Productivity Commission's Murray–Darling Basin Plan: Implementation Review 2023

Submission by the Bureau of Meteorology

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Confidentiality This is a public submission; it does NOT contain 'in confidence' material and can be placed on the Commission's website.

Contents

About the Bureau of Meteorology

The Bureau of Meteorology (the Bureau) is Australia's national weather, climate, and water agency. Its expertise and services assist Australians in dealing with the harsh realities of their natural environment, including drought, floods, fires, storms, tsunami, and tropical cyclones.

The Bureau has key functions under the *Water Act 2007 (Cth)* to collect, hold, manage, interpret, and disseminate Australia's water information. In line with these functions, the Bureau administers Part 7 of the *Water Regulations 2008* which requires over 200 organisations to provide water information which they collect to the Bureau. The products and services which the Bureau creates based on this information provide government, industry, and the community access to trusted and reliable water information. They give key insights into the pas, current and future state of Australia's water resources and contribute to efficient, productive, and sustainable water use – particularly in the Murray–Darling Basin (the Basin).

Overview of submission

The Bureau welcomes the opportunity to provide a submission to the Productivity Commission’s Murray–Darling Basin Plan: Implementation Review 2023. This submission is broken into 3 sections:

1. The first section of this submission characterises historical, recent, and predicted changes to water availability in the Basin. This is to provide context for the Productivity Commission to explore the question on whether the Murray–Darling Basin Plan (the Plan) is sufficiently robust and adaptable to deal with climate variability and change. The section makes note of 2 distinct climate change challenges:
   a. A projected long-term decline in water supply due to a decline in cool season rainfall reducing runoff generation and groundwater recharge, and an increase in water demand across the Basin due to increased evapotranspiration associated with increased temperatures.
   b. A projected increase in variability in the Basin's climate. The Basin is likely to experience longer periods spent in drought and an increased intensity of extreme rainfall events that can lead to short duration high intensity runoff events.
2. In consideration of the Bureau's responsibilities under the Water Act, the second section outlines the contribution water information makes to efficient, sustainable, and productive water policy development, water management and water use.
3. To address the Review's interest in the implementation of water markets reform, the third section outlines the Bureau's plan to implement the data and systems components of the Australian Government's Water Markets Reform Roadmap.

Water availability in the Basin – past, present, and future

The Bureau maintains observational records of temperature, rainfall amounts, streamflow in rivers and groundwater extending back many decades. These observational records are complemented by modelled estimates of land surface conditions across the Basin in areas where no direct observations exist. Assessment of these observational records and of the modelled output by scientists identifies trends which are important considerations for the future management of water resources.

Current climate

The Basin's climate ranges from sub-tropical in the north, to semi-arid in the west, and temperate in the south. Average annual rainfall across the region ranges from more than 2,100 mm in the southeast highland areas to less than 300 mm in the semi-arid areas in the west. The western slopes of the Great Dividing Range are the most important runoff-generating region for the Basin.

Typically, streamflow in the northern part of the region reflects the sub-tropical rainfall distribution with higher streamflows in late summer to early autumn months (January–March) following summer rainfall. Flow in the southern part of the region reflects the more temperate climate with higher flows in the late winter to early spring months (August–October) following winter rainfall. Rainfall is highly variable from year to year and is strongly influenced by phenomena such as the Indian Ocean Dipole (IOD), El Niño and La Niña and shorter-lived phenomenon such as the Southern Annular Mode (SAM) (Bureau*2, 2020).

Historical climate variability and trends

The Bureau's national rainfall record dates back to 1900, although earlier data exist at numerous individual locations within the Basin, with the earliest records dating back to the late 1850s. This post-1900 period has been characterised by rainfall that is highly variable from year to year and from decade to decade (Figures 1 and 2). This high variability poses significant challenges for water management. There is very low skill in predicting rainfall beyond 6 months and rainfall totals at the annual to decadal timescale may not align with long-term projections given the high variability. As such, it is plausible to have a wetter than average decade in a climate that is drying over a multi-decadal time scale.

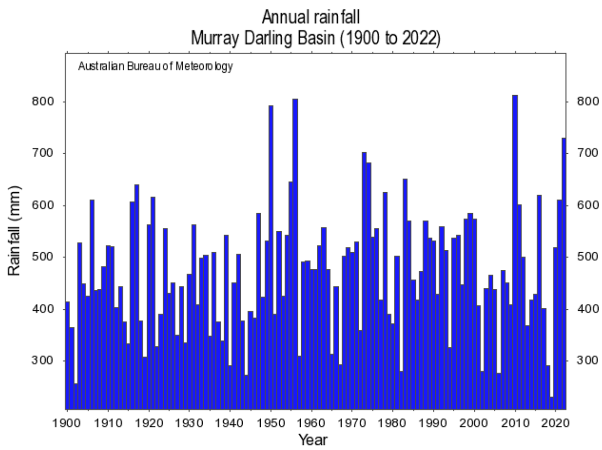

Figure 1 Total annual area-averaged rainfall in the Murray-Darling Basin 1900 to 2022.
From http://www.bom.gov.au/climate/change

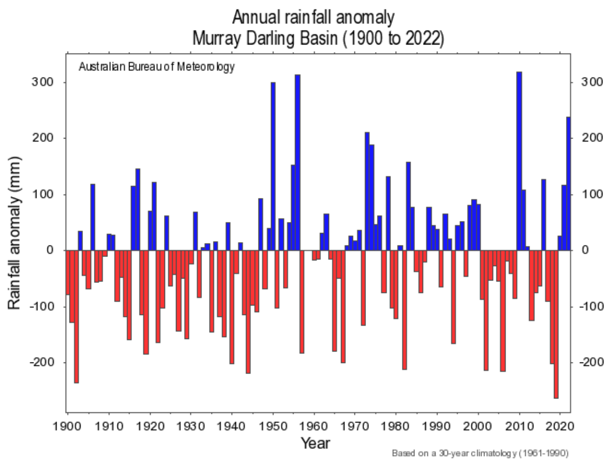

Figure 2 Annual area averaged rainfall anomaly in the Murray-Darling Basin, based on a 30-year climatology from 1961-1990.

From http://www.bom.gov.au/climate/change

Trends in changing temperature are much clearer. Temperatures have risen across Australia and the Basin since the start of national temperature records in 1910, and especially since 1950 (Figure 3). Averaged across the Basin as a whole, there has been a rise of around 1.4°C in mean temperature during this time, at an average rate of 0.13°C per decade (Bureau*2, 2020).

Both the northern and southern basins experienced warming during the period from 1910 to 2021. This rise in average temperature has been observed across all seasons for both daytime and night-time temperatures. There has also been an increase in the incidence of extreme daily heat events. (Bureau*2, 2020)

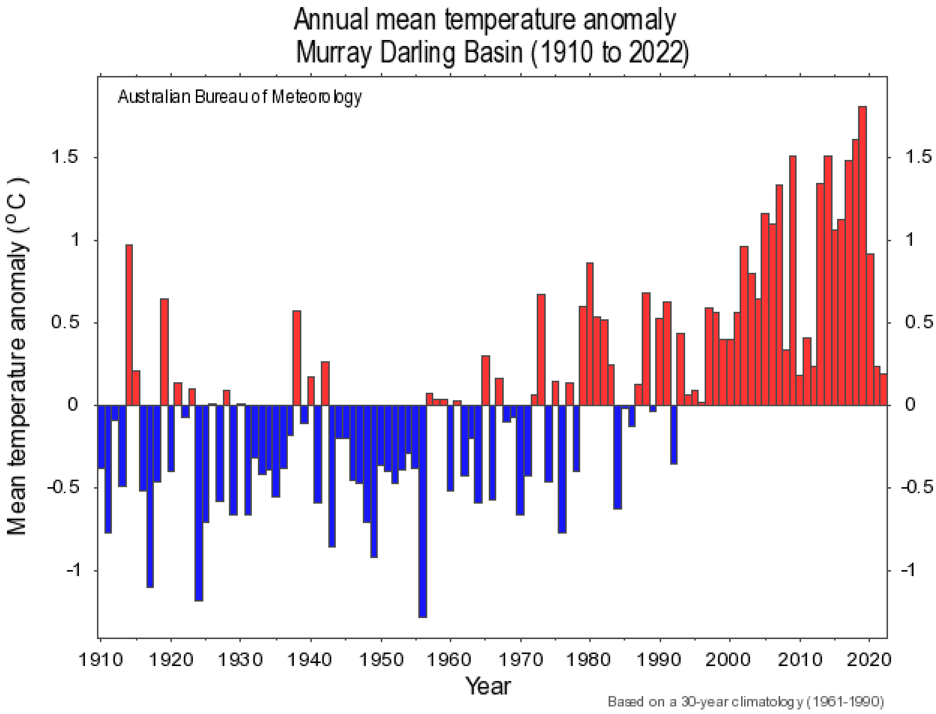

Figure 3 – Anomaly of annual mean temperature across the Basin

Climate and water in the past 20 years

In the past 20 years, the Basin has seen both the wettest and driest years since the Bureau's national rainfall records commenced in 1900 (2010 with 812 mm of area-averaged rainfall and 2019 with 230 mm of area-averaged rainfall, respectively). Several multi-year drought period records were broken in the Millennium Drought during the 2000s, and again during the drought of 2017-19. The 2017-19 drought saw new low rainfall and high temperature records set at the 1-year, 2-year and 3-year time periods. Further information on major droughts in Australia can be found on the Bureau's website (Previous droughts (bom.gov.au)).

The rivers of the Murray–Darling Basin reached record low flows in December 2019 but saw substantial recovery from 2000 to 2022 with widespread and prolonged flooding, particularly in the second half of 2022. The 2020-22 period, dominated by a multi-year La Niña event, was significantly wetter than average across most of the Basin, with many regions, particularly in New South Wales, having their wettest 3-year period on record.

Rainfall

A declining trend in cool season rainfall underlies these periods of droughts and floods. For the period 2002 to 2022, cool season (May to October) rainfall in the Basin has been drier than the long-term climate record, particularly in upper catchments where most of the Basin's streamflow originates (Figure 4). The wet conditions in 2021 and 2022 have had only a minor impact on this trend. The May to October cool season is a hydrologically and agriculturally important time of the year with rainfall during the cooler months important for recharging rivers, aquifers and storages, which are then drawn on during the warmer months for agriculture (Bureau*2, 2020).

Since 2002, warm season (November to April) rainfall has been close to average across the northern Basin and higher than average in the southern Basin (Figure 5). Though the southern Basin has seen an above average rainfall trend during these months, rainfall in the warmer months is less effective in generating runoff than rainfall during the cool season, due to higher temperatures and higher evapotranspiration. As such it does not contribute as significantly to recharge of water systems as rainfall in the cooler months does.

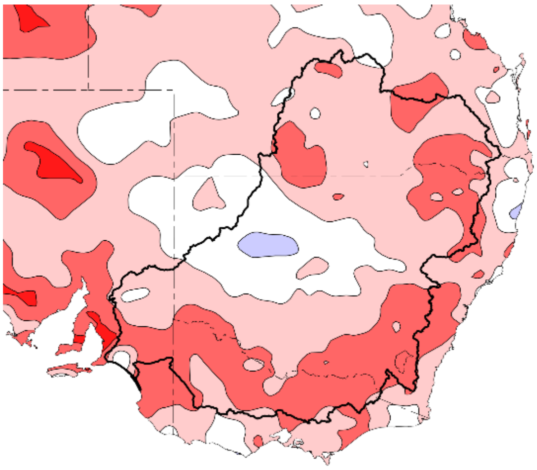

Figure 4 - Cool Season (May to October) rainfall deciles – 2002–2022

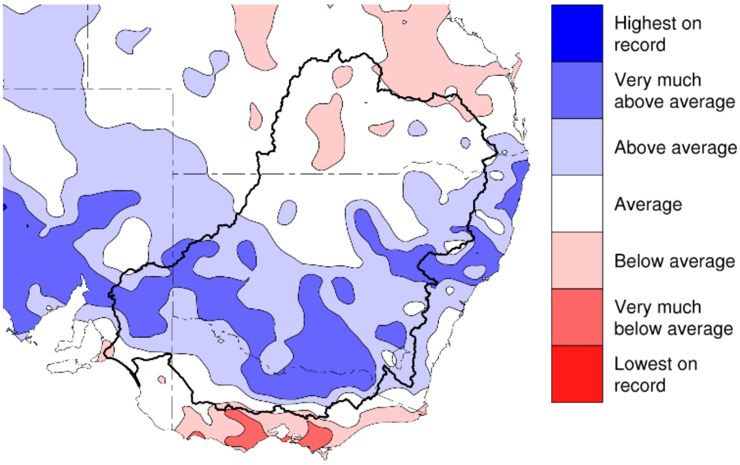

Figure 5 - Warm Season (November to April) rainfall deciles – 2002–2022

Temperature

Temperatures have risen across the Basin since the start of national temperature records in 1910. Record-warm monthly and seasonal temperatures have been observed in recent years. The year 2019 was the warmest year on record, with every year between 2013 and 2020 in the top 15 warmest. 2021 and 2022, which were abnormally wet years, were cooler than the 2013-20 period but still warmer than the long-term average (since 1910).

High temperatures add to water demand and increase stress on natural and human systems, increasing evapotranspiration from natural and cultivated vegetation. Overall, higher temperatures have compounding impacts on water availability. More water in the landscape and in storages is lost to evapotranspiration, water demand from the environment and agriculture increases, and catchments dry more quickly during periods of low rainfall and take longer to saturate and produce runoff at the end of a dry period.

Water storages

Water storage volumes in the Basin are highly variable and, as with all water storages, depend on or are impacted by rainfall, streamflow, runoff and evapotranspiration and water consumption. Total water storage volumes in the past 30 years (Figure 6) highlight the period of low water availability between 2003 and 2010, the extremely low water availability in the northern Basin during 2018 and 2019 and the subsequent recovery in the recent years. The chart also highlights that the volume of water captured in major public storages is significantly less in the northern Basin, where there is a higher reliability on unregulated streamflow for consumptive uses.

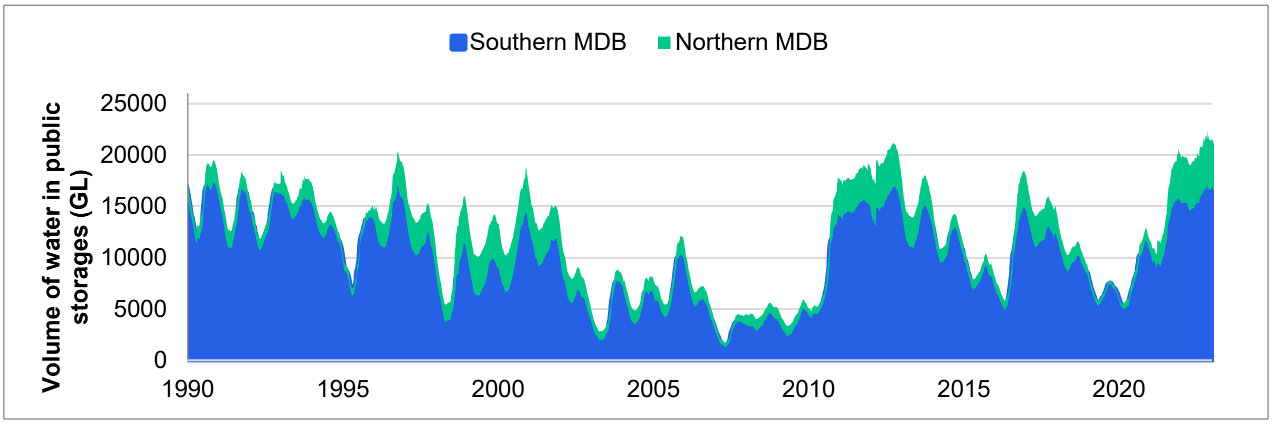

Figure 6 - Total water storage volume across major irrigation storages in the southern Basin (blue) and northern Basin (green) from 1900 to 2022.

Groundwater

Whilst groundwater and surface water can be highly connected, groundwater can offer an important alternative water source when there are shortages in surface water. Alluvial aquifer systems in the Basin are impacted by low rainfall, especially during the cooler months, and by reduced stream recharge and increased pumping for consumptive use during times of low surface water availability. Observed trends in groundwater levels often lag behind trends in surface water availability as groundwater systems can take longer to recover.

In 2019, the Basin received just 49% of its annual average rainfall, breaking the previous low annual rainfall record that was set in 1902. 2019 was also the third year of the driest 3 years on record. These extremely dry conditions had a significant impact on groundwater levels, due to reduced recharge and increased extraction over a sustained period (Figure 7). Above average rainfall and flooding through 2020-2022 increased recharge and reduced groundwater extraction. This resulted in a recovery of groundwater levels to above average conditions by 2022 (Figure 8).

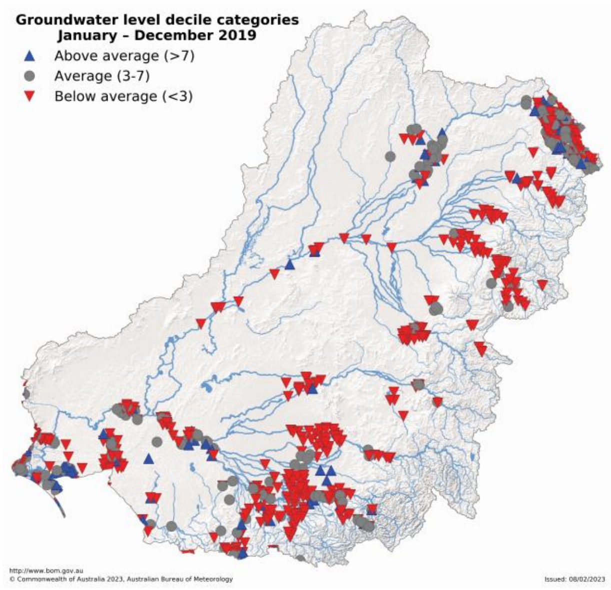

Figure 7 - Deciles for annual groundwater level peak in Jan. – Dec. 2019 (Reference period 1997 – 2022)

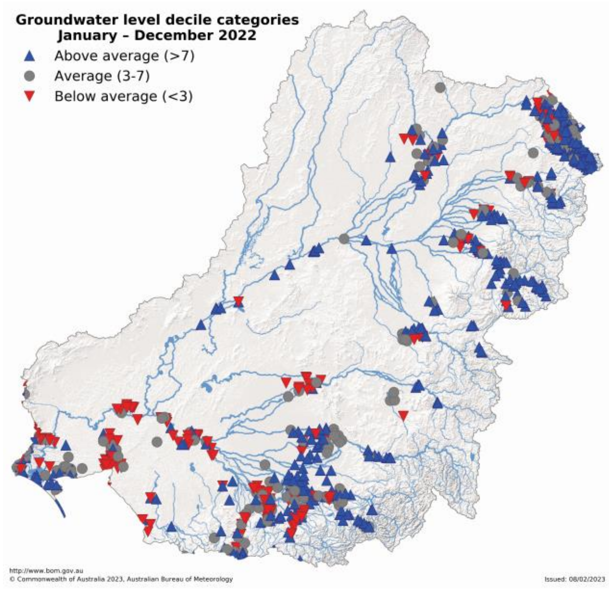

Figure 8 - Deciles for annual groundwater level peak in Jan – Dec 2022 (Reference period 1997 – 2022)

Future climate and water

The future state of the Basin and water-dependent industries is highly dependent upon the nature and magnitude of climate change impacts. Modelling of future climates provides indications of plausible hydroclimatic changes to conditions across the Basin. While the climate in the Basin has high year-to-year natural variability which is prone to dry and wet extremes, evidence provided by the CSIRO and the Bureau identify the climate of the Basin is changing and the future is likely to be warmer, drier and include more frequent droughts and extreme weather events (Bureau*2, 2020, 2022).

Plausible futures are explored in detail in the Bureau's National Hydrological Projections Reports. The National Hydrological Projections report for the Murray-Basin Region aligns broadly with the southern Basin, and the report for the Central Slopes Region aligns broadly with the northern Basin (Bureau*2, 2022).

To be sufficiently robust and adaptable in dealing with the challenges of climate change, the Basin Plan needs to consider 2 factors:

- A likely projected long-term decline in water supply due to a decline in cool season rainfall reducing runoff generation and groundwater recharge, alongside an increase in water demand across the Basin due to increased evapotranspiration associated with increased temperatures, and
- A projected increase in variability in the Basin's climate. Variability has increased over the past 123 years and this trend is likely to continue. This will result in longer periods spent in drought and the increased intensity of extreme rainfall that can lead to short duration high intensity runoff events.

The difference between these 2 challenges is visualised in Figure 9, taken from the National Hydrological Projections Report for the Murray Basin. The data helps to understand long-term changes, the year-to-year variability and projected averages. The blue and red lines show median rainfall from 16 plausible climate scenarios for the RCP 4.5 (moderate) and RCP 8.5 (high) greenhouse gas emission scenarios respectively. The shaded areas show the 10th to 90th percentile range for each of those emissions scenarios. The black line shows what a plausible individual scenario looks like. Under this scenario rainfall regularly exceeds the 90th percentile and regularly dips below the 10th percentile. This shows why effective water planning must adequately anticipate changes to averages as well as the extremes.

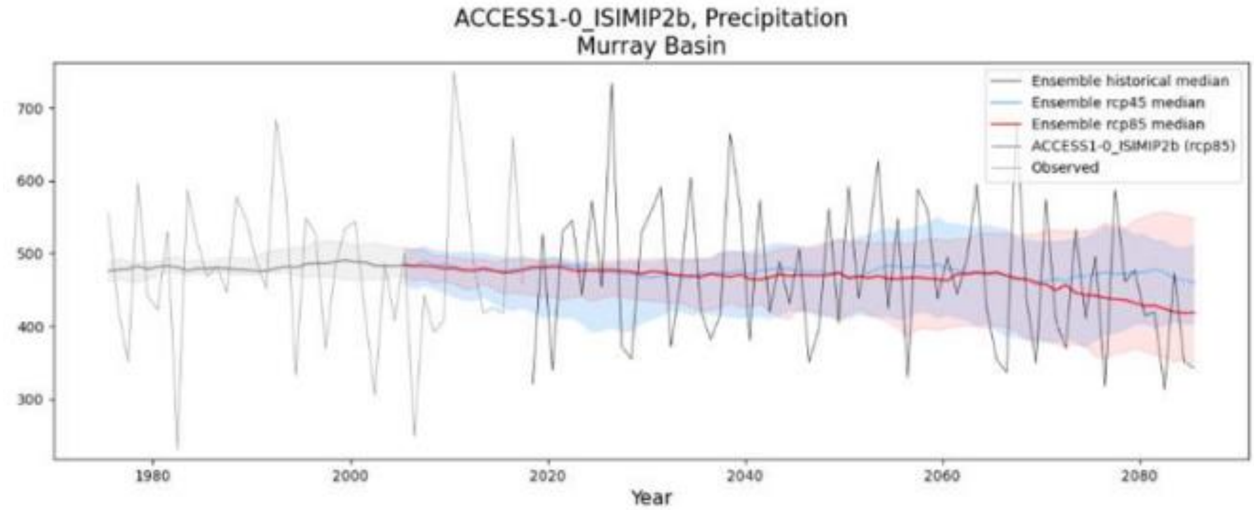

Figure 9 - Annual modelled precipitation projected to 2099 by each of the 16-member ensemble for RCP4.5 (blue) and RCP8.5 (red) in the Murray Basin region. The shaded areas represent the 10th to 90th percentile range for all ensemble members in the historical and future time periods. The time series for ACCESS1-0_ISIMIP2b (RCP8.5) is included (dotted line) to show the variability projected for an individual ensemble member. The grey line represents the observed historical median precipitation based on AWAP data. For more detail see Murray_Basin_National_Hydrological_Projections_Assessment_Report.pdf (bom.gov.au)

Rainfall

It is expected that the large variability in year-to-year rainfall totals will continue with some years being much wetter than average and some years being much drier than average. A continuation of the longer-term observed trends towards drying with a reduction in cool season rainfall is also projected (Bureau1, 2020).

Temperature

Climate projections indicate that the long-term warming trend in temperature will continue. The Basin area has warmed by around one degree since 1910 and will continue to warm (by 0.6–1.5 ºC in 2030 relative to 1995, and by 0.9–2.5 ºC in 2050 without mitigation), with more hot days and fewer cold days.

Runoff and soil moisture

Runoff has generally been well below average in both the northern and southern Basin over recent years and is generally projected to decrease in the future. A small decline in rainfall typically leads to a 2 to 3 times larger decline in streamflow. However, the disproportional change in rainfall/streamflow relationships can be much larger. Increases in temperature throughout the year are expected to increase potential evapotranspiration. In regions where reduction in rainfall, runoff and soil moisture is projected, this will increase the gap between supply and demand (Bureau*2, 2020, 2022).

Figure 10 provides projections of runoff using the same approach as Figure 9, showing that the changes to runoff, and therefore water availability, are much higher than for rainfall. The decline in runoff is stronger for the high emission scenario, where increasing temperatures lead to higher rates in water losses through evapotranspiration.

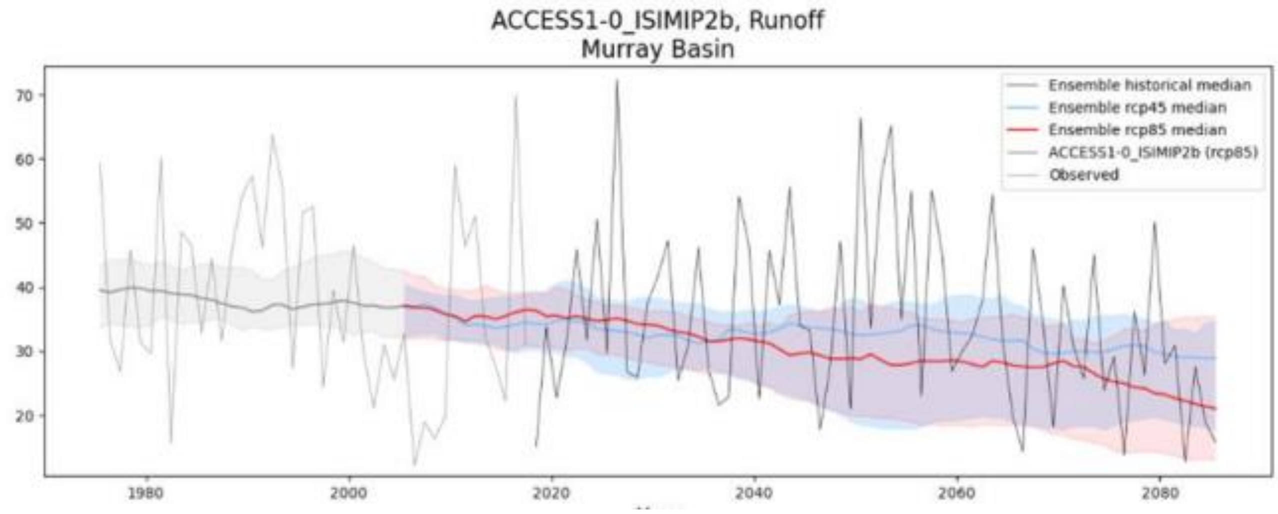

Figure 10 - Annual modelled runoff (mm) projected to 2099 by ensemble members for RCP4.5 (blue) and RCP8.5 (red) greenhouse gas emission scenarios in the Murray Basin region. The shaded areas represent the 10th to 90th percentile range for all ensemble members in the historical and future time periods. The time series for ACCESS1-0_ISIMIP2b (RCP8.5) is included (dotted line) to show the variability projected for an individual ensemble member. The grey line represents the modelled historical median runoff. For more detail see Murray_Basin_National_Hydrological_Projections_Assessment_Report.pdf (bom.gov.au)

Water information in support of water policy, management and use

All Australians have a stake in water policy and management. Water policy makers need access to water information to inform long-term water plans and strategies. Water managers need access to water information to effectively manage rivers and dams, and to implement plans. Water license holders need access to water information to make decisions about water use and trade. Communities need access to water information so they can effectively advocate for their interests and have transparency around how water management and policy decisions are made. To support these needs all Australians should have access to water information.

The Bureau's role in water information

During the Millennium Drought, it became apparent that water security and availability were a national issue requiring a national response. At this time Australia's water data and information were siloed across different organisations, using inconsistent standards and definitions hampering any national approach to ensuring secure and safe access to water. The Bureau, as the only public agency that is independent from policy and management decisions with the capability to collate information from over 200 organisations, was and continues to be uniquely placed to collect and publish national water information. As such, the *Water Act 2007* provided the Bureau the responsibility for collecting, managing, and disseminating Australia's water information.

Since 2008, the Bureau has been working closely with data collectors and stakeholders across Australia on data collection, warehousing and management, agreements for sharing and licensing data and upgrades to hydrological monitoring systems. Currently, the Bureau collects around 15,000 water information data files each day from over 200 agencies. The data collected under Part 7 of the *Water Regulations 2008* is used to underpin the Bureau's water information products (Water Information: Bureau of Meteorology (bom.gov.au)). The Bureau also develops and curates unique, trusted national scale, authoritative datasets that are critical inputs to water assessments, such as Design Rainfalls, Australian Gridded Climate Data and Geofabric. A list of the Bureau's current water information products is provided in Appendix 1.

The Bureau’s current capability to provide reliable and accurate information for water related hazards and water security is to be extended using a whole of Earth System Modelling approach to allow seamless (both spatially and temporally) hydrology across Australia. A fully coupled Earth System Model will enable the Bureau to better understand the complex interactions between land, atmosphere, and oceans. This builds on the Bureau’s current capabilities such as the Australian Water Outlook (AWO) and streamflow forecasting, and will translate into historical, nowcasting, short term (day to weeks), long range (seasonal to multiyear) and projections (decadal). Hydrological fields such as rainfall, evapotranspiration, soil moisture, streamflow and inundation extents will be available at 1km down to 30m resolution both at gauged and ungauged locations.

As Australia's trusted national weather agency, the Bureau has the unique opportunity to combine the collected water information with the climate and weather information it holds. This enables the Bureau to cover the entire information flow from weather observations, to modelling, to forecasts and warnings.

The Bureau vision for the future of water information

The water information ecosystem has fundamentally changed over the past 15 years. The growing number of water information sources has improved the availability of water information but has created the challenge of finding trusted information and the right information. At the same time, technology for sharing data and hydrological modelling have advanced substantially, and the expectation of water information users have grown. For these reasons, in 2022, the Bureau refreshed its approach to delivering on its water information responsibilities and produced a new vision, outlined in Figure 11.

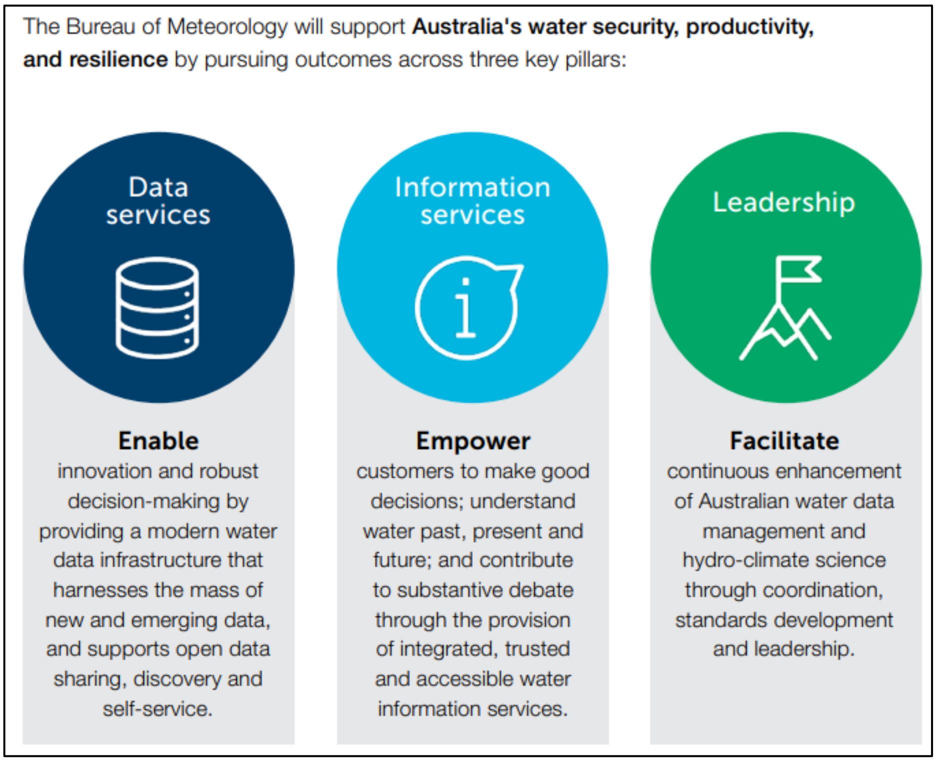

Figure 11 - The Bureau's vision for water information

Delivering on this vision will see the Bureau uplift its collection of Australia's water data, making that data more accessible and providing information services that are accessible to a broad range of non-expert users. The Murray–Darling Basin Water Information Portal (MDB WIP, 2023) is a first step in this direction. Developed in collaboration with the MDBA, the Department of Climate Change, Energy, the Environment and Water (DCCEEW) and Basin state government, the MDB WIP seeks to be a highly accessible and transparent source of information on all components of the water cycle – rainfall, streamflow, soil moisture, groundwater, water storage, water quality, water use and water trade. It seeks to be accessible at a Grade 7 level (13-year-olds), which is a significant change to the existing suite of water information products and services that are targeted at a more technical user base.

Murray–Darling Basin water market reforms

Water markets have become increasingly important as irrigation-dependent activity increases, water reliability falls, and the differences between high and low flows across the Basin become more extreme. During the 2017–19 drought there was widespread concern about access to water and the conduct of market participants in the Basin. (Quinlivan 2022). In 2019, the Australian Competition and Consumer Commission (ACCC) was tasked to review the operation of these markets and recommend reforms. In response to this review, the Department of Climate Change, Energy, the Environment and Water (DCCEEW) released their Water market reform roadmap in October 2022.

The data and systems reforms to be implemented under this roadmap seek to enhance transparency and availability of market data to improve knowledge and understanding of market activities and prices and enable regulators to identify and enforce compliance with market conduct rules (Quinlivan 2022).

The Bureau's role in water markets reform in the Basin

The Bureau is leading delivery of the data and systems components of the Roadmap, including

- A water data hub – a new digital platform for national water data management
- A water market website – allowing market participants and observers to access Basin wide near real-time water market information including pre-trade bids and offers.
- Water market data standards – which will facilitate the supply of water markets data to the Bureau.

These three components will improve water market transparency and future-proof national water information systems. They expand on the Bureau's long-standing water information management responsibilities under the *Water Act 2007* and will better support data sharing and access.

The water data hub, water market website and water market data standards will continue to build transparency, integrity, and confidence in the Basin's ~$5.1 billion water market through improved information access for decision-makers and farmers (Bureau 2022*3). All this will further ensure that all water users will have access to the information they need to ensure this critical resource is managed appropriately.

The Bureau has made significant progress on the ICT design for the national Water Data Hub and is working closely with data providers on the development of the new water market data standards with the first phase of stakeholder consultation completed.

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- Quinlivan, Daryl AO (2022), Water market reform: final roadmap report, Chapter 4 – Data and systems

Appendix 1 – Summary of Bureau products and services

Water information products and services

The Bureau has a large number of products and services on water data, water status, and water forecasts it makes publicly available via its website or more tailored through subscription services. These include:

- **Australian Water Data Service** (AWDS) provides access to spatial water data, APIs and maps that underpin water related insights, analysis and information published on the Bureau.
  Australian Water Data Service (bom.gov.au)
- **Design rainfalls**
  Providing statistical estimates of rainfall for specified depths, probabilities and durations to be used by engineers and hydrologists in the design of infrastructure including gutters, roofs, culverts, stormwater drains, flood mitigation levees, retarding basins and dams
  Design Rainfalls: Water Information: Bureau of Meteorology (bom.gov.au)
- **Geofabric** is a specialised Geographic Information System (GIS). It registers the spatial relationships between important hydrological features such as rivers, water bodies, aquifers and monitoring points.
  Geofabric: Water Information: Bureau of Meteorology (bom.gov.au)
- Groundwater Information Suite provides data on bore water levels and trends, and associated data on hydrogeology and groundwater management. This includes the **Australian Groundwater Explorer, National Atlas of Groundwater Dependent Ecosystems_and the National Groundwater Information System**
  (www.bom.gov.au/water/groundwater/index.shtml)
- **Hydrological Reference Stations** are a network of 467 monitoring stations that identifies streamflow trends and detects long-term variability and change in streamflow (Introduction: Hydrologic Reference Stations: Water Information: Bureau of Meteorology (bom.gov.au))
- **The Australian Water Outlook** provides Australia-wide information on key landscape water balance components, for **Historical**: daily gridded outputs of precipitation, soil moisture, runoff and deep drainage from 1911 until yesterday. **Seasonal forecasts (1-3 month)** with monthly outputs available for root-zone soil moisture, evapotranspiration, and runoff –updated monthly. **Projections** of changes in precipitation, soil moisture, evapotranspiration, and runoff for a series of aggregated periods out to the end of the century.
  (https://awo.bom.gov.au/).
- A **National Water Account** which provides a detailed annual accounting of water assets and liabilities for 11 key water-use regions.
  (www.bom.gov.au/water/nwa/2020/)
- **Water Data Online** provides watercourse level, watercourse discharge, storage level, storage volume, electrical conductivity, turbidity, pH and water temperature information from approximately 5000 water monitoring stations across Australia, many of which are updated daily.
  (www.bom.gov.au/waterdata)
- **Water Storage Dashboard** allows comparison of water levels and volumes for more than 300 publicly owned lakes, reservoirs and weirs in each States and Territory, and shows how much water is available over the entire country.
  (www.bom.gov.au/water/dashboards/#/waterstorages/summary/state)

- **Water Markets Dashboard** allows viewing and comparison of the volumes and prices of water entitlements and allocations being traded in Australia. One can also view the number and volume of entitlements that are on issue nationally.
(www.bom.gov.au/water/market)
- The **Murray–Darling Water Information Portal** (MDB WIP) brings together current, recent, and historic data on water availability, water in storages, groundwater, streamflow, allocation volumes, water take, water markets, water quality, and rainfall and soil moisture for the Basin in a central location. Users can search the portal for information by town, river, catchment, and current location.
(www.mdwip.bom.gov.au)
- **Streamflow forecasts** including 7-day and seasonal streamflow.

Bureau of Meteorology Real Time Data Services:

The Bureau provides a range of real-time data services, many of which are used by water managers to operate water infrastructure safety and efficiently
(http://reg.bom.gov.au/other/charges.shtml)