Farming Resilient Futures

Three possibilities for the Goulburn Murray region

JANUARY 2024

Table of contents

Acknowledgement of Country

We acknowledge the Traditional Owners of the land included in the Goulburn Murray region, including the Yorta Yorta, Taungurung, Dja Dja Wurrung, Barapa Barapa, Wamba Wemba and Wadi Wadi people (Figure 1).

We recognise their continuing connection to land, waters and culture and pay our respects to their Elders, past and present, and we acknowledge emerging leaders.

Moreover, we express gratitude for the knowledge and insight that Traditional Owners and other Aboriginal and Torres Strait Islander people contribute to our shared work in Australia.

We pay respects to all Aboriginal and Torres Strait Islander communities. We recognise that Australia was founded on the genocide and dispossession of First Nations people and acknowledge that sovereignty was not ceded in this country. We embrace the spirit of reconciliation, working towards self-determination, equity of outcomes, and an equal voice for Australia's First People.

Registered Aboriginal Parties (RAPs)

- Dja Dja Wurrung Clans Aboriginal Corporation
- Taungurung Land and Waters Council Aboriginal Corporation
- Yorta Yorta Nation Aboriginal Corporation

FIGURE 1: REGISTERED ABORIGINAL PARTIES IN THE GOULBURN MURRAY REGION

Farming Resilient Futures

This report presents three possible futures for the Goulburn Murray region in 2050:

- Future 1. Trends Continue
- Future 2. Big Global Change
- Future 3. Global & Local Transformation

The futures have emerged from modelling conducted by Deakin University with RMCG for the Goulburn Murray Resilience Taskforce.

To understand what 2050 might look like in the Goulburn Murray region, RMCG worked with Deakin and Taskforce members to explore three possible futures using data stories. Data stories are a way of conveying complex data, by embedding it in familiar context and adding narrative, making the results of research easier to share with broad audiences.

In this Farming Resilient Futures report, the possible futures were developed through consideration of global scenarios developed by Deakin, selected local interventions and consideration of the eight resilience principles in the Goulburn Murray Resilience Strategy. The characters and data stories are based upon the knowledge and insights of the Goulburn Murray Resilience Taskforce and the wider RMCG team. Together, we asked:

- What impact might global action on Sustainable Development Goals (SDGs) have on the region?
- What impact might local interventions have on the region?
- How do global action and local interventions interact?

The results give regional leaders and policymakers new insight into the possible impacts of current trends versus achieving SDGs and local intervention.

While the futures we have developed are based on sound data, all projections come with great uncertainty. It is also worth noting that the characters in the stories are entirely fictional, created and developed to explore the outputs of Deakin's modelling. The full method and underlying data are provided in Appendices 1 and 2 of this report.

Farming Resilient Futures will introduce you to the characters and the three possible futures by 2050, all of which are also plausible based on current data and expert knowledge.

Which future is preferred is for the region to determine.

Research team

- Alfred Deakin Professor Brett Bryan
- Reihaneh Bandari
- Dr. Enayat Moallemi

Engagement & data stories team

- Claire Flanagan-Smith
- Steph McNulty
- Jamie Rooney
- Brooke Zuidema

Acknowledgements

- Ian Potter Foundation
- Monash University
- North Central Catchment Management Authority
- Goulburn Murray Resilience Taskforce members

Context

The Region

FIGURE 2: MAP OF THE GOULBURN MURRAY REGION

The Goulburn Murray region is a part of Northern Victoria. It covers 9,950 square kilometres and includes several vibrant and diverse communities, abundant natural assets, and extensive agricultural production.

The region supports a population of more than 150,000 across rural areas and regional centres such as Swan Hill, Echuca, and Shepparton (Figure 2). The region is home to diverse communities, with 12% of the population born overseas and 3% identifying as Aboriginal and Torres Strait Islander.

The region supports several industries and nearly 120,000 jobs. Of these industries, agriculture is a significant employer. Agricultural production accounts for 85% of land use and contributes $3 billion to Victoria's economy. Other dominant employers include health care, retail trade, manufacturing, accommodation, and administration.

Agriculture in the Goulburn Murray region relies on natural resources and access to water. The region encompasses five irrigation districts and accounts for more than 80% of irrigation water use in the state. Dominant agricultural production includes dairy, horticulture, and cropping. Most water use is concentrated on pasture, cereal, and fruit production.

The region includes several areas of national and international environmental importance. This includes RAMSAR wetlands such as Barmah Forest, Gunbower Forest, and Kerang Wetlands. The region also encompasses 14 National Parks and 65,000ha of protected land.

The Goulburn Murray Resilience Strategy

The Goulburn Murray Resilience Strategy resulted from people in the region thinking about what they could do to support resilience in the face of change.

The strategy is a response to the macro drivers of change impacting our region – both positive and challenging – such as demographic change, shifting social norms, climate change and global markets.

A Regional Resilience Taskforce was established to be the custodians of the region's shared vision and voice, and to translate that vision into resilience-building action. The Taskforce is responsible for embedding the resilience principles into key governance structures and processes, and for catalysing, testing and scaling up and out interventions. It monitors unintended systemic consequences and risks and the progress of the system towards a desired future. The Resilience Strategy is underpinned by eight resilience principles which describe the characteristics of resilient systems.

THRIVING IN THE FACE OF CHANGE

Regardless of future change, communities across the Goulburn Murray region wish to live in a place with the following characteristics:

Together: A region that has pride, wellbeing, cohesion and a spirit of resilience and ingenuity.

Attractive: A region with desirable places to live, work and invest. With protected and healthy biodiversity, waterways and landscapes.

Prosperous: A region with diverse industry, where agriculture continues to be an important part of the economy, supporting a range of primary, secondary and tertiary operations diverse in size, type and ownership.

- Develop a complexity perspective
- Develop governance that embraces change
- Foster cohesion, self-organisation and local responsibility
- Design for flexibility
- Manage networks and connectivity
- Value, retain and build response and recovery capacity
- Focus on slow variables, leverage & tipping points
- Learn for change

Sustainable Development Goals

In 2015, the United Nations Member States developed 17 Sustainable Development Goals (SDGs), intended to bring together countries across the globe to act on some of the world's most complex and perverse challenges. The United Nations recognised that issues cannot be resolved in isolation but require sustained and concerted effort from every nation. The SDGs have become a guide for development to 2030, with the intention of creating a better future for the global population.

The 2023 SDGs Report[1] indicated that the goals will only be achieved with strong political will and full adoption of knowledge, technologies, and resources available to nations. Without a concerted effort, the report warns, the poorest and most vulnerable will continue to suffer the worst effects of the challenges the globe is facing. The United Nations is clear that urgent action is needed to address the goals and deliver meaningful outcomes for people and the planet.

"Unless we act now, the 2030 Agenda will become an epitaph for a world that might have been."

~ ANTONIO GUTERRES

(SECRETARY-GENERAL, UNITED NATIONS)

1. United Nations 2023, Global Sustainable Development Report https://sdgs.un.org/gsdr/gsdr2023

Research and data stories
Deakin Local SDG research

While the SDGs provide consistent guides for international and national leaders, there is uncertainty as to how they can be used at a local level. What do they mean for a town or a region like the Goulburn Murray?

With Funding from the Ian Potter Foundation, The School of Life and Environmental Sciences team at Deakin University established the Local SDGs Project to "develop robust pathways towards future-proofing Australian communities and enabling people and nature to prosper and thrive." [2]

Following a first case study in Forrest, Victoria, the Deakin team has been working with the Goulburn Murray Resilience Taskforce to apply systems modelling and participatory approaches to assess how local Goulburn Murray communities would be impacted if the SDGs are achieved in the future.

Deakin's Local SDGs Project involves comprehensive case studies that use mixed qualitative (participatory) and quantitative (modelling) methods to assess options for "improving multiple socio-economic and environmental dimensions of sustainability in regional Australian communities".

The modelling for this project is based on:

- data, including extensive historical data and trends for the region,
- global shared socio-economic pathways (SSPs)[3] and representative concentration pathways (RCPs)[4]
- the impact of interventions set out in the Goulburn Murray Resilience Strategy[5], as determined by members of the Goulburn Murray Resilience Taskforce.

See Appendix 2 for more information on the data that underpins the modelling.

Data stories

The futures presented in the following pages are data stories. Data stories are a way of conveying complex research results by embedding them in a familiar context and adding narrative.

These stories act as a conduit between research results, regional strategies, and real-life experiences. By placing the results of research within familiar settings and adding narrative, we can look more deeply into the implications they hold. Through these stories, we weave data with our imagination, providing the means to better comprehend and discuss the possible futures ahead of us.

2. Project website: www.localsdgs.org
3. From the Intergovernmental Panel on Climate Change (IPCC) IPCC Sixth Assessment Report: https://www.ipcc.ch/assessment-report/ar6/
4. RCPs are greenhouse gas concentration (not emissions) trajectories adopted by the IPCC
5. Strategy and Taskforce website: https://www.rdv.vic.gov.au/resources/resilience

2050: Possible futures at a glance

Future 1. Trends continue

Global and regional trends in agriculture, migration and water have continued to 2050. Climate emissions travelled along a moderate reduction path. Regionally, agricultural profits have increased, but risk and uncertainty are high and environmental condition is decreasing.

In 2050, the world has made moderate progress on climate change, and fossil fuel use persists. The warming climate shapes the Goulburn Murray region; evaporation soars, erratic rainfall intensifies, and water competition tightens.

Despite this, the region's agricultural profits inch upwards, driven by the adoption of technologies and continued levels of fertilisers and pesticide use to achieve productivity gains. However, uptake of innovation is slow, and enterprises deal with greater risk due to increased and increasing climate variability. There are very few small farms left in the region as larger farm sizes can manage climate risks more easily. Ever larger farms are highly intensive, using glasshouses and shed style dairy systems to bolster growth. Thanks to intensification, some agricultural land has been replaced by dryland agriculture and other alternative uses.

Climate variability and reliance on chemicals continues to have a huge impact on the environment. Natural assets are suffering from heat, reduced inflows, flooding, and pollution. Landscapes are even more reliant on environmental water, experiencing larger and more frequent algal blooms.

Future 2. Big global change

Focus on achieving the SDGs has sparked global emissions cuts and dietary shifts. Climatic warming has peaked and is set to improve. But the Goulburn Murray region is struggling to capitalise on global trends.

Things are looking up. Sustained efforts to achieve the SDGs have significantly reduced global emissions. Global diets have diversified, with the adoption of plant-based diets and sustainably produced animal products. The region has experienced a warmer, drier climate, but optimism is emerging as warming peaks, soon to recede.

As climate change peaks, the overall risk profile for farming is looking better, with greater climate certainty supporting future investment. While the region's agricultural profits exceeded 2020 levels, the region didn't keep up with global trends and reduced dairy sector production has hampered returns. High technology and practice change costs have limited growth in both the horticultural and dairy sectors.

Water for agriculture is still declining in the region, but putting the brakes on climate change meant there was enough water during the 2030s and early '40s to support on-farm investment for many businesses.

Despite global progress, the region's natural assets have suffered without intense local coordination over recent decades. Warmer conditions, diminished inflows, flooding, and on-farm nutrient pollution mean algal blooms have increased.

Future 3. Global & local transformation

Focus on achieving the SDGs sparks global emissions cuts and dietary shifts. Climatic warming has peaked and is set to improve. Through proactive intervention, the Goulburn Murray region is a beacon of resilience, thriving in the face of change.

Coordinated global and regional action has led to remarkable outcomes for the Goulburn Murray in 2050. In line with the SDGs, climate warming has not only peaked but will soon recede. Global diets have diversified with the adoption of plant-based diets and sustainably produced animal products. In the Goulburn Murray, decades of proactive local intervention mean the region is thriving.

While the climate remains hotter and rainfall variable, the region has capitalised on global change. Coordinated regional research, learning and the Regional Resilience Fund are the foundation of regional shifts to production systems that increase water, energy, and nutrient efficiency.

Agricultural profits are soaring thanks to increased production of horticulture and other crops, including Indigenous-owned and developed varieties. Despite a dip below 2020 levels, dairy remains a robust and profitable regional industry. Regional Smart Farming initiatives and the Goulburn Murray Learning Centre have supported farmers to make transformational shifts in their systems.

Thanks to coordinated regional intervention, natural assets have notably improved. Thanks to intensification, a coordinated regional circular economy nutrient management is vastly improved, reducing input costs, improving production and reducing runoff. Coordinated efforts to preserve, regenerate and expand natural landscapes have triggered a boom in agricultural and environmental tourism.

Figure 3 provides a comparison of key data elements for the three scenarios considered in the data stories.

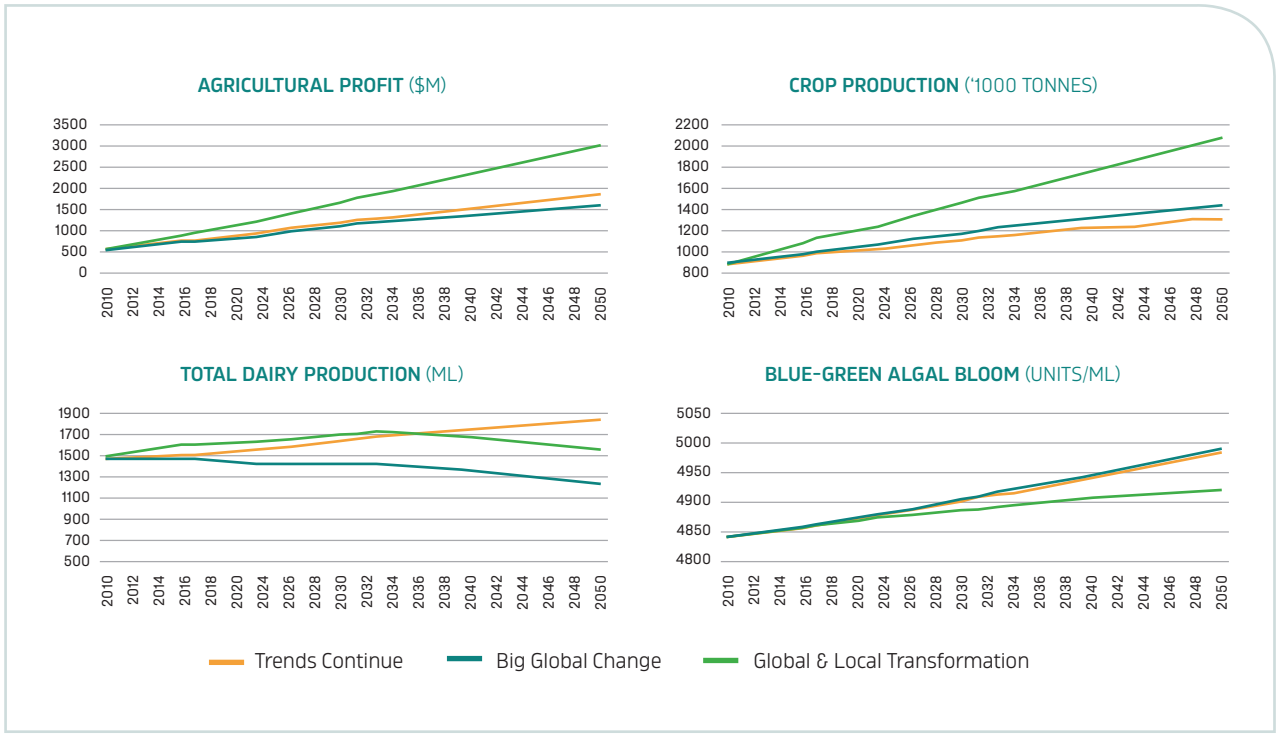

FIGURE 3: A SNAPSHOT COMPARING OF THE TRAJECTORY OF KEY MODELLING COMPONENTS ACROSS THE THREE SCENARIOS

See Appendix 1 for the method used to develop these scenarios, Appendix 2 for the underlying data and Appendix 3 for the detailed rmodel results and analysis.

The Goulburn Family

Meet the Goulburn family, parents Aisha and Conor and their children Bilal and Maeve. It's 2024 and here is what life looks like for them in the Goulburn Murray Region.

In 2023, the Goulburns live on a medium-sized farm about 20km from the centre of Shepparton. Conor works on the farm full-time, and Aisha manages the farm's financials and administration. Aisha also works part-time as a teacher at a primary school in Shepparton, which is growing thanks to people moving to the region looking for a tree change during the pandemic.

Their children Bilal, eight, and Maeve, five, love helping with small jobs on the farm. When Aisha works on the farm, the children travel to the local primary school on the school bus. Thanks to people moving into their district, there are more kids at their school and more after-school activities.

The family run a dairy farm with 300 head of cattle, which is typical of a medium-sized operation in the Goulburn Murray region. They are transitioning from fully irrigated dairy to a partial mixed rations (PMR) system , which includes a variety of feed sources such as cut and carry, annual/perennial pasture, feed crops, silage and holding feedstock. Conor and Aisha have been considering transitioning their production system in response to the reduction in water allocations for agriculture across the region and to adapt to the changing climate.

Conor and Aisha are part of their local Landcare group and have received grants through Landcare and the local Catchment Management Authority to support revegetation and fencing of the creek that runs through the back of their property. They would like to extend the riparian vegetation across local properties to create biolinks along the entire creek corridor.

So, what does 2050 look like for the Goulburns? Let's find out....

6. A PMR is when an engineered mix of grain and forage is fed to dairy cows in between bouts of grazing, making up part of the cows' diet. Read more here: https://www.dairyaustralia.com.au/feed-and-nutrition/feeding-systems/partial-mixed-rations

7. Biolinks, also known as wildlife corridors, are connected natural habitats that support the processes that occur in a healthy environment. This includes the movement of species to find food and water, and also includes processes that benefit us like clean air, water and soil structure. More here: https://www.dcceew.gov.au/environment/biodiversity/conservation/wildlife-corridors

The Goulburns in 2050

It's 2050, and the world has changed. We're going to check in on the Goulburn family and see what 2050 looks like from their perspective under three different possible futures.

But first, let's look at the things common in every future.

Now in their 60s, Conor and Aisha want to retire over the next five years.

They're weighing up their options about where they might live in their retirement.

Bilal, who at 35 has a young family of his own, lives nearby and travels to Shepparton to work as a bank adviser with businesses across the region.

Maeve, now in her early 30s, helps run the family business, but she and her partner want to manage their own farm. They're thinking about the best way to realise their aspirations for the future.

What will the future hold for them?

Life in future 1. Trends continue

Conor and Aisha are still living on the farm, which Maeve has helped run for the last 15 years.

The farm has changed gradually over the last few decades. The Goulburns are still using the PMR system, which has allowed them to adapt to operational and economic conditions like changes in water allocations and the highly variable climatic conditions in the region. On average, their production has increased a little since the 2020s, but profit has fluctuated widely over that time. They have made their gains through adopting affordable technology and continued use of fertiliser and chemical inputs; a trend mirrored across the region.

While they were keen to convert to a barn-style system[8] , low profit margins, market uncertainty, as well as rising interest rates and debt prevented them from making these changes.

During the Big Drought of the late 2030s, they took on more debt to invest in irrigation efficiency and water-efficient crops. Whilst they own water entitlements and have adopted irrigation efficiencies, these were not enough to prevent them from buying water during the drought. Aisha is still working part time at the school to help service their debt.

Overall, the region's agriculture sector has produced profits, but climate risks are now dire. As the son of local dairy farmers, Bilal is a trusted rural advisor at the bank. Many of his smaller dairy farmer clients have struggled to transition to more resilient farming systems. His larger farm clients have continued investing in highly automated and efficient barn-style systems, and their production has increased.

Those who left farming sold their land to buyers seeking alternative land uses or larger farming enterprises better able to afford the large risks associated with the region's more variable climate. Agricultural products are being produced on less land by fewer people. The future of agriculture in the region is looking shaky, with no sign of carbon in the atmosphere declining, even large enterprises worried about being able to manage the associated risks.

8. Also known as contained housing, barn-style systems allow dairy farmers to manage weather extremes and better manage waste. More here: https://cdn-prod.dairyaustralia.com.au › 2023/03/20

Maeve is in her early 30s and works part-time on the family farm. As her parents can't afford to employ her full time, she also works part-time as a farmhand in a large agricultural enterprise nearby. She left the region in her early 20s to study horticulture in Melbourne, as there were no local tertiary options.

The creek at the back of the Goulburns' property has been hit badly by drought and floods, leading to fish kills and more persistent and frequent algal blooms. In fact, the natural environment has become badly degraded across the Goulburn Murray region.

The Goulburns have worked hard to counter these impacts with their local Landcare group, but they can't counter the effects of climate change and increased nutrients across the region. Instead, they're focussing on protecting very small pockets of biodiversity.

What's next?

In 2050, it's the prospect of even hotter and drier conditions that influence the Goulburns next steps.

Bilal and his family are moving into Shepparton to live in a place with a pool and easy access to his office.

Maeve and her partner, not able to take on the risk of taking on the family farm, are moving down south to explore career options in a cooler climate.

For Conor and Aisha, degradation of the natural environment across the region has been too much. Despite their best efforts, they have been unable to improve the environmental condition on their property or influence change across the region. The condition of the land under climate change, combined with increasing debt has influenced their decision to retire earlier than they planned. Conor and Aisha are selling their land to a neighbouring farm and moving to a property on the coast.

The Goulburns in 2050
Life in future 2. Big global change

The world has changed a lot, with significant action on climate change. But the dairy sector in the region has taken a hit in the region as global demands for animal products have reduced, and plant-based diets have increased dramatically. Consumers are looking for sustainably produced, high-quality animal products and in smaller total volumes.

Regionally, a combination of decades facing drought and floods has also taken its toll on dairy production and profitability. Dairy farms have had to get much larger and more intensive to sustain profits, and smaller operations are hard to find. Low-input horticultural crops are doing very well in the region thanks to the increased global demand for plant product.

Through the bank, Bilal saw many dairy farmers exit the industry during the 2030s, selling to much larger enterprises or non-farmers, so the number of farmers in the region has reduced. As a result, larger farms rely less on local banking services. So, head office is talking about big changes. Bilal is nervous about his family's future in the region.

On the Goulburns' farm, production has decreased since the 2020s, as drops in milk price caused their profitability to fluctuate. They had to take on significantly more debt to come through the last couple of decades, which undermined their ability to invest in more significant change. As a result, the Goulburns haven't realised their ambition to transition to a sustainable barn-style system that is humane and has fully automated watering and monitoring. They have increased their stocking rate to increase production, but its negative impact on the environment worries them. Aisha works extra hours at the school to bolster the Goulburns' income.

Maeve works part-time on the family farm. She also works part-time at a large, automated dairy farm. In the early 2040s, Maeve was keen to set up a barn-style system at the family farm, but costs were high and her parents had too much debt following their investment in more PMR feeding systems during the Big Drought of the 2030s.

While the regional climate is showing signs of improvement, the region's natural assets have suffered. The Goulburns and members of their local Landcare group have worked hard to fence waterways and create bio-links. But group numbers are dwindling due to the amalgamation of local farms. There hasn't been enough coordinated regional support to protect assets, so there is increasing contamination from upstream and weeds are blowing in from poorly managed neighbouring properties. After decades of damage, vast parts of this once-beautiful landscape will never fully recover.

What's next?

In 2050, the local bank has terminated its agribusiness services, so Bilal will telecommute to the Melbourne office. He and his family will miss Maeve and her partner, who have decided to work in a farm enterprise in another region, one with greater support for small-scale sustainable dairy farming.

For Conor and Aisha, the degradation of the natural environment and loss of friends and family from the region drives their decision. While they have strong connections to the region, the lack of coordinated effort to prevent landscape degradation and take advantage of global trends has worn them out. They are paying off their debt by selling their land to a larger dairy enterprise and have started looking for a small place near the coast.

Life in future 3. Global & local transformation

Conor and Aisha are on the brink of retirement, but they've got a lot more to give to the Goulburn Murray region, which has given them so much.

The world has taken significant action on climate change, and the Goulburns know that the hotter and drier regional climate is about to take a turn for the better. Global demand for plant products has increased dramatically, and while demand for animal products has changed, there is a strong market for high-quality and sustainably produced dairy products. The regional community, working together through networks like the Goulburn Murray Resilience Taskforce, anticipated and navigated these changes by implementing the interventions from their adaptive Goulburn Murray Resilience Strategy.

On the Goulburn farm, the family has realised their whole farm plan with support from coordinated regional training, seed funding and peer-to-peer learning.

The Goulburn Murray Learning Centre was established in late 2020s as a regionally based centre of agriculture and land management learning. It provides a local resource to coordinate local research, data, extension, knowledge sharing and adoption. Here, the Goulburns learned how to vastly increase their water use efficiency. They also learned the skills and gained the confidence to convert to a barn-style system with automated robotics and a biogas system to capture and reuse methane from animal effluent.

Maeve studied intensive horticulture in the region, then spent five years working on a local farm producing tomatoes in greenhouses. On the back of their more efficient dairy system, her parents agreed to participate in a pilot program to support the transition to covered horticulture. The initiative was seeded by the Regional Resilience Fund, a fund that incentivises investment that increases the resilience of farm enterprises. Using some of her parent's land, Maeve and her partner gained funding through a collaborative agriculture venture to set up greenhouses on the Goulburns' farm.

Moving to the barn-style dairy system and intensive horticulture means the Goulburns are now farming on less of their original farm and have placed the remainder under a Trust for Nature covenant. This means they can market their milk as sustainable under the trusted and nationally recognised Healthy Environment accreditation.

Farm transition has happened across the region and investment in agriculture across the region is strong. Bilal has supported farms of all sizes to innovate in partnership with the Goulburn Murray Learning Centre and Regional Resilience Funds.

Bilal is also working with lots of locals who have set up tourism businesses, capitalising on the thriving agriculture sector and the resilience of natural places in the region. He is also on the Board of the Agricultural Redevelopment Coordination (ARC) Project, who provide one stop shop advice to increase development and investment in thriving agricultural businesses. The ARC has been a great support to the development of Indigenous cropping in the region, led by Traditional Owners in the region. There is now widespread use of Kangaroo Grass as a native perennial cereal grain for use in broad acre dryland cropping.

Agritourism in the region has been supported by interventions from the Resilience Taskforce, including the Agritourism Network and coordinated efforts to foster environmental tourism. In fact, in the early 2040's, Aisha was one of the first to join the Agritourism Network. She left primary teaching to set up Farm-to-Table tours, where she and her team teach visitors about local sustainable and humane farming practices while showcasing delicious local dairy and horticultural products.

Thanks to coordinated efforts across communities, farms big and small, industry and government, the

health of waterways is better than expected, despite drought and flood patterns in recent decades. The rate and severity of algal blooms have been reduced relative to former trends and are expected to improve now that the climate is stabilising.

Membership of locals in Landcare and other environmental groups has grown. The Goulburns and their community have increased the total amount of quality habitat in the region. Thanks to the consistent and coordinated effort of catchment management authorities, Landcare, government agencies, universities and industry, priority areas and regional tributaries linked to the Murray River have been fully fenced and revegetated, and the River is flourishing.

What's next?

Climate warming has peaked, and natural assets are showing signs of improvement, thanks to regionally coordinated efforts. Maeve and her partner have started the succession process by purchasing the land from her parents and further progressing the collaborative model that helped them move into horticulture. They're looking forward to a prosperous future in the Goulburn Murray region.

Bilal and his family have built a place that backs onto the same creek as his parents. They're not farming, but they're actively involved in Landcare and taking great pleasure from watching the landscape recover and thrive.

Conor and Aisha are gladly passing the reins to the next generation. But they aren't going anywhere. The Goulburn Murray region, beautiful and thriving, is where they belong.

Recommendations for future intervention

As was made clear in the Goulburn Murray Resilience Strategy, lack of resilience is hurting the Goulburn Murray region's economies and communities.

Whatever the future holds, the results of modelling work by Deakin points to the value of the Goulburn Murray region prioritising agricultural sustainability, agricultural diversification, ecosystem restoration and collaboration. Specifically:

Sustainable farming, efficient water management:

- Prioritise climate-resilient and sustainable farming practices to deal with future warming and climatic variability
- Increase further efficient water management to adapt to climate variability and address declining water resources.

Targeted agricultural diversification:

- Support the capacity of the farm sector to diversify to align with changing global dietary trends.
- In particular, explore options for diversifying the dairy industry to adapt to market changes, with a focus on high value markets.

Landscape conservation and ecosystem restoration:

- Continue coordinated efforts to restore and expand natural landscapes, preserving, regenerating, and expanding natural assets.
- Encourage a circular economy nutrient management approach to reduce environmental impact, improve production efficiency, and support agricultural and environmental tourism.

Collaboration and education:

- Continue collaboration among stakeholders, researchers, and farmers.
- Prioritise education and training to support the adoption of new technologies and sustainable practices.

The work of the Goulburn Murray taskforce and its partners is already shifting the focus from merely responding to shocks and events to a deeper understanding of systemic structures and patterns. In doing so, this region is developing an approach that will achieve enduring, positive change.

By fully embracing proactive intervention and innovative solutions, this region can both contribute to the global pursuit of sustainable development, and navigate towards the best agricultural and environmental outcomes for the region in 2050.

Appendix 1: Detailed data stories method

Partnership

Researchers from Deakin University's Local SDGs program partnered with environmental and agricultural specialists from RM Consulting Group (RMCG) to develop the Goulburn Murray case study.

Together, we worked with the Goulburn Murray Resilience Taskforce to understand the impact that resilience interventions and action on the United Nations Sustainable Development Goals might have in the Goulburn Murray region.

Approach

In partnership with the Deakin team, the RMCG team developed a series of data stories for the Goulburn Murray region based on three modelled "possible futures".

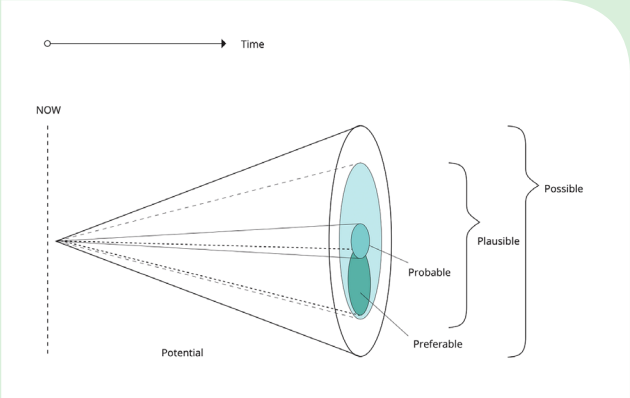

FIGURE 4: FUTURES CONE, ADAPTED FROM VOROS[9]

The three futures presented in this report result from modelled outputs from Deakin's Local Environmental and Socio-Economic model (LESEM). Data inputs for the model are drawn from a variety of sources and include both global and local scale data (see Appendix 2 for further detail on the data than underpins the LESEM).

The data stories approach allows us to move beyond traditional data reporting to present complex information in a way that resonates with stakeholders and decision-makers. It allows for a more nuanced understanding of the possible futures, as it highlights the interdependencies between different variables and factors and how these can play out in other contexts. The data stories approach is a powerful tool for communicating complex data and model outputs in a meaningful and actionable way for decision-makers and stakeholders.

By focusing on local interventions (drawn from the Goulburn Murray Resilience Strategy), global shared socio-economic pathways (SSPs) and representative concentration pathways (RCPs), we have been able to explore a range of possible futures and illustrate the potential impact of different strategies in a way that is easy to understand.

9. Voros, J 2017, 'Big History and anticipation: Using Big History as a framework for global foresight', in R Poli (ed.) Handbook of anticipation: Theoretical and applied aspects of the use of future in decision making, Springer International, Cham. https://doi.org/10.1007/978-3-319-31737-3_95-1

Method

TASK	DESCRIPTION	PURPOSE	DETAIL
Stage one: Introductions and System Understanding			
Desktop research	Modelling	To collect data to input to the model	The Deakin team began to develop the complex system model using desktop studies and initial discussions with regional stakeholders.
Taskforce workshop 1	Modelling Data stories	To understand how the modelling can further taskforce objectives and collect data to inform the model	At this workshop, we introduced the project purpose and asked the taskforce to tell the team how Deakin's modelling can further the goals of the Taskforce. We confirmed the major regional challenges and aspirations and discussed how the local interventions align with SDGs. Finally, we ranked the local interventions / SDGs according to current priority and uncovered the underlying assumptions to inform modelling.
Refine model	Modelling	To refine model using workshop outputs	Deakin further refined the model using workshop outputs and additional desktop research.
Stage 2: Stress Testing			
Taskforce workshop 2	Modelling Data stories		At this workshop, the Deakin team presented the results of LESEM to Taskforce members. We discussed the linkages across different aspects of the model and identified feedback loops and potential gaps. Finally, we discussed the circumstances under which the interventions could fail to deliver the intended outcomes and which interventions will best contribute to the Strategy aspirations in the short and long term.
Refine model	Modelling	To refine model using workshop outputs	Once again, Deakin refined the model using workshop outputs, desktop research and discussion with the RMCG team as the data stories began to emerge.
Develop characters, scenarios and data stories	Data stories	To begin developing the data stories report and supporting animation	We developed a series of data stories for the Goulburn Murray region using the results of modelling, climate projections for the region, agricultural industry forecasts, and current and projected environmental condition data. We also further tested with RMCG subject matter experts for validity. We engaged a media company to begin storyboarding a short animation to illustrate the results of the research and data stories.
Stage 3: Pathways for Success			
Taskforce workshop	Modelling Data stories	To confirm model findings and data stories	The Deakin and RMCG teams presented the modelling and data stories reports at the final workshop. We tested the data stories with Taskforce members, drawing on their regional understanding and knowledge about the intent of Resilience Strategy interventions.
Finalise data stories	Data stories	Finalise data stories report and animation	We refined the data stories report and developed the animation based upon the feedback of Taskforce members.

Appendix 2: Underlying data
The LESEM

Deakin University's Local SDG project team developed a systems dynamics model known as the LESEM (Local Environmental and Socio-Economic model) for the Goulburn Murray region in northern Victoria, Australia.

The LESEM was created to investigate and model complex interactions between global Sustainable Development Goals (SDGs), current regional settings and potential regional interventions.

Through background research and the codesign process, the Deakin team selected five SDGs as the focus of the LESEM:

- SDG 6: Clean water and sanitation
- SDG 2: Zero Hunger (Agricultural activities)
- SDG 8: Economic growth
- SDG 13: Climate action
- SDG 15: Life on land

As described later in this appendix, the model was developed using global and local data, with a focus on outcomes relating to these four SDGs. It was further refined in consultation with members of the Goulburn Murray Regional Taskforce from 2022 to 2023.

Using LESEM, the Deakin team modelled global and local[10] scenarios in a matrix (see Figure 5). The results of three of these scenarios form the basis of the futures described in this report, and are described later in this Appendix.

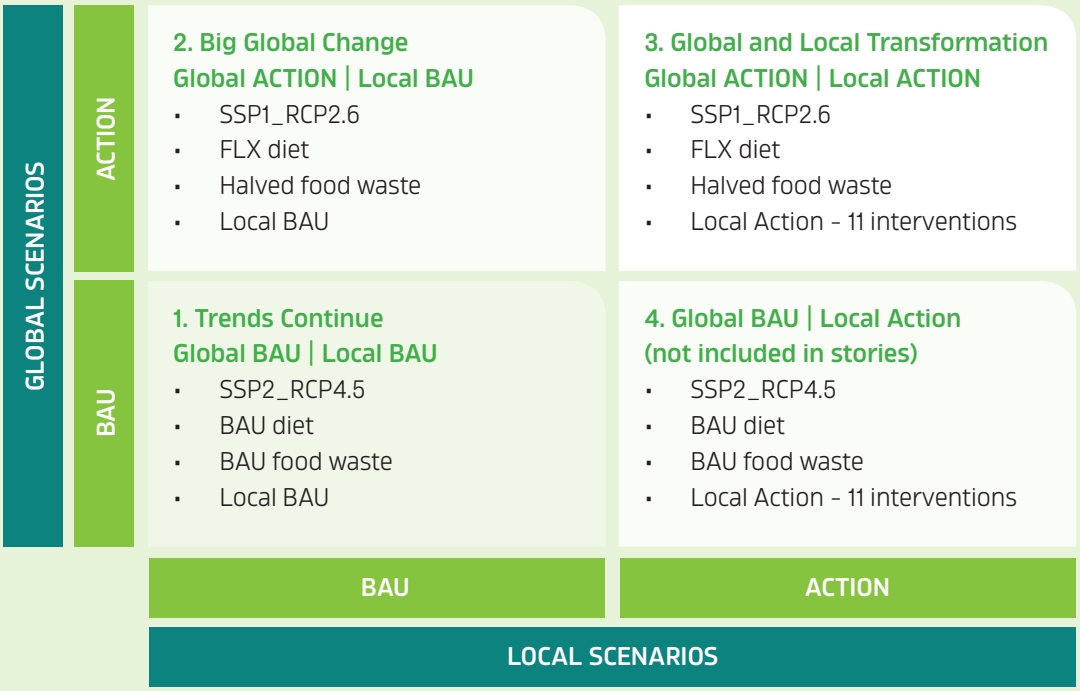

FIGURE 5: GLOBAL AND LOCAL SCENARIOS MATRIX, PRESENTED BY THE DEAKIN TEAM TO THE GOULBURN MURRAY RESILIENCE TASKFORCE SEPTEMBER 2023

The global and local key data sources that underpin the scenarios are explained in the following sections.

10. Note that for the purposes of this project, "local" means anything from and about the Goulburn Murray region

Key global data sources

Shared Socio-economic Pathways

One of the primary sources of global data in the LESEM is the Shared Socio-economic Pathways (SSPs) developed by the IPCC to explore different possible future socio-economic and environmental conditions. The SSPs show how economic development, population, energy use, technological advancement and environmental policies may interact and could plausibly impact global carbon emissions. The SSPs describe five possible futures (Figure 6) and are commonly utilised by policymakers and scientists to inform future decisions relating to climate action.

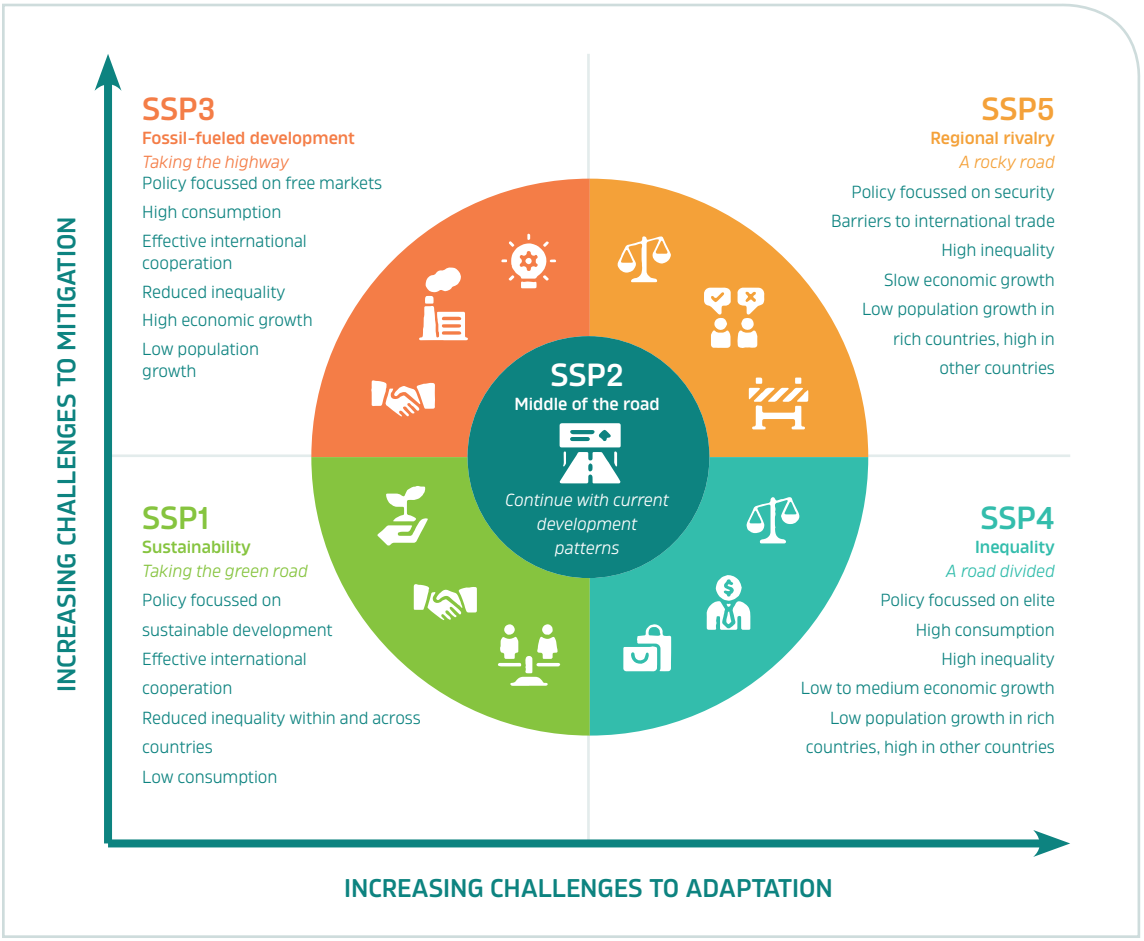

FIGURE 6: THE FIVE SSPS

Representative Concentration Pathways

Representative Concentration Pathways (RCPs) (see Figure 7) are a set of scenarios used in climate science to project future greenhouse gas emissions and their concentrations in the Earth's atmosphere. Developed by a group of scientists associated with the Climate Change Working Group (WGIII) of the IPCC, RCPs are often used in conjunction with SSPs to provide an overview of how emissions trajectories and socio-economic trends will interact under different global futures.

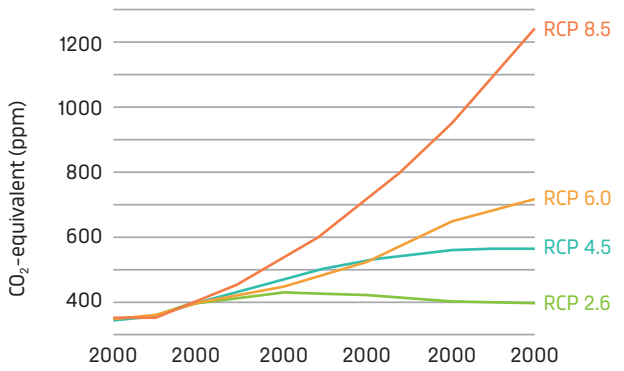

FIGURE 7: REPRESENTATIVE CONCENTRATION PATHWAYS

Four RCPs are typically used in research, selected through collaborative effort to encompass a wide range of potential future greenhouse gas concentration trajectories:

- RCP2.6 (low emissions): This pathway represents a future where strong and immediate mitigation efforts are put in place to significantly reduce greenhouse gas emissions. Atmospheric concentration of greenhouse gases will peak mid-century and slowly decline after that, keeping global warming well below two degrees.
- RCP2.6 has a projected increase in global mean temperature of well below 2 degrees Celsius above pre-industrial levels by the end of the century. It aligns with the international target set in the Paris Agreement to limit global warming to well below 2 degrees Celsius and to pursue efforts to limit it to 1.5 degrees Celsius.
- RCP4.5 (intermediate emissions): In this pathway, action is taken to reduce emissions, but not as forcefully as in RCP 2.6. The world will continue increasing the release of greenhouse gases until mid-century and then reduce gradually. Concentrations of greenhouse gases in the atmosphere will remain relatively steady for the rest of the century.
- RCP4.5 is associated with a projected increase in global mean temperature of around 2.4 degrees Celsius above pre-industrial levels by the end of the century. While this is still a significant level of warming, it is considered to be a more moderate and manageable outcome compared to the higher emissions scenarios. However, it may still result in adverse climate impacts, such as sea-level rise, changing precipitation patterns, and more frequent extreme weather events.
- RCP6.0 (stabilised emissions): In this pathway, there are moderate efforts to reduce emissions. The peak in emissions happens this century but is higher than in RCP4.5. This leads to far higher concentrations of greenhouse gas emissions and a projected increase in global mean temperature of around 3.0 degrees Celsius above pre-industrial levels by the end of the century. This level of warming is considered significant and may lead to various climate impacts, including sea-level rise, altered precipitation patterns, more frequent extreme weather events, and ecosystem changes.
- RCP8.5 (high emissions): This pathway represents a future with little to no mitigation efforts. This causes emissions to increase rapidly and results in severe climate impacts.
  RCP8.5 is associated with a projected increase in global mean temperature of approximately 4.5 degrees Celsius above pre-industrial levels by the end of the century. This level of warming is considered to have severe and potentially catastrophic impacts on the climate, including more extreme weather events, sea-level rise, and ecosystem disruptions.

Global diet and food waste

The other significant global scenario parameters in the LESEM are global diet and food waste[11]. By combining the diet parameter and waste parameter under different SSP scenarios, the model is able to project a food demand which translates into demand for product.

Regarding global diets, the team modelled two distinct types of diets: a Business as Usual (BAU) diet and a Flexitarian diet (FLX). Each diet will change the relative amounts of agricultural commodities demanded globally:

- BAU diet sees the continuation of recent historical trends in dietary preferences
- FLX diet sees a shift to predominantly plant-based eating patterns, with the flexibility to include animal products in moderation.
- For food waste, the Deakin team assumed two scenarios of food loss and waste: BAU waste and Halve waste.
- In the BAU waste scenario, current levels of food loss and waste continue
- In Halve waste, food loss and waste is halved, which means that less total production is required to meet global diet demands.

11. Bandari, Reihaneh & Moallemi, Enayat A. & Kharrazi, Ali & Trogrlić, Robert & Bryan, Brett. (2023). Transdisciplinary approaches to local sustainability: aligning local governance and navigating spillovers with global action towards the Sustainable Development Goals. 10.21203/rs.3.rs-3386907/v1.

Key local data sources

Local resilience interventions

The interventions used in the LESEM were drawn from the Goulburn Murray Resilience Strategy. The Strategy identified five focus areas to support the social, economic, and environmental resilience for the region:

- A – Futures of agriculture
- B – Learning for change
- C – Circular economy
- D – Natural and built assets
- E – Leadership and coordination.

Each focus area has a suite of regional resilience interventions, which included things like:

- Agricultural Redevelopment Coordination
- Indigenous crop production
- AgriTourism network
- Regional Resilience Fund – Agriculture & natural assets
- Goulburn Murray learning centre
- One Basin CRC regional hub
- Regional circular economy coordination
- Circular economy seed fund

The team worked with members of the Goulburn Murray Taskforce to determine what impact implementing the Resilience Strategy interventions would have in relation to the chosen SDG goals. These impacts were themselves called “interventions” in the LESEM. Figure 8 shows the 11 interventions used in the model.

2 ZERO HUNGER	Intervention 1 agricultural productivity	+2% annually
	Intervention 2 water use efficency in farms	+10% by 2050
6 CLEAN WATER AND SANITATION	Intervention 3 water recovery	+15% by 2050
	Intervention 4 conveyance water loss	+15% by 2050
8 DECENT WORK AND ECONOMIC GROWTH	Intervention 5 input costs	+10% by 2050
	Intervention 6 premium produce growth	+10% by 2050
	Intervention 7 migration rate	+20% by 2050
	Intervention 8 birth rate	+10% by 2050
15 LIFE ON LAND	Intervention 9 fertiliser application	-20% by 2050
	Intervention 10 N and P generated animal manure	-20% by 2050
	Intervention 11 N and P runoff fraction	-20% by 2050

FIGURE 8: IMPACTS OF LOCAL RESILIENCE INTERVENTIONS

Local contextual analysis

The Deakin team conducted a local contextual analysis to collect data to inform the model. This included interviews with local stakeholders and a comprehensive review of locally relevant literature including published papers, reports, and policy documents.[12]

For the literature, the team worked with regional stakeholders to identify and assemble relevant documents including published and unpublished historical information; strategic, policy and planning documents; and scenario framing activities. They also used a snowball process to identify other scientific and grey literature[13] documents relevant to the region in three areas:

1. Sustainable development: water, irrigation, agriculture, energy, health, education, gender equality, economic growth, employment, inequality, local community, sustainable consumption and production, climate change, environment, biodiversity, and land degradation
2. Planning: strategic, scenario, management
3. Local context: e.g., Goulburn-Murray, Murray-Darling Basin, local councils.

The sources included more than 120 published papers, reports and books from agencies and organisations such as the Department of Environment, Land, Water and Planning (DELWP, now DEECA), the Murray Darling Basin Authority (MDBA), the Goulburn Broken Catchment Management Authority (GBCMA), the North Central Catchment Management Authority (NCCMA), Goulburn-Murray Water (GMW), the Department of Economic Development, Jobs, Transport and Resources (DEDJTR, now DJSIR), the Department of the Environment, Water, Heritage and the Arts (DEWHA), and local shire councils.

The team also interviewed over 40 people in the Goulburn-Murray region, including community members, business leaders, government officials, and others. The focus of the interviews was on learning about the local economy, environment, what makes the region special, and what potential opportunities there might be in the future.

12. Reihaneh Bandari, Enayat A. Moallemi, Rebecca E. Lester, David Downie, Brett A. Bryan, Prioritising Sustainable Development Goals, characterising interactions, and identifying solutions for local sustainability, Environmental Science & Policy, Volume 127, 2022, Pages 325-336, ISSN 1462-9011, https://doi.org/10.1016/j.envsci.2021.09.016
13. Grey literature: Research that has not been formally published and therefore not able to be searched through search engines or research databases. It is often very high quality and an excellent source of up to data.

How data sources were used in the stories

The global and local data was used to create two local scenarios and two global scenarios.

The two local scenarios:

4. Local ACTION: Regional resilience interventions implemented
5. Local BAU (business as usual): No regional resilience interventions implemented

The two global scenarios:

1. Global ACTION: SSP1_RCP2.6, FLX diet and halving food waste
2. Global BAU: SSP2_RCP4.5, BAU diet, BAU food waste

These were combined to make four scenarios for the Goulburn Murray region to be modelled in the LESEM:

1. Trends Continue: Global BAU & Local BAU
2. Big Global Change: Global ACTION & Local BAU
3. Global and Local Transformation: Global ACTION & Local ACTION
4. Global BAU & Local ACTION (not included in data stories)

The first three scenario results were used to build data story narratives, the fourth was not included due to strong overlap with other scenarios that meant differences in the narrative were too slight or convoluted to be interesting or useful.

Table 1 shows the data that underpins each of the futures in this report, and the reasoning behind the selection of each data source.

TABLE 1 – DESCRIPTION OF DATA USED TO BUILD STORY NARRATIVES

FUTURES	REASONING
Future 1. Trends Continue ▪ SSP2 ▪ RCP4.5 ▪ Business as usual diet ▪ Business as usual food waste ▪ No local resilience interventions	This scenario was designed to model a future that continues along current trends, including moderate action on climate and moderate efforts to improve farm efficiency. To be clear, this means that factors like population growth and agricultural productivity continue on their current path, rather than staying where they are today. SSP2 and RCP 4.5 were selected for this scenario as they are commonly used for business-as-usual modelling: ▪ SSP2 represents a middle of the road approach to addressing climate change. ▪ RCP 4.5 has emissions (but not atmospheric concentrations) peaking around the mid-21st century and then declining due to moderate mitigation efforts.
Future 2. Big Global Change ▪ SSP1 ▪ RCP2.6 ▪ FLX diet ▪ Halved food waste ▪ Local business as usual ▪ No regional resilience interventions	This scenario was designed to model a future where there is strong global action on climate change but continued business-as-usual in the Goulburn Murray region, i.e. no local resilience interventions. SSP1 was selected as it represents a global shift to sustainable lifestyles, such as lower resource and energy consumption as well as more plant-based diets. The pathway predicts increasing commitment to achieving the global SDGs. RCP 2.6 was chosen as it complements SSP1, representing a future where global efforts cut emissions significantly and limit warming below two degrees Celsius. Regarding food demand, the scenario settings are for the FLX diet and Halved food waste. Again, this is in line with global SDGs.
Future 3. Global & Local Transformation ▪ SSP1 ▪ RCP2.6 ▪ FLX diet ▪ Halved food waste ▪ 11 impacts from regional resilience interventions	The global and local transformation scenario was designed to model what happens when there is both strong global action on emissions and strong local action to both take advantage of global change and address regional challenges. As per Future 2, SSP1 was used to demonstrate a global shift to sustainable lifestyles, supported by RCP 2.6, FLX diet and Halved food waste The team worked with members of the Goulburn Murray Taskforce to agree to a set of 11 impacts that are the result of implementing resilience interventions from the Goulburn Murray Resilience Strategy. In the LESEM, these 11 impacts are called interventions.

Appendix 3: Detailed model results & analysis

Agricultural profit

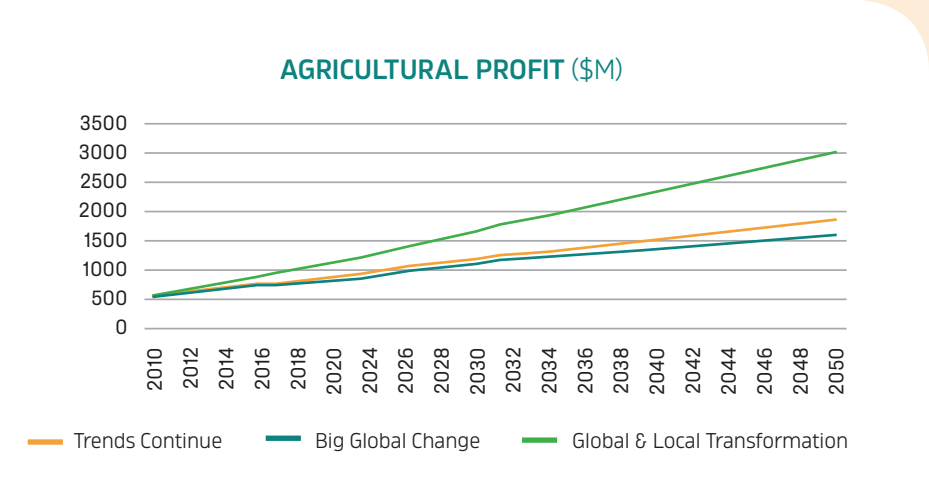

FIGURE 9: PROJECTED AGRICULTURAL PROFITS UNDER ALL THREE FUTURES

Comparison of the trajectory of agricultural profits for the three modelled scenarios used in the data stories is shown in Figure 9. Further detail on what is driving these trends is provided next.

Future 1. Trends Continue

In this future, agricultural profits are slowly rising across the Goulburn Murray region. Some enterprises have increased production and management efficiencies by increasing the intensity of production systems such as glasshouse and mixed feed base dairying, as well as smart farming practices such as automated watering systems, effluent re-use, and modernising irrigation infrastructure. Those who can afford to rely on pesticides and fertiliser have been able to moderately increase their profits. While the agricultural sector in the region is doing well, some smaller dairy farms are struggling to raise capital and reduce their debt in order to transition to more resilient farming systems.

Future 2. Big Global Change

In this future, agricultural profits will rise moderately, albeit at a lower level than seen in Future 1. While the region's agricultural profits exceeded 2020 levels, the region didn't make the most of global trends. Incremental gains were achieved through intensification of production systems but the adoption of these practices has been limited to those enterprises with enough capital to make the transition. High technology and practice change costs have limited growth in both the horticultural and dairy sectors. Difficulty adopting practice changes combined with global demand for more horticulture and high value animal products is limiting the region's agricultural profit, as the region hasn't been able to adapt to meet global demands as quickly as other regions.

Future 3. Global & Local Transformation

In Future 3, significant gains in production efficiencies have been made by 2050 leading to significantly higher regional profit being achieved on a smaller footprint of land. Additionally, global demand for plant-based diets has increased, contributing to increased profit from dryland and horticultural crops across the Goulburn Murray region.

Improvements in management and operation of agricultural enterprises has been supported by regional resilience interventions including the Goulburn Murray Learning Centre, a regional hub that supports two-way learning between researchers and farmers. These initiatives have driven significant adoption of agricultural technology including artificial intelligence and robotics.

The Goulburn Murray Learning Centre has international ties with agricultural research bodies abroad. These international connections have facilitated the cross-pollination of ideas and accelerated knowledge exchange related to improved agricultural technologies.

Skilled workforce

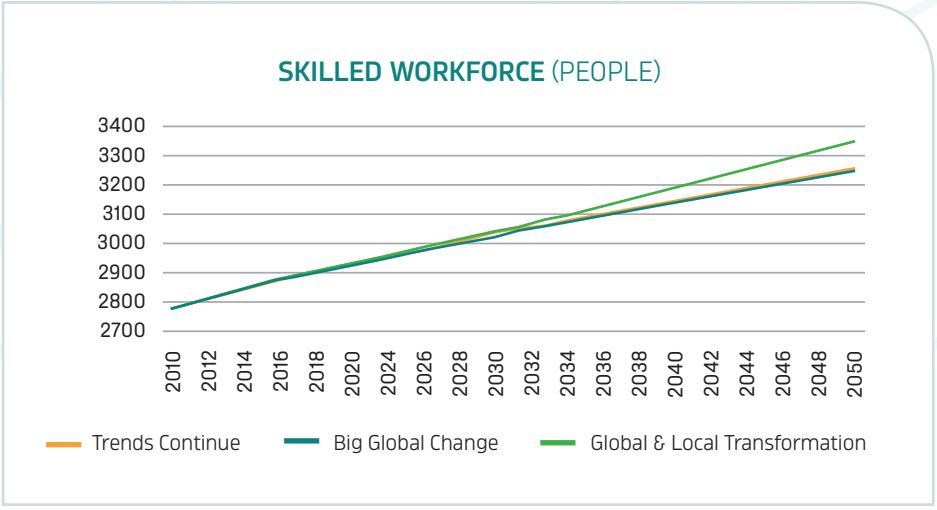

FIGURE 10: PROJECTED SKILLED WORKFORCE UNDER ALL THREE FUTURES

Comparison of the trajectory of skilled workforce data for the three modelled scenarios used in the data stories is shown in Figure 10. Further detail on what is driving these trends is provided next.

Future 1. Trends Continue

In 2050, the population is broadly increasing across the Goulburn Murray. This was partly driven by an influx of in migration from Melbourne during and after the COVID-19 pandemic, but also by increasing urbanisation of the Shepparton and Moira local government areas and agricultural trends. While the region's population is generally increasing, there is depopulation of areas that are heavily reliant on irrigated agriculture, such as Gannawarra and Loddon. With an ageing population, the agricultural sector is facing a challenge to attract and retain the next generation of farmers across the region. As a result, there is a lack of younger generation farmers available to run agricultural enterprises. Modest efforts are being made to develop the next generation of skilled labour for the agricultural sector.

Future 2. Big Global Change

The modelled skilled workforce results for Future 2 are the same as Future 1.

Future 3. Global & Local Transformation

In Future 3, the population and skilled workforce is increasing at a larger rate across the Goulburn Murray region. The growth of the intensive horticulture sector in the region has contributed to this growth. Local regional resilience interventions including the Rural Skills Connect and Regional Resilience Fund have been established in an effort to attract, retain, and build the skills of the next generation farmers across the region. This builds on coordinated regional research through the Goulburn Murray learning centre and from the One Basin CRC. In addition, an AgriTourism Network has been set up to facilitate increased connection and collaboration across agritourism providers in the region.

Crop production

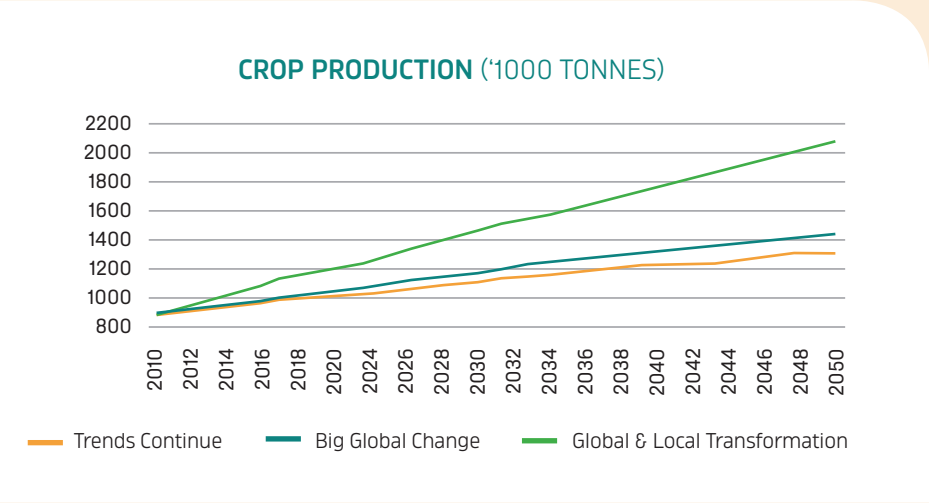

FIGURE 11: PROJECTED CROP PRODUCTION UNDER ALL THREE FUTURES

Comparison of the trajectory of crop production for the three modelled scenarios used in the data stories is shown in Figure 11. Further detail on what is driving these trends is provided next.

Future 1. Trends Continue

Under this future, the area of land used for dairy has decreased significantly and much of the productive agricultural land is now used for dryland cropping or intensive agriculture such as annual vegetable production and perennial horticulture. This shift in production systems is driven by domestic and global food demand as well as increasing profitability for these commodities including fresh fruit and cereal crops.

Future 2. Big Global Change

In Future 2, crop production has increased, driven by changes in global diets and a push to low carbon agricultural production. Due to the global demand for plant-based diets, crop production continues to increase in the region, but not at the rate of demand as the region has not set itself up for successful expansion and transition.

Future 3. Global & Local Transformation

In Future 3, crop production increases significantly by 2050. A diverse mix of enterprises is emerging at an increased rate across the region with greater opportunities for horticulture and mixed farming resulting in increased intensification of production systems. Large areas previously used for irrigation have been converted to cropping and dryland farming, and horticulture has expanded across the region. This transition has been supported by the Agricultural Redevelopment Coordination project.

Dairy production

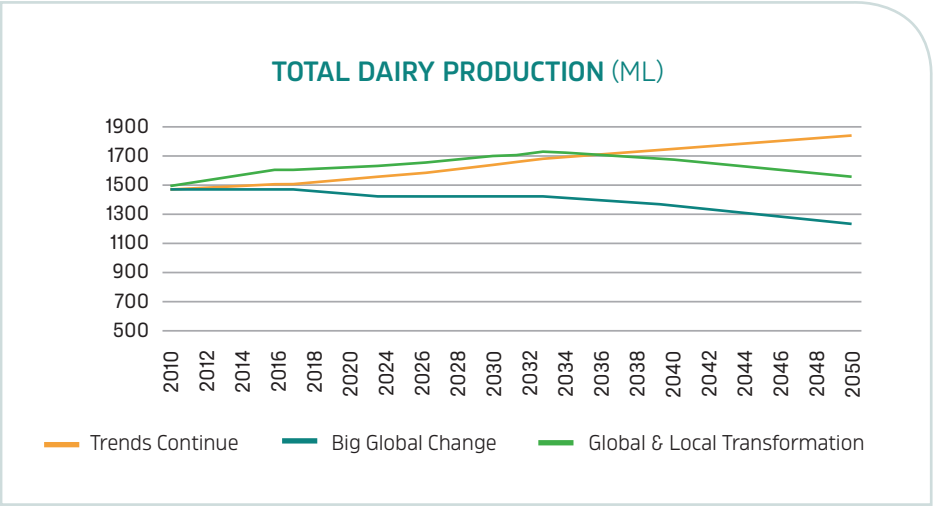

FIGURE 12: PROJECTED DAIRY PRODUCTION UNDER ALL THREE FUTURES

Comparison of the trajectory of total dairy production for the three modelled scenarios used in the data stories is shown in Figure 12. Further detail on what is driving these trends is provided next.

Future 1. Trends Continue

By 2050 in Future 1, the area of land used for dairy has decreased significantly and much of the productive agricultural land is now used for dryland cropping or intensive agriculture such as annual vegetable production and perennial horticulture. Despite the decrease in land area, the increase in intensive dairy farms has seen a slight increase in total dairy production. Smaller farms have left the industry due to the impacts of climate change. Larger farms have been able to manage the risks of climate change reasonably well so far, but investment is declining as the climate outlook looks dire.

Future 2. Big Global Change

Total dairy production in the region under Future 2 is expected to decrease. Warming climates had already put pressure on dairy production, but an increase in global demand for plant-based diets and low carbon agriculture has proved difficult for the region to manage. Despite that, the larger dairy enterprises with the capital to intensify their operations have been able to invest in water and carbon efficiency and market their products as a high value commodity.

Future 3. Global & Local Transformation

In Future 3, total dairy production has fallen since the droughts of the 2030s, but is higher than Future 2 and closer to the historical trends of Future 1. The area of land used for dairy has reduced significantly as a third of the region's dairy farms have barn style production systems. These systems are being managed to use considerably less water and better manage waste and emissions, thereby achieving higher production per ML of water with lower emissions.

With the global increase in plant based diets, regional dairy producers have increased their production of premium sustainable animal products. They have been able to market their improved environmental credentials to maintain access to the smaller overall market for animal products.

All of this change has been supported by regional resilience interventions including training offered through the Goulburn Murray Learning Centre, regional circular economy coordination and regionally coordinated projects to support research into and adoption of robotics and artificial intelligence by regional farming enterprises.

Agricultural land

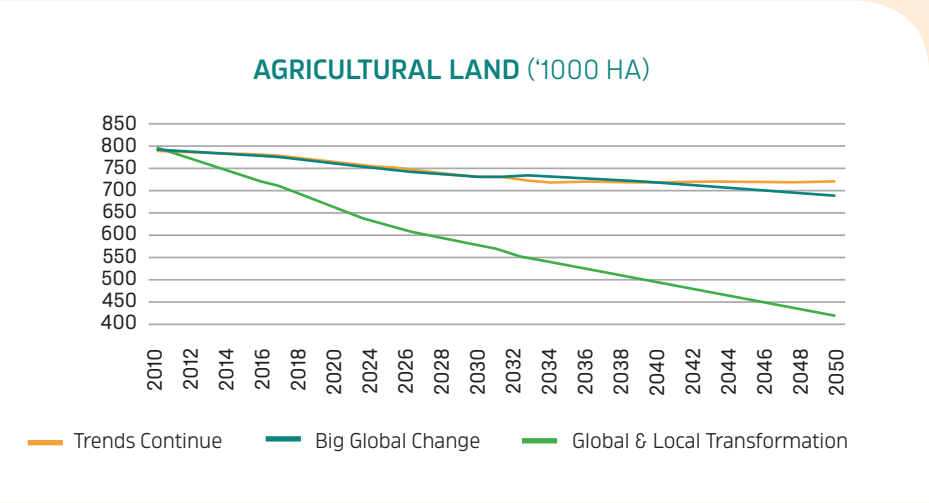

FIGURE 13: PROJECTED AGRICULTURAL LAND UNDER ALL THREE FUTURES

Comparison of the trajectory of agricultural land for the three modelled scenarios used in the data stories is shown in Figure 13. Further detail on what is driving these trends is provided next.

Future 1. Trends Continue

Overall, the area of land under agricultural production is shrinking in the Goulburn Murray region. This is driven by decreased water availability, support for further development of intensive agricultural production systems such as glasshouses and barn-style dairy, and increasing efficiency in the management and operation of agricultural production systems in general. Further reduction in agricultural land has also been caused by increasing urbanisation around rural centres. This has seen an increase in agricultural land now available for non-agricultural uses.

Future 2. Big Global Change

By 2050 in Future 2, the amount of land used for agriculture in the region has continued to shrink in the region at much the same rate and due to the same reasons. Further reduction in agricultural land has also been caused by increasing urbanisation around rural centres. This has seen an increase in agricultural land now available for non-agricultural uses

Future 3. Global & Local Transformation

In Future 3, the area of land under agricultural production has reduced significantly. This is partly due to competing land uses, but has largely been driven by the shift to intensive horticulture. Regional coordination through the Agricultural Redevelopment Coordination project has supported the consolidation of high value land for farming and other land has been freed up for other uses including environmental restoration.

Blue-green algal blooms

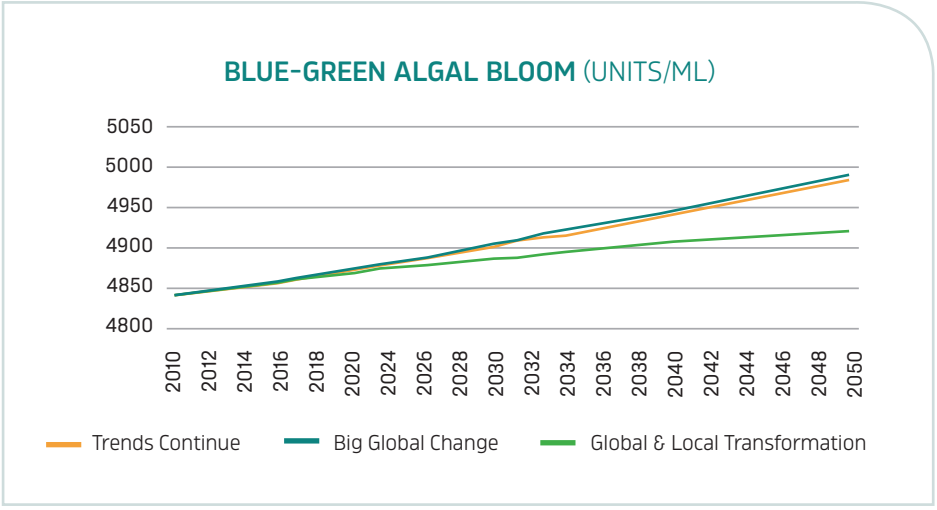

FIGURE 14: PROJECTED BLUE-GREEN ALGAL BLOOMS UNDER ALL THREE FUTURES

Comparison of the trajectory of blue-green algal blooms for the three modelled scenarios used in the data stories is shown in Figure 14. Further detail on what is driving these trends is provided next.

Future 1. Trends Continue

Global warming and reliance on chemicals to bolster agricultural production continues to have a huge impact on the environment in this future. Natural assets are suffering from heat, reduced inflows, flooding, and pollution, causing an increase in larger and more frequent algal blooms. There is a lack of coordinated effort to drive improvements at a regional level, with agricultural production benefits prioritised over environmental protection and improvement. Therefore, the increased use of fertilisers and pesticides, the slow uptake of practices that improve nutrient-use efficiency such as better management of dairy effluent ponds, higher temperatures coupled with lower flows due to climate change are exacerbating the rate and incidence of algal blooms in waterways and waterbodies across the region

Future 2. Big Global Change

Environmental degradation continues across the region, due to a lack of coordinated efforts to support practice change. The increasing use of fertilisers and pesticides under a warmer and drier climate has exacerbated the rate and frequency of algal blooms in waterways and waterbodies.

Future 3. Global & Local Transformation

In Future 3, rates of algal blooms have still increased across regional waterways and waterbodies of the region despite global and local efforts. This is because of atmospheric carbon concentrations have only recently peaked, so the region is still experiencing higher temperatures coupled with lower flows conducive to higher rates of algal bloom. This should begin to turn around in the coming decades as atmospheric concentrations slowly decline.

The rate of algal blooms in Future 3 are lower than those seen in Futures 1 and 2, allowing some system recovery. This is because of local resilience interventions that led to better management of nutrients and animal waste through circular economy interventions, reducing nutrient rich runoff.

Public and private land managers have been working in partnership to improve water quality associated with agriculture. With the support of these partnerships and regional learning forums, farm enterprises rapidly adopted sustainable farming practices and technological change that led to improved production efficiencies and reduced impact on environmental systems.

Net water availability

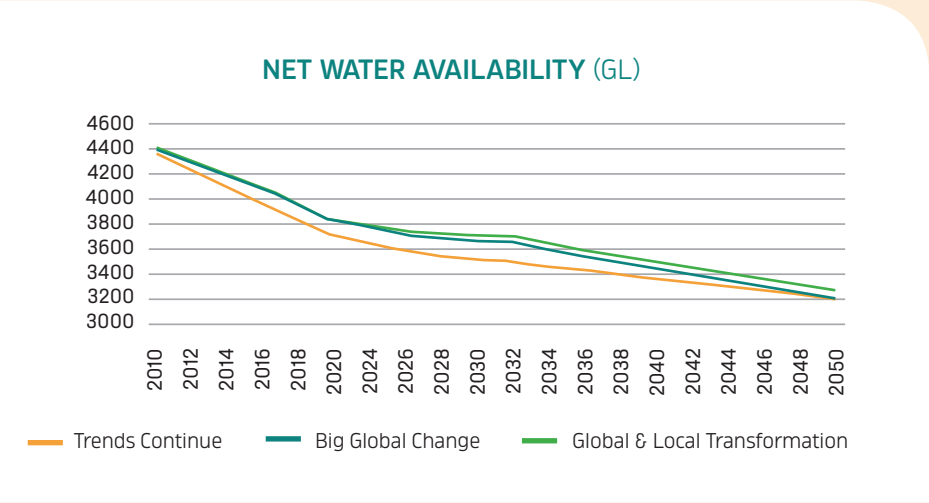

FIGURE 15: PROJECTED NET WATER AVAILABILITY UNDER ALL THREE FUTURES

Comparison of the trajectory of net water availability for the three modelled scenarios used in the data stories is shown in Figure 15. Further detail on what is driving these trends is provided next.

Future 1. Trends Continue

In 2050, water availability is declining across the region primarily driven by climate change (evaporation, reduced rainfall), and increasing competition for water resources across the Murray Darling Basin. Water policy reforms continue to influence how much water is available across the Goulburn Murray and how it is used. The amount of water available for irrigated agriculture is decreasing, which is in turn driving a reduction in the irrigation footprint. As a result of these combined factors, water scarcity continues to be a major challenge across the region.

Future 2. Big Global Change

Net water availability in Future 2 followed the same trajectory as Future 1 but the decline happened at a slower rate during the 2030s and 2040s, helping support transition to water efficient production.

Water scarcity continues to be a major challenge across the region.

Future 3. Global & Local Transformation

Future 3 saw net water availability travel on a trajectory similar to, though slightly better than, Future 2. The region took advantage of this period where the rate of loss slowed in the 2030s and 40s by rapidly transitioning to a more diverse mix of water efficient production systems and enterprises.

At the regional level, this transformation was supported by the Regional Resilience Fund for Agriculture and the Goulburn Murray Learning Centre. Significant resources are still provided through these programs to support region wide shifts in production systems, increase the diversity of enterprise mix and address the challenge of water scarcity.

The region remains sustainable and resilient in the face of water scarcity, making more from less.

River water salinity

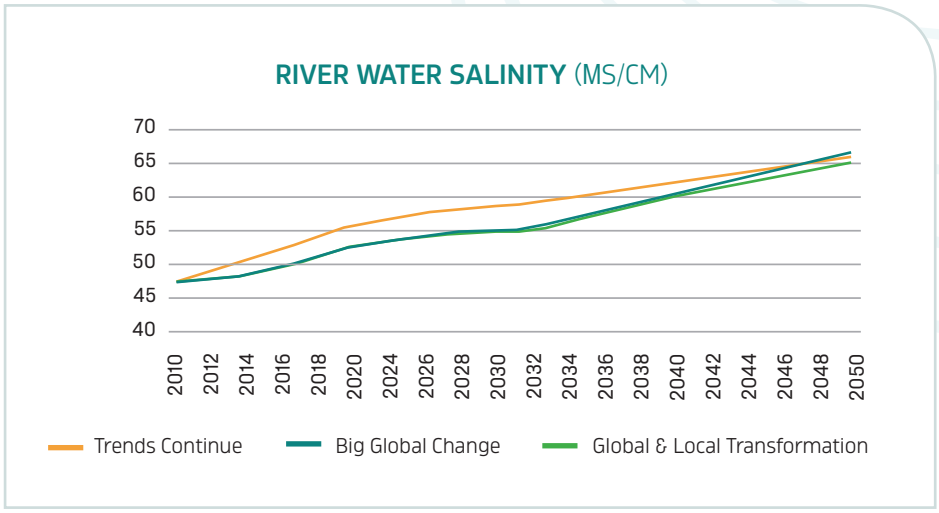

FIGURE 16: PROJECTED RIVER WATER SALINITY UNDER ALL THREE FUTURES

Comparison of the trajectory of river water salinity for the three modelled scenarios used in the data stories is shown in Figure 16. Further detail on what is driving these trends is provided next.

Future 1. Trends Continue

In 2050, river salinity is increasing in the Goulburn Murray. This is driven by a decreasing water availability due to increased evaporation and reduced river inflows caused by climate change.

Future 2. Big Global Change

Future 2, river salinity in the region is still increasing, but at a lower rate relative to Future 1 until mid-century but the levels catch up by 2050 due to evaporation rates increasing as the impacts of climate change continue. There is speculation that salinity will improve as atmospheric carbon levels decline, but further intervention may be needed.

Future 3. Global & Local Transformation

The trajectory for Future 3 was much the same as for Future 2. Once again, rates were lower through the 2030s and 40s than under Future 1. There is speculation that salinity will improve as atmospheric carbon levels decline, but further intervention may be needed.

FARMING RESILIENT FUTURES