Australian Government

Murray–Darling Basin Authority

Basin Plan Review

2025 Murray–Darling Basin Outlook: Technical Report

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The 2025 Basin Outlook Technical Report, in conjunction with *The future of climate and water availability in the Murray–Darling Basin: Sustainable Yields report* (MDBA 2025b), forms part of our response to our obligation under the *Water Act 2007* (Cth)(s 50)(4A)(c). For further information, please see the Basin Plan Review Strategic Climate Risk Assessment.

Cataloguing data

2025 *Murray–Darling Basin Outlook Technical Report*, Murray–Darling Basin Authority Canberra, 2025. CC BY 4.0

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Acknowledgement of First Nations people

We offer respect to the Traditional Custodians of Country in the Murray–Darling Basin and to their Nations. We pay our respects to Elders past and present.

We acknowledge their enduring deep Cultural, social, environmental, spiritual and economic connection to their lands and waters. First Nations people have been looking after Country in sophisticated ways for more than 65,000 years and continue to do so on behalf of their Nations and people.

We have heard many First Nations people express that when the lands and waters of Nations are not healthy, the people are unwell, and the ability to practise Culture and look after Country is impacted.

This includes being able to swim in the local waterways and harvest traditional foods and resources. First Nations people see waterways as living entities and live by the principle that everything is connected. Since colonisation, land, water and people have been separated. This goes against the way First Nations people see Country.

First Nations people in the Basin have been excluded from decision-making processes about water. Water management laws have contributed to disparity and dispossession, as they were developed without recognising First Nations' sovereignty. We acknowledge that this causes distress.

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Cultural sensitivity

First Nations people should be aware that this publication may contain images, names or quotes from deceased persons.

Foreword

The Murray–Darling Basin Outlook presents an assessment of how the Basin's water resources and its diverse and unique values may respond to a changing climate as we move toward 2050. It builds on the largest evidence base assembled since the Basin Plan was adopted in 2012 and contributes to the 2026 Basin Plan Review.

The Outlook looks beyond the Basin's current condition (as described in the 2025 Sustainable Rivers Audit) and is informed by a range of plausible climate scenarios described in *The future of climate and water availability in the Murray–Darling Basin: Sustainable Yields report*.

The Basin has become hotter and drier over the past 5 decades. This trend is expected to continue, with higher temperatures, less cool-season rainfall, more intense rainfall events and reduced runoff – particularly in the southern Basin. The Outlook examines how these changes may affect water availability and water security, environmental conditions, First Nations Cultural values, and the broad social and economic fabric of Basin communities.

The analysis supports a more adaptive approach to water management in a changing climate. While the Basin Outlook focuses on a hotter and drier future, it also considers a range of other plausible climate outcomes.

The findings highlight the potential stresses on the Basin's water systems and the ongoing importance of the Basin Plan. Continuing implementation of the Plan, including the accreditation of remaining water resource plans and reducing impediments to efficient water delivery, will improve the Basin's resilience to climate pressures. At the same time, the Basin Plan must continue to evolve to ensure it remains fit for purpose in a changing environment.

The Basin Outlook provides a shared foundation for governments, communities, industries and First Nations peoples to consider the challenges and opportunities that lie ahead. While uncertainty will always remain, the evidence is clear that change is already well underway. Through science, planning and cooperation, we can ensure that the Basin continues to support the people, cultures, industries and ecosystems that depend on it.

Daryl Quinlivan
Chair Murray–Darling Basin Authority

What is the 2025 Basin Outlook report

The purpose of the 2025 Murray–Darling Basin Outlook (Basin Outlook) is to help Basin governments and stakeholders prepare for a hotter and drier future as climate change continues. The Basin Outlook Technical Report describes how the Basin's environmental, First Nations, social and economic values may change by 2050 if existing management arrangements do not change. This approach of showing how the Basin's values may change highlights potential vulnerabilities to ongoing climate change. These insights will support adaptation to ongoing climate change and guide decisions on the management of our Basin's water resources.

The Basin Outlook assessment draws on the best available science and multiple lines of evidence. Key sources include the:

- *2025 Sustainable Rivers Audit* (MDBA 2025a), which assessed current conditions and trends of environmental, social, economic and First Nations values, and serves as a starting point for the Basin Outlook assessments
- *The future of climate and water availability in the Murray–Darling Basin: Sustainable Yields report* (MDBA 2025b), exploring plausible future hydroclimate scenarios and accompanying hydroclimate data, which the Murray–Darling Basin Authority (MDBA) will use in the Basin Plan Review
- *Water Country: Water Future*, which is a report on First Nations values and how changing conditions in the Basin might affect First Nations people (SRAO FNLG 2025). This report is authored by a group of First Nations water experts formed by the MDBA and does not speak on behalf of all First Nations people
- Future condition reports for environmental values (Jacobs Group 2025) and for social and economic values (MJA 2025a), which were informed by extensive literature, analyses and expert opinion.
- The 2025 National Climate Risk Assessment, which provides a broader perspective on climate risks across Australia's society and environment, including the economy, communities, agriculture, health, infrastructure and ecosystems.

The knowledge base will continue to improve. The 2026 Basin Plan Review and future 10-yearly reviews are checkpoints along the adaptive management pathway to 2050 and beyond, and provide an opportunity to continue to use the best available science. This will improve our projections of how the Basin could respond to climate change, and support effective adaptation strategies to improve management of the Basin's water resources.

1. Key findings of the Basin Outlook

Changes to the Basin's climate

The Murray–Darling Basin Authority is preparing for a future climate that is likely to be hotter and drier. Based on the work of the 2025 Sustainable Yields project examining the 3 plausible scenarios (see below), we have high confidence in the direction of change of hydroclimate variables such as temperature, rainfall and runoff to 2050. We also have high confidence that extreme events (such as drought and heavy rainfall) will increase in severity and intensity.

Within the broad trajectory of change to the Basin's climate, there is uncertainty regarding the timing and magnitude of the changes that will be experienced across regions. Therefore, while anticipating a hotter and drier climate, the MDBA will also draw upon the plausible climate range to account for this uncertainty. This ensures that operational and adaptation planning considers the relative risks and benefits of different actions against an uncertain future.

Across the range of plausible future climates, the key findings are as follows.

The Basin is *virtually certain* to be hotter.

Temperatures have risen across the Basin by approximately 1.4 °C since the start of national records in 1910, with most of the increase having occurred since 1970. By 2050, temperatures are projected to increase by approximately 1.3 °C to 1.8 °C above 1990 levels. Hotter temperatures mean more water is evaporated from soil, rivers and dams and transpired from plants (evapotranspiration). This increases aridity and the demand for water while reducing water availability.

Annual rainfall is *likely* to become more variable.

Rainfall across the Basin has historically been variable, particularly in the northern Basin, and this variability is expected to increase. Increased annual rainfall variability may lead to longer dry spells and longer wet spells. This variability is particularly influenced by the natural variability of regional climate drivers in the Southern, Pacific and Indian Oceans.

Heavy rainfall is *very likely* to become more intense.

The intensity of heavy rainfall events is very likely to increase across the Basin, particularly in the warmer months. This increases the risk of flood, particularly in urban areas and small catchments. This can then result in poor water quality events caused by the runoff of nutrients, sediments and other contaminants into waterways.

Cool-season rainfall is *likely* to decline in the northern Basin and *very likely* to decline in the southern Basin.

Seasonal changes to rainfall patterns are projected for both the northern and southern Basins. Cool-season rainfall is likely to decline in the northern Basin and very likely to decline in the southern Basin. In the southern Basin, reduced cool-season rainfall, particularly in the south-east, would reduce water availability and river flows.

Drought is *very likely* to become more severe, occur more frequently and may be of longer duration.

More severe and more frequent droughts are very likely to occur due to increased temperatures, more variable annual rainfall, and less rainfall in the cooler months. It is expected that rainfall events will be relatively short and intense, with higher losses to evaporation. Changes to rainfall patterns, coupled with increased evapotranspiration, mean Basin runoff is very likely to decline. This can lead to more severe, more frequent and longer periods of drought conditions. The projections align with observed historical data which show a trend of increased frequency of drought occurrence in recent decades compared with early records.

Runoff and water availability are *very likely* to decline, particularly in the south.

Due largely to the expected reduction in cool-season rainfall, there is very likely to be an overall decline in runoff across the Basin. This decline is likely to be greater in the south compared with the north, and more pronounced for the cool season than the warm season due to an increase in warm-season heavy rainfall events.

The frequency of moderate flood inundation is *likely* to decline, but flood height and duration for large floods may increase.

Moderate floods that occur more frequently are likely to decline across the Basin, particularly in the southern Basin. Very large floods may increase in parts of the Basin, particularly in the north, because very heavy rainfall events are very likely to become more intense.

Changes to the Basin's values

The *2025 Murray–Darling Basin Outlook technical report* (Basin Outlook) intentionally explores what could happen by 2050 if the status quo in the management of Basin water resources is maintained under a hotter and drier future. The key findings present many challenges, but it is important to remember that the Basin governments, industries and communities have already adapted to climate change and, with the right information, can continue to do so up to, and beyond, 2050. This means that future conditions may be better than these projected outcomes, as long as there is continued, effective action to adapt to climate change.

Northern Basin climate and runoff

Annual average rainfall will marginally decrease (–1.4%), with slight increases in the warm season and larger decreases in the cool season. Annual runoff will also decrease (–7.4%), due to a relatively large decrease during the cool season and a slight increase in the warm season.

The number of heavy rainfall days will increase in the northern Basin (+5.2%). The frequency of droughts that historically occurred once in every 20 years will occur more regularly (once in every 15 years).

Southern Basin climate and runoff

Annual average rainfall will slightly decrease (–2.6%), driven mostly by reduced rainfall in the cool season. Annual runoff will also decrease (–14.3%), with similar decreases across the warm and cool seasons.

The number of heavy rainfall days will increase in the southern Basin (+5.2%). The frequency of droughts that historically occurred once in every 20 years will occur more regularly (once in every 14 years).

End of system

Sea level is projected to rise by around 25 cm. Rising sea levels coupled with storm surges may increase salinity in the Lower Lakes and change salinity environments in the Coorong, with increased salinity in estuarine areas and decreased salinity in areas historically saltier than sea water.

Flows, groundwater and water quality

River baseflows, freshes and overbank flows are expected to become less frequent. This will disconnect waterholes for longer periods and reduce connectivity between rivers and their wetlands and floodplains.

These changes to flow and rainfall are likely to reduce groundwater recharge and levels, particularly in upland regions and some floodplain areas.

Reduced river flows, combined with hotter temperatures and more frequent heavy rainfall days, are likely to increase the frequency of poor water quality events, including harmful algal blooms, hypoxia (low oxygen) and elevated salinity.

Changes to environmental values

Germination, growth and reproduction of native plants will be disrupted, and native fish and waterbird populations will continue to decline.

Populations of native plants that depend on rivers will likely change, with some species becoming more or less common, and certain plant communities expanding or shrinking.

Populations of native fish species are likely to decline in numerous systems and may be lost from severely affected systems. Key habitats, including drought refuges and niche wetlands used by threatened small-bodied species, are expected to deteriorate.

Waterbird populations are likely to decline, driven by loss of habitat. Opportunities for large breeding events will become less frequent as dry and drought conditions increase in duration.

First Nations of the Basin

First Nations people and Water Country will be acutely affected by a changing climate.

The fragility of Water Country presents further challenges for First Nations people under a changing climate. A changing climate risks further irreversible damage to First Nations people, Water Country and knowledge systems.

First Nations people have a unique and enduring connection with, and obligation to look after, Water Country. As the Basin's lands, waters and environment become increasingly distressed, so too do First Nations people. Impacts on Water Country are linked to and are felt by First Nations people through poor outcomes related to their health and wellbeing.

The nature of impacts on Water Country heightens anxieties for First Nations people, who carry the burden of seeing their ancestral lands, waters and ecosystems degrade in ways that disrupt continuity to the intergenerational care of Country and the passing on of knowledge to future generations. Damage to sacred sites, the loss of traditional food and medicines, and impacts on places that hold story, ceremony and other practices, are examples of types of on-ground threats that are unique to First Nations people in the Basin.

Changes to water entitlements and markets

Reduced water availability will affect the reliability of both entitlement and non-entitlement water.

Entitlement water can be held by individuals, industries and governments. It includes consumptive water rights and environmental water entitlements. Non-entitlement water is managed through state water sharing arrangements and is not tied to an entitlement. It provides important environmental and user benefits. Allocations of entitlement water are expected to reduce as total average water availability decreases. Changes in the reliability of non-entitlement water will vary between types. Passing flows are likely to remain relatively reliable, but unregulated flows are expected to decline more substantially, with implications for maintaining Basin ecosystems.

Higher water allocation prices could drive changes in the types of primary production in the southern Basin.

In the southern Basin, average water allocation prices are expected to increase. In response, markets may shift water towards higher-value permanent horticulture (for example, almonds and citrus) in preference to opportunistic annual crops (rice and some pastures for dairy cattle).

High reliability entitlement holders are better placed than general reliability entitlement holders to maintain access to water under a drier climate.

General reliability users are likely to face longer stretches of low or nil allocations compared to high reliability entitlement holders. This uneven exposure to a drier future means general reliability users are more likely to scale back or exit irrigated agriculture, while high reliability users are better placed to consolidate scarce water.

More extensive water markets in the southern Basin give irrigators greater scope to manage water scarcity risks.

Southern Basin irrigators can lean on trade and carryover to mitigate risks from water insecurity. In the northern Basin, users would be exposed to more variable water availability and have fewer market options to smooth supply across years.

Critical human water needs

Pressure to meet critical human water needs will increase.

During the Tinderbox drought (2017–2019), many communities in the Basin, particularly in the north, experienced extreme water security issues followed by cases of water restrictions or no water availability. Under a hotter and drier climate, droughts are to become more frequent, placing greater pressure on reliable supply of critical human water needs. Provisions to manage critical human water needs, set out in the Basin Plan and water resource plans, are likely to be activated more frequently.

Social and economic values

The impacts from a hotter and drier climate on primary industries, tourism, and the health and wellbeing of people living in the Basin strongly align with the impacts that are expected to be felt across much of Australia. The National Climate Risk Assessment (Australian Climate Service 2025a) identified that nationally significant climate risks to communities, health and social support, and primary industries will increase through to 2050.

Maintaining agricultural production is expected to become more challenging.

Higher temperatures in the northern Basin may see more opportunistic cropping, less perennial horticulture, and impacts to the livestock industry. In the southern Basin, reduced water availability and quality are expected to challenge irrigated industries and forestry. With only incremental adaptation, agricultural productivity gains may plateau, yields may decrease, land and water competition may intensify, and soil health may decline.

Larger regional economies and tourism are likely to continue to grow, but business activity could be interrupted by extreme climate events.

Population migration will continue from rural areas to larger regional centres that have essential services, infrastructure and diverse economies. Regional tourism is likely to continue to grow, but could be interrupted by extreme climate events, such as floods and algal blooms, that affect business activity.

Communities that are small, remote and heavily reliant on agriculture are more vulnerable to a hotter and drier climate.

Communities in small, remote towns with high dependency on agriculture are more vulnerable to changes in water availability and temperature extremes. These climate vulnerabilities combined with global structural changes, such as labour-saving agricultural technologies, may continue the trend of ageing demographics and lower population growth relative to large regional centres. The pressures from reduced water availability and greater adaptation demands are expected to increase the risk of slower economic and employment growth in these towns.

2. Introduction

The Murray–Darling Basin is a highly regulated system, which spans 4 Australian states (New South Wales, Victoria, Queensland, South Australia) and the Australian Capital Territory and is one of Australia's most significant river systems.

The Basin supports more than 2.4 million people, including more than 120,000 First Nations people representing more than 50 First Nations. More than 77,000 km of rivers and waterways underpin significant agricultural industries, responsible for around one-third of Australia's total food production and diverse export markets.

The Basin includes thousands of dams and weirs, along with a complex network of regulating structures that control the flow and availability of water. Managing this vast and complex system has required high-level government intervention, particularly to balance environmental health with economic productivity. During recent decades, a series of reforms, infrastructure projects and water sharing mechanisms have been introduced to address environmental degradation and overallocation of water resources.

The Basin is a dynamic system that faces significant challenges related to climate change, water reliability and environmental degradation. Ongoing efforts are required to ensure its long-term health and sustainability, for both the environment and the industries and communities that depend on it.

Understanding the potential future condition of the Basin is critical to safeguarding its capacity to sustain rivers for future generations.

The Basin is one of Australia's largest river systems, crossing 4 states and one territory

The Basin Plan 2012

Basin management by the Basin governments (Australian, New South Wales, Victoria, Queensland, South Australia and the Australian Capital Territory) has changed over time, alongside the development of river infrastructure to provide more reliable water to support communities and agricultural industries. The most significant reforms came with the enactment of the *Water Act 2007* (Cth) and the Basin Plan in 2012.

The introduction of the Water Act in 2007 and the Basin Plan in 2012 were major reforms, building on previous reforms such as the introduction of the Cap on surface water diversions (1995), the establishment of The Living Murray Program (2002), and the National Water Initiative (2004). The Basin Plan 2012 was introduced to strike a balance in managing the Basin's water resources in a sustainable way. It aimed to meet the objectives of protecting and restoring the ecological health of the Basin's rivers, wetlands and floodplains. At the same time, it needed to ensure water remained available for human consumption, agriculture and industries.

The Plan sets sustainable diversion limits (SDLs), which limit the amount of surface water and groundwater that can be taken from the Basin for consumptive use. SDLs allow for water to be recovered for the environment – water that can often be directed by Commonwealth and state environmental water managers to specific areas within the Basin, for specific environmental purposes. Under the Plan, as at 30 June 2025, more than 2,100 GL of surface water has been recovered. Across the Basin, there are 5 main environmental water holders (managers) who share and distribute this water with varying sizes of entitlements:

- the Commonwealth Environmental Water Holder
- the Living Murray program, coordinated by the Murray–Darling Basin Authority (MDBA) on behalf of the Australian Government and the governments of New South Wales, Victoria and South Australia
- the Victorian Environmental Water Holder
- the New South Wales Department of Climate Change, Energy, the Environment and Water
- the South Australian Department for Environment and Water.

Overall, water use in the Basin is highly regulated, both from an infrastructure perspective (dams and weirs, irrigation channels and pipelines, locks, environmental structures and fishways) and from a policy and planning perspective (state-based water sharing arrangements, combined with the rules set out in the *Water Act 2007* (Cth) and the Basin Plan, river operations, and the joint efforts of environmental water managers).

The Basin Plan Review

This *2025 Murray–Darling Basin Outlook technical report* (Basin Outlook) contributes to the MDBA's 2026 Basin Plan Review. The review is an opportunity to reflect on lessons learned, what is working and what might need to change to support the Basin as our climate changes.

The Basin Outlook builds on the following key components of the Basin Plan Review (Figure 1):

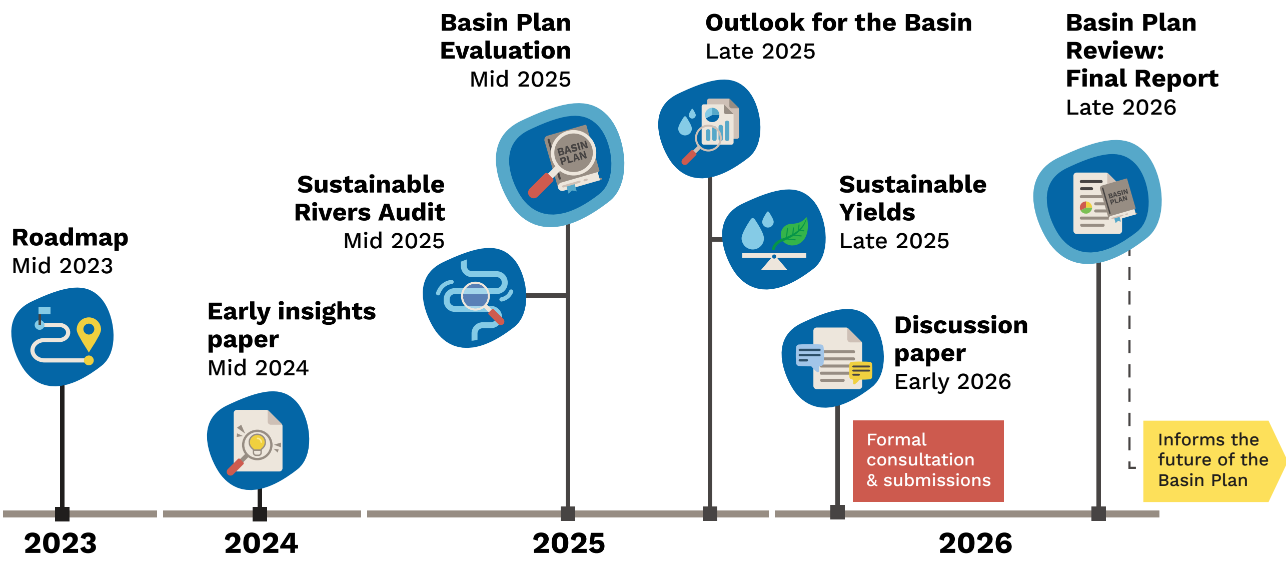
- The Sustainable Rivers Audit (MDBA 2025a) provides information about the environmental conditions and trends of the Murray–Darling Basin, alongside an assessment of social and economic trends over time. The Audit also includes a Cultural perspective to recognise the enduring connection First Nations people have to the Murray–Darling Basin.
- The Basin Plan Evaluation (MDBA 2025c) plays a critical role in tracking and communicating progress and achievements against the outcomes set in the Murray–Darling Basin Plan 2012. The Evaluation also describes the contribution of the Basin Plan to achieving outcomes, and identifies potential improvements to the Basin Plan, which will inform the Basin Plan Review.

The Basin Outlook also supports key components of the Basin Plan Review, including the:

- Basin Plan Review Discussion Paper. Using supporting knowledge and evidence, this will outline options being considered for the Basin Plan Review. This step includes formal consultation in early 2026
- Basin Plan Review Report. Due at the end of 2026, this report will present the results of the review of the Basin Plan and make recommendations to support the plan to manage the Basin's water resources into the future.

More information on the Basin Plan Review is on the **MDBA website**.

Figure 1 **Roadmap to the 2026 Basin Plan Review**



Approach to the 2025 Basin Outlook

The Basin Outlook has made its assessments and observations under a deliberate assumption that the Basin's existing management measures have not changed as we approach 2050 and beyond, but that climate change has continued. The intent of this is to highlight potential vulnerabilities under plausible future hydroclimate scenarios (see Hydroclimate future scenarios) to inform adaptive management of the Basin's water resources.

The Basin Outlook undertakes a range of assessments across 4 themes:

- **environmental** – the health of the Basin's water-dependent environment and the river flows that support it, including projections of future environmental conditions based on 3 future hydroclimate scenarios
- **First Nations** – impacts to First Nations people arising from future changes to the Basin's environmental, social, economic and Cultural conditions. The assessment was completed by the Sustainable Rivers Audit and Outlook First Nations Leadership Group alongside other lines of evidence. It is acknowledged that it does not represent all First Nations people across the Basin
- **economic** – how the Basin's economic vulnerabilities and values may evolve under 3 future hydroclimate scenarios
- **social** – how Basin communities' health, wellbeing and social cohesion may change under 3 future hydroclimate scenarios.

More information on the wider Basin Plan Review deliverables is on the MDBA website

3. Climate change

Across the globe, megatrends are reshaping societies, economies and the environment. These are large-scale, long-term forces that influence how the world changes over time.

Among these megatrends, climate change stands out as one of the most significant. Climate change is accelerating, bringing the risk of large, rapid change in the climate of the Basin. This has far-reaching impacts on ecosystems, communities and future planning (Pearson and Mummery 2025). Increasing temperatures will likely result in more heatwaves, more extreme rainfall events, reduced snow cover and increased occurrences of meteorological and hydrological drought. This will have significant impacts on water availability and water demand from communities, industries and the environment.

This *2025 Murray–Darling Basin Outlook technical report* (Basin Outlook) focuses on potential changes from ongoing climate change in the Murray–Darling Basin as they relate to Basin Plan water management. It complements the National Climate Risk Assessment (Australian Climate Service 2025a), which provides a broader perspective on climate risks across Australia's society and environment, including the economy, communities, agriculture, health, infrastructure and ecosystems.

Observed changes in the Basin's climate

Temperatures have risen across the Basin by approximately 1.4 °C since the start of national records in 1910, with almost all the increase occurring since 1970 (Chiew et al. 2025). This is a higher rate of increase than the global average of 1.1 °C since the pre-industrial period of 1850–1900 (IPCC 2023).

Hotter temperatures mean higher evapotranspiration. Evapotranspiration is a combination of water evaporation (from lakes, rivers, soils and plant surfaces) and transpiration (where water in plant tissue is converted to water vapour in the atmosphere). Hotter temperatures and higher evapotranspiration mean that the environment is drier, leading to increased water demand by both humans and the environment to meet water needs. Higher temperatures also mean that drought conditions will develop quicker and more rainfall will be needed to break a drought.

Rainfall patterns are shifting, the volume of inflows in the Basin have been decreasing during the past 50 years and droughts are increasing in frequency. Since 1970, cool-season rainfall (May to October) has been decreasing by about 1 mm per year, particularly in the southern Basin. The greatest decreases are in the higher rainfall valleys of the Basin's south-east. Rainfall reduction in these areas has a big impact on total water availability in the southern Basin system. Cool-season rainfall is also decreasing in the northern Basin, although by a less significant margin. There has been a slight increase of less than 0.5 mm per year in warm-season rainfall in the southern Basin. This increase is likely offset by higher temperatures and will have a negligible impact on water availability over the longer term. The changes in rainfall and increased temperatures have contributed to declining river inflows, which can exacerbate differences between water availability and level of demand (MDBA 2025a).

While these longer-term trends are occurring, the Basin also experiences high climate variability. Basin communities have experienced both droughts and floods, as well as early frosts, heatwaves and bushfires. Extreme events such as storms, droughts and floods are becoming more frequent and intense.

Hydroclimate future scenarios

Hydroclimate refers to the interaction between climate and the movement and distribution of water in the landscape through precipitation (rain and snow), drainage (rivers and groundwater) and return to the atmosphere (evaporation and transpiration). Hydrological models combine historical climate and water data with data from forward-looking climate models to simulate how water systems respond to future climate conditions and affect water availability and distribution.

Hydroclimate scenario modelling shows what future climates *could* look like, not forecasts of what it *will* look like.

Using the work of the Sustainable Yields project (MDBA 2025b), the Basin Outlook assesses the impact to future Basin values based on a 'hotter and drier' climate, and there is high confidence in this direction of change to 2050. However, the magnitude and timing of this change is less certain, meaning that it is important to consider a range of plausible climate futures. Considering a range of plausible climate futures helps understand future risk, consider a range of adaptation strategies and inform decision-making against a background of uncertainty. The 2050 plausible climate futures are (also see Figure 2):

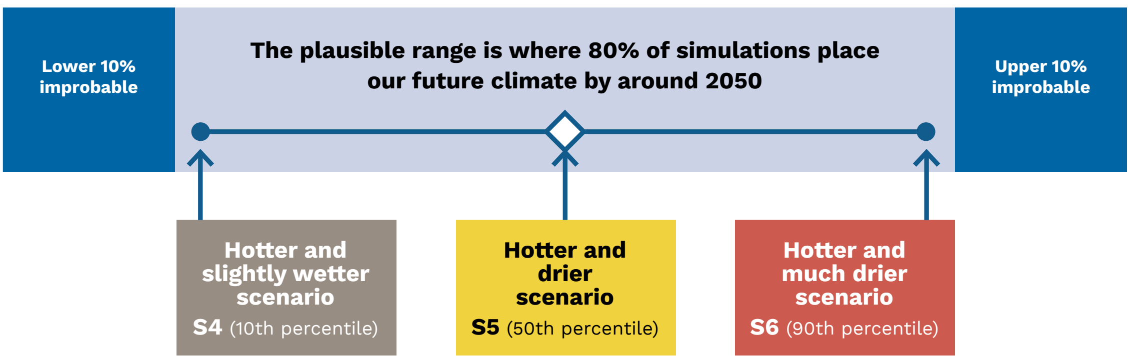
- a hotter and slightly wetter future (S4)
- a hotter and drier future – the future the MDBA is preparing for (S5)
- a hotter and much drier future (S6).

These 3 climate scenarios are based on 1.5 °C global warming relative to a 1990 baseline. This baseline represents a 30-year (1976–2005) time slice centred on 1990 and is used because global temperatures have increased significantly more since this period than in preceding decades.

Table 1 details projected changes to mean annual, seasonal and heavy daily rainfall, potential evapotranspiration, temperature, runoff, drought and groundwater recharge for the 3 plausible 2050 scenarios. For all 3 scenarios, different outcomes for the northern and southern Basins are expected because of the distinct differences in the hydroclimate and hydrology between the north and south.

For further information on the hydroclimate scenarios, refer to the 2025 Sustainable Yields report (MDBA 2025b).

Figure 2 **The Basin's plausible climate futures**



Source: MDBA 2025b

Table 1 **Projected changes to the Basin's climate under 3 plausible 2050 climate scenarios relative to 1990**

Parameter	Northern Basin			Southern Basin		
	Hotter and slightly wetter (S4)	Hotter and drier (S5)	Hotter and much drier (S6)	Hotter and slightly wetter (S4)	Hotter and drier (S5)	Hotter and much drier (S6)
Change in rainfall						
Mean annual (%)	+5.2	−1.4	−6.7	+4.6	−2.6	−8.2
Warm season (November to April) (%)	+8.6	+1.1	−5.0	+9.4	−0.5	−7.2
Cool season (May to October) (%)	+5.4	−6.6	−12.0	+1.5	−5.2	−11.5
Heavy daily rainfall above $P_{99.5}$ (%)[a]	+9.8	+5.2	+0.9	+9.8	+5.2	+0.9
Change in potential evapotranspiration (%)						
	+3.9	+4.5	+5.4	+3.9	+4.5	+5.4
Increase in temperature (°C)						
	1.3	1.6	1.8	1.3	1.6	1.8
Change in runoff						
Mean annual (%)	+16.0	−7.4	−22.0	+1.0	−14.3	−29.0
Warm season (November to April) (%)	+27.0	+2.0	−19.0	+8.0	−13.0	−26.0
Cool season (May to October) (%)	+9.0	−17.0	−31.0	0.0	−15.0	−30.0
Frequency of drought: a drought that previously occurred 1 in 20 years will occur …						
	1 in 25 years	1 in 15 years	1 in 10 years	1 in 19 years	1 in 14 years	1 in 9 years
Change in groundwater recharge						
Rainfall recharge (%)	+36.0	+3.0	−17.0	+24.0	−2.0	−23.0
Instream recharge (%)	+13.0	-10.0	−23.0	0.0	−14.0	−28.0
Overbank recharge (%)	+42.0	−20.0	−50.0	0.0	−34.0	−63.0

a P99.5 represents daily rainfall that is exceeded on 0.5% of days, or on average 1 in 200 days.
Source: Chiew et al. 2025; MDBA 2025b

Hydroclimate changes for the Murray–Darling Basin

Based on modelling in the Sustainable Yields report, climate change means that:

- the Basin is *virtually certain* to be hotter
- annual Basin rainfall is *likely* to become more variable
- very heavy rainfall in the Basin is *very likely* to become more intense
- cool-season rainfall is *likely* to decline in the northern Basin and *very likely* to decline in the southern Basin
- potential evapotranspiration is *virtually certain* to increase and the Basin will *very likely* shift to more arid conditions
- droughts are *very lik*ely to become more severe and occur more frequently, and may be of longer duration
- runoff and water availability are *very likely* to decline, particularly in the south
- the frequency of flood inundation is *likely* to decline, but flood intensity may increase
- long-term average annual flows are projected to decline, affecting water entitlements (consumptive and environmental) and the non-entitlement water that stays in our river systems.

The *italicised* descriptions of likelihood above follow the International Panel on Climate Change approach and terminology (see Table 2).

Table 2 **Descriptions of likelihood used in this report**

Description	Likelihood (%)
Virtually certain	99–100
Very likely	90–100
Likely	66–100
About equally likely or unlikely	33–66
Unlikely	0–33
Very unlikely	0–10
Exceptionally unlikely	0–1

Source: Mastrandrea et al. (2010).

Climate variability versus climate change

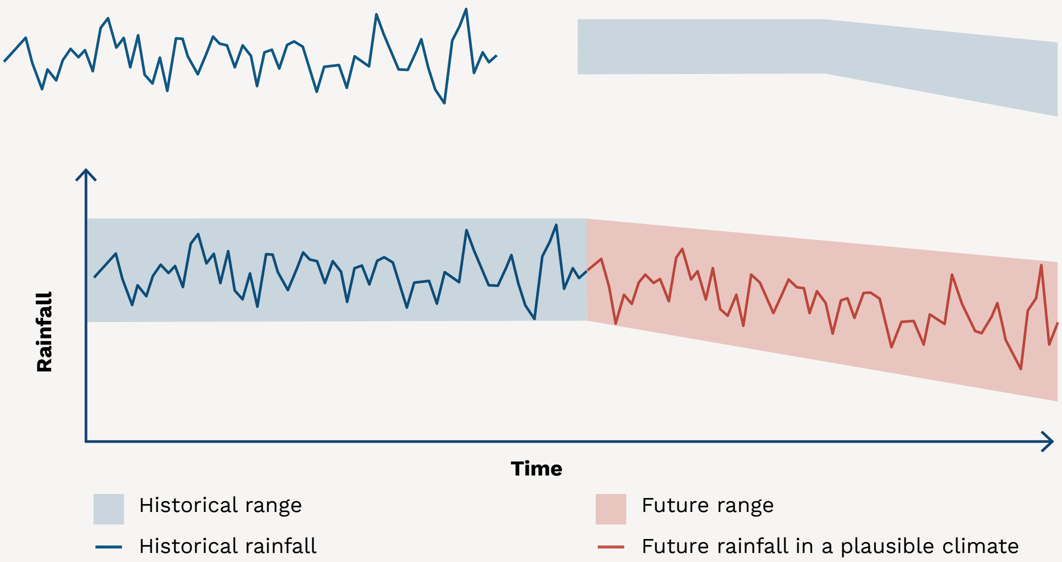
Climate change models aim to separate the effects of climate change from the effects of climate variability (Figure 3). The Basin's climate is highly variable, with temperatures and rainfall varying widely from region to region, year to year and decade to decade. It is influenced by changes in global weather systems, including large-scale circulation and climate drivers in the Pacific, Indian and Southern Oceans.

Understanding the overall trends within this variability – as well as the trends in the extremes and in the variability itself – shows what we can expect from our future climate. The Sustainable Yields report (MDBA 2025b) provides context for interpreting current trends within a longer-term perspective.

Figure 3 **Concept view of climate variability versus climate change**

Climate variability refers to the short-term changes that occur over months, seasons, years and decades. It includes extremes caused by one-off events and El Niño and La Niña climate cycles. Our climate will always experience variability.

Climate change refers to the shift in the long-term trend. This affects the range in which variability occurs. Climate change can also affect the level of extremes and of variability.



Source: MDBA (2025b)

This diagram shows the concept of variability and does not use real data.

Current status of Basin values

The 2025 Sustainable Rivers Audit (MDBA 2025a) examined the current environmental, Cultural, social and economic conditions of the Murray–Darling Basin and how these have changed over time. This sets the starting point for the Basin Outlook to understand how the values may change further.

The Sustainable Rivers Audit key findings were:

- For the past 50 years, the Basin has been gradually getting hotter and drier, while average inflows have decreased. (See **River flows and connectivity** for further details on the current status and the outlook for the future.)
- In recent years, groundwater levels have risen in response to the wetter conditions, but the trend over the longer term has been one of decline. (See **Groundwater** for further details on the current status and the outlook for the future.)
- Salinity management in the southern Basin has improved greatly over the past 50 years. Water quality in some areas of the Basin can deteriorate quickly as a result of droughts and floods. (See **Water quality** for further details on the current status and the outlook for the future.)
- Many aspects of the Basin's environmental health have improved since the Millennium drought. (See **Environmental values** for further details on the current status and the outlook for the future.)
- The exclusion of First Nations people from water management arrangements has caused harm, and First Nations peoples' wellbeing is intrinsically linked to the health of Country. (See **First Nations** for further details on the current status and the outlook for the future.)
- People living in the Basin recommend it as a great place to live. However, residents in communities that depend on agriculture are more likely to be less confident about the future of their community, and their ability to maintain their quality of life while coping with events like droughts and floods. (See **Social values** for further details on the current status and the outlook for the future.)
- The Basin's economy continues to grow and service industries are expanding in regional areas. (See **Economic values** for further details on the current status and the outlook for the future.)

4. The future of the Basin's values – a view to 2050

The Murray–Darling Basin is one of Australia's most significant and complex regions. It encompasses a landscape of striking contrasts – from bustling inland cities to small agricultural towns. The region supports diverse communities, industries and natural environments. It is also a place experiencing significant transformation, driven by climate change, population movements, shifting economies and long-running water reforms.

The Murray–Darling Basin Authority is preparing for a future climate that is likely to be hotter and drier. Changes in the Basin are not expected to be experienced equally across all communities and environments (Pearson and Mummery 2025). How much change occurs, the types of change, and whether the impact is positive or negative depends on other factors such as location, future social and economic conditions and water availability. Therefore, while anticipating a hotter and drier climate, the MDBA will also draw upon the plausible climate range to account for this uncertainty.

The *2025 Murray–Darling Basin Outlook technical report* (Basin Outlook) assesses the potential futures of 4 values: environmental, First Nations, economic and social. These assessments are based on past trends, modelling, simulations and expert analysis.

Environmental values

The Murray–Darling Basin is a system of interconnected rivers, wetlands and floodplains. The Basin includes subtropical rainforests, alpine meadows, and rivers and floodplains that snake their way from upland regions through semi-arid to arid lowlands, ending in the lower lakes, the Coorong and the Murray Mouth in South Australia. This diversity of habitats supports thousands of species, including plants, fish, birds, insects, reptiles and mammals. The Basin is home to 16 internationally recognised Ramsar wetland complexes and contains habitat for more than 500 species listed as nationally threatened under the *Environment Protection and Biodiversity Conservation Act 1999* (Cth).

Current status

Many aspects of the Basin's environmental health have improved since the Millennium drought. Recent years of wetter weather (since 2020), along with the delivery of environmental water to key locations, has created many positive environmental health outcomes. This is important, because good environmental health means increased resilience to future drought periods.

Source: MDBA (2025a)

Assessment of environmental values

The environmental values considered in the Basin Outlook are:

- river flows and connectivity
- groundwater levels
- water quality
- river-dependent vegetation
- fish
- waterbirds.

Although these do not represent all environmental values supported by the Basin, they cover fundamental aspects of riverine systems and can be used as indicators of the broader riverine ecosystem health.

The future condition of environmental values under climate change scenarios through to 2050 were categorised as:

Strong positive	positive trends at increasing rates, magnitudes and extent
Positive	positive trends from the current status
Negative	negative trends from the current status
Strong negative	negative trends at increasing rates, magnitudes and extent
Mixed	mix of positive and negative trends from the current status.

Groundwater trends are described in terms of changes to groundwater levels (rising or falling), rather than positive or negative.

An overview of the potential future condition of each of the Basin's environmental values is presented in Table 3. Assessment details for each value are discussed after the table.

Table 3 **Summary of the Basin Outlook for environmental values**

Value	Hotter and slightly wetter (S4)	Hotter and drier (S5)	Hotter and much drier (S6)
River flows and connectivity 	Positive	Negative	Strong negative
	Under S4, there will likely be an increase in lateral connectivity and fewer disruptions to longitudinal connectivity. Under S5 and S6, it is likely there will be a decrease in lateral connectivity and increased periods of disconnection for waterholes and refuges. Increasing magnitude of hotter and drier conditions will increase the duration of dry spells and cease-to-flow events.		
Groundwater levels 	Rising	Localised falling	Falling
	Under S4, there is likely to be a rise in groundwater levels with an increase in recharge. Under S5, there may be a fall in groundwater levels, particularly in upland areas. Under S6, rainfall, overbank and stream recharge are all likely to decrease, resulting in a fall in groundwater levels across most of the Basin.		
Water quality 	Negative	Strong negative	Strong negative
	Across all scenarios, there are likely to be negative changes to water quality from higher temperatures, including increased hypoxic events and harmful algal blooms. Particularly under S5 and S6, the frequency and magnitude of negative water quality events is likely to increase, and the extent or location of events will likely become more widespread.		
River-dependent vegetation 	Mixed	Negative	Strong negative
	Under S4, there may be a mix of positive and negative outcomes, including improved water access for forests, woodland and shrublands, changes in species composition, and greater pressure from introduced plants and animals. Under S5 and S6, increasing magnitude of hotter and drier conditions will increasingly disrupt life history processes such as germination, growth, reproduction, survival and dispersal, leading to changes in species composition and spatial and temporal presence.		
Native fish 	Mixed	Strong negative	Strong negative
	Under S4, there may be a combination of positive and negative outcomes. Improved flows would benefit many species, but fish death events may become more frequent. Under S5 and S6, reduced river flows and water quality will negatively impact native fish, with these affects more severe under S6.		
Waterbirds 	Positive	Negative	Strong negative
	Under S4, marginal increases in waterbird populations are expected from increased habitat and breeding opportunities. Conversely, under S5 and S6, populations could decline further under the drier conditions, with rates of decline more severe under S6.		

River flows and connectivity

Current status

For the past 50 years, the Basin has been gradually getting hotter and drier, while average inflows have decreased.

Rainfall has declined across the Basin since 1970, particularly in the southern Basin. The catchments with the wettest climates of the southern Basin are also seeing the most significant declines in rainfall. Changes in these catchments have a disproportionately high impact on the water availability across the southern Basin. Since 1975, inflows have declined alongside shifts in seasonal rainfall patterns. Even if water extractions and management practices were unchanged since 1975, there is likely to be a reduction in flow-related outcomes across the Basin because of lower inflows.

The Basin experiences substantial spatial and temporal variability in its weather. Spatially, the Basin comprises very different climates and different weather events, which impact regions differently. Temporally, the Basin's weather varies from season to season, year to year and decade to decade. The Basin experiences very intense periods of wet and dry, and long periods of above or below average rainfall.

Source: MDBA (2025a)

Rivers flows and connectivity are crucial for maintaining healthy river ecosystems and the services they provide. Climate, geomorphology and water resource development are key drivers of river flows and connectivity (Hart et al. 2021, Jacobs Group 2025). These drivers impact runoff and river flow through changes to rainfall and evapotranspiration, capture in storages, irrigation and water transfer, groundwater extraction and plantation forestry (Leblanc et al. 2012, Hart et al. 2021, King et al. 2022).

River flows and connectivity are vulnerable to changes that impact these drivers and alter flow regime components and flow characteristics. Changes to river flows and connectivity have flow-on effects to other environmental values such as groundwater, water quality, habitat provision, river-dependent vegetation, fish and waterbirds. The extent to which the Basin's environmental values are affected by changes in connectivity, flow regime components and flow characteristics depends on the degree to which changes disrupt key ecosystem processes. These processes include recruitment, growth and survival of biota (including plants, animals and invertebrates), their capacity to move and disperse, and healthy nutrient and carbon cycling that underpins food web productivity.

Water availability is the foundation of river health

Water availability is the most important factor driving the condition of the Basin's rivers. In simple terms, without water, the river cannot function as a healthy system. Most of the southern Basin's water comes from rainfall across a relatively small area, particularly the eastern slopes of the Great Dividing Range in southern New South Wales and in northern Victoria. As cool-season rainfall declines in these high-yield catchments, inflows into the southern Basin's rivers are directly affected.

Since the 1970s, southern valleys have experienced significant reductions in cool-season rainfall, which has led to lower stream flows and diminished water availability for both environmental and human uses. Even when water extraction levels are constant, reduced inflows result in less water reaching the rivers, wetlands and floodplains.

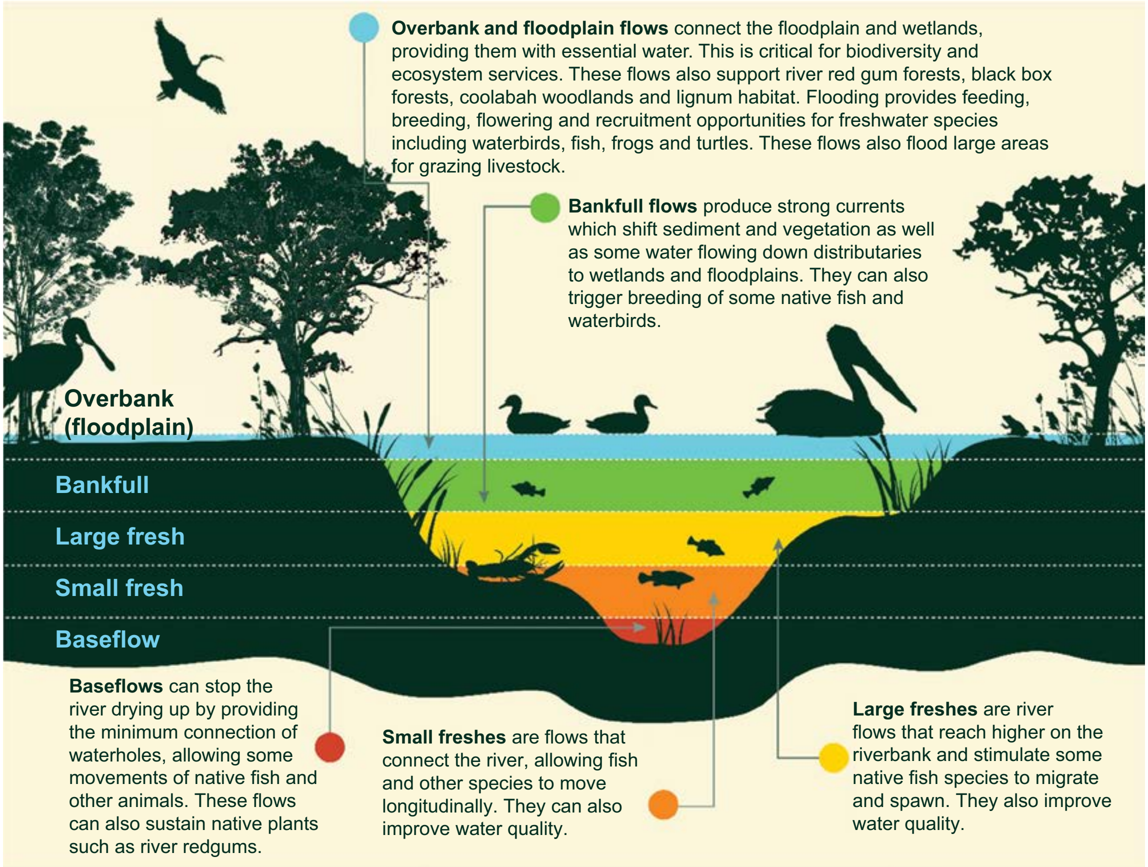
In the northern Basin, rainfall is highly variable, but on average the warmer months bring higher rainfalls. During dry periods, the ephemeral rivers cease to flow. Due to the flat landscape, during floods, water spills over river channels and reaches large areas of the floodplains. Some of this water reaches wetlands and billabongs, soaks into the soil or evaporates, and may even finds its way back to river channels and into the Barwon–Darling River.

Periods of extreme drought have further tested the resilience of the Basin's rivers. The Millennium drought (1997–2009) and the Tinderbox drought (2017–19) caused dramatic declines in river flows, depleted storages and exposed deficiencies in water management systems. While recent years have brought short-term relief through heavy rainfall and widespread flooding, the long-term trend is clear: the Basin is drying.

The variability of rainfall and streamflow is not new, but climate change is increasing the severity and frequency of both droughts and floods. Warmer temperatures mean that even when rain falls, more is lost to evapotranspiration and less reaches the rivers. As the climate continues to change, the challenge of managing water availability for both ecosystems and communities will only grow.

Plausible future outcomes for river flows and connectivity have been considered in relation to flow regime components – specifically, mean annual flow, cease-to-flow days, baseflows, freshes, overbank flows and dry spells (inter-event period and drought) (Figure 4; Jacobs Group 2025). Changes to flow characteristics, such as the timing, frequency, duration and magnitude of flow events, flow velocity, rates of rise and fall in water level, and duration of dry conditions between floods are also discussed in this report.

Figure 4: **Different flow regime components**



Source: Jacobs Group (2025), adapted from Sheldon et al. (2024)

The way our Basin rivers flow into the future under a changing climate is expected to change. These changes will impact the connectivity of our river systems along a river's length (longitudinal connectivity), between the river and its wetlands and floodplains (lateral connectivity), and between the river and groundwater (vertical connectivity).

Projected outcomes for river flows and connectivity, under each of the climate scenarios, are summarised in the table below.

Hotter and slightly wetter (S4)	Hotter and drier (S5)	Hotter and much drier (S6)
Positive	Negative	Strong negative
Positive: there will likely be an increase in lateral connectivity and fewer disruptions to longitudinal connectivity.	**Negative:** there will likely be a decrease in lateral connectivity and increased periods of disconnection for waterholes and refuges.	**Strong negative:** it is highly likely there will be a decrease in lateral connectivity and increased periods of disconnection for waterholes and refuges.

Details regarding the plausible changes to flow components are given in Table 4.

Table 4 **Summary of flow responses to plausible climate scenarios**

Flow component	Hotter and slightly wetter (S4)	Hotter and drier (S5)	Hotter and much drier (S6)
Mean annual flow	Up to 30% increase in flow due to increased rainfall and runoff Changes are predicted to be greater during summer and autumn, and greater in the northern Basin than in the southern Basin	Up to 20% decrease, and up to 60% decrease during extended droughts Changes are predicted to be greater during winter and spring Dry catchments will show a greater percentage reduction than wet catchments	Up to 40% decrease, and up to 70% decrease during extended droughts Changes are predicted to be greater during winter and spring Dry catchments will show a greater percentage reduction than wet catchments
Cease-to-flow days	Cease-to-flow days in ephemeral streams will reduce	Cease-to-flow days will increase in ephemeral streams. Some perennial streams may become ephemeral	Cease-to-flow days will increase in ephemeral streams. Some perennial streams may become ephemeral
Baseflows	Up to 10% increase	Up to 20% decrease	Up to 30% decrease
Freshes	Up to 15% increase Changes to the frequency of small and large freshes will vary between sites and valleys Flashier flows may result from increased occurrence of heavy daily rainfall (+9.8%)	Up to 20% decrease, up to 50% decrease during extended multi-year droughts Changes to the frequency of small and large freshes will vary between sites and valleys Flashier flows may result from increased occurrence of heavy daily rainfall The required frequency of large freshes is highly unlikely to be met in around 2050, especially in the southern Basin	Up to 40% decrease, and up to 70% decrease during extended multi-year droughts Changes to the frequency of small and large freshes will vary between sites and valleys Flashier flows may result from increased occurrence of heavy daily rainfall The required frequency of large freshes is highly unlikely to be met in around 2050, especially in the southern Basin

Table 4 (continued)

Flow component	Hotter and slightly wetter (S4)	Hotter and drier (S5)	Hotter and much drier (S6)
Overbank flows	Up to 15% to 45% increase Increases in smaller overbank flows are similar to those for mean annual flow; moderate to extreme overbank floods are likely to increase in frequency from an increase in very heavy rainfall (+9.8%) Changes are predicted to be greater in the northern Basin than in the southern Basin	Up to 20% decrease, and up to 60% decrease during extended multi-year droughts A more extreme decrease in floodplain inundation events is predicted for the southern Basin, along with a shift in the seasonality of overbank flows to summer In some areas of the northern Basin, the frequency of moderate to extreme floods may increase	Up to 40% decrease, and up to 60% decrease during extended multi-year droughts A more extreme decrease in floodplain inundation events is predicted for the southern Basin, along with a shift in the seasonality of overbank flows to summer
Dry spells (interevent period) and drought	Dry spells will reduce in duration and be less frequent Northern Basin – decrease in drought frequency. 1-in-20-year droughts (3-year duration) likely to occur every 25 years Southern Basin – minor change in drought frequency. 1-in-20-year droughts (3-year duration) likely to occur every 19 years	Dry spells will increase in length and occur more often Increase in drought frequency. 1-in-20-year droughts (3-year duration) likely to occur every 14–15 years	Dry spells will increase in length and occur more often Increase in drought frequency. 1-in-20-year droughts (3-year duration) likely to occur every 9–10 years

Source: Jacobs Group (2025), adapted from Chiew et al. (2025) and Zhang et al. (2020)

Groundwater

Current status

In recent years, groundwater levels have risen in response to the wetter conditions, but the trend over the longer term has been one of decline.

While longer-term decline is evident, analysis of groundwater trends over the past 5 years shows increasing water levels in many bores. This is likely due to the end of the Tinderbox drought (2017–19) followed by a number of years with above average rainfall. Longer-term analysis of 10- to 20-year groundwater trends shows that most bores have stabilised at a lower level than before the Millennium drought. This analysis recognises that targets for groundwater levels have not been developed across all areas of the Basin and further work is required to determine whether these lower groundwater levels impact the environment.

Source: MDBA (2025a)

Groundwater is an important component of river connectivity and supports other environmental values, especially floodplain trees. It is also an important water supply for communities and irrigated agriculture in some parts of the Basin. Groundwater and surface water are a single, connected resource. The movement of groundwater is driven by patterns of recharge and discharge. Recharge occurs when water flows into aquifers and discharge occurs when water flows out of aquifers and into streams and wetlands, and by vegetation transpiration. Groundwater levels are recharged by 3 main processes: rainfall recharge, instream recharge, and overbank recharge.

Groundwater salinity and level are largely driven by climate, water resource development, evapotranspiration and geomorphology (Jacobs Group 2025; Kalu et al. 2025). Rainfall and runoff, coupled with extraction of surface flows and groundwater, influence discharge and recharge interactions between groundwater and surface water. Surface-to-groundwater interactions in the Basin are best expressed over multiyear to decadal timescales, rather than short-term fluctuations (Crosbie et al. 2023; Kalu et al. 2025). For example, the recent wet period from 2020 to 2024 is likely to sustain an upward trend in groundwater levels in many areas in the Basin until about 2029 (Kalu et al. 2025).

There is a strong relationship between low surface water availability and increasing groundwater use, such as during times of drought. Additionally, land use, vegetation cover and type, and associated evapotranspiration rates also influence groundwater level and salinity. Groundwater is vulnerable to changes that impact these key drivers, with follow-on effects for groundwater-dependent ecosystems. Plausible future outcomes for groundwater have been considered in relation to groundwater interactions with streams, wetlands and floodplains.

Projected outcomes for groundwater, under each of the climate scenarios, are summarised in the table below. Further details are provided for each scenario.

Hotter and slightly wetter (S4)	Hotter and drier (S5)	Hotter and much drier (S6)
Rising	Localised falling	Falling
Rising groundwater levels: groundwater levels are expected to rise across the Basin, with likely increases in rainfall, overbank and stream recharge.	**Localised falling groundwater levels:** overbank and stream recharge is likely to decrease across the Basin, while rainfall recharge is likely to decrease in upland areas. Groundwater levels are likely to decline, particularly in upland areas and some floodplain locations.	**Falling groundwater levels:** rainfall, overbank and stream recharge are all likely to decrease, resulting in a fall in groundwater levels across the Basin.

Under all hydroclimate scenarios

Changes in recharge are broadly equated to changes in groundwater levels, so that a reduction (or increase) in recharge results in a reduction (or increase) in groundwater levels. The groundwater level response to changes in recharge will vary between catchments.

For groundwater, trends are described in terms of changes to groundwater levels (for example, rising levels or falling levels), rather than positive or negative. This is because groundwater interaction with surface water systems and vegetation, including native vegetation and agricultural crops, depends predominantly on maintenance of groundwater levels. In addition, changes in groundwater level may have positive or negative impacts on surface systems, including vegetation, depending on the salinity of groundwater and other local factors.

S5

Under a hotter and drier scenario (S5)

Groundwater interactions with streams and wetlands

Overbank and stream recharge to groundwater may decrease, while rainfall recharge is likely to be more varied across the Basin. Rainfall recharge is likely to decline in upland areas, impacting baseflows and wetland levels. In some parts of the Basin, rainfall recharge may increase due to the potential loss of vegetation and subsequent reduction in transpiration.

In general, a drying climate reduces groundwater discharge into streams. This may cause the perenniality of upland streams to decrease, and the points where these streams begin to flow may move further downstream. As a result, refuge pools in these streams could become fewer and less persistent.

The salinity of groundwater near rivers could increase with greater evapotranspiration and a reduced freshening effect from fewer overbank flows and less stream recharge.

Groundwater interactions with floodplains

Groundwater levels in floodplains may fall due to less recharge from rainfall, overbank flow and stream loss sources. The potential impact of this on vegetation is uncertain. If groundwater is fresh but becomes too deep for plants to access, then vegetation condition is likely to be negatively affected. Conversely, if groundwater is saline and causing stress to plants, then inaccessibility from falling groundwater levels could benefit vegetation. This benefit could predominantly occur in the mid and lower reaches of the Murray River.

Changes to the concentration of salt in the subsurface of floodplains are uncertain. If vegetation uses less groundwater, then salt concentrations in the subsurface would reduce. However, this may be offset by an increase in evaporation and reduction in overbank flow and stream losses.

In areas of lower groundwater levels, groundwater quality may decline due to leakage from more saline aquifers. This may impact vegetation as well as consumptive or other uses.

S4 Under a hotter and slightly wetter scenario (S4)

Groundwater interactions with streams and wetlands

Groundwater levels are expected to rise across the Basin with likely increases in rainfall, overbank and stream recharge. As a result, the perenniality of streams may increase, shortening cease-to-flow periods, and wetlands would receive increased groundwater discharge, becoming more permanently inundated. Greater groundwater contributions to wetlands may also lower water temperatures. However, rises in groundwater levels may be partially mitigated by higher evapotranspiration and reduce the potential for increased groundwater flow to streams and wetlands.

Surface water salinity may potentially increase from increased groundwater discharge, predominantly in saline lower river reaches and upland tributaries in the southern Basin. Higher salt loads discharging from groundwater to instream habitats may be offset by higher instream and overbank flows. Where instream flows are lower (for example, upland tributaries) the salinity impact may be greater. Changes in groundwater interactions and associated salinity could be observed more quickly in upland catchments and more slowly in areas of extensive alluvial plains.

Groundwater interactions with floodplains

Rises in groundwater levels and lower salinity may occur in response to increased recharge from elevated in-stream and overbank flows, and this may result in more access to groundwater for vegetation, or for consumptive or other uses. This increased recharge will also likely offset a concentration of salt in the subsurface caused by high groundwater availability for vegetation transpiration.

S6

Under a hotter and much drier scenario (S6)

Groundwater interactions with streams and wetlands

The outcomes described for the S5 scenario are exacerbated under this (S6) scenario. The rate of change is likely to be faster, and ecosystems may have less opportunity to adapt.

Groundwater levels are expected to fall as rainfall, overbank and stream recharge are all likely to decrease. As a result, groundwater contributions to wetlands are likely to decline and permanency is likely to decrease, with some wetlands becoming permanently dry. These impacts are likely to affect wetlands in upland parts of catchments, where groundwater levels may fall significantly, and in the lower parts of valleys where the hydraulic gradients that control groundwater movement are very flat. With a reduction in groundwater contributions to wetlands, water temperature could become hotter and more variable. Baseflow contributions to streams are likely to decline, refuge pools will become less prevalent and persistent, and low-flow and cease-to-flow periods will become longer.

Groundwater salinity may also increase due to lower groundwater levels resulting in gradual inflows from a more saline aquifer, for example, Central Condamine, Namoi, and Mallee.

Groundwater interactions with floodplains

The outcomes described for the S5 scenario are exacerbated under this (S6) scenario. A larger decline in recharge by around 2050 (compared to the hotter and drier scenario) means a faster rate of change in groundwater levels. This will limit the ability of vegetation to adapt and lead to more significant change in the structure and composition of floodplain vegetation. There are also likely to be greater impacts to agriculture and communities that have a heavy reliance on groundwater.

Water quality

Current status

Salinity management in the southern Basin has improved greatly over the past 50 years.

Since the late 1980s, salinity levels have declined in the southern Basin. River salinity has consistently met the modelled target (800 electrical conductivity at Morgan 95% of the time) since 2010. There has been significant government investment in salinity management under successive salinity management strategies since 1988, and this targeted action has been successful in reducing or maintaining target salinity levels. Actions that have contributed to this improvement include improved irrigation efficiency, land and water management plans, salt interception schemes and environmental flows. Reduction in salinity has had a very positive impact on overall water quality and Basin health.

Water quality in some areas of the Basin can deteriorate quickly as a result of droughts and floods.

Water quality in some areas of the Basin is highly sensitive to extreme events. Salinity, nutrient pollution from runoff, and elevated turbidity levels from erosion continue to be the primary factors affecting water quality. Drought, floods and fires can exacerbate these factors and cause changes in the Basin's rivers that create ideal conditions for carbon-rich water and blue-green algae events. These events can lead to significant environmental impacts and corresponding Cultural and social impacts, such as mass fish deaths. There appears to be an increased frequency of blue-green algae and carbon-rich water events, particularly since the end of the Millennium drought.

Source: MDBA (2025a)

Water quality is fundamental to human and environmental health, economic prosperity and social equity. The Murray–Darling Basin faces a significant threat from adverse water quality challenges that stem from a complex interplay of natural factors, historical land and water management practices, and the impacts of climate change. These drivers interact and cause change to water temperature, salinity, nutrients, turbidity, dissolved oxygen (DO) and toxic chemicals that threaten water quality (Jacobs Group 2025). Changes to some of these factors can manifest as hypoxic water events and harmful algal blooms that impact the environment, people and industry. Water quality is vulnerable to changes in hydroclimate parameters such as temperature, rainfall, flow regime components and flow characteristics. Changes to water quality impact other environmental values such as river-dependent vegetation, fish and waterbirds. Plausible future outcomes for water quality have been considered in relation to DO and hypoxic water events, harmful algal blooms, salinity, nutrients and turbidity, metals and other toxic chemicals, bushfire, and sea level rise (Jacobs Group 2025).

Projected outcomes for water quality, under each of the climate scenarios, are summarised in the table below. Further details are provided for each scenario.

Hotter and slightly wetter (S4)	Hotter and drier (S5)	Hotter and much drier (S6)
Negative ↘	Strong negative ↓	Strong negative ↓
Negative: there may be changes to water quality, including increased hypoxic events and harmful algal blooms.	**Strong negative:** there are likely to be changes to many aspects of water quality, including low dissolved oxygen (DO) levels; increased nutrient, sediment, metal and other toxic chemical loads; and elevated salinity events. There will likely be increased hypoxic events and harmful algal blooms.	**Strong negative:** there are likely to be widespread changes to many aspects of water quality, including low DO levels; increased nutrient, sediment, metal and other toxic chemical loads; and elevated salinity events at selected locations. There will likely be increased hypoxic events and harmful algal blooms.

Under all hydroclimate scenarios

Dissolved oxygen and hypoxic water events

Conditions conducive to low DO levels, such as warmer water from high temperature events and flooding in spring-summer (when it occurs), will likely occur under all hydroclimate scenarios. High temperature events, when they do occur, will persist for longer periods, particularly in the northern Basin (Robertson and Freebairn 2024).

The incidence of hypoxic carbon-rich water events may increase. More carbon dioxide in the atmosphere could increase plant biomass on floodplains. Export of this organic load into rivers during flood events could deplete dissolved oxygen in the water. Hypoxic water events could occur in areas where events have not been seen before.

Harmful algal blooms

There will likely be an increase in the frequency and duration of harmful algal blooms, and expanded seasonal timeframes, noting there may be different species under different conditions. This increased risk will extend to storages and weir pools.

Salinity

Implications for salinity across the Basin are uncertain as changes to groundwater dynamics are expected to be highly variable at localised scales. The MDBA and Basin governments have a long and successful history of working together to manage salinity. Strategies are in place and are being reviewed to ensure that salinity management arrangements are fit-for-purpose to address current and future salinity risks.

Nutrients and turbidity

Turbidity outcomes will be impacted by factors such as the abundance and distribution of carp and land management.

Metals and other toxic chemicals

The threat of contamination with metals and low pH may increase due to more high-intensity rainfall events. Agricultural practices, such as precision agriculture and more efficient use of agrichemicals (fertilisers, pesticides) and water, will influence metal and other toxic chemical runoff.

Bushfire

Impacts from bushfire runoff may lead to increased turbidity, hypoxic events and harmful algal blooms. Bushfire frequency and intensity is likely to be greatest under the hotter and much drier (S6) scenario, but is also expected to increase under the S4 and S5 scenarios.

Sea level rise and storm surge in the Coorong and Lower Lakes

Rising sea levels coupled with storm surges may increase salinity in the Lower Lakes and change salinity environments in the Coorong – with increases in estuarine areas and decreases in areas saltier than seawater.

S5

Under a hotter and drier scenario (S5)

Dissolved oxygen and hypoxic water events

Hypoxic, carbon-rich water events may occur in areas where overbank flows occur less frequently and there is a build-up of floodplain organic matter that enters rivers after inundation. Previously permanent streams may become ephemeral, leading to low DO and increased incidence of hypoxic water events. This is most likely to occur in unregulated systems.

In isolated river reaches, dissolved oxygen concentrations in refuge pools and wetlands that remain during cease-to-flow periods, will be lower, and thermal stratification will be stronger, and hypoxia may result upon disturbance of stratification.

Harmful algal blooms

Harmful algae blooms may increase and become more widespread due to greater volumes of nutrients being washed into waterways following high-intensity rainfall events, increased ambient temperatures, and low-flow conditions. Increases in nutrients caused by thermal stratification, particularly as river systems dry to pools, may also contribute to a rise in harmful algal blooms.

Salinity

Elevated salinity levels will likely occur at end of system (lower Murray and lower Darling) during prolonged low-flow periods due to a lack of flushing. If riverbeds or wetland sediments interact with groundwater during drought or cease-to-flow periods, any salt subsequently stored in pools and sediments will be mobilised on rewetting, leading to a salt slug moving through the system.

Nutrients and turbidity

Greater volumes of nutrients and sediments may be washed into waterways from an increase in higher-intensity rainfall events.

Metals and other toxic chemicals

Soil acidification risks could be exacerbated by increased exposure of sulfidic sediments (common in the regulated lowland rivers of the southern Basin, especially in the Edward-Wakool River system and the lower Murray wetlands) due to more frequent drought and reduced rainfall and overbank flows. Heavy metal mobilisation may increase due to reduced flows and water levels in some locations – for example, the Lower Murray Reclaimed Irrigation Areas, Lower Lakes and Coorong. In 2014, the MDBA introduced an Emergency Framework for the Lower Lakes to prevent irreversible damage from acidification.

S4

Under a hotter and slightly wetter scenario (S4)

Dissolved oxygen and hypoxic water events

Localised hypoxic events in areas that rarely had occurrences in the past may increase from more high-intensity rainfall events. Current regional examples include the Broken River system and parts of central-west NSW. Water quality responses to temperature may be dampened, relative to the S5 and S6 scenarios, due to the increased flows and reduced stagnation that are likely to result in less extreme water temperatures.

Harmful algal blooms

The timing and duration of harmful algal blooms may change, and could occur in new locations in the Basin. Harmful algal bloom species may also change, including the potential introduction of new species. An increase in freshes and overbank flows under this scenario are unlikely to disperse harmful algal blooms. Hotter conditions and nutrient inputs are considered likely to outweigh the influence of additional flow in a wetter climate.

Salinity

Salt export from the Basin may be greater with increased flows. This increase in flows may offset a potential higher concentration in salt loads caused by more evaporative losses under a hotter climate. There are likely to be localised impacts related to salt levels in both soil and groundwater, because of changes to groundwater discharge or recharge patterns.

Nutrients and turbidity

Nutrients and turbidity are likely to increase in wetter conditions. If there is also more thermal stratification, there will be greater nutrient cycling from the sediment, increasing instream productivity.

Metals and other toxic chemicals

Increased runoff of metals and other toxic chemicals is likely in wetter conditions. Higher storage levels and more persistent thermal stratification may also lead to release of less oxidised metals – for example, Hume Dam releases and manganese and iron challenges with water treatment processes.

S6

Under a hotter and much drier scenario (S6)

Dissolved oxygen and hypoxic water events

Low dissolved oxygen levels will occur more frequently and be more widespread due to higher water temperatures, decreases in baseflows and freshes, and increased cease-to-flow periods, leading to isolated and hypoxic river reaches, pools and wetlands. The risk of thermal stratification may become prevalent in areas not previously seen, such as weir pools or reservoirs with greater depth and flows.

Thermal stratification and hypoxic events during low-flow conditions are expected to become more frequent, particularly in unregulated systems. When flows do occur, and mix with the hypoxic water, these events will become more severe.

Harmful algal blooms

Harmful algal blooms will occur more frequently and be more widespread due to higher water temperatures, decreases in flows, and periods of increased nutrient concentrations associated with high-intensity rainfall events and thermal stratification.

Salinity

Higher salinity concentrations in lakes, weir pools and storages may occur as evaporative losses become more pronounced from the combination of increased evaporation and less flow. However, impacts will depend on changes to groundwater levels and saline groundwater discharge to surface waters. Impacts are likely to occur in areas with fewer salinity management controls, such as the northern Basin, Lower Darling, and downstream of Lock 1 in the Lower Murray.

Nutrients and turbidity

Internal nutrient cycling (for example, Phosphorus flux from sediments) will likely become a more important source of nutrients (compared to catchment inputs) as thermal stratification increases, with fewer freshes and overbank flows resulting in less connection to the catchment. This may result in changes to the timing of nutrient pulses and in turn harmful algal blooms.

Metals and other toxic chemicals

Impacts will be similar to the hotter and drier (S5) scenario. Internal loading (oxidation of sulfidic materials) may become more important than external loading as runoff from the land into waterways reduces, and an increase in thermal stratification events will lead to greater mobilisation of metals from sediments. The risk of metal mobilisation in the Coorong could be reduced by more seawater incursions minimising sediment exposure.

Box 1 Impact of water quality on First Nations people

Issues with water quality in the Basin, and the subsequent impact on First Nations and First Nations people, have been highlighted in many publications. In its **submission** to the National Water Agreement consultation in 2024, the NSW Aboriginal Land Council said (DCCEEW 2024):

> Many communities across NSW do not have access to clean, safe drinking and domestic-use water. Drought, overirrigation, cotton farming and coal seam gas have impacted river water supply and quality. With increased rainfall, the river suffers algal blooms and black water events. Using the example of Walgett, town water supply relies on Artesian Basin bore water in times of drought or when water quality of the river deems it unpotable. The quality of Artesian Basin bore water is questionable and extremely high in sodium. People with chronic health conditions (renal, heart, diabetes etc.) are particularly vulnerable.

In the First Nations report for the Sustainable Rivers Audit (SRA), the Sustainable Rivers Audit and Outlook First Nations Leadership Group (SRAO FNLG) assessed **Water health and quality**. They found that 'Water health and quality is very poor and does not support people and native species. Water is polluted with chemicals, excess nutrients and silt. It is often too cold for fish to thrive. Where once First Nations people would drink from and swim in the river, now it is often too polluted. It is not healthy for people or Country' (SRAO FNLG 2024). They also found it was **deteriorating.**

In the First Nations report for the Basin Outlook, the SRAO FNLG found that 'If water health and quality continue to deteriorate and pollutants (heavy metals, chemicals, excess nutrients) are not removed, irreversible damage to Country will continue. Without urgent, strong, coordinated action, the deterioration of water health and quality will lock in long-term ecological and Cultural losses – further damaging the life, knowledge, and spirit of Country' (SRAO FNLG 2025).

River-dependent vegetation

Current status

Tree stand condition is mostly fair, good or very good across the Basin.

Tree stand condition is determined on a valley-by-valley basis and assesses the condition of the Basin's river-dependent vegetation. Of all the valleys, 87% had tree stands that were in at least 'fair' condition, including 43% rated as 'good' or 'very good' condition. There is no indication of tree stand conditions improving at the valley scale, and long-term trends are largely variable or stable. There is a connection between tree stand condition and climate, with condition tending to deteriorate during dry years and improving after floods or substantial rainfall.

Source: MDBA (2025a)

River-dependent vegetation plays critical roles in the healthy functioning of rivers, wetlands and floodplains. These roles include enhancing water quality and productivity, stabilising banks and soils, regulating microclimates, and providing food and habitat for wildlife. River-dependent vegetation also has Cultural and economic significance for First Nations people, as well as a broader biodiversity value because it comprises a high diversity of plant species and communities.

The distribution, abundance, structure and composition of river-dependent vegetation is strongly influenced by hydrology and water availability. This includes river flows and connectivity, access to suitable groundwater, water quality and rainfall. Land use, livestock, and introduced plants and animals also impact river-dependent vegetation.

River-dependent vegetation is vulnerable to changes that impact these key drivers. Changes to the drivers impact life history processes, such as germination, growth and survival, flowering, seed set and dispersal. This in turn affects the ability of river-dependent vegetation to support the healthy functioning of ecosystems. Plausible future outcomes for river-dependent vegetation have been considered in relation to broad structural types of vegetation – forests and woodlands, shrublands, and herbaceous vegetation (Jacobs Group 2025).

Projected outcomes for river-dependent vegetation, under each of the climate scenarios, are summarised in the table below. Further details are provided for each scenario.

Hotter and slightly wetter (S4)	Hotter and drier (S5)	Hotter and much drier (S6)
Mixed	Negative	Strong negative
Mixed: a mix of positive and negative outcomes, including improved water access for forests, woodland and shrublands, changes in species composition of plant communities, and greater pressure from introduced plants and animals.	**Negative**: many populations of native river-dependent vegetation are likely to experience disruptions to their life history processes such as germination, growth, reproduction, survival and dispersal. There will likely be a change in composition and a likely reduction in spatial and temporal distribution.	**Strong negative:** the increased magnitude of change is highly likely to disrupt life history processes such as germination, growth, reproduction, survival and dispersal. There will be a change in composition and a reduction in spatial and temporal distribution.

Under all hydroclimate scenarios

Flow regime components and flow characteristics

The diversity and cover of river-dependent vegetation may decline if plant reproduction and establishment is disrupted by overbank flows occurring more in summer than winter–spring. However, these timing shifts in overbank flows may benefit black box and coolabah seedlings, and lignum. Native plant species distributions are likely to change (increase, shift, or be restricted) to areas where preferred flow regimes exist. Plant community composition will likely change due to changes in flow, rainfall and temperature. Areas of vegetation that are already highly fragmented may be more vulnerable to changes.

Rainfall

Seedling and establishment success may be reduced if ponding, scouring and erosion increase from increased high-intensity rainfall events and flashier flows.

Temperature and evapotranspiration

Higher air temperatures may disrupt flowering and seed-set, including timing for pollination and the abundance of pollinators. An increase in the spread of disease and introduced species, such as borers, may also occur. An increase in extreme heat events may disrupt the photosynthesis process.

Short-lived herbaceous plants may germinate but not complete their life cycle due to short-term wetting of seedbanks, followed by high temperatures and evapotranspiration. This may deplete the soil seedbank.

An increase in soil temperature may negatively affect soil seed bank viability, along with mycorrhizal fungi and soil bacteria. This will impact the potential for native vegetation to respond to flow events. This is likely to be exacerbated with increasing magnitude of air temperature change and increasing intensity and frequency of fire under S6, but may occur under S4 and S5. Upland alpine vegetation, such as bogs, herbfields and alpine streams, will be negatively affected by warmer air temperatures, and reduced snow fall and snow melt.

Carbon dioxide in the atmosphere

Plant biomass on floodplains may increase if photosynthesis accelerates with increased carbon dioxide in the atmosphere.

Introduced species

Changes to suitable habitat for introduced plants will vary from species to species. Some introduced species will benefit from more regular inundation of the floodplain, while others will benefit from an increase in the length of dry spells (Capon et al. 2022).

S5

Under a hotter and drier scenario (S5)

River-dependent vegetation in general

Increased dieback of floodplain vegetation may occur in areas where soil salinisation is exacerbated by an increase in the frequency of droughts.

Some introduced plant species, such as those that persist in dry conditions, may expand in distribution with an increase in the frequency and duration of droughts. Bank vegetation extent may be reduced if increased frequency and intensity of bushfires reduces bank stability and increases bank erosion. Increased bushfire frequency and intensity may also destroy both soil and aerial seedbanks.

Forests, woodlands and shrublands

Increased stress on trees and lignum, from a decrease in the frequency of overbank flows, may lead to a decline in health, which may result in mortality. Death is more likely to occur where trees and lignum are already known to be stressed or vulnerable. A reduction in winter-spring overbank flows is likely to negatively impact river red gum trees. The recruitment of floodplain trees may be negatively affected by reduced rainfall and flooding, particularly where average annual rainfall is below 300 mm, and black box woodland populations may be negatively impacted by an increase in the frequency of 1-in-20-year droughts.

Herbaceous vegetation

Herbaceous river-dependent vegetation is likely to decline in abundance and extent due to a decrease in the frequency and duration of freshes and overbank flows. Germination and the survival of propagules may decline through a reduction in soil moisture. These declines will be exacerbated by reduced rainfall, higher air temperatures and evapotranspiration, and lower humidity.

In some locations, river red gum trees may encroach into open wetlands if inundation frequency and duration decreases and allows tree seedlings to establish between inundation events.

S4

Under a hotter and slightly wetter scenario (S4)

River-dependent vegetation in general

More abundant rainfall, particularly high-intensity rainfall events, may increase groundwater levels. In locations where groundwater is saline, this could have negative impacts on vegetation growth. Some introduced plants, such as modified pasture grasses in the southern Basin, may expand in range under hotter and slightly wetter conditions (Aither 2024).

Forests, woodlands and shrublands

Increases in the frequency of overbank flows may provide benefits to forest, woodland and shrubland populations – noting adult trees and seedlings and lignum plants are sensitive to prolonged flooding, so benefits depend on interactions with flood duration.

Species, including lignum that can reproduce via vegetative mechanisms may be able to expand in range as they can rapidly take advantage of wetter conditions. Black box woodland populations may also benefit. Mature tree fall may happen more frequently if increased inundation of unstable banks (due to erosion) occurs. If flows are variable, however, banks may be stabilised due to increased groundcover.

Herbaceous vegetation

Compositional changes in wetland and floodplain communities are likely to occur. An increase in the frequency of freshes and overbank flows may benefit herbaceous vegetation, noting prolonged inundation may not be beneficial. The condition of persistent propagules (such as rhizomes, stolons and tubers) may also benefit if soil moisture is raised by an increase in the frequency of freshes and overbank flows, and higher rainfall. Opportunities for germination and the success of germination events for herbaceous plant species may improve if higher rainfall, humidity and flows improve soil moisture, noting increased air temperatures and evapotranspiration may offset this. An increased frequency of overbank flows may, however, also lead to an increase in carp numbers and a resultant reduction in submerged macrophyte abundance.

S6

Under a hotter and much drier scenario (S6)

Forests, woodlands and shrublands

The mortality rate of trees and lignum is likely to increase due to reduced soil moisture and water availability associated with 40–70% reductions in overbank flows, less rainfall, increased temperature and evapotranspiration, and lower groundwater levels. As soil moisture decreases there will be increased stress on mature trees and lignum and reduced recruitment success. A lack of recruitment may be particularly evident in unregulated systems and areas beyond the management footprint for water for the environment.

Lignum rootstock viability is likely to be negatively affected by reduced overbank flows and increased inter-flood dry periods, impacting the ability to respond to flows. Less abundant, more sparse lignum structure is likely to have implications for waterbird breeding. Coolabah trees, which are typically more resistant to drought, may also be negatively affected by increased inter-flood periods, reduced rainfall and decline in groundwater levels.

Reductions in bank vegetation cover, from reduced flows and rainfall and higher temperatures, may mean erosion is more severe when flows occur, leading to bank slumping and tree fall.

Herbaceous vegetation

Important refugia for aquatic plants, such as semi-permanent wetlands and waterholes, may be lost because of reduced overbank flow and an increase in cease-to-flow events. Submerged plant species are at the greatest risk of being lost. The combination of reduced rainfall, flows and soil moisture, increased air and soil temperature, and reduced canopy cover and shading will reduce soil seedbanks and germination success.

As rhizomes are lost, establishment from seed will be harder due to interactive impacts of carp and poorer water quality. This will lead to reduced cover and distribution of aquatic vegetation.

Native fish

Current status

Native fish populations are in poor condition and introduced species are a significant issue.

Populations of native fish are generally not in good condition, although there is evidence of improvements in some species in some catchments. Murray cod and golden perch are recruiting well in some areas, which means that fish are surviving their first years of life. However, many species are not recruiting well, such as spangled perch, Macquarie perch, two-spined blackfish and climbing galaxias. At the same time, carp are found in every valley and other introduced species like gambusia, goldfish and redfin are found in most valleys

Source: MDBA (2025a)

Native fish are important to the Basin's Cultural, environmental, social and economic values. For First Nations people, native fish provide a vital Cultural connection. Native fish also play critical roles in the functions of river ecosystems, including food chain dynamics and nutrient cycling, and contribute to the economy through recreational fishing and tourism.

The poor condition of native fish in the Basin is driven by historical water resource development, historical habitat destruction and removal, and ongoing pressures. Ongoing pressures include the effects of climate change, barriers to fish movement, introduced fish species, poor water quality and habitat degradation. In the future, intensifying climate change, competing water demands, increased pollution and microplastics may also impact native fish communities (Lintermans et al. 2025).

Native fish are aquatic species and are vulnerable to changes that impact river flows, connectivity and water quality such as changes in rainfall, runoff, temperature, and flow regime components and characteristics. Plausible future outcomes for native fish have been considered in relation to habitat access, growth and body condition, reproduction and recruitment, movement and connectivity, and population maintenance and survival.

Projected outcomes for native fish, under each of the climate scenarios, are summarised in the table below. Further details are provided for each scenario.

Hotter and slightly wetter (S4)	Hotter and drier (S5)	Hotter and much drier (S6)
Mixed	Strong negative	Strong negative
Mixed: many species may benefit from improved river flow regimes and connectivity, but higher water temperatures and more frequent fish death events will have adverse impacts.	**Strong negative:** populations of native fish species will decline in multiple systems and are likely to be lost from severely affected systems.	**Strong negative:** localised extinctions are expected, and Basin-scale extinctions are possible, along with population declines for many species in multiple systems.

Under all hydroclimate scenarios

Flow regime components and flow characteristics

Fish distributions are likely to change (or be restricted) in areas where preferred flow regimes and habitat types exist, and movements of some species are expected to be impacted by seasonal flow changes. Fish death events are expected to increase if hypoxic water events become more frequent.

Rainfall & temperature

Nesting and substrate spawning species, such as Murray cod, river blackfish, Macquarie perch and freshwater catfish, may be negatively affected by excessively high flow velocities during spawning and nesting. These flow conditions could arise more frequently from projected increases in high-intensity rainfall events.

Movement cues (Lennox et al. 2019), survival of temperature sensitive eggs and juveniles (King et al. 2022), and fish metabolism (Bond et al. 2011) may be impacted by increased water temperatures. Thermally sensitive species, such as northern river blackfish, may be lost if water temperatures exceed tolerance thresholds.

Introduced species

Introduced species with wider tolerances to changes in flow, temperature, and water quality parameters may be able to adapt more quickly and increase in abundance and distribution. Increased water temperatures and intense rainfall and flow events increase the risk of incursions from introduced species, such as tilapia (Hutchinson et al. 2011).

S5

Under a hotter and drier scenario (S5)

Populations, recruitment and reproduction

Populations of native fish species will decline in numerous systems and may be lost from severely affected systems (particularly unregulated). Wild populations of wetland and floodplain specialists will be at much greater risk of being lost because of deterioration or direct losses of niche habitat that they depend on for their survival, matched with their inability to recolonise elsewhere due to changes in inundation extent and frequency. These impacts were observed during the Millennium drought when extended hydrological drought caused the extinction of the Yarra pygmy perch (Wedderburn et al. 2019).

Species that require specific in-channel flow regimes to meet lifecycle requirements are likely to decline in abundance in systems where the frequency and duration of those flows (for example, freshes) decline. Opportunities for dispersal of eggs and larvae from breeding sites may also reduce with a fall in the frequency and volume of freshes.

Breeding and recruitment of diadromous and estuarine species may be adversely affected by reduced end-of-system flows, connectivity between freshwater and marine habitats, and reduced extent of critical estuarine habitats.

Habitat access, availability and quality

Critical drought refuges needed for survival during dry periods may decrease in availability and quality. Food availability, growth and body condition may also reduce due to a decrease in floodplain inundation and complexity of flow environments.

Species that undertake large scale movements to achieve Basin-significant recruitment events (for example, golden perch) may have their lifecycle processes and populations impacted by decreased longitudinal connectivity and increased cease-to-flow events. Fish death events will increase in frequency with increased disconnection, cease-to-flow events, and formation of thermal stratification (that is, conditions that are precursors to fish death events).

Introduced species, disease and parasites

Parasite loads and diseases (for example, anchor worm, an invasive parasite that benefits from low-flow and cease-to-flow conditions) may increase and cause serious physiological distress to affected fish, potentially impacting native fish populations with higher infestation rates.

S4

Under a hotter and slightly wetter scenario (S4)

Populations, recruitment and reproduction

Breeding and recruitment of diadromous and estuarine species, and species that breed over large spatial scales, for example golden perch, may benefit from an overall increase in flow and end-of-system connectivity.

Small-bodied fish, particularly wetland specialists, may benefit from an increased frequency and duration of wetland and floodplain habitats. Boom-and-bust species (for example, spangled perch, bony herring) may increase in abundance and occurrence because of dynamic river flows.

Habitat access, availability and quality

Refuge availability, along with opportunities for fish dispersal and movement, may be improved by increased baseflows and connectivity. Habitat access, particularly in the northern Basin, will likewise be improved by decreased drought frequency and cease-to-flow days, and the quality of pool refuges in unregulated systems may improve from higher flows flushing accumulated sediment and deepening pools. Fish growth rates and body condition may also be improved from increased riverine and floodplain productivity associated with improvements to the flow regime.

Habitat quality is, however, expected to be degraded by more frequent and severe algal blooms and turbidity, leading to direct physiological effects from inadequate dissolved oxygen and indirect effects such as reduced aquatic vegetation growth.

Introduced species, disease and parasites

Incursions and establishment of introduced species, such as tilapia, from surrounding catchments are possible under all scenarios but are of increased risk under a wetter climate. Carp populations and ranges may particularly increase in response to increased habitat availability and their ability to adapt to change and tolerate a wide range of water quality conditions.

S6

Under a hotter and much drier scenario (S6)

The outcome statements for S6 are in addition to those from S5, and reflect an increase in the severity, extent and frequency of outcomes.

Populations, recruitment and reproduction

Populations of native fish species will decline across the Basin. Individual species are likely to be lost from severely affected systems (particularly unregulated systems) and possibly lost from the Basin altogether.

Populations of native fish may have limited ability to recover following major fish deaths and other extreme events. Threatened species in mid and upland systems may be greatly impacted by the combination of bushfires and storms.

Habitat access, availability and quality

The availability and quality of habitats, including refuges and nurseries, may decrease, and there may be a corresponding increase in the fragmentation of remaining habitat. Species with specialist requirements, including those needing flowing and off-channel (anabranches and wetlands) habitats, are particularly vulnerable to habitat loss. A reliance on man-made refuges, which are much lower in habitat value than natural refuges, may increase.

Introduced species, disease and parasites

Fish crowding and isolation may increase as waterbodies disconnect more frequently and faster, making fish vulnerable to deteriorating water quality, predation, parasites and disease.

Waterbirds

Current status

Waterbird numbers have responded well to the recent wet years as wetlands fill and thrive.

Waterbird numbers have increased since the Millennium drought and particularly in the past 5 years because of the wetter conditions. However, over the long term, there is a decreasing trend in total waterbird population numbers. The long-term population pattern also shows less boom periods and more bust periods where populations comprise fewer than 100,000 individuals. A declining population is less resilient and more vulnerable to disease, climate change and other drivers. Although waterbird population abundance has declined, it is positive to see that species diversity has been sustained.

Source: MDBA (2025a)

Waterbirds are a key indicator of healthy and functioning wetland and floodplain ecosystems because of their strong association with available surface water conditions and their diverse habitat requirements. They have value for the broader community, including Cultural significance for First Nations people. In the Basin, waterbird populations are driven largely by climate and water resource development, which influences the availability and quality of floodplain and wetland habitat. Widespread flooding is essential to support large breeding events, while refugia are critical during dry times to maintain populations. Waterbird populations in the Basin are vulnerable to changes in flow regimes induced by water resource development and a changing climate, which influence the availability, distribution, diversity and quality of waterbird habitat. Plausible future outcomes for waterbirds have been considered in relation to potential changes to waterbird habitat availability and successful breeding and recruitment. Future outcomes for waterbirds will likely vary for different species and different systems, depending on the changes in forecast flow and the tolerance limits of individual species.

Projected outcomes for waterbirds, under each of the climate scenarios, are summarised in the table below. Further details are provided for each scenario.

Hotter and slightly wetter (S4)	Hotter and drier (S5)	Hotter and much drier (S6)
Positive	Strong negative	Strong negative
Positive: marginal increases in waterbird populations from improved opportunities for feeding, breeding and fledging of chicks in response to the increase in frequency, extent and duration of flooding.	**Negative:** waterbird populations decline in response to a corresponding decline in suitable habitat, including its availability, extent and quality.	**Strong negative:** waterbird population declines are to accelerate as flow conditions that support breeding events become too far apart and too limited in extent and duration.

Under all hydroclimate scenarios

River flows and connectivity

Waterbird populations will likely experience increased stress through reductions in habitat and breeding opportunities when the time between flooding exceeds 3 years (Commonwealth of Australia 2023; Rogers and Ralph 2011). This is more likely to occur under a hotter and drier climate but it is still possible under a hotter and wetter climate during drought. Unfledged chicks and nests may be destroyed by more regular intense rainfall events and rapid rises in water level.

Waterbirds may be more vulnerable to diseases and parasites under warmer temperatures, particularly individuals that are already heat stressed. For example, avian botulism and associated waterbird deaths may increase (Brandis et al. 2019, cited by King et al. 2022). If, however, the warmer water reduces the survivability of viral particles, this disease risk may be offset.

Water quality

Waterbird food supplies and breeding opportunities are likely to become more frequently impacted by poor water quality (for example, hypoxia, harmful algal blooms, turbidity). Species that breed in large groups and require substantial food resources may be most vulnerable to these changes.

Changes to vegetation

Waterbird habitat, particularly vegetation quality, may be affected by changes to temperature, rainfall, flow regimes and other factors such as plant disease. These impacts will likely impact different waterbird species to different degrees, depending on the specificity of their habitat needs. Species with less specific requirements are likely to continue to find available habitat.

Sea level rise

Waterbirds in the Coorong, particularly shorebirds, are expected to be impacted by sea level rise. There is, however, great uncertainty as to when impacts will occur and the possible outcomes of these impacts, due to the complexity of the ecosystem and its hydrology.

Migratory shorebirds may continue to be affected by climate change at northern hemisphere breeding grounds and the loss and degradation of Yellow Sea foraging grounds which are used to refuel en route to the Basin.

S5

Under a hotter and drier scenario (S5)

Habitat access, availability and quality

Refuge habitat that supports waterbirds during extended dry periods may reduce in availability and quality, leading to further long-term decline in waterbird numbers. Highly productive wetland habitats, particularly in the northern Basin, that naturally undergo wetting and drying cycles will likely become available less often.

The body condition and growth of waterbirds may be hindered by decreased food availability and quality caused by changes to wetland inundation, with flow-on impacts to breeding success, recruitment of juveniles and resilience to other threats such as disease. Waterbirds, particularly eggs and chicks, may also become more vulnerable to feral pigs, foxes and other predators as wetland extent and depth decreases. Migratory shorebird populations will likely further reduce from reduced food availability and quality if end-of-system flows decrease, as was observed during the Millennium drought.

Populations, breeding and recruitment

Waterbird populations will likely decline in response to a decline in habitat availability, extent and quality, and an increase in the interval between breeding events, as a result of more drought and dry conditions. Successful recruitment of juvenile birds to adulthood will likely be hindered by reductions in suitable foraging habitat from reduced overbank flows, and breeding and fledging of chicks will likely be negatively affected by decreases in frequency, duration and volume of spring and summer flows and extent of floodplain inundation.

S4

Under a hotter and slightly scenario wetter (S4)

Habitat access, availability and quality

Increased frequency and area of wetland and floodplain inundation is likely to lead to higher numbers and increased diversity of waterbirds supported and dispersed across the Basin. These hydrological changes can also support the maintenance of waterbird breeding habitat for shelter, roosting and nesting.

Populations, breeding and recruitment

Annual waterbird numbers are predicted to increase by between 7% and 13% under this scenario (Bino et al. 2021). Breeding opportunities and fledging of chicks will likely improve in response to the increase in frequency, extent and duration of flooding and increased habitat availability (Fu et al. 2015), and recruitment of juvenile birds to adulthood will also likely increase. Migratory shorebird populations in the Coorong may slow their decline in response to improved end-of-system flows, provided extensive mudflats are not submerged and shallow foraging habitat remains.

S6

Under a hotter and much drier scenario (S6)

Outcome statements for S6 are the same as S5, but reflect an acceleration and increased severity, extent and frequency of outcomes. Additional statements for S6 are provided below.

Habitat access, availability and quality

If severe drought extends beyond the Murray–Darling Basin, impacts to multiple waterbird populations across Australia may lead to substantial negative consequences for the Basin's waterbird community. A loss of critical breeding habitat is likely at key sites (for example, Narran Lakes), and waterbirds are likely to become more reliant on regulated permanent river reaches and wetlands that are of poorer habitat quality and lower in productivity. Body condition and fitness may be reduced, and the mortality rate may increase, from poor water quality and an associated increased prevalence of avian diseases (for example, botulism).

Populations, breeding and recruitment

Waterbird population declines will likely accelerate as flow conditions that support breeding events become too far apart and too limited in extent and duration. Waterbird diversity (population size per species) at the Basin scale is expected to decline, but species richness should remain stable. It is expected that species will continue to move across the Basin to find suitable habitat. Simply, it is expected that all species will be supported somewhere, but in fewer numbers.

First Nations

The Murray–Darling Basin Authority (MDBA) acknowledges and respects the deep Cultural, social, environmental, spiritual and economic connection First Nations people have to the land and waters of the Murray–Darling Basin. The MDBA has included First Nations people and knowledge throughout the processes and reports leading to the Basin Plan Review, including through the SRA and Outlook First Nations Leadership Group (SRAO FNLG) and its 2 reports (SRAO FNLG 2024, 2025), the Looking Back to Move Forward report (CIR 2024) and the Basin Plan Evaluation (MDBA 2025c).

This section draws on learnings from those publications as well as other published material, including the recently published Aboriginal and Torres Strait Islander peoples technical report for the National Climate Risk Assessment (NCRA) (Australian Climate Service 2025b).

It should be noted that this summary does not necessarily represent the experiences of all First Nations people. The assessments made in the report *Water Country: Water Future* (SRAO FNLG 2025), are summarised in Table 5.

Table 5 Summary of the Basin Outlook for First Nations values (SRAO FNLG 2025)

Value	Outlook
Water Country	• Water health and quality: If water health and quality continues to deteriorate and pollutants (heavy metals, chemicals, excess nutrients) are not removed, irreversible damage to Country will continue. Without urgent, strong, coordinated action, the deterioration of water health and quality will lock in long-term ecological and Cultural losses posing further risks to the life, knowledge, and spirit of Country. • Health of Country: The impacts of environmental decline are stark and visible. Riverbanks are collapsing, our wetlands are relying on flow releases and modified infrastructure. Invasive species are spreading where native species once thrived. Flows do not contain the necessary components to maintain Country and spiritual systems. There is an immediate Cultural and ecological crisis for the spirit and health of Water Country. Without meaningful intervention, the situation will remain unchanged and continue to place Country and First Nations People at risk.
First Nations people	• Health and wellbeing of First Nations people: While First Nations peoples remain resilient – surviving impact, dispossession, forced removal, and exclusion from decision-making – this resilience cannot be a substitute for justice or action. Looking ahead, the health and wellbeing of First Nations peoples, encompassing physical, mental, spiritual, and Cultural dimensions remains at serious risk without urgent, systemic change. The future can be different – but only if self-determination, truth-telling, and Country-led healing are placed at the heart of climate, health, and policy responses.

Water Country: Water Future (SRAO FNLG 2025) also considers the outlook for First Law–Lore, which clearly identifies the importance of the recognition and inclusion of First Nations rights in water and environmental management. The report also says that without targeted intervention and reform, the exclusion of First Nations people in water management will remain entrenched, continuing to undermine both justice and sustainability for First Nations people.

Water Country

The report, *Water Country – a story of connection, loss, change, and hope for the future* (SRAO FNLG 2024) assessed the health of Country as 'very poor' and static: Country is in very poor health and heavily degraded, and the situation is not changing. Riverbanks, floodplains, wetlands and billabongs are affected by lack of water, erosion, introduced species and loss of vegetation. Although environmental flows have improved Country health in some areas, the overall health of Water Country is still poor.

Climate change will create additional stresses for Water Country.

The Aboriginal and Torres Strait Islander peoples technical report for the NCRA (Australian Climate Service 2025b) identifies the key risks for Country from the changing climate. Risks include to land, sea and Country (natural environments, biodiversity, ecosystems) through the changing climate; increased extreme weather events; and rising, warming waters that impact biodiversity, Cultural sites, communities and settlements.

Climate stresses have a disproportionate effect on First Nations people because of their connection to Country and the role of Country in First Nations knowledge systems. The First Nations report for the Basin Outlook says (SRAO FNLG 2025):

> Where First Nations people once drank directly from the river, gathered food, and swam without harm, today the water is often unsafe and polluted. These pollutants do more than cause physical damage – they erode Cultural practices and the relationship between people and Country. The decline in water health and quality is not only harmful, but is causing irreversible damage and continues to risk other parts of Water Country.

In their submission to the Productivity Commission inquiry on national water reform in 2024, the Interim First Nations Water Working Group said (Productivity Commission 2024) stated that:

> ... climate change poses a significant and disproportionate burden on First Nations communities, their Country and Cultural values. First Peoples across Australia are already observing changes to seasons, coastlines, waterways, flora and fauna that impact not only the health of Country, but also Indigenous knowledge systems and Cultural economies. Extreme events such as heatwaves, cyclones, intense flooding and severe droughts have the effect of exacerbating existing pressures on freshwater resources and further entrenching First Peoples' socio-economic disadvantage – and are likely to become increasingly frequent into the future.

First Nations people

The report, *Water Country – a story of connection, loss, change, and hope for the future*, assessed the health and wellbeing of First Nations people (physical, mental, spiritual, Cultural) as 'poor' and static: First Nations people have poor health and wellbeing, and the situation is not changing. First Nations people are resilient. But when Country is sick, people are sick. Many First Nations people suffer the physical, mental, spiritual and Cultural effects of separation from Country and generational trauma (SRAO FNLG 2024).

The effects of climate change on the health and wellbeing of First Nations people are often larger than for non-First Nations people. The United Nations has said (United Nations 2025) that:

> Indigenous peoples are among the first to face the direct consequences of climate change, due to their dependence upon, and close relationship, with the environment and its resources. Climate change exacerbates the difficulties already faced by indigenous communities including political and economic marginalization, loss of land and resources, human rights violations, discrimination and unemployment.

The Aboriginal and Torres Strait Islander peoples technical report for the NCRA (Australian Climate Service 2025b) identifies the key risks for First Nations people from the changing climate. These include:

- ***Risk to self-determination***, whereby Aboriginal and Torres Strait Islander peoples' right to freely pursue their economic, social and Cultural development is at risk due to their disproportionate experiences of the effects of climate change and lack of inclusion in decision-making in connection to caring for Country and climate adaptation strategies. This is an interconnected risk that compounds other key risks.
- ***Risk to land, sea and Country*** (natural environments, biodiversity, ecosystems) through the changing climate, increased extreme weather events and rising, warming waters that impact biodiversity, Cultural sites, communities and settlements.

- ***Risk to Cultural knowledges, practices, values and sites*** due to climate change impacts on Country and through climate action increasing opportunities for biopiracy.
- ***Risk to people's health, wellbeing and identity from the effects of climate change***. This causes increased prevalence and acuity of mental and physical health conditions from Country being sick, as well as displacement from Country due to extreme weather.
- ***Risk to economic participation and social and Cultural economic development*** for Aboriginal and Torres Strait Islander peoples, communities and nations from climate-related hazards and their impacts.
- ***Risk to water and food security*** as waterways are integral to the quality, longevity, and Cultural way of life for Aboriginal and Torres Strait Islander peoples. Therefore, the disruption of waterways and related infrastructure due to climate events can have harmful, far-reaching and long-term effects.
- ***Risk to remote and rural communities***, which are exposed to increased risks as climate hazards and events increase interruptions to water, energy, medical and telecommunication infrastructure and reduce food and water security through diminished road, air and water access.

In a discussion paper on climate change and Aboriginal and Torres Strait Islander health, the Lowitja Institute (2021) stated:

> There are many varied direct and indirect climate change impacts on the morbidity and mortality of Aboriginal and Torres Strait Islander people. Climate change is compounding historical injustices and disrupts Cultural and spiritual connections to Country that are central to health and wellbeing. Health services are struggling to operate in extreme weather with increasing demands and a reduced workforce. All these forces combine to exacerbate already unacceptable levels of ill-health within Aboriginal and Torres Strait Islander populations.

The First Nations report for the Basin Outlook describes the connection between the health Water Country and First Nations people (SRAO FNLG 2025):

> For First Nations people, disconnection from damaged water systems leads to worsening mental health, intergenerational trauma, and the erosion of Cultural identity. Sacred sites are increasingly exposed to damage from both extreme wet and dry conditions. In some areas, First Nations have already been forced to relocate ancestral remains due to constant flow fluctuations and drying soils causing widespread ground failure, as the absence of moisture weakens soil stability and its ability to act as a natural conduit.
>
> This not only causes deep grief, but also disrupts Cultural law, ceremony, and the intergenerational transmission of knowledge once grounded in place. When a culturally significant site disappears, erodes, or is altered, the knowledge connected to it may no longer be accessible or even visible.

As climate pressures increase, traditional practices, knowledge systems, and access to bush medicines will continue to be disrupted, exacerbating existing First Nations peoples' health inequities, chronic disease, and mortality rates within communities

The First Nations report for the Basin Outlook calls for the recognition and inclusion of First Nations rights in water and environmental management. The report identifies this as a critical and unresolved challenge and a direct barrier to effective climate and environmental action.

Critical human water needs

We need water for fundamental human needs such as drinking, food preparation and hygiene.

The importance of these needs is recognised in the *Water Act 2007* (Cth) by establishing the notion of critical human water needs. Critical human water needs refers to the minimum amount of water needed to meet basic human needs. It also includes non-human needs, where a failure to meet these needs would cause too much damage to social, economic or national security – for example, water for significant local industries or community uses such as firefighting.

Provisions in the Basin Plan and Water Resource Plans

The Water Act, the Basin Plan and the Murray–Darling Basin Agreement work together to set out specific water volumes and arrangements to meet critical human water needs for the River Murray system. The Basin Plan does not guarantee that water critical for human needs will be available within the River Murray system in all years but makes clear how this water will be prioritised during severe droughts.

Outside of the River Murray system (including the northern Basin), the Basin Plan has a limited role in supporting critical human water needs. Here the Basin Plan requires that Basin state government water resource plans outline how critical human water needs will be met in each water resource plan area during periods of extreme events or poor water quality. These provisions apply to all water resource plan areas across the Basin.

For further information, see the MDBA web page on water critical for human needs.

Meeting critical human water needs during climate extremes

Over the past 10 years, critical human water needs were sustained in the River Murray system of the southern Basin but were affected in the northern Basin during drought periods (MDBA 2025c). During the Tinderbox drought (2017–2019), many communities in the northern Basin experienced extreme water security issues resulting in water restrictions or no water availability (MDBA 2025d).

Water security issues during the Tinderbox drought affected multiple river systems, small towns and major regional centres.

In the Queensland Border Rivers, water security in the township of Stanthorpe, with a population of over 5,000, was severely affected. The town was in water crisis in 2019 and its local water supply officially ran out in January 2020. Water was trucked in from Connolly Dam near Warwick (Morris 2020).

At the downstream end of the Darling (Baaka) system, the town of Wilcannia, around 700 residents, had similar water supply issues, with the river ceasing to flow in 2019. The town draws water from the river and poor water quality in the remaining pools strongly affected the water supply. Most residents preferred trucked-in drinking water (Feik 2019).

Large regional centres, such as Orange – home to over 40,000 residents – also had water security challenges. During the Tinderbox drought, Orange was forced onto stage 5 water restrictions and surface water storages were at just 20% capacity in early 2020. There were also concerns that the town may run out of water by the end of 2020 if drought conditions continued (Doman et al. 2020).

These events have affected Basin residents' confidence about future water security. In 2023, just over half (51%) of Basin residents felt confident that their community will have access to sufficient water quantity and quality in the future, compared to 62% of those living outside the Basin. In some parts of the northern Basin (particularly the Darling LGA) only 18% were confident (Schimer et al. 2025).

To improve water security across many of the areas impacted by the Tinderbox drought, the New South Wales Government has prepared regional water strategies. The strategies use the latest climate and scientific evidence to plan and manage each region's water needs over the next 20 years. This includes innovative ways to deliver safe and secure water supplies.

Meeting critical human water needs under climate change

The National Climate Risk Assessment identified that Australia faces severe risks to water security from climate change (Australian Climate Service 2025a).

In the Basin, it is anticipated that the challenges in maintaining water security and meeting critical human water needs will increase under a hotter and drier climate. This is a combined effect of more frequent and intense droughts, reduced rainfall and river flows, greater evapotranspiration which increases conveyance losses, and poor water quality events. Remote communities that rely on drawing water from rivers that cease to flow in certain drought events may be particularly vulnerable (Meridian Urban 2025).

Pressure on reliable supply of critical human water needs would be exacerbated further under a hotter and much drier climate as the drivers of water insecurity become more intense. However, these pressures may be alleviated by increases in river flows under a hotter and slightly wetter climate, though more frequent events of poor water quality may partially offset this benefit.

Activation of critical human water need provisions

Under a hotter and drier climate, it is likely that provisions for critical human water needs in the Basin Plan and water resource plans will be activated more frequently. These provisions will be relied on more often to support the immediate water needs of towns and communities who rely on the rivers of the Murray–Darling Basin for their critical human water needs.

For the River Murray system, Tier 2 (very low water availability) and Tier 3 (extremely low water availability) provisions are likely to be triggered more frequently under a hotter and drier climate. These provisions may be triggered at an even higher frequency under a hotter and much drier climate. Conversely, under a hotter and slightly wetter climate, increased river flows may reduce the frequency of Tier 2 and Tier 3 water sharing arrangements.

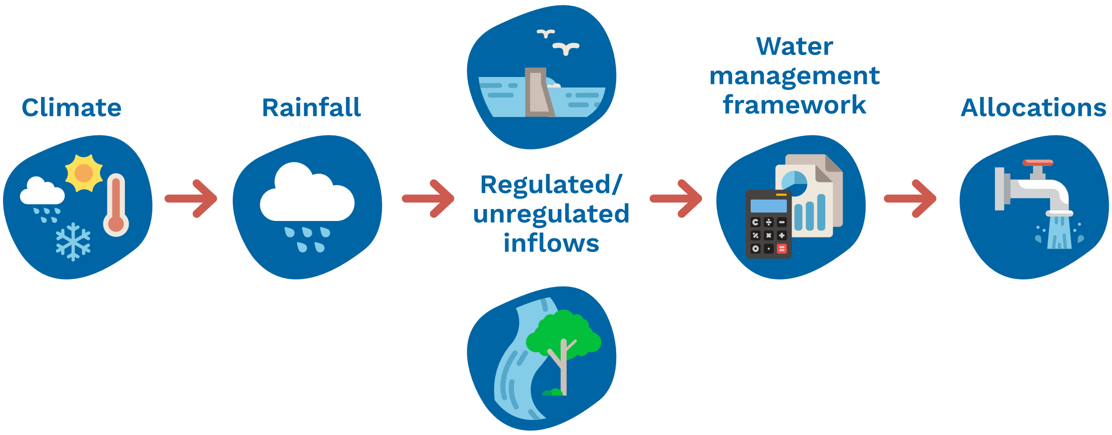
Local adaptation to a drier future

Over recent years, there has been an increase in local solutions to meet critical human water needs and this trend is expected to continue under a hotter and drier climate. During the Tinderbox drought, local solutions included accessing bore water, as towns on the Namoi River did (Vincent 2018), and establishing emergency block banks, such as those placed in the Lower Darling (Baaka) River, to provide pools of water for the critical needs of landholders (NSW Government 2020).

Water entitlements and allocations

The Basin has a well-established connection between climate, rainfall, river inflows and how water is allocated (Figure 5). Climate and weather patterns determine rainfall, which in turn drives both regulated inflows into dams and storages and unregulated flows through river systems. These surface and subsurface inputs form the physical basis of water availability in the Basin.

Figure 5 **Established connection between climate and water allocations**



Water in the Basin can broadly be divided into entitlement water and non-entitlement water, and each is managed differently under the allocation framework.

Water entitlements (or licences) represent the right of the holder to take up to a certain amount of water from the river system. Entitlement water is water for which the rights are held by individuals, farms, industries, towns and governments. This includes environmental water entitlements held by federal or state governments to manage water for environmental outcomes. Entitlement types differ by how reliably they allocate water year on year, with more reliable entitlements generally receiving priority access (for example, see Box 2).

Non-entitlement water is managed through state water sharing arrangements and is not tied to an entitlement. It provides important environmental and user benefits. This water is important to the reliability of all entitlements and for underpinning the achievement of environmental outcomes that cannot be met with managed environmental water alone.

Box 2 Water reliability

High reliability and general reliability allocation levels over the past 20 years in the Murrumbidgee

Figures 6 and 7 show how high reliability and general reliability allocations vary both across years and within each water year (1 July – 30 June in most places). The graphs show data over the past 20 years that includes the dry sequence between 1 July 2005 and 1 July 2010 in the Murrumbidgee (Zone 13). When storage levels are low (around 50% of capacity or less), general reliability allocations can remain very low, or even zero, for extended periods.

High reliability allocations are prioritised but, in this sequence, they also started at zero for 3 consecutive water years. As inflows from rainfall increase storage volumes, state agencies announce higher allocations, changing how much water is available to different entitlement holders over time, with high reliability allocations receiving priority before general reliability allocations rise.

Figure 6 **Murrumbidgee (Zone 13) storage levels, high reliability allocation levels from 1 July 2005 to 1 July 2025**

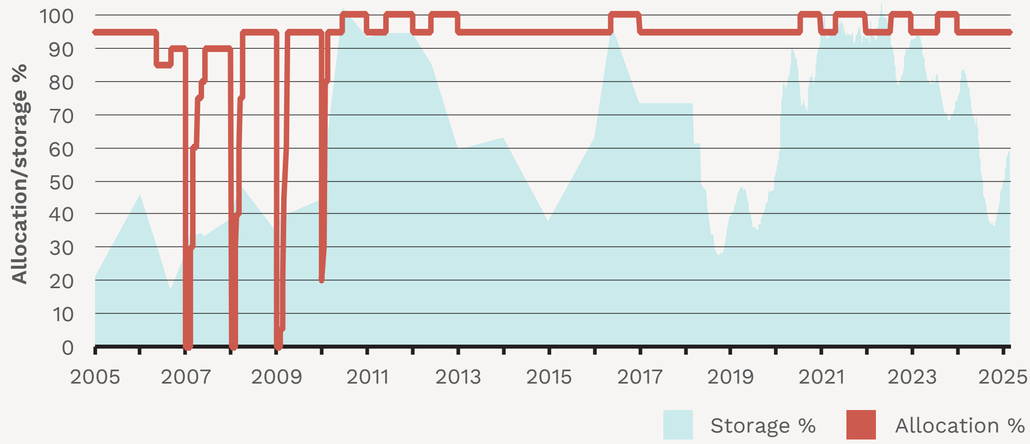
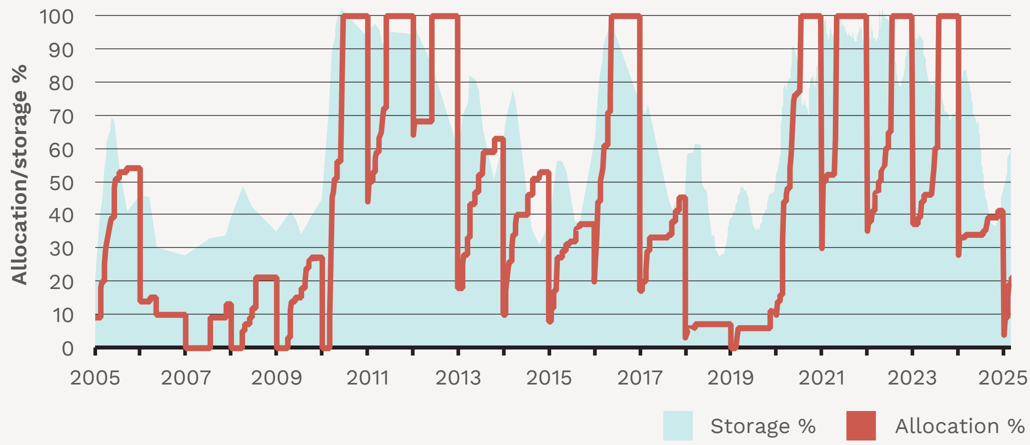


Figure 7 **Murrumbidgee (Zone 13) storage levels, general reliability allocation levels from 1 July 2005 to 1 July 2025**

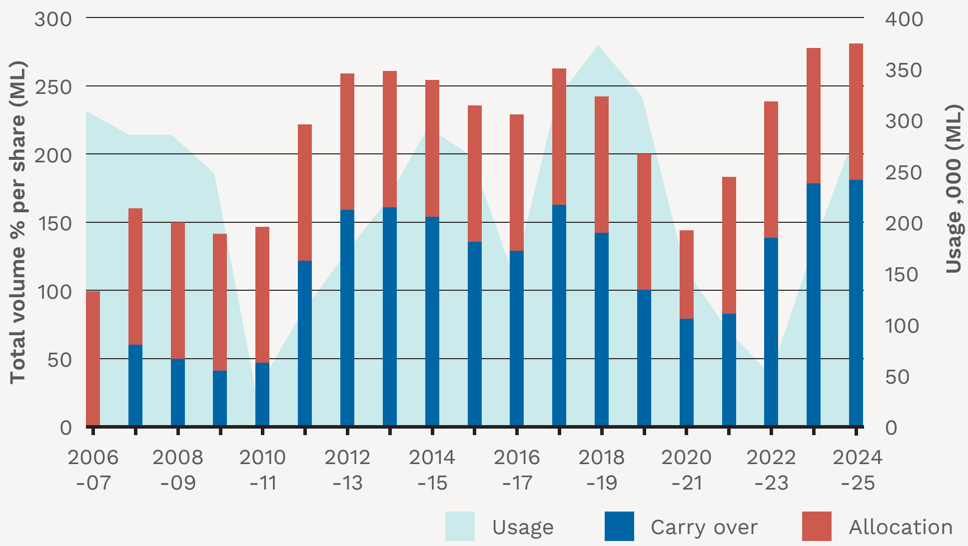


Source: Waterflow premium access

Box 2 (continued)

Figure 8 shows how groundwater availability and water usage can also vary across water years. The graph shows data over the past 18 years and can be compared against the storage levels and general reliability allocations in the Murrumbidgee shown in Figure 7. Dry periods and low storage levels were experienced in around 2014–15 and 2018–19 according to Figure 7. These timeframes also coincide with increases in usage for groundwater (illustrated by the light blue shaded area) in Figure 8. Groundwater usage is lowest in 2010–11 and 2022–23, coinciding with when large inflows occur (2010–11) or when general reliability allocations have been high for extended periods.

Figure 8 **New South Wales lower Murrumbidgee deep groundwater source from 1 July 2006 to 1 July 2025**



Source: NSW DCCEEW (2025)

How water availability changes for different entitlements under climate change

The Sustainable Yields report (MDBA 2025b) has found that, under current water management arrangements, climate change will disproportionately impact non-entitlement water. Under climate change, the balance between entitlement and non-entitlement water in the Basin is expected to shift by 2050. As the total volume of average available water is projected to decrease over time, the proportion that is non-entitlement water is expected to decline while the proportion that is entitlement water is expected to rise.

Non-entitlement water comprises volumes of water that serve a range of purposes and have varying levels of prioritisation through state water sharing arrangements. Although climate change will disproportionately impact non-entitlement water, changes in the volumes and/or reliability of non-entitlement water will vary between its different types. For example, passing flows are to remain relatively reliable, whereas unregulated flows are more exposed to a hotter and drier climate.

The reliability of entitlement water and types of non-entitlement water is an effect of a developed river system. Water infrastructure (that is, dams and weirs) and water sharing arrangements are designed with security of supply for entitlement holders and communities as a primary deliverable. Hence, entitlement water, and types of non-entitlement water that are vital for communities, are generally more reliable. In contrast, unregulated flows, are more exposed to year-to-year variation in climatic conditions and system inflows and are therefore anticipated to experience a greater degree of impact under a hotter and drier climate.

Impacts of reduced water availability on MDB high reliability and MDB general reliability water users

Water management arrangements across the Basin are complex, with each jurisdiction having adopted an entitlement framework most suitable for the natural and development-related characteristics in their catchments. Hence there is a wide degree of variation in entitlement rules and allocation procedures between catchments and between jurisdictions – there are hundreds of different types of entitlements across the Basin.

For the purposes of the Basin Outlook, the MDBA has adopted a generalised nomenclature, examining the impacts of climate change on 2 categories of entitlement: *MDB high reliability* and *MDB general reliability*. MDB high reliability holders receive more reliable water access in drier conditions, whereas MDB general reliability holders may not receive any water until conditions improve. This broad categorisation enables a Basin-scale perspective for the purposes of the Basin Outlook.

Assuming water management frameworks used by the Basin state governments to allocate water remain constant, climate change is likely to widen the gap between entitlement types, because reliability and priority differ. High reliability holders are more likely to maintain access to water in dry futures, while general reliability users face longer stretches of low or nil allocations.

The relative advantage of high reliability over general reliability is likely to grow as average availability falls, and this will be reflected in entitlement prices and ownership patterns. Market and delivery constraints matter more in dry sequences, so planning for trade limits, river capacity and carryover rules is as important as the headline allocation number. Targeted risk tools, including carryover access, forward allocation contracts and insurance-style products, can reduce variability for both entitlement types, although they are most accessible to larger and better capitalised users.

This uneven exposure means general reliability users are more likely to scale-back or exit irrigated agriculture, while high reliability users are better placed to consolidate scarce water. Without adaptation support, general reliability users will bear a disproportionate share of adjustment costs, particularly in northern catchments and in southern zones where temporary prices and delivery constraints spike in dry periods.

Basin governments consider climate change impacts on the availability of their water resources. For example, New South Wales Regional Water Strategies and South Australian Water Allocations Plans.

A third category of water users – groundwater and unregulated – are particularly exposed to anticipated increases in year-to-year variability and more severe extreme climatic events. More information is provided for these categories in the following sections.

High reliability water users

High reliability products would continue to provide priority access, but reliability of allocations can still soften in hotter, drier futures. Permanent horticulture depends on these products, so timing and delivery risks matter even when end-of-season allocations improve. Key impacts to high reliability water users include several factors:

- **Reliability and allocations.** Opening allocations are lower and later in dry sequences, and final allocations can still recover in wetter finishes, but overall reliability is lower than in the past.
- **Industry exposure.** Delivery constraints and trade limits can create shortfalls at critical times – for example, lower Murray horticulture**.**
- **Value and consolidation.** The premium on high reliability entitlements is likely to increase, concentrating ownership among larger, well-capitalised businesses that can carry higher costs and use carryover effectively.
- **Risk management.** Carryover, forward leasing and structured allocation contracts help to smooth supply and prices, although short, sharp shortfalls can still occur in extreme dry periods, with anticipated substantial impacts on some enterprises such as horticulture.

General reliability water users

General reliability users carry most of the allocation and timing risk. Planting decisions, cash flow and investment confidence become more dependent on seasonal outlooks and temporary prices. Key impacts to general reliability water users may include several factors:

- **Allocations and timing.** More years with very low or zero allocations, lower and later openings, and less certain in-year recovery. Modelling, in NSW Regional Water Strategy regions, also found that the risk of low or no allocations for general security licenses increases under a dry climate scenario (for example, NSW DPE 2023).
- **Production impacts.** Annual crops could contract in dry sequences, with more seasons where planting is deferred or cancelled.
- **Market dependence and equity.** In the southern Basin, deeper markets allow water trading, but many users are priced out when temporary prices exceed profitability. In the northern Basin, thinner markets and less regulation mean fewer trading options, so operators rely more on on-farm storage, local inflows and reducing production.
- **Business viability.** Larger balance sheets can use leasing, forwards and carryover to manage risk, whereas smaller and mid-sized farms face higher exit pressure during extended dry periods.

Groundwater and unregulated water users

Groundwater and unregulated water users may be exposed to declining recharge, falling watertables and shorter access windows tied to flow events and cease-to-pump thresholds. There are several key impacts, which are location-specific because connectivity and aquifer types differ across the Basin:

- **Allocations linked to resource condition.** As inflow declines, seasonal groundwater allocations may tighten to protect streams and groundwater-dependent ecosystems, especially in highly connected catchments where vertical connectivity is vulnerable and cease of baseflow is a key risk.

- **Un-supplemented access rules occur more often.** In unregulated streams and flows linked to specific inflow requirements, shared cease-to-pump rules for surface water and groundwater may tighten access during dry periods, shrinking pumping windows and increasing reliance on opportunistic events.
- **Salinity and end-of-catchment risks.** In the western Murray and some fractured rock or upper alluvium settings, saline groundwater discharge and dryland salinity may remain management concerns, intersecting with climate-driven watertable changes.
- **Management levers.** Trigger-based allocations, coordinated cease-to-pump settings across surface water and groundwater, and, where suitable, active measures such as managed aquifer recharge can bolster resilience under longer, more intense droughts.

Impacts in the southern Basin versus northern Basin

Changes in water availability will differ between the southern and northern Basin, because each has distinct hydrological settings and market structures.

The northern Basin features flatter, drier landscapes with many unregulated rivers that depend on rainfall, which lead to high evaporation and inconsistent water availability. These conditions shape a smaller, more homogeneous irrigation profile, with summer irrigation centred on cotton more than other irrigated crops. Water markets in the north are less extensive, so irrigators have fewer trading opportunities to buffer low allocations. The region also has a higher presence of larger corporate farms, which can use economies of scale to absorb or adapt to variability differently than smaller operators. Large enterprises are more resilient to climate variability than small-scale operations as they have more land and capital to absorb impacts, can spread fixed costs and more readily adopt climate-resilient technologies.

The southern Basin is a regulated system with higher rainfall in key catchments and topography that supports large, connected rivers such as the Murray, Murrumbidgee and Goulburn rivers. Storages and river regulation provide a more reliable supply and support a diverse mix of production, from permanent horticulture such as grapes, nuts and citrus, to annual irrigated crops such as cotton and rice, to pastures that support dairy and mixed farming. More extensive water markets in the south give irrigators greater scope to manage scarcity through trade, although access is uneven, especially in dry years when competition for water favours industries with a higher capacity to pay.

These regional differences frame the analysis that follows on allocations, entitlements and market responses under the 3 climate scenarios. They help explain why southern Basin users can often lean more on trade and carryover to manage risk, whereas northern Basin users are more exposed to episodic inflows and have fewer market options to smooth supply variability.

Impacts in the southern Basin

Under all 3 hydroclimate scenarios to 2050, there is a continued preference for high reliability water in the southern Basin, which favours existing entitlement holders and perennial higher-value crop producers with willingness to pay.

Carryover has increased since 2008, so more water is stored between years. This leaves the southern Basin better placed for drought, with materially lower prices in dry years than they otherwise would be without carryover (MJA 2025a). Key trade limits – including the Murrumbidgee export limit and the Barmah Choke – are likely to bind more often and create persistent price differences between trade zones, with below-Barmah prices often being higher.

It is likely that demand continues to shift towards permanent horticulture in the lower Victorian Murray and towards cotton in southern New South Wales. Dairy and rice farming are likely to contract. This would concentrate demand downstream and increase reliance on trade into zones below the Barmah Choke. Permanent horticulture shifts are also likely to increase demand for groundwater as mitigation against reduced surface water allocations, although this may not necessarily result in increased groundwater extraction given allocation limits and local management rules. Dairy farming systems in particular can be vulnerable to water shortages (NCRA 2025).

Changes to allocation reliability may influence planting and investment decisions. It may also impact agricultural asset values, with the extent of this impact dependent on the capacity of each business to understand and manage risk. New risks are also emerging, including dry period delivery shortfalls to horticulture on the lower Murray and insufficient temporary water to avoid drying off permanent plantings, as identified in Gupta and Hughes (2018).

Under repeats of historical drought, price peaks are not projected to exceed the Millennium drought, although average prices are modelled to be higher and very low price years to be less frequent, which could place pressure on flexible annual crops (MJA 2025a). Delivery risks to the lower Murray may remain during very dry periods, given its tighter import limits and expanded horticulture.

Impacts in the northern Basin

In the northern Basin, there is less market depth and irrigators have fewer opportunities to buffer low allocations through trading, so outcomes depend more on local inflows, on-farm management and the rules in each catchment.

Many northern systems use continuous allocation accounting, which shapes inter-year risk management and places more emphasis on timing and storage rather than interregional trade. Production is more homogeneous, with large enterprises focusing on broadacre summer crops (such as cotton) that can absorb variability through scale, while smaller operators are more exposed to episodic inflows and local constraints. Groundwater also contributes as a risk mitigation tool. For example, large cotton-growing regions such as the Namoi are large users of groundwater, and Basin areas in Queensland make use of the Central Condamine Alluvium.

Quantified allocation and price projections are less developed for the north, but the hydrological and institutional differences point to higher volatility in access and fewer market tools to smooth supply across years.

Water markets and trading

Water in the Murray–Darling Basin can be bought and sold on water markets – within catchments, between catchments (where possible) and along river systems. The connected and interstate water markets in the southern Basin are some of the most advanced water markets in the world.

The Basin Plan sets out water trading rules, under which the Basin state governments set their water market rules and procedures. Under this system, water in the Basin can move between users via the open market, through either permanent trades (entitlements) or temporary trades (allocations).

Water markets and trade have become increasingly important in the Basin. They enable users to buy and sell water entitlements and allocations, which encourages more flexible, efficient and productive use of water throughout the Basin. They allow agricultural businesses to adapt to a changing climate and manage water availability risks, by selling either crops or water to maintain their revenue streams, and environmental water holders to more effectively deliver water for the environment.

Allocation prices and traded volumes are largely driven by water availability. When storages are nearing capacity during wet years, allocation trade values are lower. Conversely, when storages are low during stretches of dry condition, allocation trade values are substantially higher.

Market activity and trading under climate change

To manage reduced water availability and allocation uncertainty under a hotter and drier future, market participants could make greater use of water market products and de-risking strategies, such as shifting ownership towards investors and large corporate farms, greater reliance on carryover, forward water leasing and new risk management tools (for example, water price insurance). Under these conditions, inter-valley trade constraints and market rules may come into effect more regularly and play a bigger role in determining price differences between regions (MJA 2025a).

Under a hotter and drier climate, water allocation prices are expected to be higher on average. In the southern Basin, reduced inflows are expected to result in lower average water allocations (MDBA 2025c). Fixed water needs for horticultural crops and other permanent plantings are expected to sustain high levels of water demand. As a result, average water allocation prices are likely to be higher. As corporate ownership of entitlements expands, smaller irrigators may rely more on the allocation market rather than holding entitlements. This would increase their exposure to allocation price spikes in dry years.

Under all future climate scenarios, large agribusinesses are likely to continue their dominance of entitlement markets. Water scarcity would continue to support strong prices for entitlements to high reliability allocations. However, under hotter and drier scenarios, severe reductions in water availability could see large corporate irrigators further increase their share of water entitlements, placing pressure on smaller producers for market access.

Should the future trend towards a hotter and slightly wetter climate, then water allocation prices may rise moderately, with more years above historical averages but fewer extreme spikes. Trade could remain accessible to a wider range of irrigators, including annual crop growers and smaller operators. The frequency of key trade constraints may also reduce as river flows and connectivity improve.

If a hotter and much drier climate were to eventuate, then allocation prices could frequently exceed $600/ML, with extreme volatility compounded by binding physical trade limits such as the Barmah Choke (MJA 2025a). Under these climate conditions, divergence between the northern and southern Basins may increase. The southern Basin may maintain some resilience through storages and high reliability products, while the northern Basin may experience systemic water scarcity.

Economic values

Economic conditions in the Basin are driven by many factors such as technological advances, population dynamics, consumer demands, global markets and trade, as well as climate risks. Among these drivers, climate change is expected to have the highest economic impact for water-dependent industries such as agriculture and forestry (MJA 2025b). Rising temperatures, more variable rainfall and more frequent extreme weather events will create cascading and compounding pressures on agricultural systems. These, along with future opportunities such as emerging carbon markets, renewable energy options and land use diversification, have the potential to change farm practices and profitability, and reshape water markets (MJA 2025b).

In the 2025 Sustainable Rivers Audit, the MDBA provided a broad picture of the past and current condition of the Basin's economy, as described below.

Current status

The Basin's economy continues to grow and service industries are expanding in regional areas.

The Basin's economy, including its agricultural sector, has increased in line with the rest of regional Australia in recent decades. The Basin's economy is valued at more than $230 billion each year. In 2022, Basin-irrigated agricultural businesses employed more than 16,000 people (full-time equivalents) and Basin dryland agriculture businesses employed more than 25,000 people (full-time equivalents). Agricultural land values in the Basin have markedly increased in the past 20 years. Service industries are growing in regional areas, particularly in the larger regional towns. Tourism has also grown over the past 20 years, in line with the rest of regional Australia.

Source: MDBA (2025a)

The Basin Outlook considers potential changes to social and economic vulnerability of Local Government Areas (LGAs) in the Basin and to economic values to around 2050. Aligned with the Sustainable Rivers Audit, the economic values considered are those that have a strong connection to the Basin's water resources, namely:

- regional economies
- agriculture (dryland and irrigated)
- tourism and recreation.

The key evidence source for the conclusions below is the Marsden Jacobs Associates (MJA 2025a) report, supported by other published material, including the National Climate Risk Assessment (NCRA) (Australian Climate Service 2025b).

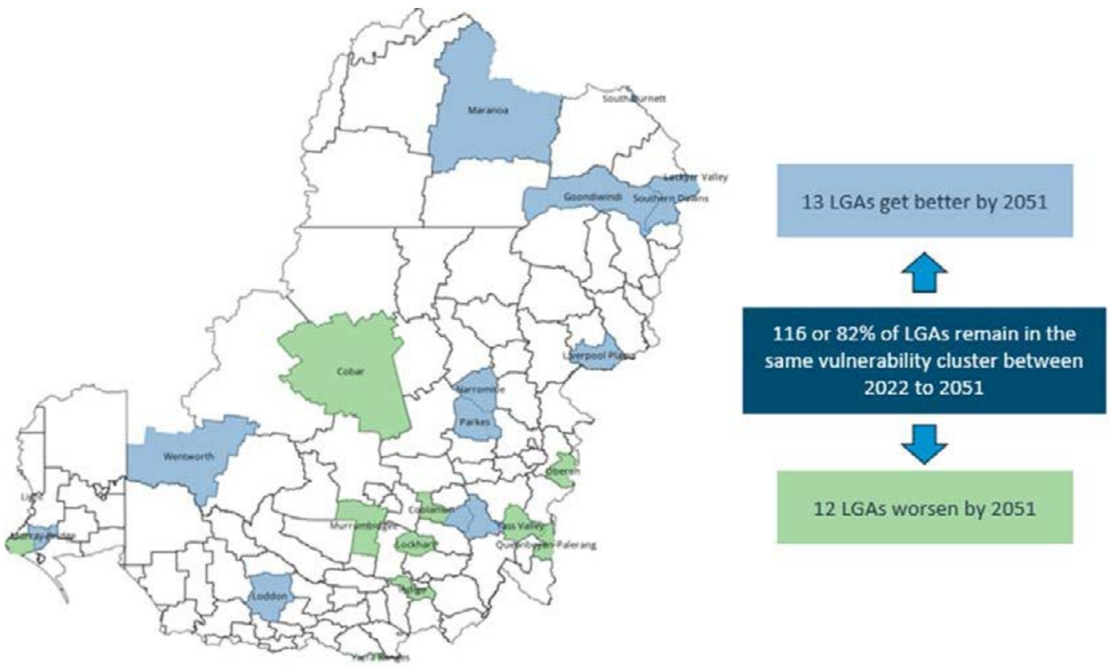
Vulnerability to climate change across the Basin

The future economic vulnerability to climate change was simulated by MJA (2025b) for all LGAs in the Basin through to 2051. These simulations of population and economic indicators show that by 2051, the vulnerability of most (82%) LGAs would not have meaningfully changed from current levels (using a 2022 baseline). However, 13 (9%) LGAs become more resilient and 12 (8.5%) LGAs become more vulnerable (Figure 9).

Those LGAs that become more vulnerable by 2051 share similar characteristics: they are projected to have slower population and employment growth, declining gross value added and ageing demographics, with no meaningful improvement in economic diversity. Conversely, LGAs projected to become less vulnerable over time show higher population and employment growth, with a broadening economic base.

LGAs that depend on agriculture and are exposed to overlapping hazards from climate change will be particularly vulnerable into the future. For these LGAs, compounding pressures from climate-driven reductions in water availability and increased adaptation demands are likely to increase the potential for slower economic and employment growth (MJA 2025a).

Figure 9 **Basin Local Government Areas vulnerability clusters, change from 2022 to 2051**



Source: MJA (2025a)

Regional economies

Long-term population and economic trends

Irrespective of future climates, regional economies experiencing faster population growth are likely to be larger in size, more economically diverse and service-oriented (except in mining-based communities), located closer to major urban centres and less reliant on agriculture (MJA 2025a). Smaller and more remote communities typically have poorer services, infrastructure and digital connectivity than urban centres (MJA 2025a). These factors and other long-term shifts, such as the adoption of labour-saving agricultural technologies, are expected to see continuing population migration towards larger regional centres and major cities. This could exacerbate the trend of ageing demographics and lower population growth for some small, remote, agriculture-dependent LGAs (MJA 2025a). Ageing demographics would contribute to pressure on access to services, reduce adaptive capacity and increase vulnerability (MJA 2025a).

Impacts from climate change

In addition to the long-term population and economic trends described previously, climate change will also impact regional economies in the Basin. In the northern Basin, extreme heat and more variable water availability could affect agricultural systems and further stress vulnerable LGAs. In the southern Basin, reduced rainfall and water availability may impact irrigated and dryland farming. Under a hotter and slightly wetter climate, these impacts across the northern Basin could ease, but challenges may remain in the southern Basin if variability in water supply increases. Conversely, under a hotter and much drier climate, the impacts described may be exacerbated and become more widespread.

Beyond rainfall, runoff and temperature changes, climate change risks from more frequent and intense extreme events, such as riverine flooding and bushfires, pose additional threats to regional economies in the Basin.

Agriculture (dryland and irrigated)

Maintaining current agricultural practices and production is expected to become more challenging under a hotter and drier climate. Climate change is expected to reduce the profitability and increase volatility in both dryland and irrigated agriculture, particularly for livestock and annual cropping enterprises (MJA 2025a). Reduced rainfall and runoff would put pressure on dryland and irrigated agriculture in the southern Basin, while northern Basin agriculture may be more impacted by higher temperatures. Water scarcity, rather than high temperatures, has the strongest impact on agricultural value (Jalilov et al. 2025).

A hotter and drier climate is likely to reduce the cultivated area of irrigated crops. Reductions in water availability are expected to impact irrigated summer crops more than winter broadacre crops, which are more resilient to moisture variations (Jalilov et al. 2025).

The NCRA report (Australian Climate Service 2025a) has detailed expected water quality impacts:

> Future water quality risks to agriculture are almost certain to increase due to factors such as algae formation, increased salinity and acid sulphate soil exposure. More frequent bushfires are very likely to pose significant risks to water quality. Higher rainfall variability and an increase in extreme rain events are likely to increase risks of flooding, soil erosion, the addition of 'excess' nutrients (eutrophication) and contamination from chemical and sedimentary sources.

Higher temperatures, especially during heatwaves, can increase the risk of sunburn and affect horticulture quality and yields. Some horticulture may benefit from a reduction in frosts, but yields may reduce for many flowering crops that rely on colder temperatures during winter months (Australian Climate Service 2025a).

Forestry is very likely to face challenges from hotter climates, increased bushfire risk, reduced rainfall and increased frequency and severity of droughts. Collectively, these climate conditions can impact tree establishment and growth rates and increase susceptibility to heat-induced mortality and pest infestations. However, higher temperatures and reductions in frost could benefit growth rates in cooler areas (Australian Climate Service 2025a).

Biosecurity threats are also likely to increase with climate change. A changing climate may shift the range of pests or see exotic species become more invasive, and higher temperatures can reduce the effectiveness of herbicides and pesticides (Australian Climate Service 2025a). This may increase the susceptibility of plants and animals to pests and disease.

Northern Basin agriculture

In the northern Basin, a hotter and drier climate would see higher average temperatures, variable water availability and more frequent extreme events. Opportunistic irrigated cropping such as cotton is expected to continue and annual crops may adapt by using less water-dependent varieties. This climate scenario may increase suitability for cereal and oilseed crops, while perennial horticulture may be less suitable (Boland et al. 2024).

A hotter and drier climate may also impact yields and product quality in livestock industries. For example, heat stress could cause widespread production losses, while reduced pasture growth and quality may create competition for increasingly scarce agricultural land. The health and welfare of animals, physical infrastructure (from fences to freight networks) and labour may also be affected (Greenwood et al. 2025).

Under a hotter and slightly wetter future climate with increased runoff and fluctuating allocations, production may be highly variable based on seasonal conditions, and this instability could challenge the availability of a skilled workforce. Under a hotter and much drier climate, dryland and mixed annual enterprises may still expand but operate at lower productivity, relying on opportunistic cropping and grazing (Boland et al. 2024).

Southern Basin agriculture

Like the northern Basin, there could be changes to the mix of crops grown in the southern Basin. Higher temperatures and fewer frosts may increase the suitability of annual crops in some regions. However, as shown in the previous section on 'Water markets and trading', reduced rainfall and runoff is expected to increase average water allocation prices and favour production of higher value perennial horticulture crops (for example, almonds) in preference to annual crops (for example, rice) (MJA 2025a).

Horticulture production systems are expected to continue adapting to reduced water availability by using varietal advancements, and other technological improvements such as protected cropping systems with precise monitoring and management of water, nutrients and temperature.

Under a hotter and slightly wetter future climate, horticulture may use the more secure water entitlements to increase production volumes, while irrigated annual crops like rice and cotton could expand in wetter years. Under a hotter and much drier climate, severe and frequent droughts may lead to a contraction of perennial horticulture, with many long-lived crops unable to be irrigated.

Adaptation will shape agricultural futures

Under a hotter drier climate and with the current pace of incremental agricultural adaptation (for example, the uptake of low-risk technologies, diversification of farming systems, and water trading among sectors and regions), productivity and efficiency gains may plateau (Boland et al. 2024, CSIRO 2024). However, with more transformative adaptation, such as synthetic biology, carbon sequestration, protected and mixed cropping systems, precision analytics and artificial-intelligence–powered automation, regional centres with skilled workforces could implement sophisticated agriculture practices to increase climate resilience (CSIRO 2024).

Tourism and recreation

Overall, regional tourism in the Basin is projected to grow, especially as average global wealth rises and international visitors continue to spend around 40 cents of every tourist dollar in regional Australia (MJA 2025b).

Climate change and changes to water availability and water quality have the potential to impact future water-dependent tourism and recreation in the Basin. More frequent and intense extreme weather events such as droughts, floods and harmful water quality events (such as harmful algal blooms, hypoxic water events and fish deaths) could impact water-based recreational activities and deter tourists from visiting affected Basin regions.

Future tourism visitor numbers and community livelihoods based around freshwater activities, such as boating, fishing, camping and cultural experiences along rivers, may be negatively impacted by reduced water quantity and quality under a hotter and drier climate (MJA 2025a). Snow-based tourism operations in alpine regions may also be impacted. Reduced water in wetland birdwatching hotspots across the Basin also has been shown to decrease birdwatcher visitation ecotourism and subsequent expenditure in local economies (Smart et al. 2025).

These impacts to tourism and recreation may be eased under a hotter and slightly wetter climate that would better support the visual amenity of waterways in the Basin. In contrast, a hotter and much drier future would further deteriorate the amenity and water quality of waterways in the Basin, leading to more severe and widespread impacts.

Social values

The social values of the Basin are sensitive to a wide array of factors, including climate, water, water management and non-water-related drivers, operating at local, regional and national scales. An in-depth assessment of how the Basin's social values may be affected by climate change is beyond the scope of this report. However, the Basin Outlook summarises (below) some of the key social aspects of the Basin and how they may interact with the changing climate.

Social conditions are critical to the long-term health and wellbeing of people living in the Basin's regional and rural communities. Access to essential services, positive social contact and confidence in their community's future and its ability to cope with challenges, such as climate change, are increasingly recognised as fundamental to people's quality of life and health, and the viability and liveability of regional communities (MDBA 2025c).

Climate change may create serious challenges for Basin communities. Rising temperatures, changes to water availability and security, and declining water quality all have the potential to increase social vulnerability and negatively impact health and wellbeing. More frequent extreme weather events and natural disasters such as bushfires increase health risks and psychological stress, especially in communities with poor access to health services (MJA 2025a).

In the 2025 Sustainable Rivers Audit, the MDBA provided a broad picture of the past and current social condition of the Basin, as described below.

Current status

People living in the Basin recommend it as a great place to live. However, residents in communities that depend on agriculture are more likely to be less confident about the future of their community, and their ability to maintain their quality of life while coping with events like droughts and floods.

While the Basin is constantly changing due to climate impacts, water management and other drivers of change, people living in the Basin do recommend it as a great place to live and report higher levels of wellbeing than those in the rest of regional Australia. The population of the whole Basin is increasing, but population dynamics within the Basin are influenced by remoteness and economic diversity. For example, communities with stable or declining populations tend to be smaller, more remote, have less economic diversity and depend more on agriculture. Despite high reports of wellbeing, social and economic advantage and disadvantage vary greatly across the Basin. Remoteness and identifying as a First Nations person are significant contributors to social condition. These factors and other social trends – such as confidence in the future of their community – are largely consistent with the rest of regional Australia in recent decades.

Source: MDBA (2025a)

The Basin Outlook considers changes to social values under future climates to around 2050. The social values considered are:

- health, which considers the physical, emotional and mental aspects of health
- wellbeing, which considers access to livelihood opportunities, social connection, amenity and standard of living in local communities, and safety and confidence in the future
- social cohesion, which refers to the bonds that connect individuals within a community, encompassing trust, inclusivity and the ability to work together for the common good.

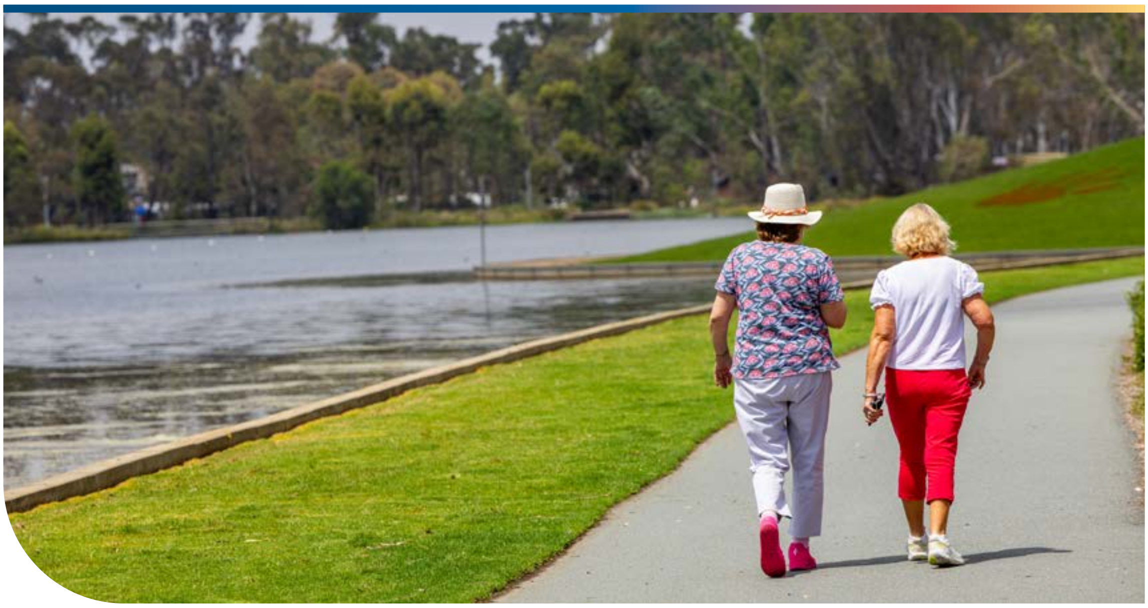
Health

Health risks

Under a hotter and drier climate, risks to human health in the Basin may increase. A hotter climate enables the spread of some vector-borne and parasitic diseases to new areas. Heatwaves increase the risk of morbidity and mortality, and bushfires increase presentations to hospital as a result of cardiovascular and respiratory distress (Lee et al. 2023). Increasing incidence of extreme climatic events, such as floods and droughts, is associated with higher risk of both physical injury and long-term mental health challenges (MJA 2025a). These health risks may be less pronounced under a hotter and slightly wetter climate, and escalated under a hotter and much drier climate.

Vulnerable groups of people

Exposure to health risks may vary across the Basin. Groups at higher risk include those who are socially and economically disadvantaged and/or living with disability, as well as First Nations people (Lee et al. 2023). Increased risks of morbidity and mortality depend on the success of public health investment in preventative measures, people's ability to adopt protective behaviours (such as finding areas for cooling during heatwaves) and their ability to access health services for timely treatment (Charlson et al. 2021).



Health services

Demand for health services is likely to be increase following extreme climate events. This may further stress mental, physical and social health systems in LGAs that currently have poor access to health care (MJA 2025a). Pressures on local health services under a hotter and slightly wetter climate may be less than under drier climates. However, there could be sustained pressure on these services under a hotter and much drier climate.

Wellbeing

Wellbeing refers to overall quality of life for those living in Basin communities. It depends on a person's health, access to livelihood opportunities, social connection, amenity, standard of living in their local community, safety and confidence in the future (Schirmer et al. 2025).

Future climate change may reduce people's confidence in their prospects and increase anxiety about health, livelihood and ability to have a high quality of life (Zander et al. 2019). This suggests the wellbeing of Basin residents could be affected by anticipating (worrying about) climate change impacts, not just directly experiencing climatic events (MDBA 2025c).

Under a hotter and drier climate, ecological grief may be experienced in parts of the Basin where climate change has significantly changed ecosystems. Degradation of healthy ecosystems could also impact the wellbeing of certain communities of people, such as First Nations people, fishers and land stewards, who depend on these systems for Cultural, spiritual and livelihood benefits (MJA 2025a). There are likely to be less impacts on wellbeing under a hotter and slightly wetter climate than under drier climate futures; these impacts are likely to be more widespread and severe under a hotter and much drier climate.

Social cohesion

Social cohesion is a component of community resilience to climate change. Climate change has the potential to both increase and decrease social cohesion, making probable outcomes difficult to predict (MJA 2025a). It is common for communities that experience extreme climatic events, such as floods and droughts, to see an increase in levels of community support and cohesion for periods of time (see, for example, Fan et al. 2020). Conversely, some communities experience significant loss of social cohesion after disasters occur (Townshend et al. 2015) and the impacts of climate change could increase community conflict, both in the short and long terms.

Whether social cohesion will increase or decrease in Basin communities in response to the impacts of climate change will depend on a range of social factors (MJA 2025a). These factors include the strength of community leadership, place attachment, sense of community and community participation (Sobhaninia 2024). Small populations and remote locations can amplify the need for social cohesion (Downey et al. 2025). Pressures on social cohesion are likely to be relatively modest under a hotter and wetter climate, and more intense and persistent under a hotter and much drier climate.

5. Climate risks to Basin Plan objectives

The Basin Plan 2012 includes several objectives for the Basin that encompass environmental, economic and social values. Climate change may affect the ability to achieve those objectives. Outlined below are key findings from the MDBA's Strategic Climate Risk Assessment, which is a structured approach to identifying climate risks to consider whether management responses need to change under future climates through the Basin Plan Review. It has drawn on relevant experts and science projects that support the Basin Plan Review.

Throughout the Basin Plan Review, the Murray–Darling Basin Authority (MDBA) is considering the risks posed by climate change, how, where and by whom these risks are being managed, and how this affects the capacity to adapt to changing conditions. This supports decision-making about how the Basin Plan can be improved in response to climate change. Policy responses that consider the management of climate change risk will be included in the Basin Plan Review Discussion Paper and Final Report (see **What's next?**).

Cross-cutting climate risks

Climate change poses cross-cutting risks to water security, ecosystem functions, water-dependent industries, and social and economic wellbeing. Cross-cutting risks show where climate impacts are interconnected, where vulnerabilities are systemic and where responses need to be coordinated. It is important to note that many risk management strategies are outside the remit of the Basin Plan and the MDBA. Basin state governments are primarily responsible for managing the natural resources within their jurisdictions.

Changes to long-term water availability can trigger cascading impacts on multiple Basin Plan objectives relating to water user security, ecosystem functions, agricultural systems and social values. These risks are often realised during acute extreme events such as extended droughts or water quality incidents, as experienced during recent decades. However, their severity and frequency are exacerbated by the chronic effects of a changing climate.

Climate risks to environmental objectives and outcomes

Climate hazards – including increased temperature, reduced rainfall, droughts and floods – can affect water quality and availability. These hazards can contribute stress on species that rely on water for their ongoing health. For example, climate change poses risks to the ability to support and maintain the ecological character of Ramsar wetlands and other water-dependent ecosystems. This could be caused by inadequate inundation levels, poor water quality or both.

To mitigate this risk, held and planned environmental water may be prioritised for Ramsar wetlands or other high-value water-dependent ecosystems, risking the ability to deliver a diversity of environmental outcomes elsewhere. Drought refugia in deep waterholes that support water-dependent flora and fauna may come under pressure during more severe dry periods, exacerbated by increasing threats from invasive species. Furthermore, existing environmental watering requirements and management regimes, including trade rules, may not be appropriate to the changing climate that operates beyond historical bounds.

The Basin Plan manages risks to environmental objectives through adaptive and integrated water management. Environmental watering strategies guide the delivery of water to support ecosystem resilience, including during droughts and in response to increasing climate variability. Environmental water managers deliver their portfolio of entitlements in response to seasonal conditions and natural cues to maximise environmental outcomes, as informed by an expanding body of on-ground monitoring and insights.

Climate risks to objectives for productive and resilient water-dependent industries

Risks to agricultural and other water-dependent industries have been identified if long-term reductions in water availability manifest under climate change. These include reduced agricultural productivity as a result of reduced annual allocations, poor water quality or increased barriers to trade. Climate hazards – including increased drought and low-flow periods, sea level rise and increased extreme weather events – may put pressure on agricultural productivity.

The Basin Plan supports resilient and productive industries through targeted investment in water-efficient infrastructure. This is essential for adapting to a drier, more variable climate. Basin-specific programs modernise irrigation systems, improve water use efficiency, and reduce losses across urban, industrial and agricultural sectors. By improving long-term water security and fostering innovation, these programs help Basin communities and industries remain viable and competitive in the face of increasing climate risks.

Climate risks to social values, including critical human water needs and recreation

Without enough good-quality water, social and recreational objectives are at risk. Ageing infrastructure, insufficient sources of funding to develop alternative sources of supply and insufficient capability within the local water utility compound the risks to Basin Plan objectives. Water security issues also exacerbate systemic disadvantage for First Nations people, especially in the northern Basin.

Climate change poses risks to the ability to manage Basin water resources in a manner that meets critical human water needs and recreational and social use. This can arise either because of reduced connectivity and water volume, or poor water quality.

The Basin Plan protects communities by prioritising critical human water needs during droughts, extreme heat and adverse water quality events. These mechanisms ensure that community wellbeing, Cultural values and recreational opportunities are safeguarded even as climate change places growing pressure on water availability and reliability.

6. Insights for resilience and adaptation

The Murray–Darling Basin is facing a future shaped by climate. The *2025 Murray–Darling Basin Outlook technical report* (Basin Outlook) has laid out a range of projected conditions for the Basin's environmental systems, communities, economies and First Nations people under the current Basin Plan, deliberately assuming that the Basin's existing management measures remain unchanged. It has done so using the best available science, technical analysis and expert insight. While there is uncertainty in the detail, one thing is clear: the Basin will not look the same in 2050 or beyond as it does today.

Change is certain – the challenge is what we do with it

The changes ahead are not hypothetical or distant – they are already underway. Shifts in climate, land use, population, technology, market dynamics and Cultural expectations are influencing how water is used, shared and valued. This in turn changes and shapes Basin communities, industries and ecosystems (Pearson and Mummery 2025).

These changes do not affect all places equally. Some communities and ecosystems are already experiencing stress, while others have been less exposed. As we move towards 2050 and beyond, some river catchments, industries and communities will experience more rapid or more severe impacts depending on local conditions, economic diversity, social and economic vulnerability, infrastructure, Cultural values and adaptive capacity. Recognising this unevenness is essential to designing fair and effective responses.

The 2025 Sustainable Rivers Audit (MDBA 2025a), the 2025 Basin Plan Evaluation (MDBA 2025c) and the Basin Outlook show that the Basin has a strong foundation for resilience. Its people, industries and governments have shown time and again that they can adapt to difficult circumstances – from prolonged droughts and devastating floods to economic transformation and policy reform. We must all continue to look to the future that emerges and choose how to navigate what lies ahead.

Navigating complexity through systems thinking

The Basin is a dynamic and interconnected social, economic, ecological and Cultural system – where decisions in one part of the system inevitably influence others. Taking a whole-of-system approach is critical in ensuring we understand these relationships, account for unintended consequences and design more adaptive and resilient policies.

This kind of thinking demands that Basin governments move beyond siloed management and embrace collaboration and coordination at scale and across borders and sectors. It calls for seeing the Basin through the combined lenses of scientific, lived experience, Cultural connection and community values. For example, First Nations people and their science and knowledge, offer a model of integrated, place-based management that is more relevant than ever.

Applying systems thinking also helps us to focus on outcomes that matter – not just inputs and actions but the long-term condition of people, rivers and Country. This means designing strategies that anticipate change, allow for flexibility and build the capacity of communities and ecosystems to recover from major events. In other words, resilience.

Principles for resilience and adaptation

Considerable uncertainty remains around the scale, timing and distribution of the many change drivers – climate based or otherwise. Equally, there is uncertainty about how different communities will adapt to these drivers. However, we do know that communities will continue to use local knowledge and experience to develop innovative responses to these current and future challenges.

Uncertainty must not delay action. However, it must form an inherent part of planning. There is no single 'right way' to manage uncertainty but if approached openly and inclusively, it can become a driver of innovation, adaptation and resilience. In this context, drawing on first principles around how to design and implement policy when there are significant and multiple uncertainties is essential.

Planning for an optimal future for the Basin will require 3 critical principles:

- **Adaptability and responsiveness.** We must be prepared to learn and change course. That means using new data, listening to diverse voices and being open to innovation.
- **Collaborative governance and decision-making.** Solutions must be developed with and by the people they affect. Greater coordination among Basin state governments, other governments, First Nations people, water users and catchment managers is critical for both planning and implementation. This is not just about sharing responsibility, but also about sharing authority and action.
- **Locally-led Basin-scale strategies and connected macro-solutions.** Local action is essential, but it needs to be supported by coordinated, strategic decision-making at the Basin level. While big-picture challenges like climate adaptation, ecological restoration and sustainable water use must be met at the community and local level, they must also be solved in a coordinated way.

These principles are not new. They reflect what many communities, researchers and managers have long understood – that working together, across disciplines and jurisdictions, is the only way to build a Basin that is healthy and productive for all.

7. Preparing for the future

The Authority is preparing for a future climate that is likely to be hotter and drier. A hotter and drier future comes with climate hazards including increased temperatures, reduced water availability and more frequent extreme events, which will affect water quality, water availability and connectivity along rivers and with their floodplains. This will make it more difficult to achieve Basin Plan objectives and outcomes for the environment, First Nations people, water-dependent industries and social values.

Adapting to an uncertain future that is likely to have reduced water quality and quantity presents various policy and management challenges including:

- responding to climate change risks (to manage and adapt) in our planning and management of water for the environment
- managing events of poor water quality, especially in the northern Basin
- maintaining connectivity along rivers and with their floodplains
- supporting critical human water needs in parts of the Basin
- improving Basin Plan water regulation to address management challenges, including climate change risks and mitigations and extreme events planning.

These challenges will be considered as part of the 2026 Basin Plan Review. Through the Review, the MDBA is considering the long-term impacts of climate change through to 2050, with a focus on a hotter and drier future. The Basin Plan Review will produce recommendations to guide future decisions on how we all get the best outcomes from the water available.

In adapting to climate change, the Basin Plan will be important, but broader action is needed. Climate adaptation remains a significant challenge for governments, communities and water users, especially in the face of ongoing uncertainty.

8. What's next?

The future of the Murray–Darling Basin is not fixed. While uncertainty is guaranteed, so too is agency. Basin communities, industries and governments have the tools, the knowledge and the experience to respond to the challenges ahead. We have a Basin that, despite immense pressures, continues to sustain life, identity, Culture and economy. And we have communities – diverse, determined and deeply connected to place – who are already adapting in ways big and small.

The Basin Outlook shows how the future condition of the Basin may look under a changing climate by 2050 if existing management arrangements do not change. It is an important assessment that helps Basin governments and stakeholders prepare for a hotter and drier future as climate change continues.

The Murray–Darling Basin Authority (MDBA) has a central role to play in leading this work. Through the MDBA's core responsibilities – managing the Basin Plan, monitoring river health, coordinating water delivery and driving intergovernmental cooperation – the MDBA is uniquely placed to bring stakeholders together to progress shared objectives.

In early 2026, the MDBA will release the Basin Plan Review Discussion Paper. This will share the issues identified by the MDBA and some of the options that may be brought forward. The MDBA will seek feedback on these issues and options, and people will be able to provide a formal submission in response to the discussion paper.

In late 2026, the MDBA will deliver the Basin Plan Review report, which will present the results of the review of the Basin Plan and make recommendations to support the plan to manage the Basin's water resources into the future. The Basin Plan Review is a critical moment to ensure that we are ready to respond to the challenges of the future and that we all have rivers, for generations.

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