • Matia Undurraga • Fundo El Reinal • Lucho Palacio, Cerro Azul • Pedro Otegui, Agustin Otegui, Hugo Surraco • Lanas Trinidad facilities in Durazno & Trinidad • Gabriela Bordabehere, La Soledad • San Gregorio De Polanco caviar farm • INIA • Ignacio De Barbieri • Oscar Blumetto • INTA • Sebastian Villagra • Daiana Perri • Andrea Enriquez
October 2022	Canberra, Australia	Australian Farm Institute roundtable on Natural Capital Accounting
Week 13-14	Colorado, USA	Textile Exchange Conference
Week 14-19 Global Focus Program	Singapore, Japan, Israel, Netherlands, USA	• Urban Farming - • Meat & Livestock Australia Singapore office • ANZ Singapore office • Mitsukoshi Ginza • Genpachi honey farm • The Australian Embassy, Tokyo • Tanaka Rice Farm • Sagotani Dairy • Miyajima Island & Oyster Farm • Seven Foods Vertical Integration • Bamboo chopstick factory • Sugimoto Shoten Mushroom farm • Kushima Aoifarm Sweet Potatot • Tsuno Winery • 'Mahaneh Yehuda' Jerusalem Market • Kibbutz neot Semadar • Kibbutz Yotvata • Ein Hazeva Cannabis Farm • Kibbutz Magal • Royal Flora Holland • Koppert Cres • Aeres Agricultural University • Zonnespelt • Bio Brass: organic vegetables

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		• US Department of Agriculture • Bayer Crop Science Headquarters • New Zealand Embassy, Washington DC • National Association of State Department of Agriculture • Cargil Meat Packing • Bowles Farming Company • Olam Agri • Turlock Fruit • Meyers Water Bank • HMC Farms • Nuveen
Week 19-20	Papua New Guinea	Visits to the clothing markets that sell second hand clothing imported from Australia and New Zealand.

Acknowledgments

“Who you learn with is as important as what you learn. Learning is a relationship, not just something that can be measured by outcomes or formal metrics.” Anna Balsamo

Thank you to family and friends who supported me to make this all possible. Thank you to everyone I met along the way, that gave me their time, thoughts and insights. I appreciate it more than I can say. From conversations on airport floors, endless walks in various locations, time in board rooms, on farms, car rides, plane journeys, video calls and late-night chats. Many of you have become close friends and have influenced the shape of my report, and my thoughts on life.

A special thank you to:

- Rae (Mum) and Lindsay Young for introducing me to the wonderful world of agriculture, and all that you have done for me along the way.
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- Tommy Boland & family for hosting me and providing a great tour of Ireland.
- Jodie Redcliffe and the entire Nuffield team & family – for all the commitment and passion you bring to providing the most amazing life changing experiences.

Abbreviations

ACCU	Australian Carbon Credit Unit
AASF	Australian Agricultural Sustainability Framework
AWI	Australian Wool Innovation
CH ₄	Methane
CN30	Carbon Neutral by 2030 – MLA's target for Australian red meat.
COP	Conference of the Parties
CO ₂ e	Carbon Dioxide Equivalent
DAWE	Department of Agriculture, Water and Environment
ERF	Emissions Reduction Fund
ESG	Environmental, Social, Governance
F-Gases	Fluorinated greenhouse gases
GHG	Greenhouse Gases
HFCs	Hydrofluorocarbons
IPCC	Intergovernmental Panel on Climate Change
LULUCF	Land Use, Land Use Change and Forestry
MLA	Meat and Livestock Australia
NFF	National Farming Federation
NGGI	National greenhouse gas inventory
NO ₂	Nitrous Oxide
PFCs	Perfluorocarbons
SBTN	Science Based Targets Network
SBTi	Science Based Targets Initiative
Sf ₆	Sulfur Hexafluoride
TNCD	Taskforce on Climate-related Financial Disclosures
TNFD	Taskforce on Nature-related Financial Disclosures
UN	United Nations
UNFCCC	United Nations Framework on Convention on Climate Change

Objectives

The objectives of this report is to:

- **Examine the current carbon landscape**
Analyse the key drivers shaping the global carbon agenda, including market mechanisms, policy developments, and their implications for agriculture.
- **Unravel carbon neutrality claims**
Unpack what lies behind carbon neutral claims—how they are constructed, communicated, their credibility and the complexity involved in their verification.
- **Identify systemic challenges**
Investigate the limitations and inconsistencies in how carbon is addressed through markets and policy frameworks, and assess the resulting impacts on farmers and agricultural systems.
- **Empower farmer engagement in policy**
Develop the case for why it is critical that farmers actively engage with, understand, and influence Australia's evolving policies and global positioning on carbon and nature, to ensure that agricultural realities and opportunities are accurately represented and supported.

Introduction

Sheep's wool holds a unique position in the market, as a natural, long-lasting, yet biodegradable fibre in both land and marine environments with applications across a diverse range of industries. These attributes make it attractive across a spectrum of textile industries from bespoke tailoring and outdoor technical pieces to carpet, insulation and sound proofing.

Australia is one of the world's largest producers of wool, and with an international reputation for producing a high-quality product we account for approximately 25% of greasy wool sold on the world market (Department of Agriculture, Fisheries and Forestry, 2022). Historically, a cornerstone of the global textile industry, the amount of wool used to produce textiles has reduced significantly since the introduction of synthetic, petroleum-based fibres such as polyester and nylon. Wool now represents only around 1.2% of the global textile market (IWTO, 2018 cited in Wiedemann, 2020).

The environmental impact of the textile and fashion industry, as well as the impact of livestock on carbon emissions and the environment have created a spotlight on the wool industry to take action to consider these impacts. This report discusses the broader impact of the fashion and textile industry on the environment, and considers what impact livestock, in particular sheep, have on greenhouse gas emissions, and what a 'carbon neutral' wool product may look like.

Whilst the interest in environmental sustainability had been a simmering topic since the Kyoto Protocol, after the Paris Agreement in 2015 a particular focus on carbon neutrality swept across the entire world. The Paris Agreement was the catalyst for governments and private sectors to declare various greenhouse gas emission reduction goals and initiatives. For example, in 2017 Meat and Livestock Australia (MLA) announced the ambitious target that Australia's red meat and livestock industry (covering sheep, cattle and goats) would be Carbon Neutral by 2030 (CN30). H&M, Inditex and Adidas were among some of the biggest fashion brands to come out with an early carbon neutral target. In 2015 Kering, owner of many fashion brands including Gucci, Saint Laurent, Alexander McQueen and Yves Saint Laurent launched an Environmental Profit & Loss account to measure the environmental impact of the groups operations and supply chain. Whilst these targets demonstrated a strong market indicator that industries were committing to improve environmental outcomes, how they were going to achieve this still remained unknown.

In March, 2022 at the very beginning of my Nuffield scholarship, whilst in London, I was invited by Textile Exchange, to present at John Lewis to a group of fashion brands and consultants on what it means on farm when brands set carbon neutral goals. In the room were leading fashion brands, in both sustainability, innovation and legacy. I explained that focusing solely on a carbon neutral goal can have perverse outcomes and that often a carbon footprint didn't reflect what was happening on farm, it was only a small part of a big picture. What followed my presentation was a fascinating discussion between the brands representatives in the room on the struggles that brands have to both source and quantify their negative and positive

impacts, the mistakes they've made and questions around what should brands be asking of suppliers of raw materials in terms of practice change, quantification. The meeting highlighted to me, the confusion of players along the supply chain, from farm gate, to consumer and everyone in between about what we should be asking for, and which of the very many external influences that are trying to change us should we listen to. In addition, once an action was taken, there were questions on how could it be quantified and communicated to customers in a clear and value adding way. Where the value lay in both making a change and quantifying, and if there was a cost who was to fund it was one of the many enduring questions.



Figure 1: Presenting at Textile Exchange event at John Lewis in London (source: author)

Understanding sustainability and climate neutrality in agriculture and in particular wool is a complex challenge. It requires consideration of a multitude of influences from the evolution of a ruminant, land management, product processing, policies and laws, international obligations, market demands, and of course the increasingly changing climate.

A *wicked problem* is generally described in literature as a social or cultural issue that is incredibly difficult, or even impossible to solve due to its deep-rooted complexity and the intricate interconnections between causes and potential solutions. Climate change is often described as a *super wicked problem* because it introduces additional layers of complexity, including urgency, political and social divisions, the paradox of polluters also being solution-seekers, multiple stakeholders, and conflicting interests.

When considering climate change and its environmental impacts through the lens of agriculture, the challenges become even more intricate. Navigating the interplay between policies, legal frameworks, market demands, and consumer expectations—while striving to maintain a profitable and resilient business—can make the path forward seem both complicated and unclear. These overlapping and constantly shifting factors add to the complexity of finding sustainable solutions.

With the many moving pieces and influencing factors, to consider just one piece alone such as carbon (as I naively thought I would at the beginning of my Nuffield travel) can end up with unintended negative consequences. Demonstrated below, in the well-known picture of 'carbon tunnel vision' by Jan Konietzko of missing related and important aspects when simply focusing on one element.

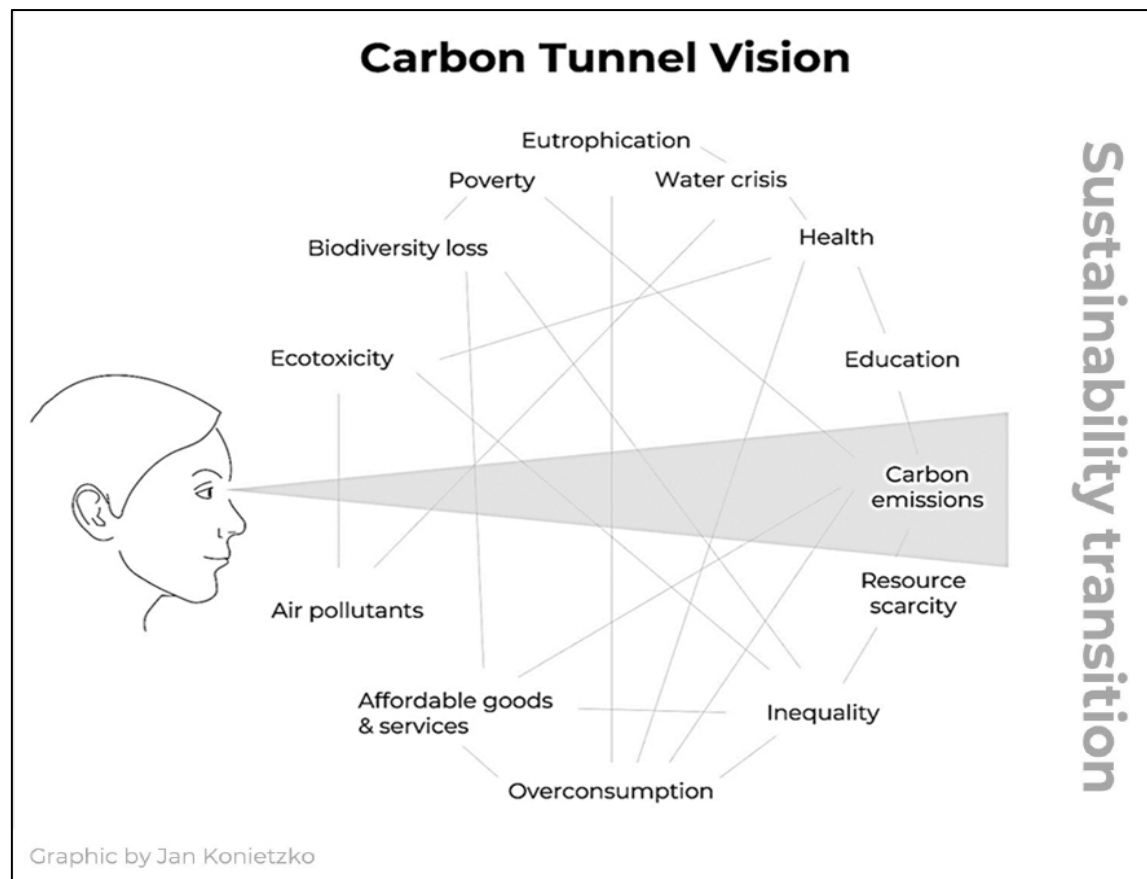


Figure 2: Carbon Tunnel Vision (source: Konietzko, J (2022))

This report attempts to give an explanation and overview of some of the climate and environment influences and policy drivers facing wool production and agriculture in general. The enormity of this topic has meant this document is in no way exhaustive and much has been left out. In addition, the speed of developments in this space means that by the time you are reading this, no doubt some of it will be outdated. My hope for this report was to clarify some of the drivers that impact agriculture, look at potential solutions and hopefully provide clarity on some of the policy drivers that will impact the ability of farmers to farm into the future, in the hope that informed decisions can be made so Australian agriculture can continue into the future.

Farmers, in particular, must navigate a landscape where a focus on achieving carbon neutrality is becoming a non-negotiable goal, how this is achieved and what value is able to be derived from it is still uncertain. There are many incredible producers in Australia and across the world that have quantified the environmental impact of their product, including some in wool production, communicated their minimal

environmental footprint and achieved a market premium. However, there are many that operate with a light footprint but have been unable to quantify and communicate that to their market for a premium, for some it is because they are commodity producers, for others it is because the cost of quantifications exceeds the market value in doing so. However, much wisdom can be taken from the leadership of these first movers, the challenges they faced and in how they farm and/or the process they took to quantify their practices and the markets they created for their product. Wool farming in Australia occurs in a diverse range of climates and environments making the successful actions on one farm, not necessarily possible on another. Given this, the report will focus more on the bigger picture in which wool as a commodity operates in terms of achieving carbon neutrality and nature markets rather than at individual farming level.

Australian Wool Innovation (AWI), alongside other Australian and international organisations, is pioneering research in on-farm technologies aimed at reducing methane emissions. As are many other wool and sheep producing countries such as Uruguay, Ireland and New Zealand. Rather than re-cap the research AWI and others have already published I have attempted to form a discussion around adjunct topics that are complementary to what they have achieved, and intertwine the insights I gained on my travels.

This report therefore summarises some concepts, ideas and thoughts that I have learnt along my Nuffield journey, since that initial meeting in London back in March 2022. The picture below aims to show the many influences that may impact wool and greater agriculture somewhere along the supply chain, the varied concepts and frameworks I have considered during this journey and the complexity of finding what to focus on and what will drive the biggest impact and value for farmers. The intent of the diagram is to convey the complexity and wickedness of the problem I set out to engage with.

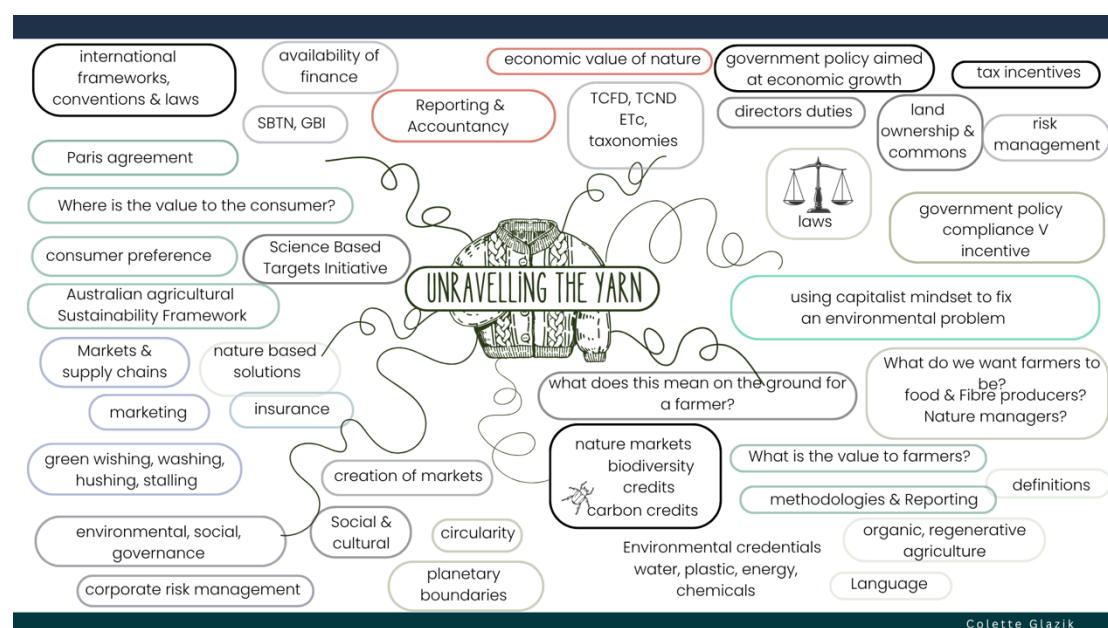


Figure 3: Unravelling the Yarn (source: author)

Case study 1: Net Zero Knits – MJ Bale

As part of Net Zero Knits Project by MJ Bale, methane reduced wool from feeding sheep asparagopsis was grown on Kingston farm as part of a PHD trial. The wool was then cycled to the Hobart Wharf (via the MJ Bale store in Hobart), where it was sailed across Bass Strait to Geelong to be washed and scoured, before being spun into a top in Bacchus Marsh, then cycled onto Macclesfield for spinning. The wool was then hand knitted into jumpers in Ballarat. Whilst the amount of wool that was produced in this project could fit in a tiny bale on the back of a bicycle, this project showcased Australian expertise in science, farming and manufacturing whilst promoting discussion around the possibilities of low carbon supply chains and possibilities.¹

The importance of innovation and out of the box thinking when tackling climate change is important. We need to challenge old ideas and ways of doing things to see what could be possible in the future. This project highlighted that it is possible to produce and process in a different way and the areas of the supply chain that could be structured in a different way.



Figure 4: Simon Cameron with Two Dogs who maintained chain of custody during the supply chain of the wool. (source: author) Figure 5: (L-R) The author, with Simon Cameron at the MJ Bale store in Hobart. (source: author)

¹ More information on the *MJ Bale Net Zero Knits* project can be found on the MJ Bale Website at: https://www.mjbale.com/pages/net-zero-knits?srltid=AfmBOooslRqoEgm9GD3K6wGbODsYdmdY8zHU5ZtU4Pa_CSgMbC5gs6Fm

Chapter one: The road to now

Greenhouse gases

In 1824, French physicist and mathematician Joseph Fourier proposed that Earth's atmosphere could influence the planet's surface temperature by 'trapping' heat. Fourier was among the first to describe what would later be known as the '*Greenhouse Effect*'. Greenhouse gases (GHG) capture energy and warm Earth's surface (similar to the effect of a glasshouse), creating a climate suitable for life. Without these gases, Earth's temperature would be around the same temperature as Earth's Moon, -23°C (Kruszelnicki, 2021).

Whilst greenhouse gases are essential to human life on earth, human activity such as burning fossil fuel and land use change has increased the amount of these naturally occurring GHG in the atmosphere, trapping more heat and warming the planet, creating climate instability, where weather patterns are changing and more weather extremes are being experienced.

The United Nations has identified the main anthropogenic (human induced) gases that are contributors to climate change to be Carbon Dioxide (CO_2), Methane (CH_4), Nitrous Oxide (NO_2) and fluorinated gases known collectively as the 'F-gases'². These gases trap heat at different levels (their 'warming potential') and 'live' in the atmosphere for different lengths of time. Given this, for ease of comparisons GHG are converted into Carbon Dioxide Equivalents (CO_2e) which allows for the gases to be compared. However, it is important to note that *'there is no absolute equivalence between different GHGs as they each vary in radiative efficiency and atmospheric lifetime'* (Ridoutt, 2021).

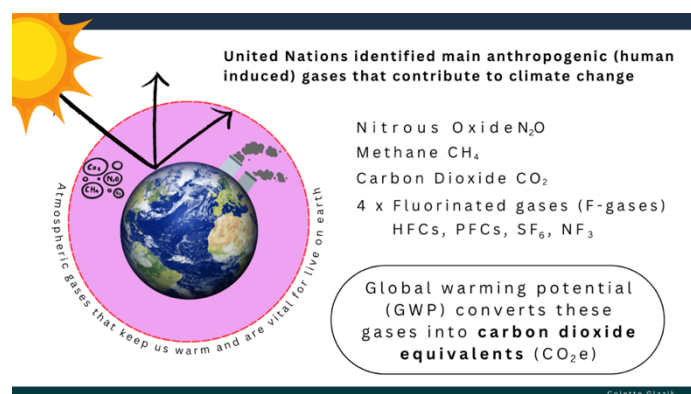


Figure 6: Greenhouse Gases (source: author)

² F-gases are human made synthetic greenhouses gases whose warming potential is often thousands more times than carbon dioxide. They are released from refrigerants, air conditioners, heat pumps, fire protection, powerlines, aerosol propellants and industrial processes. They are hydrofluorocarbons, perfluorocarbon, sulfur hexafluoride and nitrogen trifluoride.

Policy and agricultural transformation

Standing in a paddock in rural Uruguay, Australia, Japan, or Costa Rica—engaged with the sights, textures, and conversations of everyday farming—national and international policies, frameworks, and laws can feel distant and seemingly irrelevant. However, the reality is that they are shaping how we farm and how the community, markets and politicians prioritise and react to issues around food and fiber production and the broader policies on risk and climate.



Figure 7: Discussing the challenges of scaling regenerative cocoa production at Nortico in Costa Rica. (source: author)

Global frameworks, international regulations, and corporate interests shape how countries interpret and implement carbon-related policies. These interpretations are further influenced by national governments, political structures, and cultural and social norms, creating diverse regulatory landscapes. This, in turn, shapes industry standards and expectations, ultimately filtering down to on-farm practices. It is a whole policy ecosystem that interrelates where every element influences the whole.

As a result, farmers navigate a complex web of compliance, incentives, and market pressures that influence their approach to production methods, carbon management, and sustainability. Witnessing the impact of government policy on agriculture across the world, I have come to think of this as the '*Policy Cascade*', represented in figure 6 below. Whilst this cascade often works in a top-down approach, improving influence and communication to flow up can benefit producers at the end of the supply chain. When influencing up and down the chain the main issue I noted at each level was the difficulty in articulating what the problems and solutions were, the impact of those, and how a uniformed approach could be implemented across a broad range of business structures in distinct and different climates.

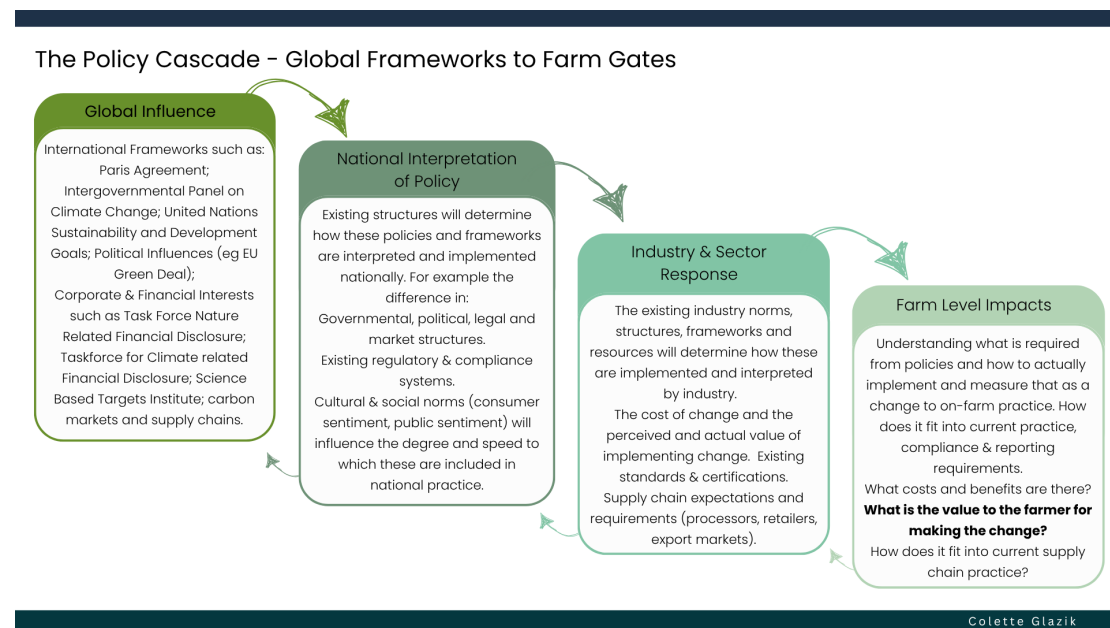


Figure 8: The Policy Cascade- Global Frameworks to Farm Gates (source: author)

The influence of international policy

The Intergovernmental Panel on Climate Change (IPCC), was established by the United Nations Environment Program and the World Meteorological Organisation, and was endorsed by the UN General Assembly in 1988. Whilst the IPCC is a scientific body, it doesn't conduct any research, but rather reviews and assesses the most recent scientific, technical and socio-economic research. Its aims 'to provide policy makers with regular scientific assessments on the current state of knowledge about climate change' (IPCC, 2024).

The United Nations Framework Convention on Climate Change (UNFCCC) was established in 1992, with information from the first assessment report of the IPCC 'playing a decisive role' in its establishment as 'a framework for international cooperation to combat climate change by limiting average global temperature increases and the resulting climate change, and coping with impacts that were, by then, inevitable' (UNFCCC, 2024). The Kyoto protocol was adopted in 1997, but entered into force in 2005³ it operationalized the UNFCCC, it had two commitment periods, the second running until 2020.

The Paris Agreement (United Nations Convention on Climate Change, Dec 12, 2015) was negotiated between member states⁴ in response to the understanding that

³ The Kyoto protocols had a complicated ratification process, which is why it took so long to come into force.

⁴ 'Member states' are countries that are party to the United Nations Convention on Climate Change.

Anthropocene greenhouse gas emissions needed to be curtailed to stabilize the climate. The ratification of the agreement in 2016 set off a notable shift towards economies considering how they could decarbonize, in an aim to keep global temperature rises to well below 2°C, with efforts focused to limit the increase to 1.5°C. This Agreement began a wave of actions, target setting, policy implementation and strategic discussions aimed at reducing GHG emissions across industries, governments and corporations. Discussion around who was responsible for decreasing their emissions, the pros and cons of taking action, what action and which was a priority and who was to bear the cost were had across all industries in the world began. Simultaneously reporting frameworks and technologies began advancing to assist in meeting these new goals. Against this backdrop carbon credit markets were established as a mechanism to incentivise and support decarbonisation.

The architecture of emissions reporting

The Paris Agreement requires countries to track, record and report their carbon emissions as well as their efforts to reduce them, these are known as National Greenhouse Gas Inventories (NGGI). The reporting of NGGI provide an opportunity for countries and industries to benchmark themselves internationally. These datasets are often the basis of reporting and target setting for governments and industries.

The IPCC had issued Guidelines for National Greenhouse Inventories which detail the methodologies to be used by countries in calculating emission inventories. To enable all countries to compile national inventories different levels of methodological complexity are available to use. Richard Eckhart, University of Melbourne in the Carbon Neutral for Agriculture (2021) course summarised them as being three tiers that vary in complexity and are chosen on the basis of national circumstance. The tiers themselves are not strict categories as they all have subsets and may be blended depending on what local data is available.

- Tier 1 is the default from the IPCC, there is no refinement to the methodologies and it refers to Food and Agriculture Organization (FAO) statistics, the data itself is fairly coarse, coming from global datasets with simplified assumptions. Using this methodology there are large uncertainties.
- Tier 2 is more accurate approach, using local research to apply country specific parameter values, there are smaller uncertainties with this. (Methane and nitrous oxide calculations in agriculture use tier 2 in Australia).
- Tier 3 are higher order methods, detailed modelling and/or inventory measurement systems driven by data at higher resolution and much lower uncertainties. (Tree carbon and soil carbon use tier 3 in Australia).

The Australian Government's National GHG inventory reports industries GHG emissions with a view to reducing the national emissions. The 2021 National Inventory, reported in April 2023, has agricultural emissions, excluding Land Use,

Land Use Change and Forestry (LULUCF), as 15% of Australia's total emissions, see the top row of Figure 1 below, labelled CO₂-e.

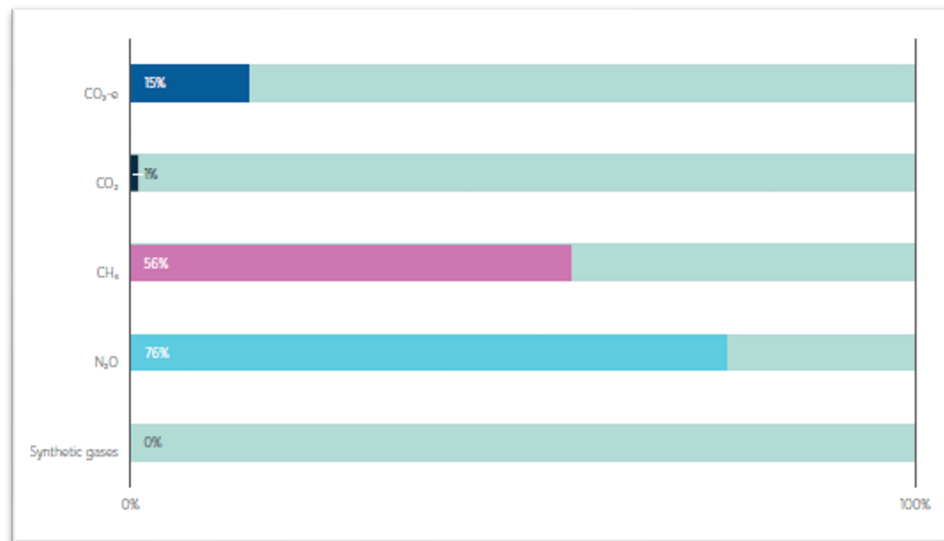


Figure 9: Share of national emissions (excluding LULUCF) for the agriculture sector by gas, 2020-21
(source: National Inventory Report Volume I, Australian Government (2023), Department of Climate Change, Energy, the Environment and Water)

NOTE: "Enteric fermentation was the main source of Agriculture emissions, contributing around two thirds of the sector's emissions. The next largest source was agricultural soils, followed by manure management. Liming and urea application contribute a small amount of the sector's emissions with rice cultivation and field burning of agricultural residues contributing the remainder." National Inventory Report Volume I, Australian Government (2023), Department of Climate Change, Energy, the Environment and Water.

Policy impact on farming

Government policy has a big impact on shaping agriculture it is designed to achieve positive outcomes, but doesn't always have the desired effect. When considering government policy, it is important to note that generally government policy is about setting minimum standards. Compared to industry policy which is typically about market differentiation and innovation. To understand how government policy can drive change in agriculture and environmental sectors to address climate change, it's valuable to examine both historical and contemporary policies, from different countries and consider the impact the transformations they've created.

Case Study 2: Crop insurance

Crop insurance was introduced in the United States in the 1930's as an experiment in response to the combined impacts of the Great Depression and the Dust Bowl. It has had a number of iterations since its inception aimed at formalising it and increasing the number of participants. Whilst it is no longer mandatory for farmers to be eligible for deficiency payments (as created by the *Federal Crop Insurance*

Reform Act of 1994), ‘farmers who accepted other benefits were required to purchase crop insurance or otherwise waive their eligibility for any disaster benefits that might be made available for the crop year’ (Risk Management Agency, US Department of Agriculture, 2025). In 2000, premium subsidies were increased to encourage the uptake and level of insurance purchased by producers.



Figure 10: Nuffield Global Focus Program participants meeting at the United States Department of Agriculture in Washington DC to discuss United States agricultural policy during the Nuffield Global Focus Program (source: author)

During my visit to California’s Fresno Valley, I spoke with farmers who had deliberately chosen to plant crops they expected to fail over several seasons—not because of agronomic suitability, but because these crops were highly insurable and would still yield a financial return. Not all crops, however, are eligible for insurance coverage. While selecting crops to secure the long-term viability of a farming business is understandable, this approach reveals a significant limitation: it can incentivise producers to make planting decisions not on suitability for the land type, but on the potential for insurance compensation.

The policy objective underpinning crop insurance has been successful in that it has supported farmers in recovering from losses and is widely endorsed and required by financial institutions, governments, and industry stakeholders. However, the lack of insurance coverage for all crop types imposes a constraint on innovation, limiting the variety of crops that producers are willing or able to trial. Despite these concerns, crop insurance has proven to be a valuable tool.

Nevertheless, the potential for crop insurance to serve as a driver of innovation could be greatly enhanced if producers were granted greater flexibility—allowing them to experiment with a broader range of crops and production methods, while still maintaining an insurable level of risk.



Figure 11: the author standing in an asparagus crop in the Fresno valley (source: author)



Figure 12: cotton growing in the Fresno Valley, California Figure 13: onions being harvested in the Fresno valley (source: author)

Case study 3: Impacts of extreme & polarising policy

We have seen a large amount of polarising policy statements and claims across the world in the last decade. The division and/or support of such policies has changed the course of elections around the world, and much has been written on the topic.

The Netherlands is known for its tiny land base and for being the second largest food exporter in the world, second to the United States. In 2020, the Netherlands had the highest livestock density of the countries in the European Union (Eurostat, 2023). The number of animals and the manure they produce and its impact has been the subject of environmental debate. Following a decision by the highest Dutch administrative court in 2019 that found the government was breaking EU law by not doing enough to reduce excess nitrogen in vulnerable natural areas, the Dutch

government released a plan to reduce the livestock numbers. This 13-year plan included paying some farmers to exit the industry and helping others to transition their methods of farming.

The policy was fiercely opposed to by farmers and the BoerBurgerBeweging (Farmer-Citizen Movement, or BBB) political party was formed to advocate for farmers. The BBB took an opposition to the policy to the election, and gained a significant vote, not only in the rural population, but also in the city population. "*The BBB's popularity has surged amid government plans to buy farmers out and reduce livestock numbers by up to a third so as to help halve illegal nitrogen emission levels by 2030*" (The Guardian – News Online 14 March 2023). Whilst the BBB's formation was seen as a success by many farmers, the underlying theme of these polarizing policies seen around the world is that governments often lack a deep understanding of agriculture and nature and the far-reaching impacts of the policies they create. Policy has the power to drive significant change in the agricultural sector—what that change looks like, now and in the future, has serious implications for anyone that eats.



Figure 14: Discussing politics in the Netherland with Erik Stegink BBB Party Chairman with Nuffield Global Focus participants at his farm Piggy's Palace. (source: author)

Private sector

In response to international efforts to address climate change, numerous reporting frameworks, organisations, accreditation systems, and markets have been established to support businesses and industries in meeting emissions reduction targets. Some of these initiatives are collaborative efforts between government bodies and the private sector, and there become interplay between government policy led by industry efforts.

However, the sheer number of goals, frameworks, methodologies, and accreditation schemes—when considered alongside national and international laws and regulations—can appear like an overwhelming omnishambles. This complexity is particularly evident in the agricultural sector, where varying commitments across

extended and often fragmented supply chains add an additional layer of difficulty in understanding, prioritising and meeting requirements.

The Taskforce on Climate-Related Financial Disclosure (TCFD), which developed a framework to help public companies and other organisations disclose climate-related risks and opportunities. Some Australian companies are already disclosing their current and future climate risks. The Australian Treasury has proposed that all companies will need to start reporting on these risks. It is expected to be rolled out over a staged approach, with large companies and financial institutions beginning to report in 2024-25 and other organisations in 2027-28.

The Taskforce on Nature-Related Financial Disclosure (TNFD) is a market-led and science-based initiative supported by national governments, businesses and financial institutions worldwide. The TNFD has developed a set of disclosure recommendations and guidance that encourage and enable business and finance to assess, report and act on their nature-related dependencies, impacts, risks and opportunities. The recommendations and guidance will enable businesses and finance to integrate nature into decision making. The TNFD's recommendations remain voluntary for Australian entities until codified under domestic law, however it is likely that they will increase the focus of nature-related risk management from investors and consumers. A legal opinion published by Pollination Law (2023) on the impacts of the TNFD in Australia has argued that directors who fail to consider nature-related risks could be found liable for breaching their duty of care and diligence under the *Corporations Act 2001* (Cth).

The Australian Agriculture Sustainability Framework (AASF)

The Australian Agriculture Sustainability Framework was developed by the National Farmers' Federation (NFF) with funding provided by the Department of Agriculture, Water and Environment (DAWE). The NFF consulted with over 1,300 stakeholders in Australia and overseas from across the entire agricultural supply chain. The rationale behind the development of the AASF was that trading partners and sources of capital and finance are increasingly expecting companies and products to meet global ESG principles (NFF, 2023). Development of the AASF provides a way for players in the entire agricultural supply chain a way to engage with ESG principles, some of which related to carbon neutrality. It is hoped the AASF will help to build capacity in the supply chain to demonstrate proof of the sustainability they require and also to assist farmers in engaging with environmental markets. Each element of the AASF has supporting documentation providing further explanation.

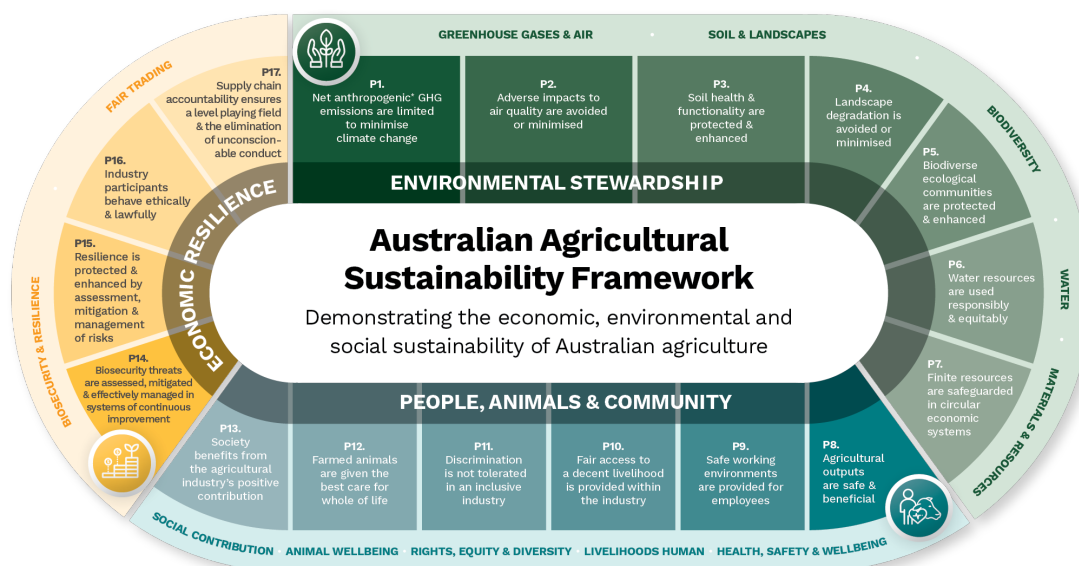


Figure 15: Australian Agricultural Sustainability Framework (source: National Farmers Federation, 2024 accessed <https://aasf.org.au>)

Effects of increasing emissions on agriculture

Despite all targets, policies and international meetings that have occurred aimed at curtailing GHG emissions, the IPCC reported in 2023 that '*[g]lobal net anthropogenic GHG emissions have been estimated to be 59 ± 6.6 GtCO₂-eq₉ in 2019, about 12% (6.5 GtCO₂-eq) higher than in 2010 and 54% (21 GtCO₂-eq) higher than in 1990*'.

This continued increase in GHG emissions will continue to have negative consequences for agriculture in Australia and around the world. The increase in number and intensity of natural disasters such as droughts, flood and fires across the world in the last decade has demonstrated the difficulty farmers will face into the future if the climate is not stabilized. Andrew Wait, Professor at the University of Sydney and Kieron Meagher, Professor, Research School of Economics at Australian National University, reported that a worldwide increase of temperature of 1.5°C '*will double the frequency of droughts - from once every 10 years to once every five*' and that '*a 2°C temperature rise...will make droughts 2.5 times more frequent*'. Illustrating the challenges that a changing climate will pose to agricultural production. Wait & Meagher (2021) further state that '*inconsistent water supplies, increased natural disasters and greater production risks will render agricultural production in many areas uneconomic*'. A bleak outlook for Australian agriculture, and a definite call to action, to understand where Australia's emissions come from, what policies are in force and are they going to help farmers farm into the future?

In addition to the impact a change in climate will have on producing agricultural products, the supply chains for those products will see increasing challenges and changes as demands for and reporting requirements of environmental credentials will increase. The future landscape for market access, access to finance and insurance,

legal and regulatory compliance and social license to operate, is anticipated to incorporate environmental, social, and governance⁵ (ESG) credentials, with Greenhouse gas (GHG) emissions reduction playing a pivotal role.

Fashion's environmental impact

Although wool represents only a small share of the global textile market, approximately 1.2% of global textile trade, it is still part of the broader fashion industry, whose environmental impact is significant. To fully understand the challenges and market drivers facing the industry, and to identify meaningful solutions, it is essential to consider the environmental footprint of fashion as a whole. Fashion accounts for approximately 10% of the world's GHG emissions and is the world's second most polluting industry, second to the oil industry (Chang, 2018, cited in Chen et al, 2021). Each year, in Australia over 300,000 tonnes of clothing are either sent to landfill or exported (Gbor & Chollet, 2024), globally 92 million tonnes ends up in landfills, which is equivalent to a rubbish truck full emptying into landfills every second (Igini, 2023).

Australia's consumption of textiles reflects a broader, international trend towards unsustainable fashion practices. Fast fashion giants like Shein and Temu exacerbate this issue, flooding markets with cheaply made, disposable clothing, made mostly out of petroleum-based fibres. As petroleum-based fibres break down they turn into microplastics, these are released through the life of the garment when they are washed by the consumer and continues after the item is disposed of. The large portion of petroleum-based fibres that are used in fashion and textile industries are contributing to a global crisis reminiscent of the single-use plastics epidemic.

As a natural fibre, wool, stands in contrast to these synthetic materials and offers an alternative that is long-lasting, sustainable, recyclable and biodegradable. Consideration needs to be given on how to address this excessive waste and pollution of the fast fashion industries.

Whilst all textiles are considered in terms of fashion waste, wool has a wonderful and unique story to tell in terms of its production and end of life, given its biodegradability and recyclability.

⁵ ESG or Environmental, Social and Governance is the how corporates talk about sustainability. It aims to encompass non-financial topics that are not necessarily captured by traditional financial reports. ESG principles are underpinned by the 17 United Nations Sustainable Development Goals (SDGs).

Case study 4: Exporting the impacts of fast fashion

Kimbe is a remote port on the northern-central coast of New Britain's Island in Papua New Guinea. Known for its reefs and palm oil plantations. Kimbe is accessible via flights on small Dash 8 planes from Port Moresby. In this remote part of Papua New Guinea are second-hand clothing shops featuring brands from Australia and New Zealand. In 2022, Australia exported \$71.5M of used clothing. In 2022 Papua New Guinea imported \$19.7m in used clothing, the majority coming from Australia (\$7.3m) and New Zealand (\$6.25m) (AJG Simoes, CA Hidalgo, 2011).



Figure 16: My family boarding a Dash-8 to Kimbe, Papua New Guinea. Figure 17: Flying over palm plantations. (source: author)

My interest on the impacts of fashion led me to me to a second-hand clothing shop in Kimbe. The shop's sign said '2,000-3,000 items a day'. Inside the double story shop were past trends and "disposable items" like Christmas t-shirts, Bounce Inc socks⁶, branded merchandise such as a Telstra⁷ tie, among thousands of other items. Common brands such as Shein, Anko⁸, Zara, and Ghanda filled the racks—most made of synthetic materials, that will degrade into micro-plastics. Despite the shop's orderly and neat presentation, the overwhelming volume stuffed into the sweltering shed was staggering. Upstairs, bales of clothing sat waiting, but whether they were new stock or unsellable castoffs was unclear.

⁶ Bounce Inc is a children's play centre that operates in Australia and New Zealand. It require patrons to wear grip socks that can be purchased on entry. Birthday party packages include a pair of socks for each child.

⁷ Telstra is Australia's biggest telecommunications and information services provider.

⁸ A brand sold in K-mart.

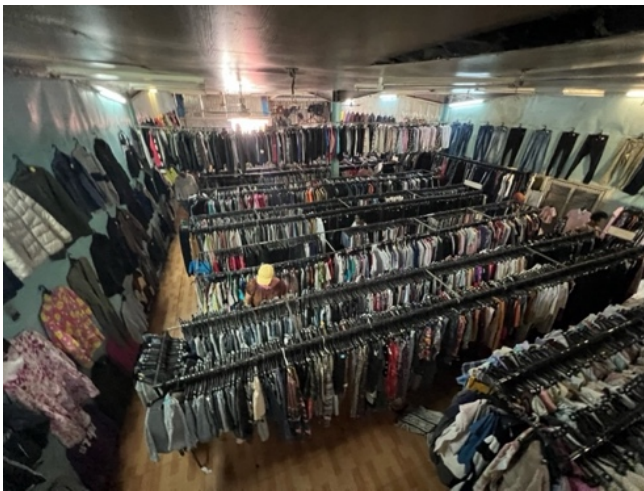


Figure 18: shop in Port Moresby, Papua New Guinea advertising 12,000 items a day of second-hand clothing. Figure 19: inside the second hand shop in Kimbe. Figure 20: second hand garments for sale. (source: author)

On my return to Port Moresby, I passed more of these shops, one stating '12,000 items a day'. While second-hand clothing trade is defended as providing affordable clothes and extending garment lifespans, it was difficult to imagine many of these items enjoying a meaningful "second life" in Kimbe. I couldn't help but wonder where the unsellable items would end up and about the pollution, they would cause to Papua New Guinea's natural wonders and beyond.

Chapter Two: Unravelling a carbon neutral claim

As mentioned above, the main anthropogenic gases that contribute to climate change are converted to carbon dioxide equivalents (CO₂e) for comparison purposes. Given this when discussing 'carbon neutrality' the reference to 'carbon' can often encompass all of the anthropogenic gases emitted. From an agricultural perspective, there are different angles to look at why a farm business will want to engage with their agricultural emissions:

1. Diversifying income streams, such as;
 - a. Undertaking a carbon project for the purpose of creating Australian Carbon Credit Units (ACCUs) and selling them.
 - b. Creating a niche product with a carbon claim attached to it.
2. Maintaining market access for product(s).
3. To be able to influence decision making up the policy chain.
4. Other reasons such as compliance, access to insurance, finance etc.
5. Ethical and moral obligations to minimise their environmental impact for future generations.

The approach to understanding emissions will vary depending on the perspective from which a farmer addresses emissions reduction. This chapter will explore the creation of carbon-neutral products - what this entails and how it can be achieved in an agricultural context. A discussion on methane, given its importance when looking at emissions for wool will consider the challenges facing the industry in accounting and methodologies of this type of emission.

2.1 Making a Carbon Neutral Claim

Climate Active is a program administered by the Australian Government for climate-neutral certification. While many private companies offer similar certifications, Climate Active is used here for illustrative purposes, as it represents the government-backed standard within Australia. Climate Active offers certification for carbon neutral claims, either for a whole organisation or for a product. The *Carbon Active Carbon Neutral Standard* is based on Australian and international carbon accounting standards.

To gain accreditation under this standard, businesses work out the emissions created by their activity, reduce emissions where possible and then purchase carbon offsets to 'cancel' out the remaining emissions from their activity, making them carbon neutral. The audit process is done by an independent but accredited climate active auditor. Carbon credits are able to come from any source. Either from Australian projects or from international carbon sequestration projects.

Options for certification are either for the entire organisation or for a service or product. For example, if a product was going to be certified the emission boundary

would be calculated for that product, then the emissions associated with the product would need to be accounted for.

To create a carbon neutral product:

1. Calculate the emissions for each scope of the supply chain;
2. Reduce or abate emissions where possible;
3. Offset the remaining emissions through carbon credits.

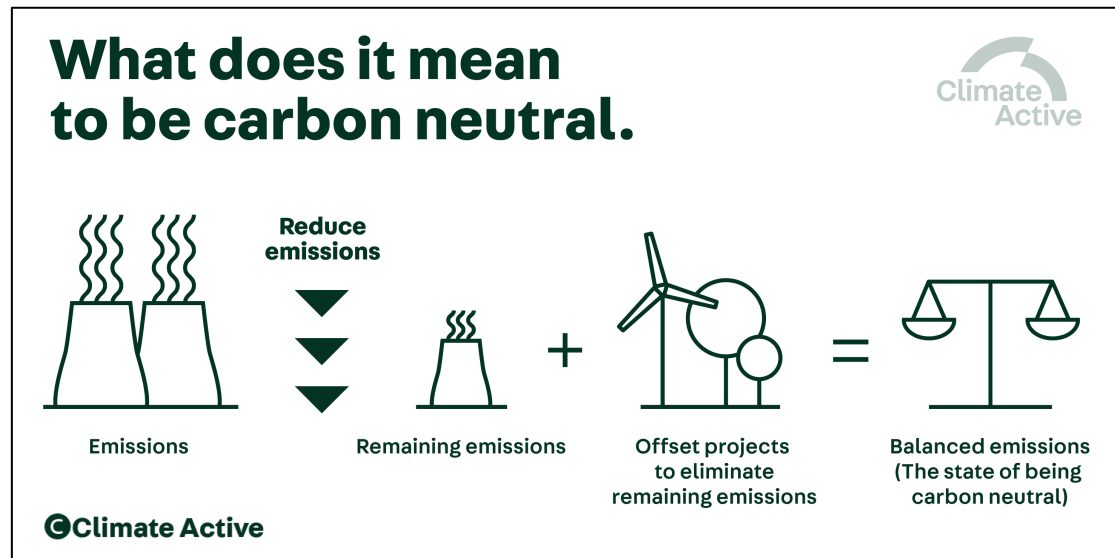


Figure 22: What does it mean to be carbon neutral. (source: Climate Active, 2024, climateactive.org.au)

Step One: Scope of Emissions

Scope of emissions works out where emissions are through the entire supply chain, the idea being that it helps to group emissions to measure progress. For a carbon neutral product all three types of emissions have to be accounted for. For some emissions it will be difficult to get an accurate measurement, so instead a best modelled estimate can be used.

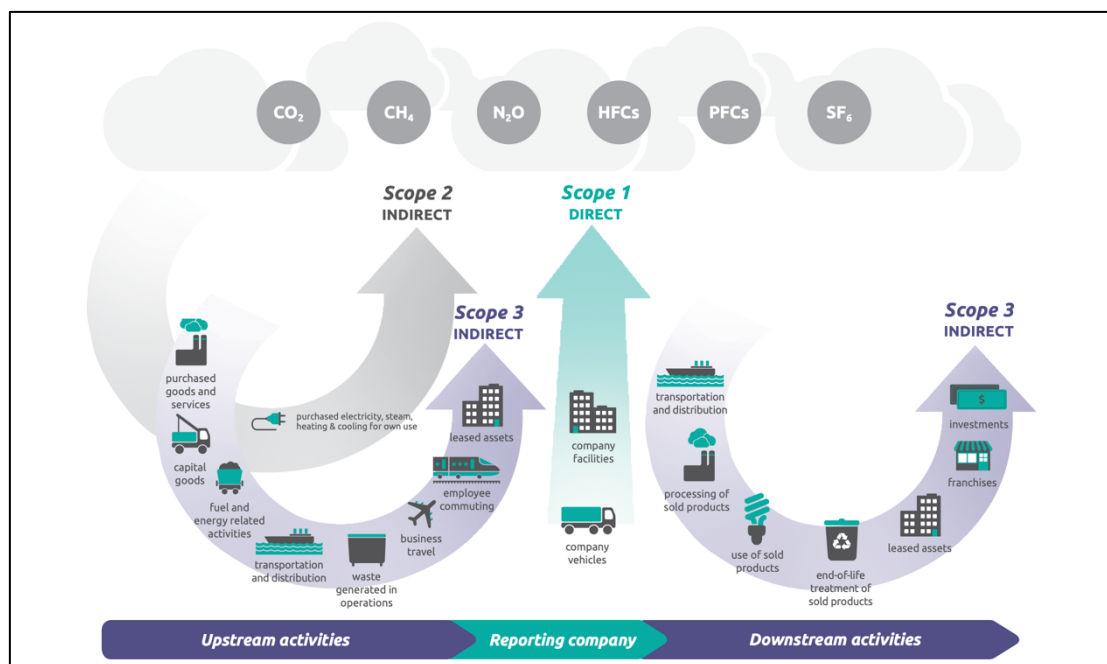


Figure 23: Overview of GHG Protocol Scopes and Emissions across the value chain (source: Corporate Value Chain (Scope 3) Accounting and Reporting Standard Supplement to the GHG Protocol Corporate Accounting and Reporting Standard, World Resources Institute & World Business Council for Sustainable Development.)

For wool producers, scope one emissions will largely come from enteric fermentation, a part of the sheep's digestive processes, which creates methane as a by-product. Bacteria break down plant material consumed by the animal in the gut, creating methane, which is then released through eructation (burping) and exhalation by the animal. This is a process that has evolved for millions of years, and has always been part of the methane cycle and flow of greenhouses gases into the atmosphere.

Enteric methane will generally make up the majority of wool producer's total emissions. Figure 24 below shows an example of the possible emission scope of a wool producer. Figure 25 demonstrates the upstream/downstream emissions scope for a livestock producer.

Scope	Examples for Wool Producers
Scope 1 or 'direct emissions', these emissions released are a direct result of an activity or series of activities at farm level.	Methane Emissions from sheep, from diesel or fuel burnt by farm vehicles.
Scope 2 or indirect emissions are emissions that occur at facilities that generate electricity, or other power that is used by the farm.	Electricity use on the farm.
Scope 3 or indirect emissions other than scope 2 that are generated in the wider economy. They occur as a consequence of the purchased inputs of the farm.	Any products that you purchase for use on farm, for example nitrogen fertiliser.
Note: Wool producers scope 1 emissions will be the wool purchaser's scope 3 emissions.	

Figure 24: Scope of emissions, examples for wool producers (source: author)

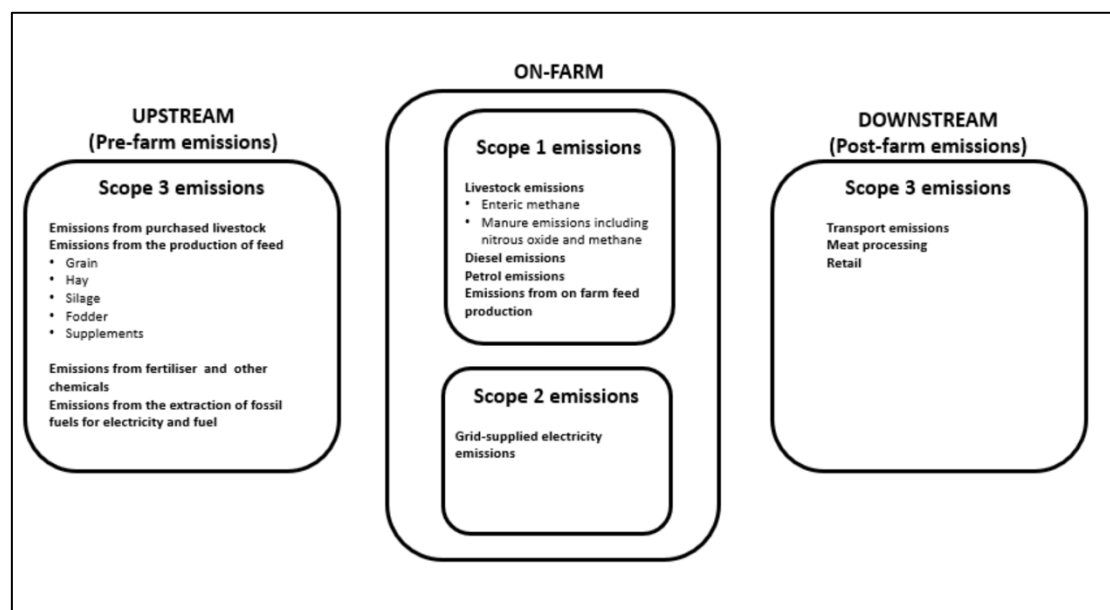


Figure 25: Up stream, on farm and downstream emissions (source: Widermann S., Carbon Accounting Technical Manual, Meat and Livestock Australia 2021)

There are many calculators that are available to work out your emissions profile, some of which are free. They have underlying models and data sets which when individual data is entered provides a figure for emissions. These tools are useful, but are only as good as the data entered as well as the underlying data sets that power them. *Generally right, specifically wrong* summarises the accuracy of some of these calculators as the methodologies behind them are using modelled estimates. From a livestock perspective the underlying models can be problematic in their treatment of enteric methane, this discussed in detail below.

Step Two: Abatement of Emissions

To create a carbon neutral wool product, once the amount of emissions is calculated, the next question would be where can emissions be reduced? As methane typically accounts for 80-90% of emissions in a ruminant grazing operation (Wiedemann & Dunn, 2021), the question becomes how can methane emissions be reduced?

Given the foundational impact methane has on the carbon emissions of ruminant production for both wool and meat, methane reduction has been the focus of research and debate when discussing targets and carbon neutrality.

There is a large amount of research directed at developing technologies to reduce methane emissions in livestock. In depth discussion of these technologies is not included in this report, however examples of research include:

- Methane reducing feed additives, such as; asparagopsis (seaweed), 3NOP, high tannin pastures;
- Genetic selection of naturally low methane emitting sheep. Some sheep are naturally low methane emitting, it is considered that this trait is quite heritable. Work is being conducted to determine how to work this into a trait as an Australian Standard Breeding Value for flock selection; and
- Development of a vaccines to reduce methane emissions.

Considerable media attention and capital have been directed toward research and commercial ventures promoting feed additives as a solution for reducing livestock methane emissions. Companies such as Sea Forest claim that their SeaFeed™ product has the ability to achieve methane reductions up to 90% in an animals whose diet is supplemented with SeaFeed™. When discussing feed additives that inhibit methane, Dr Vaughn Holder (Alltech, 2024, 02:35) explains that: *'methane is still required for that fermentation to happen correctly. So when you push methane reduction to a certain threshold, typically above the 30% inhibition level you will typically start to see negative effects on the digestibility of the diet and performance of the animal, it can be inhibited, but only to a certain extent.'*



Figures 26 and 27: Asparagopsis growing in a laboratory at Sea Forreest in Tasmania, Australia. (source: author)

It is important to recognise that the foundation of research to reduce methane emissions from ruminants is based on the doctrine that methane from ruminants is a problem that needs to be solved. These discussions fail to recognise that ruminants are part of the natural ecosystem and provide vital functions to the earth ecosystem and cycling of nutrients and gasses. The methane from their digestion has been part of the methane cycle for millions of years. It is the new sources of methane into the atmosphere, not the methane from livestock that needs to be addressed when looking at climate change. Figure 30 below explains the methane cycle in relations to cattle in more detail, as ruminants this is similar in relation to sheep. The implications of this doctrine, and how new research is disproving the link between ruminants and climate change and how that impacts methodologies for greenhouse gas emissions is discussed in more detail below.

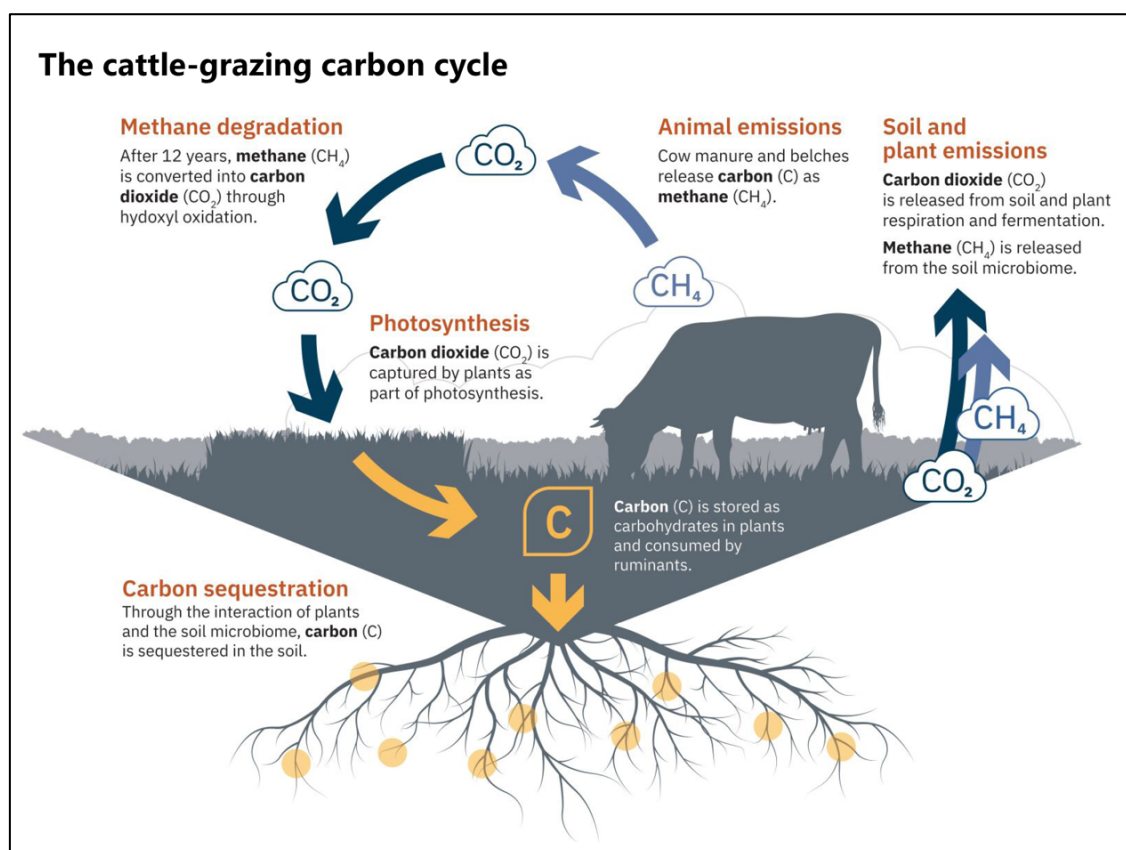


Figure 28: The cattle-grazing carbon cycle (source: Alltech, <https://www.alltech.com/blog/agriculture-vital-meeting-worlds-climate-change-goals>)

Understanding methane:

the role of methodologies in shaping perception

As discussed above, carbon dioxide equivalents ($\text{CO}_2\text{-e}$) create a single score, or metric, that standardises the differences between various GHGs, allowing the overall climate impact of a mix of emissions to be represented and compared. GWP100 climate metric is used almost universally to set goals and report emissions, deriving a

score that is on the cumulative radiative forcing over a future 100-year time horizon (Ridoutt, 2021). Under this approach, *'the global warming potentials of methane and nitrous oxide relative to carbon dioxide were reported by the Intergovernmental Panel on Climate Change in its 5th Assessment Report as 28 and 265 respectively'* (Myhre et al., 2013, cited in Ridoutt, 2021)⁹.

There has been debate about the appropriateness of the use GWP100 metric for livestock production because of the way methane behaves in the atmosphere. Methane is a short-lived gas, lasting around 10-14 years (represented in Figure 28 above), and is considered a 'flow pollutant', unlike carbon dioxide, which is a 'stock pollutant' because of its extended time in the atmosphere.

The IPCC's Sixth Assessment Report (2023) states that *'expressing methane emissions as CO₂ equivalent emissions, using GWP-100 overstates the effect of constant methane emissions on global surface temperature by a factor of 3-4 (Lynch et al., 2020, their figure 5), while understating the effect of any new methane emission source by a factor of 4-5 over the 20 years following the introduction of the new source (Lynch et al., 2020, their figure 4)'*. Ruminant livestock are sources of constant methane emissions, new methane emissions sources are those from industrial activities such as mining. The overstatement of emission related to ruminant livestock and the understatement of new methane sources from fossil fuels clearly demonstrates that there is a problem in the reporting and that it is adversely impacting agriculture, both in the policy development, and the climatic impact on the future of farming. This negative impact on farming will continue until a change to accurately reflect emissions in reporting occurs.

The importance of this finding is that livestock in agriculture are being reported to have 3-4 times more emission than are actually being emitted. This calculation is impacting the entire supply chain for ruminant livestock and the models around their environmental impact. The cost of creating carbon neutral product will be more expensive and farmers will be held to account for more emissions than they are responsible for. Policy, goals and markets are all being affected by this overstatement at the cost of livestock producers, while the industries that are contributing new sources of methane are being under-reported.

GWP*

Alternative approaches to GWP100 have been proposed, one of which is GWP*, developed to describe the future warming associated with changes in the emission rate of short-lived climate forcers (Ridoutt, 2021). GWP* is commonly discussed as

⁹ Meaning one tonne of methane has the same warming effect as 28 tonnes of carbon dioxide over a century and one tonne of nitrous oxide has a warming effect of 265 tonnes of carbon dioxide over a century.

being a suitable replacement for GWP100 for ruminant production, although it is one of several methodologies that have been proposed to replace GWP100.

As wool production has a legacy of radiative forcing from methane emissions, often from less intensive production systems, Ridoutt (2021) points out that:

'The challenge is therefore to improve these systems such that their radiative forcing footprint becomes stabilized and no longer leads to additional warming. An idea echoed by the IPCC Sixth Assessment Report where it noted that 'in reality, a decline in the methane emissions to a smaller but still positive value could cause a declining warming'.

Under the GWP100 there is concern that strategies that are chosen to reduce methane, such as more intensively managed productions systems, for example by relying on more crop based feed rations, methane will decrease, but nitrous oxide and carbon dioxide emissions will increase (Tian et al, 2020, cited in Ridoutt, 2021). When evaluated with the GWP100 metric, these strategies may seem to make progress against climate change, but they may actually offer only short-term benefits while complicating long-term climate stabilization, through the increase of stock pollutants of CO₂ and NO₂ (Ridoutt, 2021). This is something that is often overlooked when discussing the efficiency element of ruminant livestock production. For example, in some cases an increase in efficiency through supplementary feeding could reduce methane as the animal is grown faster, however the feed may have increased nitrous oxide and carbon dioxide emissions. The result in this equation could look like a reduction in emissions, however the longer-term impacts of adding more stock pollutants to the atmosphere is not necessarily of benefit, especially when attempting to stabilize the climate.

Meinshausen and Nicolls (2022) assert that a metric should act like a currency converter, estimate climate impact, support feedback control, align with climate policies, and be simple and transparent for non-specialists. They claim that GWP* is not a metric, but a model as it doesn't establish equivalence between CO₂ and other GHGs. Meinshausen and Nicolls (2022) demonstrate some of the short comings of GWP* using the case of New Zealand. Comparing their emissions inventory from 1990-2018 using both GWP100 and GWP*, the results showed that *'in one year, GWP* aggregate emission skyrocket and in a few other years a New Zealand government could theoretically claim to have reached net-zero emissions already.'* Whilst there are opposing views to the use of GWP*, the IPCC summarized that *'new emission metric approaches such as GWP*...are designed to relate emissions changes in short-lived GHGs to emission of CO₂ as they better account for the different physical behaviors of short- and long-lived gases'* (IPCC, 2023).

The merits of having a comparable metric for decisions makers is easy to understand, however over simplification can lead to obtuse reporting and poor decision making, as per the reduction of methane emissions but increasing carbon dioxide and nitrous oxide. The idea behind GWP100 is that it allows for comparison for policy makers, however the timescale can hide the trade-offs between short- and long-term goals. Given the complexity of what is being measured and the potential

policy outcomes of the measure, which metric to use will always be debated, given that with timescale, using one time scale over another can lead to different answers and outcomes.

Ocko et al (2017) have proposed that there should be mandatory reporting for multiple time frames as an inseparable pair such as systolic-diastolic blood pressure and city-highway vehicle fuel economy. This would in many cases lead to a clearer picture being presented of the impact of decisions. While Ocko et al's (2017) proposal is based on reporting both GWP100 and GWP20, the convention could be extended to other metrics, such as GWP*. They acknowledge that while the ethical considerations around decision making would remain, the technical implications of short- and long- term warming would be clear.

Which method chosen for additional reporting may still be unclear, it is however clear that some other form of reporting, potentially in addition to the GWP100 would provide more accurate emission information for agriculture. With the IPCC noting that methane from constant sources, such as livestock being overstated by 3-4 times, and that of new methane sources (such as methane from fossil fuels) being understating that by 4-5 times, more accurate reporting needs to be introduced for agriculture. The risk to agriculture both from a changing climate, and from the risks to its supply chain are obvious, and inaccurate reporting is hindering the sector.

Case Study 5: Buck Island Ranch, United States of America

Buck Island Ranch is a 10,500 acre working cattle ranch in Florida. Nearly 3,000 cattle graze across native and improved pastures, where research has been conducted across the ranch for nearly 30 years.

Archbolds Research Alliance has demonstrated that the ranch is a net carbon sink, and that this same outcome is scalable across the world. The research recognised that grazing animals have evolved on grasslands, and can change the function of them. They recorded that as cows were eating the grass and not allowing as much decomposition to happen on the ground (which releases greenhouse gases) that when the cows were removed from the grasslands, more carbon was emitted from the grasslands than when cattle were present.

The Methane Pledge

The potency of methane and its relative short life have made it the focus of reductions in order to tackle climate change. A significant reduction of methane into the atmosphere in the next decade, given its short life, will have a noticeable impact on the climate sooner.

Conference of the Parties (COP) is the supreme governing and decision-making body for the United Nations Framework Convention on Climate Change. Given the

significant impact reducing methane emission can have, COP26, held in Glasgow in 2021 drafted the Methane Pledge, a voluntary international agreement for signing countries to reduce their methane emissions by at least 30% of 2020 levels by 2030. Controversially Australia did not sign the pledge, with the then Prime Minister, Scott Morrison, citing concerns about the potential impact on farming (Paul S. and Menon P., 2021). The argument that agriculture would be damaged by reducing GHG emissions, when emissions changing the climate is currently having a significant impact on agriculture is a flawed one. The argument seems to be used as a way to protect higher polluting industries as a way to appease the Australian public by using agriculture as a scape goat. It also fails to take into account the other big methane emitters in Australia.

Disappointingly our political leaders seem to be ignorant to both industry targets, the sources of Australia's emissions and the methodologies to have emissions are calculated. *'Despite the meat and livestock association having a carbon neutral by 2030 target which suggests herd numbers can be maintained, [Barnaby] Joyce said the only way to reduce methane by 30% by 2030 would be "to go grab a rifle (and) go out and start shooting your cattle"'* (Martin, Hannam & Morton, 2021). Indeed MLA's Carbon Neutral by 2030 Roadmap states that *'Research undertaken by a consortium of organisations led by Australia's national science research agency, Commonwealth Scientific and Industrial Research Organisation (CSIRO), has shown it is possible for the Australian red meat and livestock industry to achieve CN30 while maintaining animal numbers, through continued efforts to avoid greenhouse gas emissions and store carbon in vegetation and soils'.*

Analysis by Dr Assan (2022) on Australia's methane emissions found that by focussing on coal mines alone (which represent 23% of Australia's total methane emissions) Australia could reduce the annual methane emissions by 18% by 2030. And that mitigating methane emissions from coal mines is four time cheaper than mitigating it from agriculture. The IPCC (2021) also points out that *'methane from fossil fuel sources has slightly higher emissions metric values than those from biogenic sources since it leads to additional fossil CO₂ in the atmosphere (high confidence)'.*

Australia agreed to become a signatory to the methane pledge in October 2022.

Case Study 6: Uruguay with Lanás Trinidad

During my trip to Uruguay, I was hosted by Pedro & Agustin Otegui and Hugo Surraco from Lanás Trinidad. Lanás Trinidad is the main producer and exporter of scoured wool and combed wool tops in Uruguay. The proactive and progressive nature of Lanás Trinidad was incredible to see and their entire approach to business was to ensure minimal environmental impact, a high standard of animal welfare and social responsibility. They have designed their industrial production model to be as circular as possible, ensuring minimal waste, the re-use of materials with a focus on restoration of natural environments.

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The scouring process relies on rain water that is captured in a dam, then once the wool has been cleaned, the water is separated from the lanolin and is run through aerobic and anaerobic lagoons. Methane from this process is captured and used to generate electricity. The clean water is then used to irrigate tree and forage crops.



Figure 29: aerobic and anaerobic lagoons for naturally purifying waste water. Source: author
Figure 30: forestry benefiting from purified waste used for irrigation. (Source: author)



Figure 31-34: Bales of wool at the Lanac Trinidad processing facility. Hugo Surraco and Rob Howe discussing wool, Pedro and Agustin Otegui and Rob Howe touring the processing facility. Bales of RWS wool. (Source: author)

It was clear to see that the value of partnerships and team work were strong in the industry, both with farmers and with research intuitions. Research was being

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conducted in low emission genetics, as well as the broader environment such as birds as indicator species to map out the environmental stewardship of farms.

La Soledad is a supply chain partner of Lanas Trinidad. At the helm of La Soledad, a grazing wool property, Gabriela Bordabehere was recognised for environmental stewardship in 2022 as the recipient of Gucci's Climate Action Award. Her property is covered with diverse perennial native grasslands which she manages with rotational grazing.



Figure 35: Gabriela Bordabehere, her son and the author admiring some of the La Soledad flock.
Figure 36: Gabriela Bordabehere, Rob Howe and Hugo Surraco at La Soledad, Rob was holding an impromptu evening dung beetle safari. (source: author)



Figure 37: Oscar Blumetto, INIA, presenting at La Soledad some of his research on biodiversity.
Figure 38: Rob Howe, Hugo Surraco, Gabriela Bordabehere and the author at La Soledad (source: author)

Instituto nacional de Investigación Agropecuaria (INIA) is a research organization that is have dedicated to generate, adapt and transfer technologies that respond to the needs of agriculture in Uruguay. Spending time with the researchers and seeing the projects they are putting resources towards reinforced the commitment that Uruguay has towards biodiversity, carbon neutrality and sustainability in its agricultural sector.

Ignacio De Barbieri showcased the research that was being undertaken at INIA in working out the genetics of a low methane emitting sheep. The feed intake of sheep

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was being monitored via electronic tags, and then once a day were their methane emissions were being measured for 30 minutes via box.



Figure 39: At Instituto nacional de Investigación Agropecuaria Unidad Experimental La Magnolia research facility. **Figure 40;** reading the gas measurements of the chambers in which sheep were briefly contained (source: author)

Lanas Trinidad have built on a strong legacy with decades of sustainable leadership, partnered with farmers and research institutions and were actively looking to shape a future that honored that legacy while driving innovations for generations to come.

Case Study 7: Ireland with the legend, Tommy Boland

During a short trip to Ireland in 2022, I had the pleasure of being hosted by Tommy Boland, Professor at the School of Agriculture and Food Science at the University College of Dublin. We completed a whirlwind tour of Ireland where I was shown both farms and research institutions where significant research was being undertaken to both improve efficiencies and understand the methane emissions of sheep.



Figure 41: Tommy Boland and the author in Ireland. (source: author)

In conversation during our car trip around we discussed what creates a low emission animal in terms of physical and heritable traits. Tommy summarised that:

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- A low emission sheep is linked to a number of different factors around the rumen:
 - rumen size being one, the smaller rumen size has larger rumen turnover rates, so gives lower periods of times for the methanogens to colonise the feed and utilise the hydrogen that is present;
 - rumen outflow rates, faster the feed is flowing out of the rumen, the less time there is for methanogens to use the hydrogen;
- there is evidence to show that the host animal will determine which type of microbial population will develop in the rumen;
- Lower feed intake will have lower emissions, but can often have lower performance. But in other cases those lower intake animals will have higher efficiency so they will have higher output per unit of feed intake. Feed intake is the main driver of methane emissions.
- Because the microbial population is so important, can we alter this in the early stage of the animals life and program it in one direction or another. Once the rumen microbiome population has developed it is really resilient, you can change it in the mature animal, you are trying to change a population that has already developed. So in the pre-weaning or peri-weaning opportunity to alter the microbial population and it has carry over effects from the methane emission of that animal at least up until maturity, but not sure about the entire animals life, as these studies have not been completed.
- Heritability of low methane emission animals is about .3 to .4 which is highly heritable.



Figure 42: The author delivering a lamb in Ireland. Figure 43: Sheep in Ireland. (source: author)

Step Three: Offsets

In a carbon neutral calculation, the final step is to work out what emissions cannot be abated and offset them with credits.

Australian Carbon Credit Units (ACCU) are carbon credits generated under the Australian Government's Emission Reduction Fund (ERF). One ACCU is the equivalent to one tonne of carbon dioxide equivalents (tCO₂-e). To create an ACCU projects need to be registered with the ERF. Only approved projects that fit into approved methods under the ERF are able to be registered. There are currently 30 methods under the ERF. For most sheep farmers, the relevant methods for projects to sequester carbon dioxide on their farms would fall under the ERF methods relating to soil carbon and vegetation management or in some cases blue carbon, where wetlands are being restored¹⁰. Projects are registered, certified and then issued Australian Carbon Credit Units (ACCUs) for emission avoidance or storage of carbon dioxide in vegetation or soil. When ACCUs are used to offset emissions, they are retired. The diagram below explains the process for creating and selling credits under the Emissions Reductions Fund (ERF).

¹⁰ For example, the wetland restoration project in Tasmania adjacent to the Ramsar-listed Pitt Water-Orielton Lagoon wetland and nature reserve. This project has been run by NRM South as part of the under the Australian Government's Blue Carbon Ecosystem Restoration Grant.

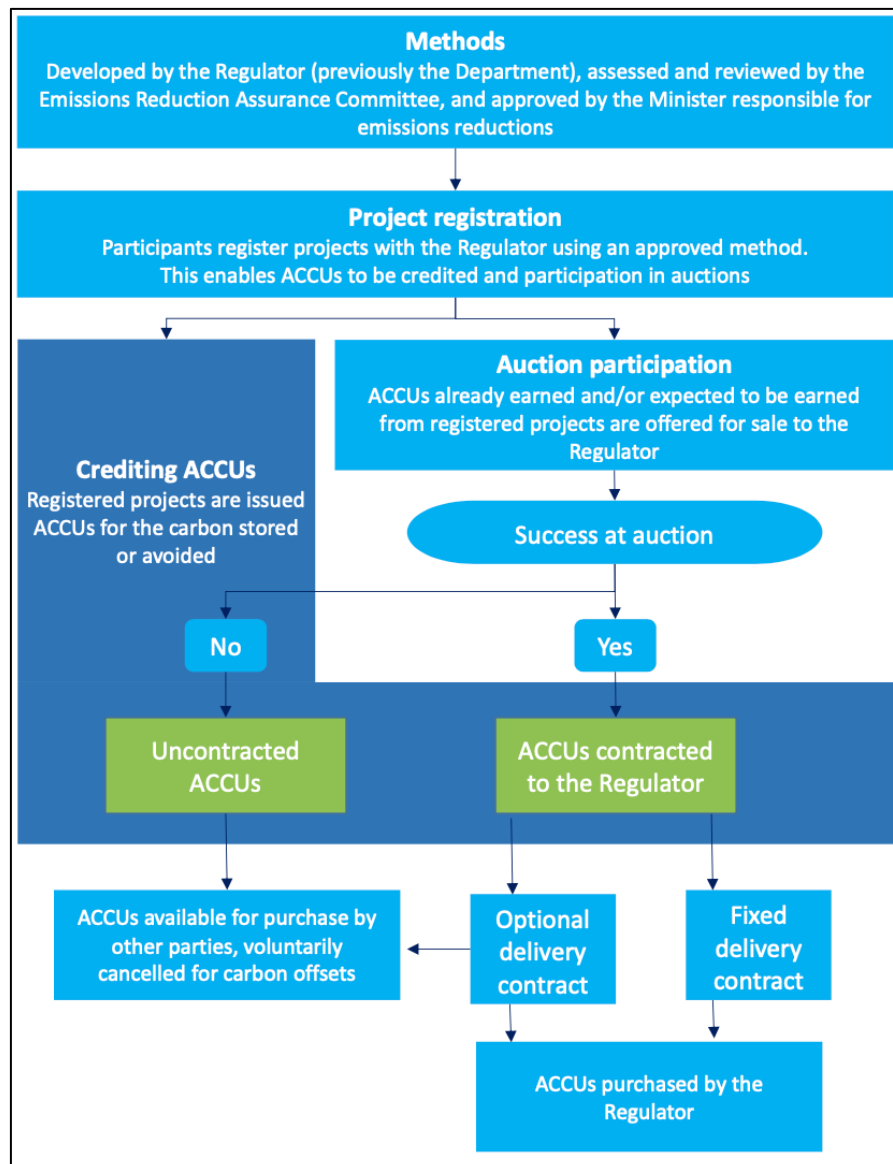


Figure 44: Crediting and purchasing mechanisms under the ERF (source: Climate Change Authority, Review of the Emissions Reduction Fund, 2020, available at https://www.climatechangeauthority.gov.au/sites/default/files/ERF%20Review%20Final%20Report%2020201009_2.pdf)

Private markets operate in a similar fashion to the ERF, while the ERF only operates in Australia, private markets operate globally. The international prices of carbon credits often differ to ACCUs as they are not fungible. The methodologies and project types different to what is allowed under the ERF. The Verra Verified Carbon Standard is an example of a credit that is created under a private crediting program.

Lifting the veil on carbon credit markets: are emissions an opportunity?

'Making a literal difference, metaphorically' Bo Burnham

As previously noted, the interest from an agricultural perspective in credits could be for creating a carbon neutral product or to create an alternative income stream from selling credits. Most carbon neutral products rely heavily on credits to reduce the harder to abate emissions.

There has been a continued rhetoric by the Australian Government, and aggregators, who develop and run carbon projects, regarding the wonderful opportunity that creating carbon credits are for Australian farmers. The creation of credits is said to be an opportunity for farmers to not only mitigate climate change, but also make additional money. It is important to note that carbon credits cannot be counted twice, they cannot be sold on the carbon credit market and then also counted against the farm's own emissions. When selling credits understanding, both how they are created and what they are used to offset is an interesting exercise in exploring the integrity of carbon markets, and in understanding if the policies around carbon are really serving Australian farmers.

The Emission Reduction Fund & the Safeguard Mechanism

The Emissions Reduction Fund (ERF) is the centre piece for the Australian Government's climate's policy. The idea behind it is to create projects which reduce greenhouse gas emissions, or sequester carbon dioxide and issue credits for those projects. The demand for the purchase of those Australian Carbon Credit Units (ACCUs) is created by the Australian Government purchasing them to meet its international obligations and by the Safeguard Mechanism which imposes rules on large industrial emitters (those emitting more than 100,000 tonnes of CO₂e per year).

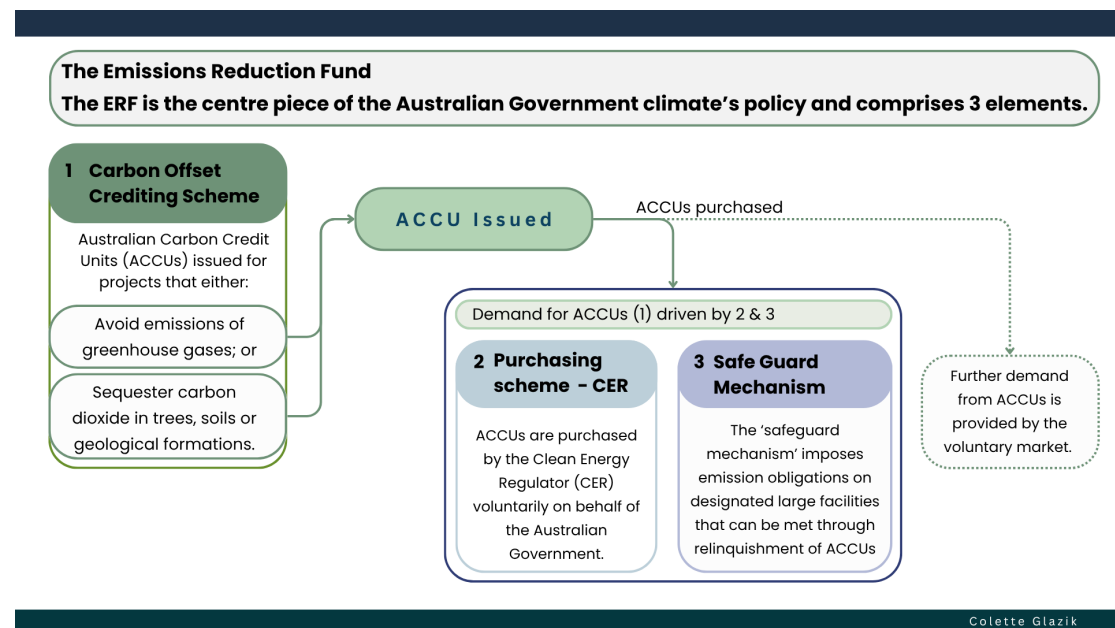


Figure 45: The Emission Reduction Fund (source: diagram designed by the author, the influence for this diagram came from MacIntosh et al 2022, The Emissions Reduction Fund (ERF): Problems and Solutions)

The Safeguard Mechanism works by requiring 'Australia's highest greenhouse gas emitting facilities to reduce their emissions in line with Australia's emission reduction targets of 43% below 2005 levels by 2030 and net zero by 2050' (Clean Energy Regulator, 2025). Use of the Safeguard Mechanism is dominated by gas and coal industries, a 'facility' is a project and while the Australian Government places restriction on their greenhouse gas pollution, carbon credits can be used to offset their emissions (Armistead & Hemming, 2023).

Understanding the importance of how the ERF works in relation to agriculture demonstrates how the government's net zero policies are working against the interest of farmers, and will impact their ability to farm into the future. The safeguard Mechanism requires companies to buy credits if they exceed their assessed emissions baseline. That is, there is an allowable amount of polluting, if this is exceeded credits need to be purchased, and can be provided by Australian farmers.

Australia has more than 100 new gas and coal projects in the development pipeline, Feik (2023). Feik (2023) presents the Woodside Scarborough and Pluto gas project in Western Australia as one example, the project will contribute 1.4 billion tonnes of carbon emissions to the atmosphere during the expected 25 years of life, noting that the Safeguard Mechanism will only require Woodside to offset approximately 3 million tonnes of emissions. 1.4 billion tonnes has been noted by Bill Hare, a climate scientist and member of a UN expert group on net-zero commitments that '1.4 billion tonnes is more than three times Australia's current annual emissions' (quoted in Feik, 2023).

The importance of this to agriculture is that the Australian Government policies on carbon credits are contributing to more greenhouse gases in the atmosphere and in turn to a more destabilized climate, which will create more pressure on farmers.

Climate Analytics (2023) completed an analysis on credits and their use in the fossil fuel industry, they found that:

- “Australian carbon credit units (ACCU) generated to offset one tonne of CO2 equivalent emissions from Liquefied Natural Gas (LNG) production in Australia, about 8.4 tonnes of CO2 equivalent lifecycle emissions are emitted globally” and
- “For coal, the equivalent is even bigger, for every tonne of CO2 equivalent emissions from coal mining offset on average about 58-69 tonnes of CO2 equivalent lifecycle emissions are emitted globally.”

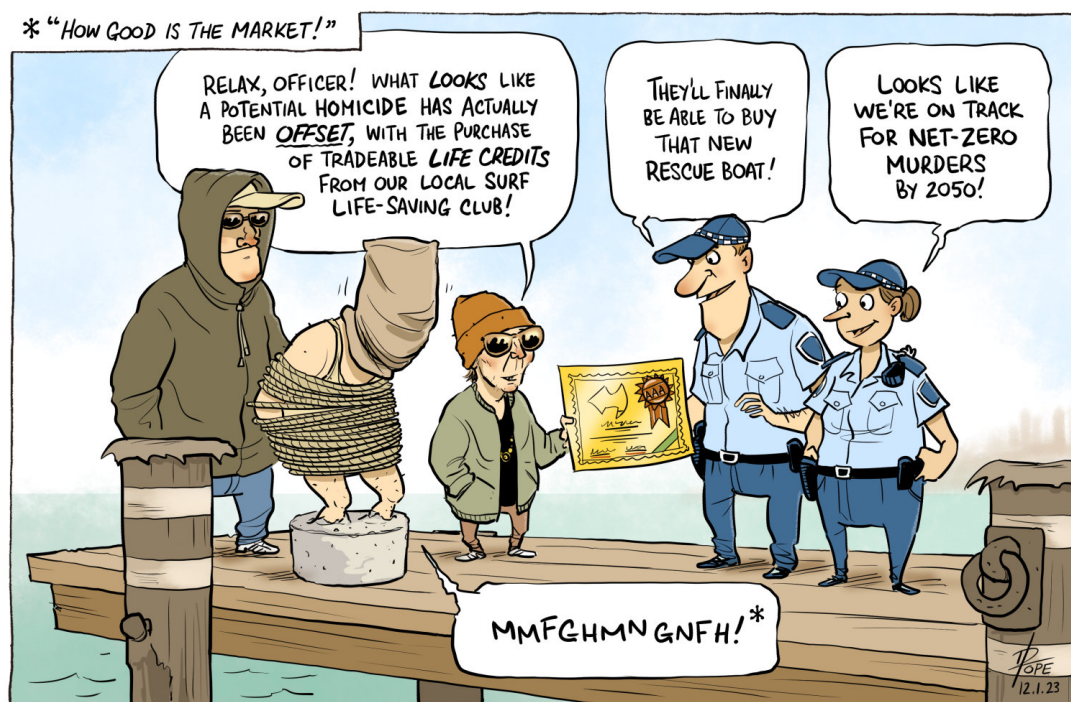


Figure 46: “How good is the market!” cartoon (source: © David Pope/The Canberra Times, reproduced with permission.)

The integrity challenge of carbon credits

The integrity of carbon credits, both ACCUs and credits verified by private companies around the world have been called into question. Research regarding ACCUs from ANU and UNSW, the Australian Institute and a number of independent researchers and academics has found ‘that there is significant evidence that up to 75% of ACCUs are not resulting in real emissions reductions or are not ‘additional’ (The Australia Institute, 2023). In January 2023 it was reported that research into credits certified by Verra showed ‘that more than 90% of their rainforest offset credits – among the most commonly used by companies – are likely to be ‘phantom credits’ and do not represent genuine carbon reductions. Companies such as Gucci, Shell, easyJet and BHP are among the companies that have purchased these credits to make environmental claims (Greenfield, 2023). Unfortunately, this type of accusation

against carbon certifying standard is not unique to Verra, but replicates across the entire industry globally.

The delivery of a carbon project can be complex and the paperwork that needs to be submitted vast. Carbon aggregators often approach farmers with opportunities to develop carbon projects on their land. It is interesting to note that *'all of the largest carbon aggregators dealing in the carbon-credits market are now either part-owned by companies with major gas interests or count ex-resources executives as directors and/or major shareholders'* (Feik, 2023). This interest in carbon aggregation business from fossil fuel companies makes sense from a business perspective in relation to ensuring a supply of carbon credits. If dealing with such companies, farmers should do their due diligence to ensure that their values align and they are looking for the same outcome from the project as the company they are dealing with.

Conclusions: Weaving it all together

“A country is only as good...only as strong as the people who make it up and the country turns into what the people want it to become...I don't believe any longer that we can afford to say that it is entirely out of our hands. We have made the world we are living and we have to make it over.” James Baldwin

When visiting the Aeres University of Applied Science, Ageres Hogeschool Dronten, Netherlands, Ron Methorst a professor gave us a presentation on the Environment inclusive Entrepreneurship (13 June 2023) and discussed the concept that in order to achieve actions that will improve environmental outcomes ‘paper problems’ need to become ‘real problems’. Meaning that often environmental problems are compliance-based solutions, but those that need to take the action often take it purely for compliance so will look for ways around the requirement that are lacking in the result intended for the policy. An example of this was seen globally during the covid pandemic – mask mandates required people to wear masks. There were those that considered it a real problem and wore their masks correctly, and there were those that did not, having a mask in their pocket to put on in case they were asked to comply.

Climate change policy and goals are often seen as a paper problem. Some of the difficulty in this is that the efforts to reduce or offset greenhouse gas emission are difficult to quantify directly, the link between the emissions and the real-world impacts can often be indirect and geographically removed. The actions relating to greenhouse gases can often have consequences that are far away both in place and time. Added to that the tangle around the policy and markets that have been created to solve the issue, it can be difficult to make an informed choice in relation to the benefits of taking action in a business. Climate change will create real problems for farmers with the increase in drought, flood, fire, supply chain disruptions and market changes.

The question of value for farmers in both understanding the carbon conversation, engaging in this topic and taking action was one I considered at every stage of my research, summarised in figure 48 below. Potential value can be, from creating a carbon neutral product, accessing markets, finance, insurance and meeting legal requirements. Or it could be longer term by influencing policy that will ensure the long-term viability of products, markets and farming assets that remain economically viable for future generations.

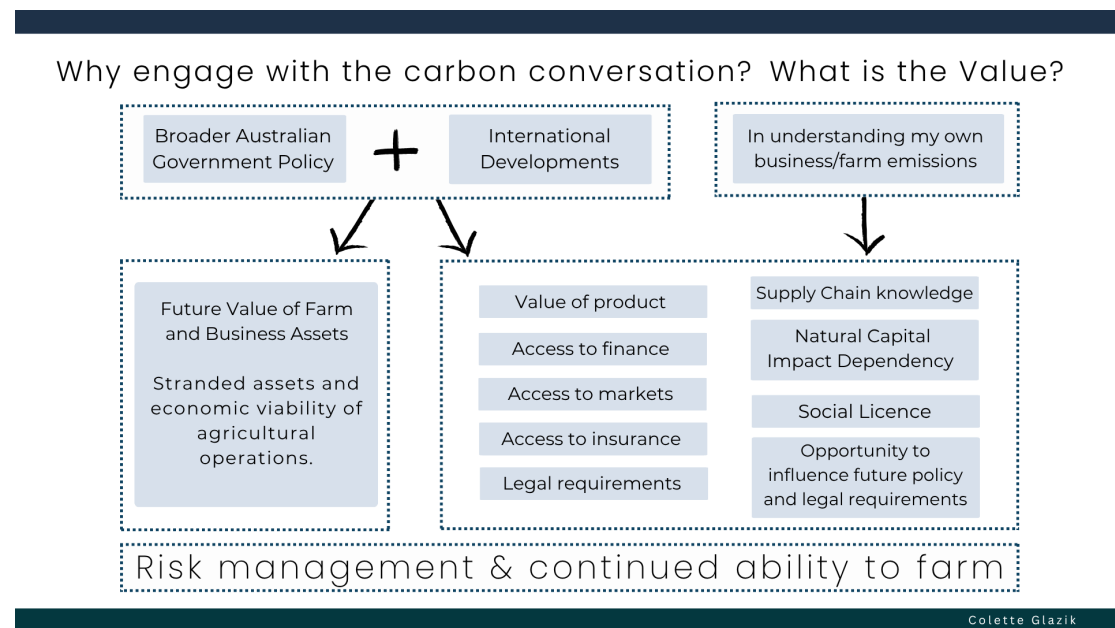


Figure 47: Why engage with the carbon conversation? What is the value? (source: author)

What's exciting about this moment is that new things can and are being built—there are options for how to move forward. While the current systems aren't perfect, they present an opportunity to create better frameworks that support both agriculture and the environment. But to shape these future structures, and tweak old ones, those with deep expertise in the supply chain—like wool producers and other farmers—need to understand how existing policies and mechanism's function, and where they fall short in delivering the outcomes needed on the ground. Only then can they effectively advocate for change, and ensure that the opportunities are in fact delivering outcomes that allow Australian farming to continue into the future.

Recommendations

- The IPCC has stated that emissions from livestock are over estimated by 3-4 times. Providing a strong foundation for change in reporting to a more accurate method for livestock emissions. Other Australian livestock sectors, such as Cattle Australia, are considering how best to approach a change in reporting. A strong collaboration between all could be a benefit to call for action to accurately report livestock emissions.
- For supply chain partners looking at carbon neutrality, engage with them to move away from reporting on just on GWP100, and look at alternative options such as dual reporting.
- Carbon literacy – often the discussion around carbon can become confusing as the phrasing and words are poorly defined and confusing, this adds additional complexity when interpreting policies around this topic. Work to enhance carbon literacy of farmers and those in the supply chain is important to understand problems, impacts and solutions. Ensuring that information is coming from those without conflicts of interest.
- Consider how broader Australian Government policy will impact the ability of Australian farmers to farm into the future and reimagine how these policies could work for all industries.

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