

Fork in the Road



farmers for
climate action

IMPACTS OF CLIMATE CHANGE
ON OUR FOOD SUPPLY

**A report on current and growing risks and vulnerabilities in
Australia's food supply chain arising from climate change.**

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Executive Summary

Climate change is heightening the risk of food shortages following extreme weather events. Empty supermarket shelves, once rare, will become a more common experience for Australians as the impacts of climate change worsen.

Climate change is also increasing the price of food, reducing availability of some lines, and decreasing the nutritional value of basic food staples like rice and wheat.

Some of the impacts are being felt already. During the first two months of 2022 much of central and northern Australia experienced food shortages due to the combined impact of flooding and the COVID-19 pandemic. The problem was not lack of food – there was plenty available on farms or in warehouses – but disruption to the supply chain required for its distribution.

We need to build resilience into our food supply system but we also need to address the broader issue of climate change. Decisive action today will help moderate the worst impacts of climate change. On the other hand, a lack of action will make it virtually certain that in coming decades Australians will for the first time face the prospect of running out of food in our major towns and cities because supply chains fail.

Resilience

A [2012 report](#) on resilience in the Australian food supply chain found that although our supply chains were highly robust and adaptable, they would be at risk if affected by two or more catastrophic events simultaneously.

Although food supply chains in Australia are in normal circumstances flexible and highly adaptable, they can be put under stress by external events such as floods and bushfires, pandemics, industrial unrest, other labour supply disruptions, loss of key inputs such as the AdBlue diesel additive, and international hostilities.

Risks

Climate change is leading to a higher frequency and severity of extreme weather events that put supply chains at risk. These include floods, bushfires, and droughts. As climate change accelerates, risks to supply of food arising from extreme weather are growing.

Risks can also arise unexpectedly from causes other than global warming. What climate change does is raise the base level risk of extreme weather events – putting further pressure, like an additional weight on the scales, on the balance of risks faced in food supply every day. The likelihood of a combination of negative events that causes food outages and empty supermarket shelves is correspondingly higher.

Farmers, transport and storage companies, retailers and others in the supply chain can and do try to manage the many risks they face, including those that arise from climate change. However, the more risks there are, the more likely it is that there will be times when supply chain risk management plans will be overwhelmed and fail, and parts of Australia will run out of food. If climate change continues unabated this likelihood will become a certainty.

Opportunities

On balance most climate change impacts appear to be negative for the food supply chain. However opportunities for farmers and supply chain businesses can arise from the actions they undertake to adapt to global warming or to mitigate climate change.

For example, red meat has an industry target of net zero carbon by 2030; changes to achieve this through herd genetics, pasture improvement, planting windbreaks which absorb carbon and so on, lead to higher quality meat.

In other industries, adaptation means a change in product. Some of Australia's favourite mango varieties could become unviable due to warmer winters, although other tropical fruits could benefit.

Another opportunity to mitigate the impact of climate change is to make supply chains shorter where possible, which contributes to diversity and resilience and helps deliver fresher produce to consumers. Government investment in making power supply more resilient with more local renewable generation and multiple shorter distribution lines would also help build resilience in the parts of the supply chain that rely on electricity.

Adoption of sustainable practices also benefits businesses supplying food to export markets, giving them a competitive marketing advantage and making them more resilient to extreme events.

The bottom line

Although further investment in resilience and adaptation is desirable, adaptation is not sustainable if climate change continues unabated. Deep cuts to emissions are therefore required to protect food supply and food supply chains.

Governments have a role in strengthening the resilience of key supply lines and helping fill gaps in the market where private sector investment is insufficient due to high levels of uncertainty. The more important role governments can play however is leadership in helping mitigate climate change. Australia faces a fork in the road, a key decision point - are we prepared to take concerted action to combat climate change over the coming decade, to prevent the worst impacts on our food supply chains?

The Paris Agreement, the legally binding international treaty on climate change which came into force in 2016, aims to limit global warming to less than 2°C above pre-industrial levels. Australia, along with more than 190 other countries, is a signatory.

Even if the Paris targets are met adaptation in the Australian food supply chain will be challenging. Current global warming, 1.07°C above pre-industrial levels, is already having negative impacts on food supply. A 2°C average warmer global climate will put the food supply chain under acute stress. If global warming exceeds the 2°C target, adaptation will be less feasible, with catastrophic consequences for Australia.

This leads to a conclusion that in addition to supporting resilience and adaptability in the supply chain, Australia should take all possible steps to meet its commitments under the Paris Agreement and encourage other countries to do the same.

Climate change impacts

The impacts of climate change are apparent at every stage of the food supply chain from inputs to the farm through to end consumers.

They include:

- At the input stage, water – episodes of drought, or extreme dry weather, are becoming more frequent and more severe with climate change.
- Production on farm is affected in multiple ways including lower crop yields, livestock stress and higher operational costs.
- Transport of food is disrupted by more frequent extreme events, such as floods or bushfires.
- Storage is becoming more vulnerable to pests and diseases in warmer weather. Costs of refrigeration are increasing, and refrigeration is less effective in heatwave conditions.
- Animal transport businesses and saleyards are being affected by increasing numbers of hot days, when they cannot operate for animal welfare reasons.
- Retailers are feeling the impacts of higher costs, shorter shelf lives and less reliability in the availability of types of food.
- Lower nutritional value of basic foods like wheat and rice.
- Costs in the supply chain flow through to consumers in the form of higher food prices.

Some impacts of climate change affect every part of the supply chain. Due to the uncertainty created by climate change, bank loans and insurance are becoming harder to obtain and more expensive. These costs are rising and will have to be passed through to consumers.

Uncertainty also makes investment in supply chain resilience more difficult. In a highly uncertain future, it is difficult for businesses to decide what measures will be effective, and investments based on inherently inaccurate predictions will potentially be wasted.



Introduction

For several weeks in January and February of 2022 much of central and northern Australia experienced food shortages, as widespread flooding cut road and rail links from the south. The Australian Defence Force had to [airlift six tonnes of food](#) and other supplies to the town of Coober Pedy; the ABC [reported](#) the food shortage in the Northern Territory had become “dire” and “supermarket shelves across the NT remain bare”.

These kinds of events were once rare. Based on past meteorological data, the Australian Rail Track Corporation described¹ the 2022 South Australian floods as “a once in 200-year event”. That optimistic timeframe will likely be rendered out of date by climate change.

Weather is and always has been variable. However, as climate continues to change rapidly, and global temperatures warm, many types of once rare weather events such as the widespread South Australian floods in early 2022 are becoming more frequent. These events include floods and other heavy rainfall events² and storms³; although at other times, also because of climate change, extended dry periods are also more likely⁴.

Similarly, bushfires will become more frequent and more severe. The 2008 Garnaut climate change review⁵ predicted that bushfire seasons would become longer and more intense, “directly observable by 2020”. This proved tragically accurate as bushfires raged across Australia in 2020.

Other extreme events including heatwaves and coastal sea surges are also increasing in frequency. It appears likely (although there is considerable uncertainty due to data limitations) that tropical cyclones may become less frequent but will be more severe and extend further southwards.

All these types of events have the potential to severely disrupt our food supplies – whether directly, by cutting supply lines, or indirectly by affecting key elements of the supply chain including production, storage, and workforce availability.

The COVID-19 pandemic has exposed more of the vulnerabilities in Australia’s food supply chain. We have seen empty supermarket shelves across parts of the country on several occasions during the pandemic. These have been exacerbated by panic buying. Nevertheless, generally⁶ panic buying of food begins with a trigger of a genuine outage of a particular product or type of product that creates a fear among consumers that shortages will continue.

The COVID-19 pandemic has revealed weaknesses in the business model for food supply, and its vulnerability has been expressed in outbreaks of panic buying – a symptom, not a cause, of a fragile food supply chain.

In an interview for this project, the National Farmers’ Federation observed that food supply chains are more fragile than is generally assumed. Climate change is a factor in increasing fragility. Our resilience, preparedness and robustness are not where they need to be. This poses ongoing challenges to sustain ability and reliability of food supply.

¹ ‘South Australian Flooding and Road Closure’, Australian Rail Track Corporation, 31 January 2022, (at www.artc.com.au, viewed 2 February 2022)

² Seneviratne, S.I., et al. (2012) ‘Changes in climate extremes and their impacts on the natural physical environment’. In: *Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation*. A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change (IPCC). Cambridge University Press

³ Selma B. Guerreiro, Hayley J. Fowler, Renaud Barbero, Seth Westra, Geert Lenderink, Stephen Blenkinsop, Elizabeth Lewis, Xiao-Feng Li. ‘Detection of continental-scale intensification of hourly rainfall extremes’. *Nature Climate Change*, 2018

⁴ Quiggin, J (2007) *Drought, Climate Change and Food Prices in Australia*, University of Queensland, Brisbane; for additional references see ABARES [research on climate and drought](#)

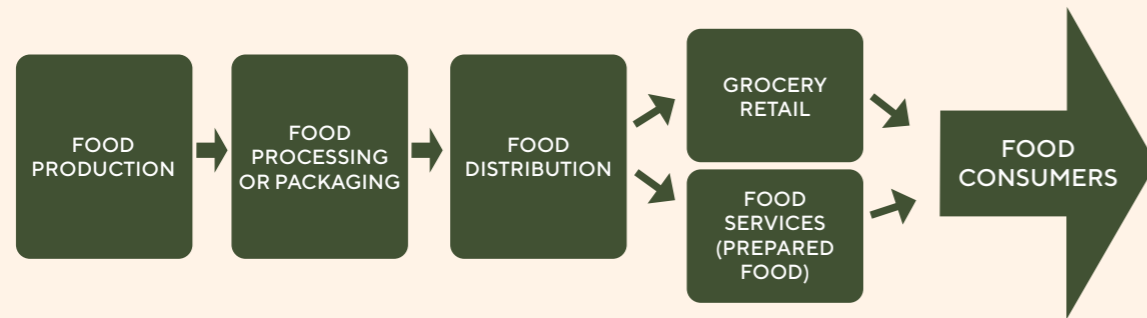
⁵ Garnaut, Ross (2008) *The Garnaut Climate Change Review* Cambridge University Press

⁶ Not always. There are multiple reasons for panic buying, not all rational. See Wang, Hao (2020) ‘Panic buying? Food hoarding during the pandemic period with city lockdown’ *Journal of Integrative Agriculture* 2020; and Lies Notebart (2021) *COVID-19 – the psychology of panic buying*, University of Western Australia.

What are food supply chains?

Australia produces food for its population of some 26 million, and millions more overseas. Around 70 percent of Australia's agriculture, fisheries and forest production is exported.¹ Food reaches consumers through many different routes, typically involving some or all of processors, manufacturers, warehouse operators, retailers, and the companies or individuals who transport food between them. These networks comprise Australia's food supply chains. There are different types of chain for different types of products, such as dry goods, fresh fruit and vegetables, meat, frozen food, dairy, and bread.

A schematic of a typical food supply chain is:



¹ ABARES Snapshot of Australian Agriculture 2021, at www.awe.gov.au/abares/products/insights viewed 7 February 2022

Figure 1 Overview of Food Supply Chain (from Bartos et. al. 2012¹)

A concept related to a supply chain is a “value chain”², where each link adds value to a product as it passes through. For most practical purposes in relation to food this parallels the concept of a supply chain. In the food supply chain illustrated above, opportunities for value creation arise in production (the basic value step), transport and handling (keeping food fresh, palatable and presentable), retail (providing information to consumers), and in food services (cooking or preparing food). Not only are components of the supply chain vulnerable to the effects of climate change, but so is the capacity for different players in the chain to add value – as outlined in the following sections of the report.

The food supply chain is reliant on external inputs at all stages, including fertiliser and water, packing materials, electricity, IT and telecommunications, fuel, and financial products (banking, loans and insurance). That reliance, together with the connections between links in the chain, creates dependencies - factors that affect the stability and operational capability of each link. These need to be managed for the supply chain to function. Dependencies can be internal (each link relies on the previous link in the chain to be functioning) or external (for example, inputs on which an operation relies).

Climate change affects the dependencies in the supply chain in numerous ways: availability and price of water, energy prices, transport (especially, cutting of key routes following extreme weather events), international competition for inputs, and availability and price of financial products (such as lending and insurance).

¹ Stephen Bartos, Matt Balmford, Alex Karolis, James Swansson, Alistair Davey (2012) Resilience in the Australian Food Supply Chain Report prepared by Sapere Research Group for the Australian Government Department of Agriculture, Forestry and Fisheries

² See for example a report from CSIRO in 2016 on adaptive value chain approaches.

Sometimes critical dependencies are not well understood and only become apparent following an event – for example, reduced urea imports in 2021-22 caused a shortage of diesel fuel additive [AdBlue](#) that threatened to interrupt truck deliveries of food in Australia. Interestingly, this also led to [calls from the industry](#) for greater electrification of Australia's truck fleet – a move that will not only help address the AdBlue dependency but also reduce greenhouse gas emissions.

The following diagram illustrates some of the main dependencies for the food supply chain:

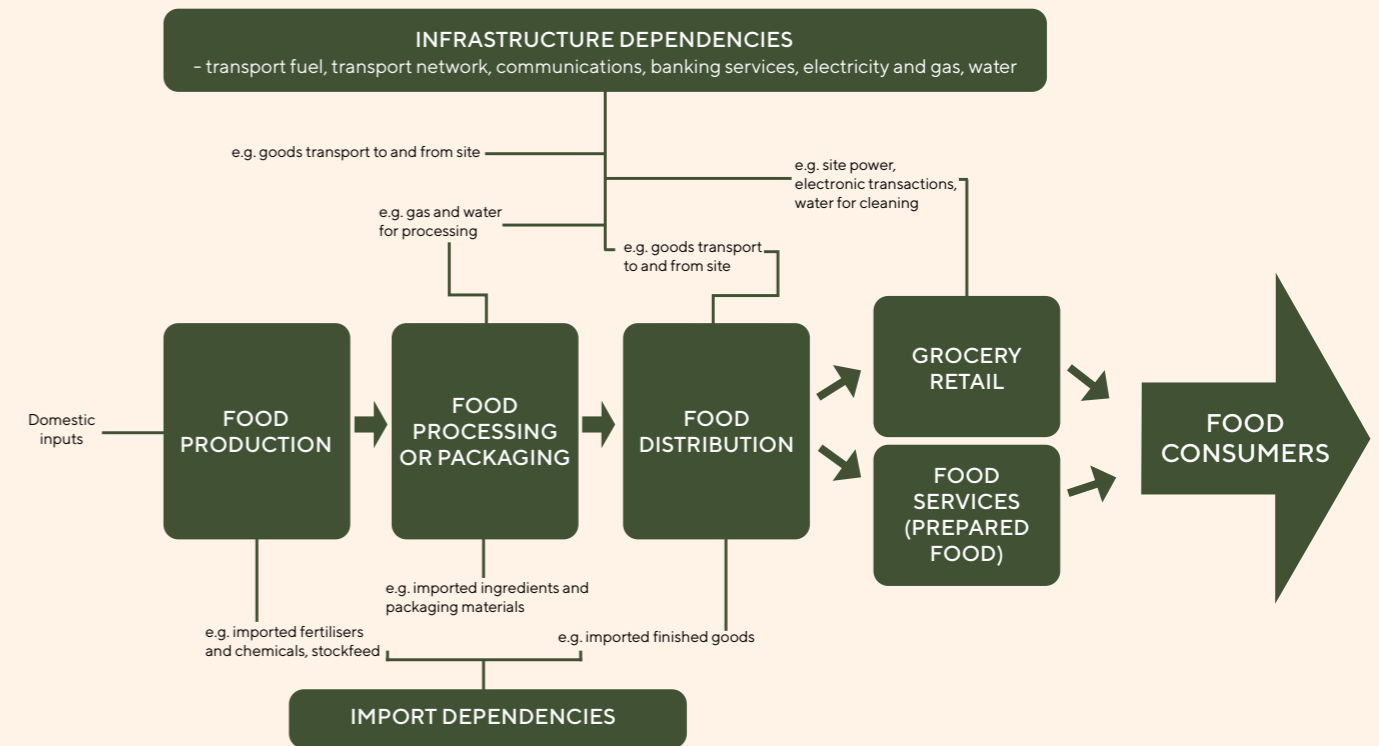


Figure 2 Food Supply Chain Dependencies (from Bartos et. al. 2012¹)

A 2021 evidence review of the impacts of climate change on the livestock supply chains² lists components of that chain as: livestock feed, water resources, animal health and production, processing, storage, transport, retail, and consumption – and draws links between the supply chain, labour, and prices.

Most of the identified impacts of climate change on livestock supply chains were negative: less predictable feed supply; increase in pests, heat stress, and disease; worsening storage conditions leading to lower food quality and safety; higher prices. The study found however that at some locations in high latitudes with cold winters livestock producers might benefit from longer growing seasons and reduced heating costs.

Severe weather events have both direct and indirect impacts. They can directly cut supply lines or have an indirect impact by causing labour shortages and disruptions to international supplies. In the same way the COVID-19 pandemic has exposed previously unidentified weaknesses in supply chains, weather events caused by climate change can reveal unexpected vulnerabilities.

¹ Stephen Bartos, Matt Balmford, Alex Karolis, James Swansson, Alistair Davey (2012) Resilience in the Australian Food Supply Chain Report prepared by Sapere Research Group for the Australian Government Department of Agriculture, Forestry and Fisheries

² Goddea, Mason-D’Croza, Mayberry, Thornton, Herrero (2021) ‘Impacts of climate change on the livestock food supply chain; a review of the evidence’ Global Food Security Vol 28, March 2021

The purpose of this study, and its methodology

The key questions for this project were how is climate change already having an impact, and what impact will it have in future, on Australia's food supply chains?

To answer these questions, this study considered Australian and international research, including reports by and to government agencies; reviewed media reporting of supply chain disruptions; consulted widely with farmers, farmer representative organisations, rural research bodies, transport and processing companies and retailers; and reviewed and updated previous work on the resilience of the Australian food supply chain. A list of bodies consulted is at Attachment A, which will be published on Farmers for Climate Action's website.

In the academic and official literature examined for this project some sources use 'climate change' and others 'global warming' to describe essentially the same phenomena. The terms are often used interchangeably; in recent years however 'climate change' has become more common. Weather on the other hand is different, always localised and short term. The National Oceanic and Atmospheric Administration (NOAA) in the United States has a good [explanation](#) of different uses of these terms.

While a great deal has been written about the impacts of climate change on food production, there has been comparatively less academic research on impacts on the supply chain post-production in transport, storage, and distribution. This flows through to policy making. In examining lessons from Queensland flooding McMahon¹ et al observe that "a broader view of climate change, beyond disasters and food production, has yet to be fully integrated into food security policy—and supply chain governance and practice—in Australia."

This report aims to help address that gap. It is organised into two sections:

1. the risks and vulnerabilities in the food supply chain from ongoing climate change, and
2. how industry and government should respond.



"A broader view of climate change, beyond disasters and food production, has yet to be fully integrated into food security policy—and supply chain governance and practice—in Australia."

¹ MacMahon, A., Smith, K. & Lawrence, G. Connecting resilience, food security and climate change: lessons from flooding in Queensland, Australia. *J Environ Stud Sci* 5, 378–391 (2015).



PART ONE

Climate change and the food supply chain

The table below summarises the key impacts of climate change at each link of the food supply chain.

Link in the supply chain	Possible impacts from climate change	Consequences
Farm inputs (fertiliser, fuel, water, pesticides)	Lack of water/extended dry periods Higher input prices	Loss of production Loss of farm income Higher prices for consumers
Farm production	Heat stress Longer/shorter growing seasons Higher incidence of pests and diseases Loss of crops or livestock in extreme weather events Higher operational costs	As above Risks to animal welfare Loss of some farming communities in regions where agriculture becomes marginal
Transport	Extreme weather events (eg floods, fires) cut supply links Cost of fuel increases Heat stress in livestock transport Difficulty of refrigeration	Lack of food on supermarket shelves (eg SA flooding 2022) Higher prices Food spoilage and waste
Processing	Lack of raw materials Lower quality produce Unavailability of staff at key times (eg during an emergency) Higher energy costs	As above At times, unavailability of some food lines
Storage	Shorter shelf lives for some heat sensitive products (eg stone fruits, table grapes, salad greens) Pests (eg in bulk grains)	Loss of food Higher prices
Retail	Less predictable and reliable supply of food Higher input costs Consumer demand for low carbon intensity food Unavailability of staff at key times (eg during an emergency)	Higher prices Risk of absences of key foodstuffs Loss of customer confidence
Food services	Similar impacts as retail Some outlets highly sensitive to unavailability of key products (eg KFC and chicken) Loss of nutritional value a concern in hospitals and aged care	Potential increase in deaths in populations reliant on food services (eg aged care)

Further detail on each of these impacts is provided in the following sections.

Table One – summary of impacts of climate change on the food supply chain



Impact on farm inputs

As climate change affects food production systems, competition for inputs like fertiliser, pesticides and other agricultural chemicals is growing [worldwide](#). The main impact for Australian farms is increased costs. These are eventually passed through the supply chain to consumers in the form of higher food prices. The global pressure on inputs such as fertiliser, chemicals and machinery has more of an impact in developing countries⁵ than in Australia. As one interviewee commented “on inputs, the far more important issue for us is the cost of labour”.

There is one key input of concern however - water. Climate change is leading to increased frequency and severity of prolonged dry periods or droughts. The evidence strongly points to a causal link between climate change and increased likelihood of drought¹.

In consultations for this project Horticulture Innovation Australia observed 40% of horticulture growers are in the Murray Darling Basin. Production in the Basin is increasing, which means a greater proportion of Australia’s fruit and vegetables will be exposed to the risk of drought. The Murray Darling Basin Authority notes² “climate change studies predict that the Basin’s climate is likely to become drier in the future and more variable...in addition to more extreme droughts, there may also be more extreme floods”. This impact is growing – from the same source, “average surface water availability across the entire Basin for 2030 is projected to fall by 10%. The impact is expected to be greater in the southern Basin”.

Average in-flows into the Murray River have already reduced by approximately 40% over the last 20 years compared to the period up until 1999/2000.³

The impacts of low rainfall or drought are noticeable in other industries - Meat and Livestock Australia for example noted the severe impact on that industry from the 2017-19 drought. MLA also drew attention to what researchers at the University of Southern Queensland and the Bureau of Meteorology describe as a flash drought⁴ – sudden intensification of drought conditions and evaporative stress. One of the key risks of climate change in livestock industries is lack of soil moisture leading to loss of pasture.

¹ ABARES Climate and drought, at www.abe.gov.au/abares/research-topics/climate; see also numerous reports from the Intergovernmental Panel on Climate Change (IPCC), including Climate Change and Land (2019) and IPCC Working Group I report, Climate Change 2021: the Physical Science Basis (2021)

² www.mdba.gov.au/importance-murray-darling-basin/environment/climate-change viewed 12 February 2022

³ Murray-Darling Basin Authority, The 2020 Basin Plan Evaluation, <https://www.mdba.gov.au/sites/default/files/pubs/bp-eval-2020-full-report.pdf>.

⁴ Hanh Nguyen, Matthew C. Wheeler, Harry H. Hendon, Eun-Pa Lim, Jason A. Otkin, ‘The 2019 flash droughts in subtropical eastern Australia and their association with large-scale climate drivers’, Weather and Climate Extremes, Volume 32, 2021. The authors note large-scale climate drivers for this phenomenon, among them global warming, explain only about half the flash drought magnitude and more data is needed.

⁵ Robert Mendelsohn, Jinxia Wang, ‘The impact of climate on farm inputs in developing countries agriculture’.

Impact on production

Farm production is the most important link in the food supply chain, the source of the food that makes its way on to dining tables through the other links of the chain. The Australian Academy of Science (AAS) describes agriculture as “one of the most climate-vulnerable industries, sensitive to changing rainfall, temperatures and extreme weather events”¹.

Not surprisingly, therefore, the impact of climate change on food production has attracted considerable attention. Information on the issues involved has been published by Commonwealth and States’ departments of agriculture, CSIRO, ABARES, AAS, academic researchers, rural research corporations, industry and farm advocacy bodies, and many others, including Farmers for Climate Action. There is a large volume of information directly applicable to Australia, and many times more information available about global impacts in the international literature, including detailed analysis and projections in successive IPCC reports.

Production is therefore not the focus of this report – there is a great deal of information about climate change and farm production available elsewhere. It was not the focus of the consultations that were undertaken during the project. Even so, farm organisations and researchers consulted mentioned a range of negative impacts including

- dairy farmers having to relocate to regions with cooler temperatures and more reliable rainfall;
- tropical adapted grasses, becoming more prevalent in northern Australia due to higher temperatures, with lower digestibility which affects livestock;
- reduction in grain production in times of drought;
- reduction in chilling hours in the Goulburn valley is having a noticeable impact on pome and stone fruit;
- losses of crops and livestock on farm due to increased pests (among those mentioned in interviews were Queensland fruit fly moving southwards as warmer conditions prevail; ticks and buffalo fly; Russian wheat aphid; lens snail; fall armyworm) and diseases;
- most of Australia’s sugarcane is grown at less than a metre above sea level, so will increasingly be affected by salinity (this has already severely damaged Fiji’s sugar industry);
- direct impact of heatwaves leading to losses of crops and livestock; and
- loss of production in floods, bushfires and droughts.

Some farm businesses are relocating. Examples cited in interviews included a move by dairy farmers to cooler climates with more reliable rainfall, and similar moves by wine grape growers. A favoured destination due to climate change has been Tasmania; although some interviewees questioned whether Tasmania would be able to sustain much more movement due to the pressure it put on that State’s limited resources. There is an associated problem of stranded assets in regions from which production is relocated – for example, milk processors having to [mothball plants](#) in some locations.

However not all the impacts identified in the consultations were negative. Climate change has created opportunities in the production link of the supply chain including:

¹ Howlett B, Henry R Australian agriculture and climate change: a two-way street Australian Academy of Science at <https://www.science.org.au/curious/policy-features/australian-agriculture-and-climate-change-two-way-street> viewed 14 February 2022.



- heavy rainfall events and flooding can benefit future growing seasons by increasing soil moisture;
- a longer growing season can benefit some products – especially, tropical fruits, which may also in future have a wider range of areas in which they can be grown; and
- Australia’s technology, resources and adaptability means producers here are better able to maintain production than many competitors in export markets who are also affected by climate change, giving Australian exports a competitive edge.



A farmer perspective – adapting but concerned

Andrew Young grows salad crops on a farm near Wemen in north-western Victoria. He says that climate change is already affecting continuity of supply of products to processors in his industry. In the future climate change is likely to lead to further disruptions. The expectation that every food product will be always available has to change.

Patterns of production and supply chains will change more rapidly in future than in the past, putting pressure on producers to find other slots for their produce and different ways of meeting market demands. Andrew also anticipates carbon pricing will force existing supply chains to make economies and become more efficient.

These changes will create market opportunities for some but be difficult for those who are still working with past business models - not all farmers are paying enough attention to the scientific forecasts for future climate change and taking appropriate steps to adapt.

Climate change is increasing risks in regions like his that are reliant on irrigation; there are risks from extreme weather events, and water security is likely to be an issue in future.

One of the current problems is uncertainty – Andrew would like to see clearer political guidance on where Australia is heading with its climate change policies, to help farmers plan for the future with more confidence.

Andrew is taking steps to mitigate his own climate impact, with his farm operation [certified carbon neutral](#) since October 2021.

Impact on transport

Australia has a large and mostly well-maintained network of roads and rail that helps food make its way from farmers to consumers. Australians expect the transport network to operate effectively, without blockages and delays. Mostly this expectation is met; when it is not, public concern rises rapidly.

Early in 2022 many supermarkets in Australia experienced food shortages. The rapid spread of the Omicron variant of COVID-19 caused staff shortages that interrupted distribution networks (primarily affecting businesses getting food from warehouses to retail outlets). Analysis published at the time¹ took the view that “current shortages are likely a temporary inconvenience rather than an ongoing problem”, accurately predicting food supply chains would adjust quickly. The article did however point out that the shortages caused by labour issues during the pandemic would be more severe if they coincided with extreme weather events.

This coincidence of events occurred shortly thereafter when widespread flooding affected South Australia. In January South Australia experienced heavy and sustained rainfall across large parts of the State ([reported](#) as the wettest January since 1984). By the last week of January flooding had become widespread. An emergency flood declaration was put in place on 28 January 2022. Following the flooding key road and rail links were cut. This combined with the impact of the COVID-19 pandemic to put the food supply chain under severe stress. Many towns in central and northern Australia experienced food shortages, with numerous reports of empty supermarket shelves.

Flooding also damaged rail track on the Nullarbor, leading to shortages of some food items in [Western Australia](#). One supermarket chain took the highly unusual step of sending food and other supplies to WA by [ship](#), a mode of transport to the State that had not been used since the middle of the last century.

Direct attribution of the 2022 floods to climate change could be disputed – as with any single event, attribution of a causal link is arguable. What is not in dispute however is that climate change increases the frequency of such events. There is a well-documented upwards trend in the number of occurrences of extreme events. Climate change is leading to a higher frequency and severity of all kinds of extreme weather events – including floods, bushfires, and drought – that put the continuity of supply chains at risk. As climate change accelerates, these risks are growing. In relation to floods, the Australian Bureau of Meteorology has identified ² that global warming has already increased the risk of major disruptions to Pacific rainfall, and severe disruptions including flooding in eastern Australia and in Samoa in 2010-11.

A [2012 report on resilience in the Australian food supply chain](#) found that although our supply chains were highly robust and adaptable, they would be at risk if affected by two or more catastrophic events simultaneously. Climate change increases the likelihood of that happening. .

For example, in the 2020 bushfires in south-eastern Australia links to several dairy farms were cut off by fire (source: Dairy Australia interview). There was a great deal of cooperation and sharing of information among milk processors to find alternative routes where possible, and in some cases

¹ Bartos, S 'Relax, Australia does not have (and is not likely to have) a shortage of food' *The Conversation*, 13 January 2022

² Power, S., Delage, F., Chung, C. et al. Humans have already increased the risk of major disruptions to Pacific rainfall. *Nature Communications* 8, 14368 (2017).

delivery of milk to a processor to which the farm concerned was not contracted (contrary to normal competition policies that apply in the industry, but better than milk being wasted). Even so, some farms could not be reached, and milk had to be disposed of on farm.

Severe weather events have also affected the transport of horticultural products, which are sensitive to transport delays due to their short shelf life (most products). The risks in transport are growing – increased global warming will increase the number of severe weather events. This impact is exacerbated by elongation of supply chains to export markets (source: Horticulture Innovation Australia interview).

A direct link between rising temperatures and transport is the impact of heat on livestock in transit. If the weather gets too hot, livestock producers – for animal welfare reasons – are not able to transport their livestock (source: interview Cattle Council of Australia). While producers in the Northern Territory are used to managing in hot conditions, if global warming continues this may become more difficult. Lack of or irregularity of movements can also disrupt other parts of the supply chain, such as processing. Delays in transport due to unexpected extreme weather events can have an adverse impact on animal welfare – it is highly undesirable for animals to be left on trucks for any length of time (source: interview, Australian Meat Processor Corporation). The meat processing sector is already exposed to unacceptable risks due to lack of collaboration in the supply chain; climate change exacerbates those problems.

Sea level rise and its impact on transport was less of a concern to organisations consulted for this report. As sea levels rise due to climate change, coastal roads, ports, and low-lying airports will increasingly be at risk from damage arising from storm surges and coastal flooding. CSIRO scientists have noted¹ “the severity and frequency of storm tide events in the future will increase with rising sea levels and additionally, climate change may also change the frequency and intensity of the meteorological drivers of storm surge”. While at present much of Australia’s food is transported on coastal roads and a key food export hub, Brisbane airport, is only four metres above sea level, most of the bodies consulted took the view that alternative supply routes could be found that would avoid these problems. They were aware of the risks, but as Horticulture Innovation Australia noted, “growers who export are well aware of the issues in the supply chain”. For example, major horticulture exporters are already contingency planning for the possibility that Brisbane airport becomes unavailable or unreliable and considering alternative hubs.

¹ McInnes, K.L., G.D. Hubbert, I. Macadam, J.G. O’Grady Assessing the Impact of Climate Change on Storm Surges in Southern Australia. CSIRO Marine and Atmospheric Research, Victoria

Two modes of transport, road and rail, are particularly vulnerable to being cut by floods and bushfires. This can be either temporary, for the duration of the event, or have a longer lasting impact if sections of road and track are washed away or bridges (either road or rail) collapse and take weeks or months to restore. Either can have a significant impact on supply chains.





Impact on processing and storage

Impacts on storage and processing differ significantly among different types of food products. For those with short shelf lives – including most horticultural products and fresh meat – the information collected from interviews suggest impacts on processing and storage from climate change are not a major concern at present. There are some, but not as significant as impacts elsewhere in the chain.

Many small horticultural producers that are part of the Open Food Network (OFN) have found they have had to move to refrigeration – the food industry is moving to include fruit and vegetables as part of the cold chain (source: interview, OFN). Other industry sources in horticulture noted that while there are costs associated with refrigeration, for most products these are a relatively small proportion of overall costs. A comment was “the major distribution centres are well equipped and have plenty of capacity” (source: interview, Horticulture Innovation Australia).

In the meat industry, meat processing plants have experienced significant pressures on output and potential shortages due to labour shortages – especially noticeable during the COVID-19 pandemic – but not directly from climate change.

Operators are conscious of this risk and developing management approaches. Heat events also have a major negative impact on animal welfare in live exports. Mainly due to welfare considerations there have already been significant changes in timing and animal housing conditions in that industry.

For some products with longer storage times however there are very significant risks to storage because of climate change. High temperatures and atmospheric moisture for example greatly increase the risk that stored grain will sprout, greatly reducing its value and ability to be milled into food products. Flooding also has the potential to damage stored grain - there have been incidents of flood damage in recent southern Australian flooding (source: interview, Grains Council of Australia).

Stored grains are also susceptible to pests, a risk that is growing as climate change increases both the international movement of pests and their ability to reproduce (see case study opposite).

Risks to storage with global warming – the case of the khapra beetle (or “some like it hot”)

Khapra beetle is one of the world’s most damaging cereal pests. According to the Australian Department of Agriculture, Water and Environment, “if khapra beetle was to establish here, many of our trading partners would reject stored produce from Australia, causing huge losses and affecting our economy. A widespread incursion could cost Australia \$15.5 billion over 20 years”. (Khapra beetle – the story so far...)

This tiny pest originated in India and has spread to tropical Asia and West Africa. In hot weather conditions it can multiply rapidly and do huge amounts of damage to stored grain.

So far Australia has been free of khapra beetle. However, climate change increases the risk of an incursion. Every day of high temperatures entails a risk that beetle larvae will hatch from hiding places inside shipping containers and spread to grain storage. It is a simple causal relationship: the more frequently we experience high temperature days, the higher the risks. These risks can be managed (and to date have been) but are growing more severe.

In June last year Agriculture Minister David Littleproud observed “Hitchhiker pests, such as khapra beetle, are increasing due to climate change, changing trade patterns, supply chain complexity and poor global shipping container hygiene” (our underline).



More frequent heatwaves are likely to increase warehousing costs, and could increase amounts of food spoiled.

Photograph of adult khapra beetle and larva on grains of rice from Department of Agriculture, Water and Environment factsheet.



Retail and Consumption

Overseas retailers and consumers

Australian food has multiple end points. Around 65 to 70 per cent of agricultural production is exported. This is not all food for human consumption (the figure includes fibres like wool and cotton and grains for animal feed) but still enough to [feed some 60 million people](#). China is by far the largest importer of Australian food, at around 20% of total exports, followed by Japan, the United States, Republic of Korea, and Indonesia each at some 7-10 percent of total exports¹.

At the overseas consumption end of the supply chain Australian exporters are seeing a growing demand for supply chains to account for the carbon intensity of food products. This is driven by a mix of community or government pressure in some export markets (in particular, European markets), retailers, and consumers themselves.

Horticulture Innovation Australia expected this trend to become more evident over a 15-30 year horizon. Dairy Australia estimated around a third of consumers wanted sustainable products; they expect this proportion to increase over time. Processors and exporters alike will need to provide more information on the carbon footprint of their products. Similar observations were made by the National Farmers; Federation.

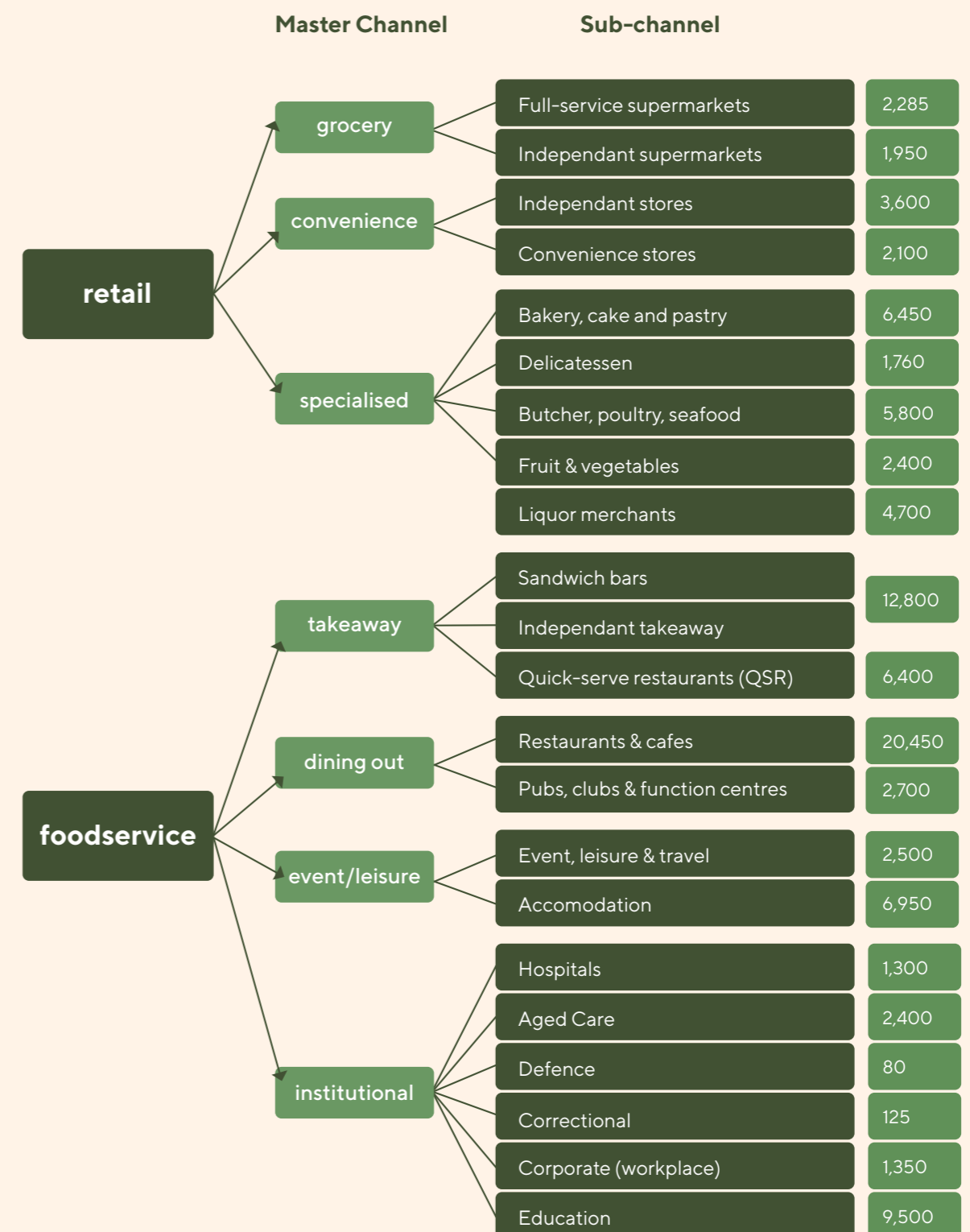
What the demand for carbon friendly products from overseas buyers (a trend likely to come to Australia in due course) implies is a need for good carbon accounting at all stages of the supply chain in order to meet market expectations. Moreover, where low emissions alternatives are available and affordable, supply chain operators who adopt them (for example, electric vehicles or solar powered refrigeration units) will gain a competitive advantage.

¹ Department of Foreign Affairs and Trade at www.dfat.gov.au/trade/organisations/wto/Pages/agricultural-trade viewed 18 February 2022

Domestic retail and consumption

There are numerous ways in which food is delivered to end consumers in Australia. As shown in the figure below, there are many thousands of small enterprises (sandwich bars, takeaway outlets, cafes, convenience stores, bakeries etc.) involved in food retail and food service.

Figure 2 – Outlet types and numbers (Department of Agriculture, Fisheries and Forestry, FOODmap: an analysis of the Australian food supply chain, at www.awe.gov.au viewed 6 February 2021)





Impacts along the whole of the chain

All the organisations consulted for this project, without exception, identified that climate change gave rise to the problem of unpredictability. Climate change is making weather patterns less predictable and increasing the chance of unexpected events. “Drought, flood, fire, and late season frosts are creating variability and a high level of unpredictability in the whole of the supply chain” (source: interview, Grain Growers Australia).

Unpredictability has costs throughout the food supply chain. For farmers, it makes production decisions higher risk, with a greater chance of error; it also increases the cost of insurance against those risks. Uncertainty means there is a higher cost to resilience (source: NFF interview). Uncertainty affects transport, warehousing, storage and retail, making businesses more reluctant to invest in facilities that may be rendered uneconomic by unpredictable future events. Uncertainty makes it harder for all participants in the supply chain to plan for the future (source: Open Food Network interview).

Financial institutions dislike uncertainty. Banks and non-bank lenders such as credit unions are much more comfortable when the future, even if cannot be predicted precisely, falls within risk boundaries that can be quantified and understood. Less predictability due to climate change means higher costs of borrowing – lenders build in a higher margin to deal with uncertainty. The same applies with insurance – insurance for farm businesses is becoming more expensive, increasing by more than 20 per cent, due to greater uncertainty (source: NFF interview). In some cases, farmers reportedly⁵ can no longer afford insurance due to climate change.

The same applies all the way up the food supply chain – businesses that transport food products from farms, or store those products, or rely on them as inputs for other manufactured foods, are starting to find - and will in future – that banking, lending and insurance products are more expensive or not available due to uncertainty caused by climate change.

As with higher fuel and electricity costs associated with climate change, these cost increases affect the whole of the supply chain and are eventually passed on to consumers. Dairy Australia noted that as power costs increase there may also be changes in food preferences, with a lower consumer demand for products that require refrigeration.

An associated problem is that our existing supply chains have been developed over the past century or more based on past weather and climate patterns. Climate change is leading to rapid and unpredictable changes, which could lead to new choke points or blockages in the supply chain. This compounds the problem of unpredictability. Existing major transport routes may remain viable or may not. A dilemma for freight transport planning is that creating major new alternative routes involves long lead times; planning them is more difficult in the face of unpredictability.

Finally, if climate change forces farmers to go out of business, there will be impacts throughout the supply chain and in rural communities. Processors, saleyards, wholesalers, warehouse operators, transport companies and other business in the supply chain are established to handle specific types of food products. If those can no longer be produced in a specific region, due to the impacts of climate change, those supply chain companies will find themselves with stranded assets – buildings, offices, equipment, that are no longer economic in that location. Loss of farm businesses will hurt rural communities, and loss of supply chain operators will multiply those effects.

A study¹ of food security, risk management and climate change included retail and food service businesses, among others in its data collection. It identified a real risk from “a systemic convergence of negative external shocks including the re-emergence of an extended drought overlaid by longer-term climate change”. Large firms had risk management systems, but “fewer than 60% [of survey respondents] judged their management as highly committed to effective risk management”. It also found that while large retailers could be expected to have risk management systems, this did not extend throughout the supply chain, an observation that applied especially to smaller companies.

There is however an upside to being small. Experience with recent natural disasters and with the pandemic suggests many small outlets, even if they do not have formal risk management systems, are more resilient in the face of external pressures. For example, in early 2022 disruptions associated with loss of staff due to the COVID-19 pandemic caused food shortages and stock runouts, resulting in empty shelves in supermarkets that were part of our major national chains. Smaller retailers, such as local butchers and greengrocers in rural towns who had networks with local suppliers, were able to maintain food stocks more easily. This resilience factor is likely to apply also to future disruptions related to climate change and extreme weather events – and indeed was frequently observed in localities affected by the 2020 bushfires and 2011 Queensland floods.

The trend observed in European markets for consumers to choose low carbon intensive foods is not as strong in Australian markets. One respondent in interviews observed that while Australian consumers may say this is their preference, a majority are not prepared to pay a premium for it. A 2018 qualitative research study² found environmental impact was not an important influence on consumers’ food choices. In the current climate following the COVID-19 pandemic “food miles are not getting as much traction as food security” (source: Dairy Australia).

Over the longer term another impact of climate change is likely to be a reduction in the nutritional value of some basic foods³. Researchers at the Harvard School of Public Health⁴ found “that when food crops like wheat, corn, rice and soy are exposed to CO₂ at levels predicted for 2050, the plants lose as much as 10% of their zinc, 5% of their iron, and 8% of their protein content”. This is a remote risk for the average Australian with a nutritious diet and low reliance on a small number of basic carbohydrates. There are though vulnerable groups with limited nutritional choices due to circumstances such as poverty or homelessness who will be at risk of nutritional deficiencies. The same may apply in food service settings such as residential aged care where there are already [questions](#) about the standard of food services by some operators.

¹ Michael, DT & Crossley, RL 2012, Food security, risk management and climate change, National Climate Change Adaptation Research Facility, Gold Coast.

² Mann, D., Thornton, L., Crawford, D., & Ball, K. (2018). Australian consumers’ views towards an environmentally sustainable eating pattern. *Public Health Nutrition*, 21(14), 2714-2722.

³ IPCC, Special Report on Climate Change and Land, Ch. 5 Food Security.

⁴ Climate Change and Nutrition, at <https://www.hsph.harvard.edu/c-change/subtopics/climate-change-nutrition/> viewed 16 February 2022.

⁵ “Climate change-driven disasters making insurance premiums too dear for farmers” Jane McNaughton ABC rural, July 2020, at www.abc.net.au/news/rural/2020-07-16 viewed 15 February 2022.

PART TWO

HOW SHOULD INDUSTRY AND GOVERNMENT RESPOND?

As climate changes, and continues to change in future, companies in the food supply chain and governments will have to change practices and policies to cope with the risks and pressures.

A great deal of action is already in train. From the anecdotal evidence gathered for this report it appears most companies in the Australian food supply chain are actively pursuing climate change policies. These policies in many cases go well beyond the Australian government's target of net zero greenhouse gas emissions by 2050.

Achieving carbon neutrality goals in food supply chains will make an important contribution to Australia's overall efforts to minimise the damaging impacts of climate change, so is worth pursuing on its own merits. It is also however a commercial imperative for businesses in the chain.

Many industry bodies noted in interviews that financial institutions were key drivers – one commented, “a lot of lenders have more ambitious climate targets than the government” – and so are customers, particularly in export markets. To remain competitive, not only farmers but the many players in the food supply chain need to address sustainability concerns. As observed by the Open Food Network “customers increasingly want transparent supply chains – they want to know where their food has been produced and how it has been transported” (source: interview).

There are four types of action that climate change requires from both government and businesses in the food supply chain if we are to avoid, as far as possible, the negative impacts from climate change – build resilience, manage risk, adapt, and mitigate.



Resilience

A 2012 study¹ of resilience in the Australian food supply chain defined resilience as the capacity of organisations or systems to return to full functionality in the face of disruption. It identified resilience in the supply chain in terms of redundancy, flexibility, and lack of concentration.

Redundancy factors included: additional stocks over and above those required to meet immediate needs; more trucks, railway rolling stock, and shipping than strictly required; alternative roads, airstrips, and ports; and sufficient trained staff to meet unexpected events (or 'surge capacity').

Flexibility factors included: multiple strategies for packaging, production lines that can adjust rapidly to changes in raw materials and ability to transfer from one mode of transport to another.

The third identified factor in 2012 was the degree to which a network is concentrated or distributed: that is, reliant on a few key nodes or having multiple overlapping channels for food distribution.

In view of the information gathered in the consultations for this project, a better way of describing that third factor would be diversity. Increased diversity of food supply chains, with multiple nodes and connections, will reduce the risks associated with single points of failure, and strengthen the various food chains' ability to cope with unexpected shocks. This point was made by many of the organisations consulted. It is also supported in the research literature.

A 2017 study² examining the impact of climate change on agriculture, fisheries and mining supply chains in Australia found "complex supply chains with a large number of nodes and links are more resilient to disruption. Critically, all chains, regardless of their complexity, will have diminished resilience as climate disruptions become more frequent. This highlights the importance of considering the broader economic benefits of diversified chains".

¹ Bartos, Balmford, Karolis, Swansson, Davey (2012) Resilience in the Australian Food Supply Chain Report for the Australian Government Department of Agriculture, Forestry and Fisheries

² Lilly Lim-Camacho, Éva E. Plagányi, Steven Crimp, Jane H. Hodgkinson, Alistair J. Hobday, Stuart Mark Howden, Barton Loechel, Complex resource supply chains display higher resilience to simulated climate shocks, Global Environmental Change, Volume 46, 2017.

There are still questions as to how well our basic transport infrastructure will cope with climate change. Impacts can arise from extreme weather events such as floods and bushfires, but also from successive high temperature days (for example, buckling of railway track, melting of bitumen roads). Higher levels of spending in strengthening infrastructure to improve resilience are likely to be needed.



Resilience – transport

Governments have a vital role in improving the resilience of the food supply chain through investment in making transport connections (especially road and rail) more numerous and diverse. Northern Australia, as the experience of the 2022 floods cutting transport links has shown, is particularly vulnerable to a single point of failure from extreme weather. Other interviewees noted the parallel rail and road links across the Nullabor plain (the major food supply connection between the eastern and western halves of Australia)

Although the inland rail link between Melbourne and Brisbane in principle should add useful additional capacity and redundancy to transport links in the southeast of Australia, several organisations consulted for this project were concerned that inland rail could be disrupted by flooding at the same time as other road and rail links. One of the areas of concern, among others, is a section of the proposed route across the Condamine floodplain; it has been the subject of intense [public debate](#). These concerns were identified in a [Senate committee report](#) released in August 2021 (presumably why it was in the minds of people consulted). The Australian Rail Track Corporation (ARTC) [considers](#) the route "the most viable, cost effective option" and is confident about its flood modelling.

The Senate Rural and Regional Affairs and Transport References Committee which conducted the inquiry into inland rail does not appear to have considered questions of climate change risks to food supply. Similarly, while climate change risks have been considered by the ARTC, it does not appear to have modelled the impact of coincident extreme weather events on food supply. It would assist in building resilience in food supply if this work could be undertaken and published.

Aside from inland rail, further investment in other rail lines (or conceivably, reopening of closed rail lines in food producing areas of Australia) will have a double benefit. Rail is a low greenhouse gas emitter, and – especially where rail lines do not run parallel to the main road transport links – access to both rail and road adds diversity to the network.

Another transport resilience concern for food supply chains is that almost all Australian food producers are in rural areas. The roads and bridges in these stages of the food supply chain are maintained by local councils, not all of which have the financial capacity to deal with the repairs and maintenance bills arising from an increased number of extreme weather events. The problem has already been observed and is likely to grow in future as extreme events become more frequent (source: interview, GrainGrowers).

Port facilities are also affected by variability in production caused by climate change. There has always been year on year seasonal fluctuation in quantities of bulk food exports from Australia; climate change suggests fluctuations will be wider than in the past. This will increase the risks associated with investment in bulk handling.

Resilience – storage and stocks

Government food stockpiles of staples such as rice are relatively common in developing countries¹. The main reasons for stockpiling are fears of loss of imports due to fluctuations in international trade and preparedness for natural disasters. A study² of stockpiling found that climate change has different impacts on food producers and food importers differently; emergency food reserves are an option for disaster preparedness but questionable in terms of long run efficiency and effectiveness.

Food stockpiles have disadvantages – cost, spoilage, opportunities for fraud and corruption, exposure of government to additional risks in operating storage facilities. In a net food exporter like Australia, government stockpiles are not a good policy option if the other resilience factors identified here are addressed.

We are seeing, as retailers learn from the COVID-19 experience, higher levels of stocks held within the food supply chain to cope with outages. This is observable in export markets too – for example, a number of milk export customers are moving from a just in time to a just in case approach, holding higher level of stocks, at a higher cost to consumers (source: Dairy Australia interview).

Resilience – shorter supply chains

Shorter supply chains are also able to respond quickly to shortages, as has been demonstrated in the pandemic experience, where local butchers and greengrocers, especially in rural towns, were able to maintain continuity of supply through their networks with producers.

A move to shorter supply chains is a global trend, apparent before but given additional impetus by the pandemic. The Economist Intelligence Unit says³ “Covid-19 will fundamentally reshape trade, accelerating the trend towards shortening supply chains. Just-in-time manufacturing using global suppliers will give way to a greater focus on use of regional supply chains, strategic use of inventories and a new approach to viewing risk.”


Regional areas of Australia provide backup or additional capacity when national food supply chains were affected by extreme weather events. Open Food Network observed the diversity in the mix of small and medium enterprises involved in the food supply chain in regional areas aided resilience and emergency response. An important characteristic was that these were high trust networks – instead of lengthy contract negotiations “they were able to get alternative routes operating with a few phone calls” (source: interview, Open Food Network).

The National Farmers’ Federation also noted that in recent crises short supply chains worked better than the large supermarket chains in food supply and suggested shorter food supply chains were more resilient in extreme events. They described the current food supply chain as a finely tuned engine, efficient and working well in normal times, but vulnerable. One aspect of diversity is competition policy – greater competition in the food industry will add more players and increase resilience.

¹ Caballero-Anthony, M., P.S. Teng, M. Shrestha, T. Nair, and J.A. Lassa. 2015. Public stockpiling and food security. Policy Brief, May 2015. S. Rajaratnam School of International Studies, Nanyang Technological University, Singapore. At www.rsis.edu.sg/wp-content/uploads/2015/06/PB150603_Public-Stockpiling.pdf. viewed 20 February 2022.

² Lassa, J.A., Teng, P., Caballero-Anthony, M. et al. Revisiting Emergency Food Reserve Policy and Practice under Disaster and Extreme Climate Events. International Journal of Disaster Risk Science 10, 1–13

³ Economist Intelligence Unit, 2021, Report The Great Unwinding - Covid-19 and the regionalisation of global supply chains



Shorter food supply chains have several advantages in terms of resilience in the face of climate change. More short chains rather than fewer long chains add desirable duplication and redundancy to the network. While any one small chain is equally as likely to be disrupted by an extreme event as a long chain, the fact that there are more of them spreads the risk of disruption.

Risk management

Governments have an important risk management role in helping address gaps in data and information on climate change impacts, to allow businesses to plan more effectively. Horticulture Innovation Australia noted “the main thing governments should be doing is providing information ... we need much stronger partnerships between government and industry in identifying pinch points in supply chain infrastructure” (source: interview). The National Farmers’ Federation had a similar view: “government needs to invest more heavily in working with industry to gather data on the impacts of climate change. At present the data is fragmented, we need a better coordinated national approach”. The NFF also supported government developing decision support tools to help farmers make well informed investment decisions about the supply chain. (source: interview).

CSIRO has well developed models for describing the impacts of climate change on weather on a regional basis. It is also coordinating a project with researchers and research funding partners on methodologies for quantifying greenhouse gas emissions in a consistent way across different industries in the agricultural sector (source: communication with CSIRO). This kind of information is important for establishing trust in our supply chains, not only on farm but at other stages up to and including the end consumers of food. Agriculture Innovation Australia is developing a plan called the [Climate Initiative](#) to guide R&D investment decisions; it has published an investment plan but outcomes of the research work are not yet available.

There are numerous gaps in research on food supply chains and their vulnerabilities. Many of the industry bodies consulted were keen to see more research on future impacts (“there’s not a lot of research into future impacts at different levels of warming” was one representative comment). In a similar vein, some interviewees would like to see a national risk assessment of the impact of climate change on food ingredients, including identification of possible impacts at different projected levels of global warming.

Manufacturers in the dairy supply chain are looking to manage risk by investment in renewable energy; dairy products are dependent on power, and companies involved in turning raw milk into dairy products are now looking to move to 100% renewable energy (source: interview, Dairy Australia). This will both help in risk management and also contribute to climate change mitigation (discussed later in this report).

One typical way in which a business manages risk is through insurance. The Productivity Commission, against the background of disruptions caused by the COVID-19 pandemic, considered risks to supply chains¹ and noted the importance of insurance. It did not however consider food supply chains, stating “food, while essential, is excluded from the analysis because Australia is a major and diversified producer of food”. This omission is unfortunate. The interviews for this project suggested that many farm businesses are finding insurance difficult or impossible to obtain due to the problem of uncertainty created by climate change.

GrainGrowers, a representative group for grain farmers, raised a concern that Australia did not offer insurance products that cope with the increasing unpredictability of climate and weather events (source: interview). The group has for some years advocated government intervention to support the insurance industry in offering farmers multi-peril crop insurance². This might include for example tax incentives for farmers to take out multi-peril insurance, which would encourage the insurance industry to develop such products.

¹ Productivity Commission 2021, Vulnerable Supply Chains, Interim Report, Canberra

² Grain Growers, 2019, Market Failure in the Crop Insurance Market, supported by research from Kondinin Group

Ongoing access to food ingredients is critical, and a role may be for government to provide information on risks arising from climate change to the supply of raw materials and food ingredients in Australia.



A 2012 study of risk management and food security found¹ that the capacity of the Australian food industry to adapt to the uncertainties that we face is being constrained by three major influences:

- patchy evidence that uncertainty is being managed with best risk management practices in either public or private sector organisations
- the regulatory burden and the capacity to deal with the burden of regulation
- uncertainty about climate change impacts and lack of confidence in climate change impact projections.

The issue of regulatory burden was raised in this project by several of the farm representative bodies consulted as an impediment to risk management. Examples mentioned were Victorian Environmental Protection Agency requirements on farmers in relation to emissions, and climate related financial disclosures. Another concern is regulation in areas related indirectly to food supply, such as in public health, where an over-cautious approach leads to unnecessary food waste.

There were also calls from several industry bodies for greater certainty in government policy, especially in relation to climate change measurement and the specific actions that will be taken. A representative comment was “we are following global and European leads, due to a lack of certainty in where Australia is going and a lack of guidance from government”. This lack of clear policy direction has other negative consequences – one of the academic researchers consulted noted that as late adopters we end up having to adhere to other countries’ standards, rather than having our own standards that suit Australian conditions.

Lack of certainty, and changes in government policy over time, make long term planning in the food supply chain difficult. This is felt especially in relation to industries with perennial crops, such as grapes, fruit, and nuts, where long lead times are part of the business (grape vines for example continue to bear fruit for 50-100 years – fruit from old vines is highly prized by many winemakers).

¹ Michael, DT & Crossley, RL 2012, Food security, risk management and climate change, National Climate Change Adaptation Research Facility, Gold Coast



A farmer perspective – dealing with change and diversifying to manage risk

Piñata Farms is a family farming business with locations ranging from Darwin in the Northern Territory to Mareeba in far north Queensland, Wamuran on the Sunshine coast, Sorell in Tasmania and others. It is Australia's largest pineapple producer, supplying fresh pineapples to market all year round, and also grows mangoes, strawberries and other speciality berries.

Managing Director Gavin Scurr observed that right now the pandemic is having far more of an impact on the supply chain; climate change is however a risk the business considers. They have spread geographically to deal with the climate risk and manage other impacts like higher insurance and energy costs. With global warming more energy is required for refrigeration in transport, and at the same time energy costs are rising: a double whammy for the supply chain.

In a worrying development for Aussie mango lovers there have been three poor mango seasons in a row due to warm winters – mangos need a cool winter to set fruit. If this warming continues, the viability of mango farming in the north of Australia might be questionable. It is though not all bad news – warmer winters help other crops like pineapples and bananas.

A big issue for industry is uncertainty about impacts of warming. Impacts will be quite different if predicted temperature rises are an average outcome of extreme ups and downs versus a temperature rise spread evenly across a year. Extremes are more challenging for a farm business and could make some products or locations uneconomic. Science may not yet have the answer, but if one could be found it would greatly assist farm risk management.

Gavin Scurr is an optimist. The climate is changing, which could compel changes in the supply chain or the types of produce that is viable, but he is confident that Australian farmers will adapt - as they have to other events in the past - and continue to grow food for all Australians.



Adaptation

Food supply chains in Australia have been adapting in a variety of ways. There is a body of research available from government bodies such as the [CSIRO](#) and the Australian Bureau of Agricultural and Resource Economics and Sciences ([ABARES](#)) aimed at encouraging adaptation, primarily aimed at the production stage of food supply.

In production, there is a move in grains away from monocultures to more diverse cropping and planting genetically different varieties. Horticulture is seeing changes in locations and product mix. Although climate change is making some regions less viable it could open up new areas for production that were not previously suitable (source: interview, Horticulture Innovation Australia).

Adaptation measures in the dairy industry include genetic modification of the herd, investment in new equipment, electrification, and other changes to business practices.

Some of the adaptation measures in dairy, such as the move to greater electrification, flow through to businesses further up the supply chain including transporters and processors. Dairy relies heavily on transport and companies in the supply chain are looking to use of electric vehicles as a way to mitigate climate change (source: interview, Dairy Australia, and research into industry practices).

For the businesses who undertake it, adaptation has benefits that can be close to or exceed the costs. Benefits to businesses include more reliable operations, improved business continuity, and lower energy costs. As noted above in the report section on resilience, shorter supply chains can improve the shelf life of food and deliver fresher produce to customers. The Open Food Network says customers are prepared to pay a premium for this (source: interview) – creating added value for customers and increased profitability for producers.

Limits to adaptation

In its 2015 report¹ on food security the Climate Council noted

“many individuals, business and communities are already demonstrating adaptation to the climatic change experienced so far...[but]...if the present rate of climate change is maintained, there will be many challenges to which adaptation is simply not possible. Transitioning urgently to a new, low carbon economy is critical.”

The IPCC Sixth Assessment report² (WG1 contribution), released in August 2021, found “the likely range of total human-caused global surface temperature increase from 1850–1900 to 2010–2019 is 0.8°C to 1.3°C, with a best estimate of 1.07°C.”

The Paris Agreement, the legally binding international treaty on climate change which came into force in 2016, aims to limit global warming to less than 2°C above pre-industrial levels. Australia, along with more than 190 other countries, is a signatory. A target of 1.5°C is preferred, but global inaction to date on climate change mitigation makes it unlikely to be achieved.

Even if the Paris targets are met adaptation in the Australian food supply chain will be challenging. Current global warming (best estimate of 1.07°C) is already having negative impacts on food supply. A 2°C average warmer global climate will put the supply chain under acute stress.

¹ Climate Council of Australia (2015) Feeding a Hungry Nation: Climate change, Food and Farming in Australia by Lesley Hughes, Will Steffen, Martin Rice and Alix Pearce

² Intergovernmental Panel on Climate Change Climate Change 2021: The Physical Science Basis (Working group 1), viewed online 20 February 2022



More frightening is the prospect that global warming exceeds the 2°C target. If this happens, adaptation will be less feasible, with catastrophic consequences for Australia. The Australian Academy of Science¹ considered the scenario of 3°C of warming. It found

“Climate change acts as a ‘threat multiplier’, exacerbating existing threats and issues via changes in average temperature, temperature extremes, rainfall patterns, storm and hail risk, potential evaporation and sea level rise (Reisinger et al. 2014; Smith et al. 2014; Stokes and Howden 2010). Climate change is an issue for the sector to deal with right now: it has already resulted in the reduced profitability of Australian broad-acre farms by an average of 22% since 2000 (Hughes et al. 2019).

Climate change scenarios of 3°C or more are likely to be very challenging for livestock systems. For example, across the top third of Australia, almost every day will be a heat stress day, affecting livestock and the people who manage them. There will also be impacts on water demand, pasture quality and quantity, and fire management ... Australia’s water security will be significantly influenced by climate change... Changes to the global water cycle are likely to cause regional conflict, particularly in the Asia–Pacific region. Food security in Australia would also be affected as climate change will limit the capacity to export food.

¹ The Australian Academy of Science The risks to Australia of a 3°C warmer world AAS, Canberra, 2021

The Climate Council draws attention to the impact of climate change on production, increasing food prices, seasonal availability of many foods, physical disruptions of supply chains due to extreme events, and the increasing difficulty and expense of adaptation if the current rate of climate change is maintained¹.

The IPCC notes that adaptation becomes much more difficult and expensive with higher temperatures. It concludes² that further temperature increases will have severe negative consequences - "every additional 0.5°C of global warming causes clearly discernible increases in the intensity and frequency of hot extremes, including heatwaves (very likely), and heavy precipitation (high confidence), as well as agricultural and ecological droughts in some regions (high confidence)".

It is small wonder insurance companies are concerned. The IPCC notes "There will be an increasing occurrence of some extreme events unprecedented in the observational record with additional global warming, even at 1.5°C of global warming." That is, we will experience extreme events not seen since record keeping began. Because no data exists on similar events (by definition, as these will be unprecedented) it is almost impossible to plan, risk manage or adapt.

The Australian Strategic Policy Institute has equated climate change with a national security threat.

Australia should be playing a leading role in advocating globally for urgent climate action, not just because we're especially vulnerable to the hazards that climate change is amplifying, but also for traditional national security reasons... No military alliance, deployment of troops or new weapon system will adequately protect Australia from this rapidly escalating threat. The only effective 'forward defence' is to reduce greenhouse gases globally, including in Australia, as quickly as possible³.

The same principle applies with food supply chains.

Adaptation will only take us part way in dealing with the impacts of climate change. More fundamentally, Australia needs to tackle the root cause of climate change, human sourced emissions of greenhouse gases. This will mean giving priority to mitigation.

On 28th February the IPCC4 released a report describing today as the "current urgent moment" – that is, the time for action is now. It found (in Chapter 11) Australasia faced "an extremely challenging future. Reducing the risks would require significant and rapid emission reductions to keep global warming to 1.5-2.0 °C, as well as robust and timely adaptation". Global warming under current policies would "leave many of the region's human and natural systems at very high risk and beyond adaptation limits". (IPCC, p 11-6). "If mitigation is ineffective, global warming will be rapid, [and] adaptation costs will increase, with worsening losses and damages" (IPCC p 11-101)

¹ Lesley Hughes, Will Steffen, Martin Rice and Alix Pearce (2015) Feeding a Hungry Nation: Climate change, Food and Farming in Australia Climate Council of Australia

² IPCC, *ibid*.

³ Glasser, R (2019) Preparing for the Era of Disasters Australian Strategic Policy Institute, Canberra

⁴ IPCC, Climate Change 2022: Impacts, Adaptation and Vulnerability, Working Group II contribution, at <https://www.ipcc.ch/report/sixth-assessment-report-working-group-ii/> viewed 1 March 2022



The key conclusions is "climate change is affecting Australia and New Zealand significantly. Some natural systems of cultural, environmental, social and economic significance are at risk of irreversible change...with impacts that cascade and compound across sectors and regions, as demonstrated by heatwaves, wildfire, cyclone, drought and flood events". (IPCC 11-98)

A summary¹ published online by three of the IPCC's vice chairs notes these grim prospects and finds:

"Adaptation alone will not be enough...it must be paired with a drastic and urgent reduction in global greenhouse emissions if we're to avert the extraordinary crises that unmitigated planetary heating would bring."

¹ Howden, Pereira, Sanchez, 'Mass starvation, extinctions, disasters: the new IPCC report's grim predictions, and why adaptation efforts are falling behind' The Conversation 28 February 2022

Mitigation

Mitigation is the process of slowing or reversing the warming caused by humans in the post-industrial era. This can involve either reductions in emission of greenhouse gases, or enhancement of what are known as “sinks” that store these gases in oceans, vegetation, and soil.

In the food supply chain, opportunities for enhancement of sinks mostly arise at the production stage – for example, better retention of soil carbon through renewable farming practices.

In the post-farm sections of the supply chain, mitigation opportunities are primarily to do with reducing emissions. Although there are opportunities for carbon storage in some circumstances – for example, use of timber as a building material in warehouses and transport storage sheds – these are more limited than opportunities for direct reduction in greenhouse gas emissions.

Opportunities to reduce emissions through reduction in food wastage arise in all of stages of the supply chain, including transport, storage, and retail.

In the later stages of the supply chain many of the opportunities for mitigation are both straightforward to implement and cost effective - measures often referred to as “low hanging fruit” in mitigation. They include:

- electrification of warehouses and storage facilities, using renewable electricity;
- improved insulation, which has the double benefit of reducing greenhouse gas emissions and saving on energy bills;
- use of electric vehicles to transport food;
- greater use of rail, a lower greenhouse gas emitting transport mode than trucks using fossil fuels
- shorter supply chains, with lower costs in fuel, storage and handling.

As noted previously in this report, many businesses are currently adopting measures like these, as part of their own risk management and adaptation strategies. They are though looking for a lead from government - many interviewees noted the importance of clear and well understood greenhouse policies in providing businesses with the confidence to make investments in these areas.

A further key role for governments is supporting infrastructure - including charging points for electric vehicles, to make them a workable proposition for the food supply chain. Other actions governments could take include making electrification cheaper, and removing regulatory and tax disadvantages to electric vehicles.

The IPCC special report on climate change and land¹ concluded that at a global level

“About 21–37% of total greenhouse gas (GHG) emissions are attributable to the food system. These are from agriculture and land use, storage, transport, packaging, processing, retail, and consumption (medium confidence). This estimate includes emissions of 9–14% from crop and livestock activities within the farm gate and 5–14% from land use and land-use change including deforestation and peatland degradation (high confidence); 5–10% is from supply chain activities (medium confidence).

¹ IPCC, 2019: Summary for Policymakers. In: Climate Change and Land: an IPCC special report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems [P.R. Shukla, J. Skea, E. Calvo Buendia, V. Masson-Delmotte, H.-O. Pörtner, D. C. Roberts, P. Zhai, R. Slade, S. Connors, R. van Diemen, M. Ferrat, E. Haughey, S. Luz, S. Neogi, M. Pathak, J. Petzold, J. Portugal Pereira, P. Vyas, E. Huntley, K. Kissick, M. Belkacemi, J. Malley, (eds.)]. In press.

Reduction of food loss and waste could lower GHG emissions and improve food security... combined food loss and waste amount to 25–30% of total food produced (medium confidence). During 2010–2016, global food loss and waste equalled 8–10% of total anthropogenic GHG emissions.”

In Australia the Academy of Science has similar findings:¹

Agriculture is not just the farm: it encompasses the supply chain... Processes that improve efficiency in any part of the supply chain benefit all players... Elimination of food waste along the entire production chain, including in the home, can contribute to reducing demand and improving sustainability.

As with adaptation, many climate change mitigation measures have productivity advantages for farmers, processors and others in the supply chain. Reduced food waste can not only mitigate climate change but improve productivity. Likewise with reduced energy costs or electrification based on renewable energy – these will generally have both mitigation impacts and cost savings for businesses. Circular economy principles can create savings and help mitigate climate change – for example, wastewater can be reused to help improve carbon retention in soil (source: interview, Australian Meat Processor Company).

Early adoption of sustainable practices also benefits businesses supplying food to export markets. In some markets this can create a competitive advantage for Australian products over those from other countries where climate change mitigation has not been pursued.

More importantly, in some markets low carbon emissions in the supply chain is a basic, without which the market cannot be accessed at all. For example, major British [supermarket chains](#) are adopting net zero carbon targets and requiring similar standards from companies supplying food to them.

Reducing emissions is thus becoming an important protective strategy for exporters; or as one industry body noted “those who cannot demonstrate their carbon credentials face a potential loss of markets” (source: interview, Victorian Farmers Federation).

¹Howlett, Henry (2021) Australian agriculture and climate change: a two-way street Australian Academy of Science at www.sceince.org.au viewed 14 February 2022





Ambitious climate change targets – the Australian red meat industry

Australian red meat producers have committed to a target of achieving carbon neutrality by 2030 (CN30). The Australian Beef Sustainability Framework indicates that the “CN30 target definition is net zero greenhouse gas emissions by 2030. This means that by 2030 the Australian beef, lamb and goat production, lot feeding, and processing value chain segments will make no net release of greenhouse gas (GHG) emissions into the atmosphere.”

This extends to the whole of the supply chain, including transport and processing. Red Meat 2030, a plan developed by the Australian red meat advisory council, outlines that CN30 will be achieved by (among other things) “Identifying required actions and coordinating across the supply chain to achieve the target.

According to beef producers’ organisation, the Cattle Council of Australia, the target was originally developed by Meat and Livestock Australia but has been supported by the industry and many producers are proud their industry has this goal.

There are additional benefits to pursuing the target. Producers are finding that measures taken to achieve carbon neutrality such as better pasture management, windbreaks, better calving and weaning, and enhancement of herd genetics improve the quality of their product. Achieving the target will also help Australian meat compete in high quality export markets.

Sources: interviews, and Beef sustainability framework at www.sustainableaustralianbeef.com.au

Over the longer term, the most important actions that both businesses and governments can take will be to reduce emissions of greenhouse gases.

Deep and lasting cuts in emissions in the food supply chain will deliver long term benefits to consumers, exporters, farmers, food manufacturers, retailers, and the many other businesses involved in food production and distribution.

Conclusion

Climate change has put food supply chains at high risk. The risks are becoming more acute as climate change continues.

Investment in resilience and adaptation is needed to combat the impacts that are already being felt throughout the supply chain.

Recent good seasons should not blind us to the prospect of damaging adverse weather events in coming years – floods, droughts, bushfires, heatwaves – that will make food supply chains less able to cope.

Recent experience with the COVID-19 pandemic has exposed the fragility of Australia's food supply chains. At the same time, recent favourable farm conditions across much of Australia have provided an opportunity for farmers and food supply chain businesses to consider investments in climate change resilience. Businesses are looking for a lead from government to give them the confidence to make those investments.

Decisive action today will help moderate the worst impacts of climate change. On the other hand, a lack of action will make it virtually certain that in coming decades Australians will for the first time face the prospect of running out of food in our major towns and cities because supply chains fail.





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With thanks to Verity Morgan-Schmidt, Simon Duncan and all who were willing to be interviewed for this report.

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