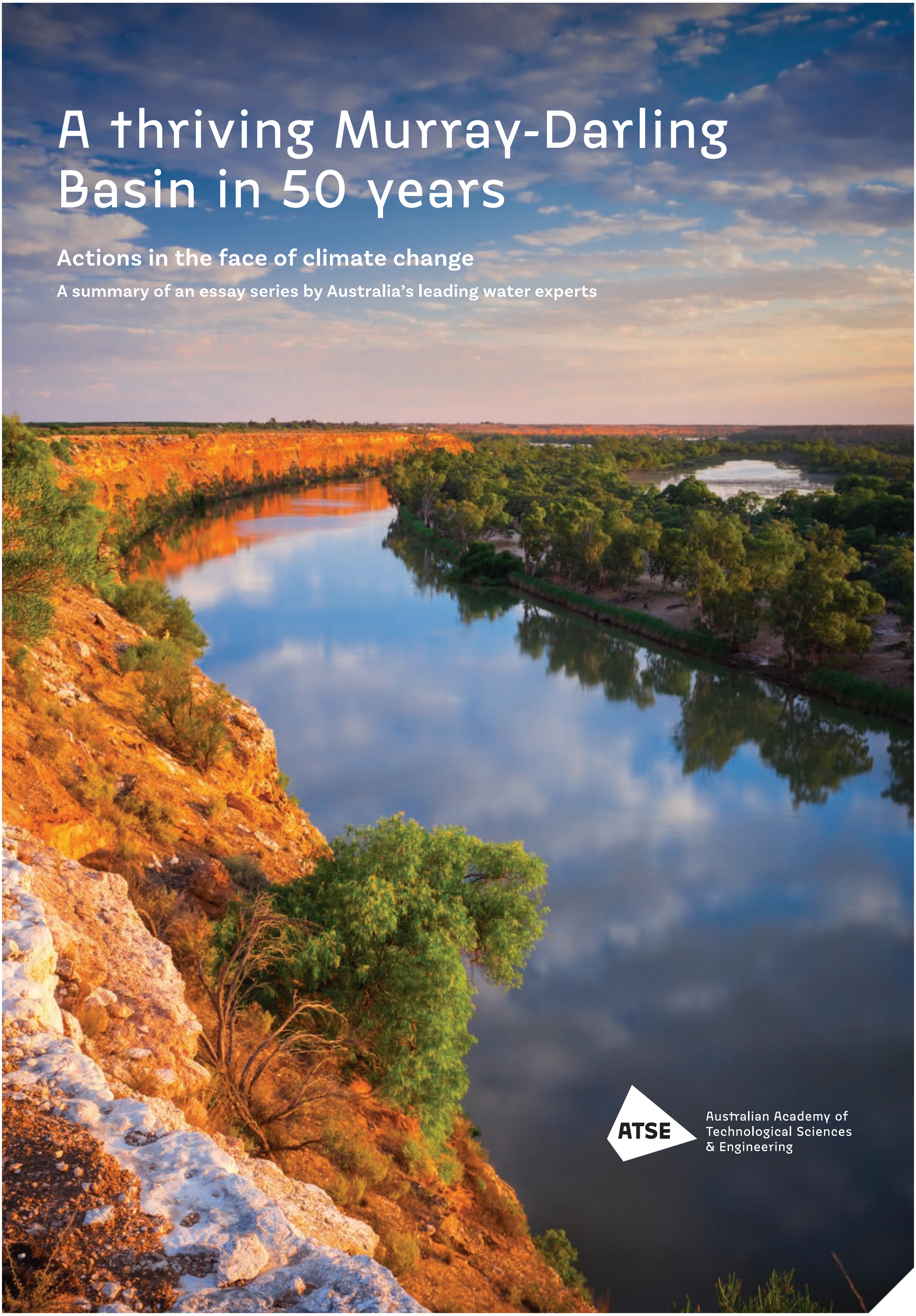
# A thriving Murray-Darling Basin in 50 years

## Actions in the face of climate change

A summary of an essay series by Australia's leading water experts



ATSE
Australian Academy of Technological Sciences & Engineering

The Thriving Murray-Darling Basin project explores what is needed in the Basin for a resilient, healthy and sustainable river system and a thriving, resilient community in the face of a changing climate over the next 50 years.

The *Murray-Darling Basin* (MDB or the Basin) is a critical Australian environmental and economic asset. It covers one-seventh of Australia's landscape, represents an economically important proportion of Australia's environmental resources and is home to substantial biodiversity.

It is responsible for delivering a major share of Australia's Gross Domestic Product. To safeguard and protect this resource for the future, Australia needs to take urgent action to overcome the climate challenges of the next 50 years.

ACTIVE MANAGEMENT OF and investment in the Basin is required to protect its ecosystems, ensuring that water is, and remains, available for diverse economic, cultural and social needs. Long-term governance featuring regional and rural community development is needed, along with the evolution of an agriculture industry based on decreased water availability and accepted water sharing policies.

Successful implementation of this 50-year vision would give the Murray-Darling Basin new life. Australians will benefit from a healthy environment and thriving ecosystems, vibrant and resilient communities, self-determination and engagement of Aboriginal and Torres Strait Islander people and communities in water management, and secure water for productive regional industries. Improved irrigation practices and technology for water allocation would secure food production, while helping us produce more with less land, less water and less intensive infrastructure.

The Basin Plan has formidable challenges of management, governance and stakeholder engagement in achieving any successful implementation. Significantly, it will require adjustments to respond to the impacts of climate change and enable a fair distribution of water between the four Basin States and the Australian Capital Territory, balancing outcomes for the environment, industry, communities and Aboriginal and Torres Strait Islander peoples.

As more water has been diverted from the environment since European colonisation, the rivers in the Basin have become less healthy, especially during droughts. Reduced river flow has resulted in more salt in the Basin's rivers and increasing outbreaks of blue-green algae. There are now fewer native fish, birds and mammals in the Basin than there were before Europeans arrived. At least 20 mammal species have gone extinct, and conservation is needed for around half of the Basin's fish species.

The Essays present key considerations for the Murray-Darling Basin Authority Climate Workplan and the 2026 Basin Plan Review in providing the best outcome in 50 years' time, informed by the applied science and technology expertise of Fellows of the Australian Academy of Technological Sciences and Engineering (ATSE).

The recommendations are derived by ATSE from its Murray-Darling Basin Essays project, co-chaired by Dr John Radcliffe FTSE and Dr Therese Flapper FTSE.

The full set of essays is available at atse.org.au

## WATER FORUM

Invited through ATSE's Water Forum, eminent ATSE Fellows and other recognised scholars developed a science- and technology-informed perspective for the long-term future of the Murray-Darling Basin by contributing essays on various aspects of its ecosystem and economy with a 50-year horizon perspective. Emphasis is placed on current evidence-based thinking about the future impacts of climate change.

The papers encompass an Indigenous Preface, the Basin's hydroclimate (Zhang et al.), its water quality (Verhoeven et al.), surface water-groundwater connectivity (Ross and Williams), river landscapes (Fitzpatrick et al.), Ramsar Wetlands (Muller and Whiterod), Coorong, Lower Lakes and Murray Mouth (Mosley et al.), the aquatic environment (Koehn), the regional economy (Boland et al.) and achieving a healthy, resilient and sustainable Basin (Wheeler).

*Cover image: A bend in the Murray River in South Australia with agriculture alongside the natural environment. Bengoode, iStock.*

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# Our 50-year vision

**A healthy environment**
With greater surface flows, stable groundwater reserves and water flow regimes that support aquatic and terrestrial ecosystems with high quality water.

**Vibrant communities**
Vibrant and resilient regional, rural and remote communities with sustainable economic futures and improved mental health outcomes including a skilled and thriving workforce.

**Aboriginal and Torres Strait Islander self-determination**
Engagement, including for cultural water.

**Water for industries and regional transition**
Sufficient water of the right quality allocated to sustain a variety of industries, enabling regional transition, where required, for productive profitable outcomes.

**Sustainable food practices**
Reducing the irrigated land footprint and improving sustainable irrigation practices while securing domestic food production.

**Technology transformation**
Innovation and adaptation, infrastructure and automation, for responsive water allocation.

**More productivity**
Producing more from less land, less water and less intensive infrastructure.

**Address the SDGs**
Addressing the Sustainable Development Goals (SDGs) and applying an Environmental, Social and Governance (ESG) framework.


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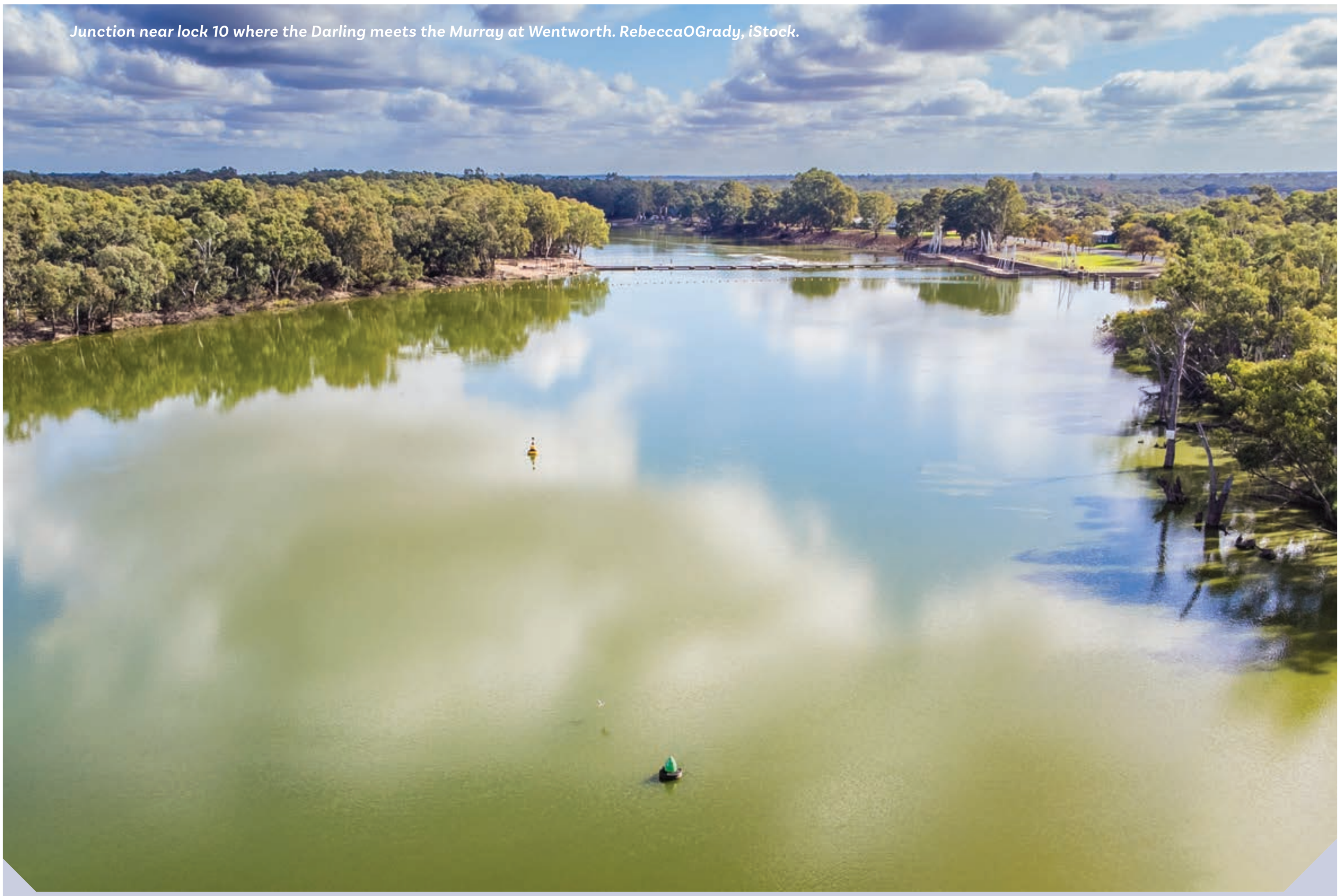

Junction near lock 10 where the Darling meets the Murray at Wentworth. RebeccaOGrady, iStock.

HOW

# Key messages

### 1. Prepare for the impacts of climate change in the Murray-Darling Basin immediately.

- Urgently increase the research investment to develop new knowledge and substantive technologies (including long-term monitoring, data analysis, modelling and assessment) to create effective long-term hydroclimate management policy accepted by all the Basin States and the ACT.
- Model flows for the next 50-years by increasing available research investment and advancing capabilities.
- Redistribute the future reduced stream flow in the MDB to optimise consumptive and environmental uses of water.
- Update Basin Plan modelling to include changes to the river operating rules for efficient connective analysis and management of both surface water and groundwater sharing.
- Review water sharing rules and carbon sequestration capabilities of freshwater wetlands, including the 16 Ramsar listed Wetlands in the MDB region.
- Avoid dewatering of the catchments, especially the wetlands, to prevent them becoming carbon emitters and damaging the Basin system further, as well as mitigate acid sulphate soil production.
- Upgrade the barrage gate control systems to effectively manage the environmental water flow for restoration of ecological health of the Coorong estuary, Lower Lakes and Murray Mouth (CLLMM) wetland region.

### 2. Act now to ensure a healthy, resilient, and sustainable Murray-Darling Basin as part of the 2026 Basin Plan Review.

- Evolve and retain a formidable and efficient water governance Framework.
- Adopt an efficient water recovery program by critically assessing the existing programs against a 50 year horizon (2076).
- Develop proper regional and rural community development and structural adjustment programs within the Basin, including empowering engagement with Aboriginal and Torres Strait Islander peoples and communities.

### 3. Build opportunities for economic development and agriculture in regional Australia aligned with future water availability.

- Increase agricultural production capabilities from decreased water supply.
- Apply optimal water sharing policies and adapt sustainable management practices with innovative and advanced technologies, capitalising on the skilled workforce.
- Implement an ESG Framework where industries value the societal expectations and environment by embedding principles of a circular economy.

**WHAT**

# Our recommendations

1. **Prioritise the following key elements of holistic, connected and interdependent governance for the MDB:**
   - Reinstate a national body to provide objective unbiased advice on national water management, including MDB issues, independent of Commonwealth and state government departments.
   - Maintain a Commonwealth Minister for Water, who encompasses the MDB, and is in an Environment, not Agriculture portfolio.
   - Maintain the Office of the Inspector-General of Water Compliance. Ensure its ability to enforce water theft and water trading offences.
   - Complete the development and implementation of Water Resource Plans (WRP) and require them to consider long-term interconnected regimes and impacts of groundwater and surface water extractions, as well as dependent ecosystems and Aboriginal and Torres Strait Islander peoples' cultural needs.
   - Include baseflows and specific rules to enable continual adaptation for climate change, with a requirement for decadal review.
   - Establish Task Forces with specific objectives and time frames for topical and technical elements. Topics of immediate need are water quantity, water quality, cultural water, economic instruments, modelling, satellite and Geographic Information System data, water trading and risk assessment.

2. **Ensure transparent, evidence-based and data-driven decision-making that includes short, medium and long-term modelling of environmental, economic, social and cultural impacts.**

3. **Establish, maintain and resource a central data custodian for all water quantity and water quality monitoring data, all modelling and all other relevant data inputs for driving decision-making, publicly available and shared by all stakeholders.**

4. **Establish, maintain and resource a single central public domain for all consultation, knowledge sharing, information and listing of all funded projects and programs, no matter the jurisdiction.**

5. **Establish an independent central Water Markets Agency that operates across the Basin, providing standardised definitions, terms and contracts for water trading as well as monitoring and possibly enforcement.**

6. **Review institutional arrangements that govern property rights at a Territory, State and Commonwealth level for consistency as well as climate-proofing. Seek to mitigate inequitable benefits from institutional governance, including addressing the cultural water rights of Aboriginal and Torres Strait Islander Peoples.**

7. **Evolve the Basin Plan using the following principles:**
   - Agreed assessment timeframes to be applied to estimation of water balances and resource condition indicators.
   - Require climate change and long-term (50 year) impact modelling for water quality and water quantity.
   - Include integrated land and water management strategies.
   - Require the consideration and modelling of cumulative effects over use, time and location.
   - Enhance governance and stakeholder representation to include State, Territory, city, regional, rural and remote communities; Indigenous Peoples; environmental and ecosystem organisations; commercial, industrial agricultural, mining and manufacturing interests; and associations, industry bodies and not-for-profit organisations. Implement a method of governance to consider appropriate representative contribution.
   - Create a robust risk assessment framework that is multi-dimensional, interdependent and driven by data, considerate of environmental, economic, community and cultural impacts.
   - Include ESG Principles to drive the Framework for adaptation and measurement.

*Allan Tannock Weir on the Warrego River, south of Cunnamulla, Queensland. tracielouise, iStock.*

# Essay summaries

The essays presented within this collection apply data-driven inputs towards decisive calls to action to provide the best opportunities for positive outcomes for the Basin.

## Hydroclimate of the Murray-Darling Basin

**Zhang L, Chiew F and Hatton T**

While addressing these issues of the MDB, Zhang et al. advocate to develop a long-term hydroclimate management policy that best adapts to the climate change of the next 50 years by minimising the impact on the hydrological characteristics of the Basin region. Around 66% of the streamflow is generated from 12% of the Basin's area. Though the MDB is typical of an arid inland river basin with low runoff and high evaporation losses, floods and droughts are very common due to very high spatial and temporal streamflow variability. Also, the Basin has warmed by one degree since 1910 and there is a risk of reduced average runoff (9% by 2030 and 23% by 2070). Zhang et al. also point out that there is an urgent need to invest in research to develop new knowledge and technologies for producing highly efficient projected water availability outputs. If implemented, policymakers will be able to develop future-ready action plans for a healthy and sustainable integrated Basin management system.

## Challenges and adaptation needs for water quality in the Murray-Darling Basin in response to climate change

**Verhoeven TJ, Khan SJ and Evans MC**

As climate change is already affecting the streamflow and degrading water quality, it is important to elevate water quality protection activities and management capabilities to meet future long-term water uses.

Verhoeven et al. note that current water management initiatives will not deliver the additional environmental benefits sought under the MDB Plan, as recently acknowledged by the Commonwealth government. They identify several types of anthropogenic and naturally occurring threats including emerging pathogens that can deteriorate the water quality of the Basin. They also make several interlinked recommendations, based on their analysis using the available hydroclimate metrics, that may lead to mitigation of water use vulnerabilities and threats to future MDB water quality under climate change.

The success of these recommendations lies in the on-going implementation of the Plan, with an integrated effort needed from all levels of the Australian government system, communities, and industries for long-term benefits. However, the reduced future flows predicted under climate change will need to be redistributed to optimise consumptive and environmental uses, while the detrimental effects of flow reductions may be counterbalanced by implementing efficient land management measures in the Basin regions.

## Surface water and groundwater connectivity in the Murray-Darling Basin: Integrated management of connected resources

**Ross A and Williams J**

Ross and Williams state that the increased use of groundwater, supporting baseflow to the unregulated rivers, depletion of streamflow due to water extraction and changes in weather conditions are due to identifiable risks (i.e., climate change, irrigation and floodplain harvesting, afforestation, coal seam gas and coal mining) associated with groundwater-surface water connectivity. Drier seasons always worsen these risk factors. They also mention that improvements and expanded coverage in integrated groundwater and surface water models are essential to develop the integrated management of those resources. These will require enhanced long-term monitoring, assessment and effective management.

Additional investments will be required to improve the accuracy of measurements and the interpretation of monitoring results, and to extend and improve integrated modelling of connected water resources, taking account of the impacts of climate change and cross impacts of extractions.

## Riverine ecosystems and health: Soil-landscapes

**Fitzpatrick RW, Mosley LM, Thomas BP and Stirling E**

Fitzpatrick et al. provide an overview of the state of soil-landscape ecosystems across the Basin and their significant decline since European settlement. Soil-landscape ecosystems are closely linked to other natural features such as climate, vegetation, geology, hydrology, water availability, and overall ecosystem services and are therefore useful for assessing a 50-year future. Eight adaptive soil-landscape management recommendations are presented based on two scenarios — a drying and a wetting scenario — as soil-landscapes behave differently under each regime. The most significant impacts on soil-landscapes from these two scenarios include acid sulphate soil production, salt leaching and salt concentration, organic matter distribution, production of sodic and saline soils, soil erosion and bank slumping and soil compaction.

Soil landscapes are substantially impacted by overgrazing, drying and drought, wetting and floods, as well as infrastructure related disturbance. To achieve the best "sustainable soil-landscape management" for the MDB in 50 years, we need an integrated approach implementing a seasonal wetting and drying regime to the river and adjacent wetland regulation. This will substantially reduce the many risks related to the prolonged drying and subsequent rewetting, which can lead to the redistribution and accumulation of environmental hazards within a soil profile and the floodplain.

## Climate change challenges and adaptation needs for Murray-Darling Basin Ramsar Wetlands of international importance

**Muller KL and Whiterod N**

Muller and Whiterod note that most of the 16 MDB Ramsar Wetlands are at risk of failing to meet their water requirements under current water sharing rules due to partial implementation of the Basin Plan. To effectively manage the adaptive capacity of MDB Ramsar Wetlands, we need to know how to interpret climate velocity (the rate of climate change) which is a function of water regime alteration. The wetlands are indeed a natural solution to climate change; hence "dewatering" wetlands may lead to substantial methane emissions and losses of significant carbon storage ('Teal Carbon' ecosystem) facilities. Muller and Whiterod also address recent assessments of climate change vulnerabilities in the MDB, which did not include an assessment of carbon stores or carbon sequestration capacity — carbon was only considered in terms of blackwater events. They advise that all water management decisions and operations need to be conducted primarily for ecological benefits and on-going ecosystem service provisions in the knowledge that this is ultimately the most cost-effective way of delivering, purifying and storing water for all users.

Australia has made commitments to the 'wise use' of all Australian Ramsar Wetlands in the face of climate change challenges, including the maintenance of their ecological character. The Basin contains 16 Ramsar-listed Wetlands of international importance that have different climate change vulnerabilities and adaptive capacities. Our economic and policy frameworks should include the ecosystem services provided by these Ramsar Wetlands as well as other ecosystems in the MDB. The alternative is the on-going degradation and loss of ecological function in the MDB, and ultimately the loss of resilience, adaptive capacity and wellbeing for the humans who depend upon it.

## The past, present and future of the Coorong, Lower Lakes and Murray Mouth

**Mosley LM, Zampatti BP and Gibbs M**

The Ramsar-listed Coorong estuary, Lower Lakes, and Murray Mouth (CLLMM) wetland region have experienced substantial ecological decay over the last century due to reduced inflows caused by inefficient river regulations and water extraction, and unfavourable hydroclimate effects and natural calamities like the Millennium Drought.

Mosley et al. conduct a critical assessment of the causes for decayed ecological health in the CLLMM region and advise on the hydrological restoration, ongoing learning, and evolution of strategies that maximise the benefits from environmental water, coupled with infrastructure improvements. They also observe that the implementation of the Basin Plan has not resulted in expected increased flow of environmental water in the River Murray, particularly at the end of system and this may, at least in part, be a consequence of climate change.

Mosley et al. propose a more automated barrage operating system, or rebuild as well as upgrade the barrage gate control systems. Enabling the operation of hundreds of gates in the barrages to manage finer-scale manipulations in response to flow, tide and prevailing wind will create a 'softer', more transparent and dynamic estuarine interface. Careful adaptive management to mitigate risks of seawater intrusion that may harm the ecological, cultural and socio-economic values of the Lower Lakes will be required.

## Restoring sustainability to Murray-Darling Basin freshwater fish and aquatic ecosystems

**Koehn JD**

Koehn describes the riverine ecosystems of the Basin and their health. They are generally in poor condition due to impacts from a range of threats, and many of these valuable ecological assets continue to decline. While much attention has been given to economic development and management in the MDB, investment in ecological management has lagged. The greatly diminished state of native fish populations (losses of > 90% in the past 150 years) together with massive fish kills in the Darling River and explosions in alien carp populations all provide clear wakeup calls to the emergency occurring in MDB aquatic ecosystems. Comprehensive attention must be given to all biota, aquatic ecosystems, and the ecological services they provide. Reductions in the amounts of environmental water recovered, pauses in Basin Plan implementation and neglecting to account for the consequences of climate change have postponed any major environmental improvements.

To build ecological resilience, there is a need to restore populations, habitats and ecosystems. Achieving this requires improved management of water for the environment including full implementation of stalled environmental water reforms, further potential changes to water policy, and a comprehensive program of additional measures to address the range of other threats impacting native fishes. Restoring ecological assets can be achieved by working across jurisdictions, communities and stakeholders. The challenge is to have the long-term vision, political will, commitment, and adequate resourcing to implement these necessary actions. As the decline of MDB native fish populations has occurred over more than a century, a long-term strategy is needed for recovery.

In 50 years, Basin aquatic ecosystems and their biota can be sufficiently restored such that they are sustainable, resilient environments to provide for the socio-ecological and economic needs of future generations in the face of the challenges of climate change.

## Challenges and adaptation opportunities for the Murray-Darling Basin in response to climate change: Industry development & adjustment

**Boland A-M, Cummins T, Flanagan-Smith C, Larsen C and Schwarzman R**

Boland et al. address the emerging challenges and opportunities for the agricultural industry in the MDB considering four plausible futures in 50 years: base case, drying and contracting agriculture, adaptive and market-driven agriculture, water abundance and agriculture powerhouse. The cases are evaluated through critical variables like water, climate, commodity mix, production systems, and market conditions. The authors conclude that the preferred future is one where industry works with society and the environment, relying on advances in technology and sustainable management practices, and embedding principles of a circular economy (eliminate waste and pollution, circulate products and materials, and regenerate nature). Hence, they identify critical adaptation factors for a future-ready agriculture as water resource sharing, producing more from less, securing domestic supply, thriving in export capabilities, using innovative and advanced technologies, capitalising on a skilled workforce, and responding to the Basin's societal and cultural values.

Irrigated agriculture has historically been responsible for around 30% of the gross value of agriculture production despite representing only 3% of the land used for agriculture in the Basin. In a 50-year period, there is a possibility of the expansion of irrigated agriculture systems as a future-ready industry with reduced water supply. But significant impacts of climate change will be visible if not addressed through innovative technology and sustainable management practices supported by a favourable policy environment.

## Achieving a healthy, resilient and sustainable Murray-Darling Basin

**Wheeler SA**

Wheeler states that continued focus is essential to ensure water governance structures are strong. Though there are a few welcome efforts to improve MDB water governance, policy reforms and continued invigilation are essential for strong governance, and to ensure that monitoring, compliance and enforcement are followed by all states — otherwise there is a real danger of further reduced environmental sustainability. Wheeler also states that there is considerable room for improvement in rural development and structural adjustment programs within the MDB, mainly the water recovery program.

Based on Wheeler's review, there are three key water recovery and economic development policy lessons that need to be considered to mitigate the hydroclimate issues in the Basin: proper structural and economic development policies, avoiding policy instruments that have substantial unintended consequences, and using buybacks as the most effective and efficient form for water recovery among all the water recovery programs in the MDB.

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# Principles for adaptation

## CONSULT

Consolidate and make transparent stakeholder and community consultation processes for Murray-Darling Basin Plans and governance.

## MONITOR

Develop and implement water monitoring to provide timely and consistent volumetric water quantity and quality data across Basin states, stakeholders and institutions.

## MODEL

Centralise publicly available modelling of Basin attributes including: surface water, groundwater interactions, flow regimes, water quality for various time-series and time-scales, climate change scenarios, uses and users.

## ASSESS

Assess impacts of Basin vegetation, fire regimes, aquatic and terrestrial species and geographic range, water chemistry, flow regimes, engineered infrastructure, management actions, population and demographic changes, and industry changes.

## RECOVER WATER

Use water buybacks as the primary short-term mechanism to deliver the water recovery target component of the Basin Plan.

## PLAN

Develop, evaluate and implement comprehensive water quantity and water quality management strategies for Basin futures including water trading and allocations connected to regional community and agriculture needs.

## REVIEW & IMPROVE

Conduct Sustainable River Audits across the Basin at the right time-scale and geospatial increment to inform data-driven decision making.

## RESOURCE

Provide resourcing including the right people with the right skills, monitoring and modelling capacity and capability, infrastructure and capital and operating finances.

## LISTEN & LEARN

Ensure community awareness and participation in the development and publication of holistic Integrated Basin Strategies with water at their heart.

## COMMIT

Ensure ongoing review and adaptation on a range of time-scales with a commitment to objectives that deliver long-term protections for the Basin.

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The Academy acknowledges the Traditional Owners of the lands on which we meet and work. We pay our respects to Elders past and present.

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