ATSE PAPER

SEPTEMBER 2022

Technologies for water management

Australian Academy of Technological Sciences & Engineering

Water management in an ecologically diverse continent like Australia is challenging, and at times contentious. Australia is recognised as a world leader in water management, but faces significant, well-documented challenges that will only increase as the climate changes.

As the climate changes, water management is becoming an increasingly difficult policy challenge for the nation. To manage freshwater river systems, particularly complex ones like the Murray Darling Basin, decision-makers need to know how much water is in the system, where it is, where it goes, and the value of this water.

To make accurate predictions for future water management, catchments need to be closely monitored which is a challenge in complex systems with multiple water management bodies. This can lead to unmanaged water withdrawals, water loss, and competing upstream and downstream demands.

Decision-makers need access to sufficient and complete information and data to provide reliability, fairness of distribution and compliance with regulations for these systems.Since the completion of the National Water Initiative in 2004, the Australian Productivity Commission has conducted multiple progress reviews identifying the many challenges that invite technological solutions. As technology advances — improving forecasting and monitoring — there are opportunities to improve the data gathered. Careful analysis of this data — using people power and technological advances — produces pertinent information that shapes crucial decisions made about Australia's water management.

Providing clear and useful information for water management from accurate and up-to-date data is a complex task made more so by Australian hydrology's large fluctuations (which is often quoted as the highest in the world).[1] Additionally, Australia has a highly complex system of water management and regulation, with different responsibilities sitting across levels of government.

The key challenges of understanding water availability, how it moves in rivers across states and territories, and forecasting changes in the short, medium, and long term, are tasked to the Australian Bureau of Meteorology (BoM) under the *Water Act 2007*. However, each state or territory — and their respective water utilities — use different technologies to measure and report their water data depending on their water management needs.

This discussion paper outlines the technology challenges created by the way water data is collected, managed, and used around Australia, and considers barriers to implementing new technology for Australia's highly complex river systems. The focus of this paper is specifically on regional water systems.

1. Chiew F and Prosser I (2011) Water and climate. In: *Water — Science and Solutions for Australia* (Editor: I Prosser), CSIRO Publishing, (ISBN 9780643100527), pp. 29–46.

UNDERSTANDING THE CHALLENGES

The challenges in monitoring and managing water vary widely, depending on the objectives and the landscape. Good information from accurate and timely data is necessary to support good decision making, but the challenges of capturing data and presenting it as useful information differ depending on the needs of the 'end user' of the information.

Based on the collective experience and expertise provided by ATSE Fellows and consultation with external stakeholders (such as senior technical staff from catchment regulators and other technical information providers such as the Bureau of Meteorology), key technological challenges can be grouped under three broad themes.

1. Technologies for data collection

2. Technologies for data management and transfer

3. Technologies for data use

KEY MESSAGES

1. Technologies for data collection

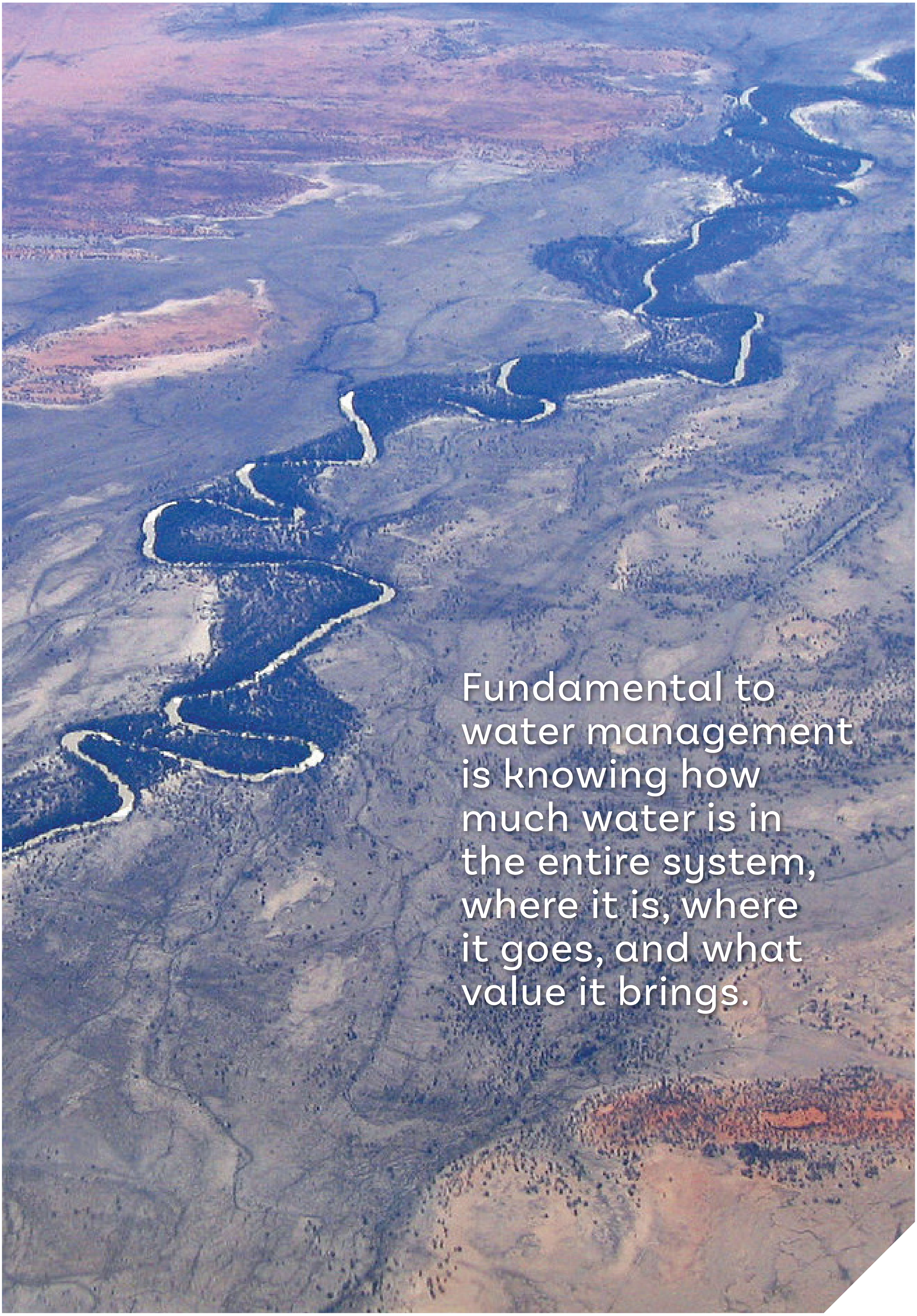
Emerging technologies for data collection need to incorporate systems for gathering metadata or contextual information if they are to work towards replacing in-field measurements.

2. Technologies for data management and transfer

Developing and implementing technologies to streamline data management, integration, and transfer – including in real or short timeframes – will allow water managers to efficiently analyse quality data and use that information to make the best possible evidence-based decisions.

3. Technologies for data use

Designing modelling technology that can handle imperfect data, in real time, to provide clear information in usable outputs should be a priority for future technology development. Providing clear information and outputs from data analysis will increase the likelihood these are used in evidence-based decision making for a range of end users.



Fundamental to water management is knowing how much water is in the entire system, where it is, where it goes, and what value it brings.

1. Technologies for data collection

New technologies for aquatic and riverine environmental monitoring are needed to improve what is currently a laborious and costly process, particularly when gathering information about:

- **Basic biological data collection** – improving the efficiency and effectiveness of biological monitoring (e.g., fish population recruitment, birds nesting and breeding events, plant and tree growth data, and invertebrate population health) to understand the impacts of water on local biodiversity.
- **Improved ecological monitoring** – assessing ecological responses in environmental or agricultural systems to water availability (floods and flushes) or water shortages (droughts or inadequate utilisation of environmental water allocations).
- **Real time water flow monitoring** – to measure data and provide real-time information about water inputs, flows, and usage across a water system. This is especially relevant for water managers and users during drought or flood conditions where real benefits such as flood control and water recapture could be realised if data could be analysed, and information provided in real (or close to real) time.

While advances in sensor technologies (such as smart water solutions that use Internet of Things technologies to monitor and measure water quality) have made some progress towards more efficient data collection, there is still some work to be done in terms of how emerging technologies can provide useful information for a variety of end users. Specifically, when using sensors, the metadata (information about the collected data and allows the user to make an informed decision about whether the data is fit for the required purpose) that would be collected by people in the field using traditional sampling methods is frequently lost. This metadata, and the context it provides for data analysis and interpretation, is critical in developing information and outputs that are appropriate for various end-users.

KEY MESSAGE

Emerging technologies for data collection need to incorporate systems for gathering metadata or contextual information if they are to work towards replacing in-field measurements.

2. Technologies for data management and transfer

Even now, before the wide implementation of the newer sensor and IoT technologies (that give continuous readings and data points when deployed), there are large quantities of data about water in Australia.

The structure of Australian water management means that each entity or organisation is often collecting and holding its own water data to meet its own specific needs. For example, an urban water utility may be focused on gathering data about how water is distributed, while State or Territory departments responsible for water management will be focused on the overall input and outflow of water across the region's water systems. Each entity also progresses and updates its own technology systems on individual timelines, leading to constant and somewhat uncoordinated technological change across the country.

In a federated country with interconnected river systems, this creates challenges when it comes to managing or sharing this data for use in analysis that informs nationwide (or multi-jurisdiction) planning and forecasting. There are multiple technologies, systems, and formats of data storage in use across different jurisdictions, which mean data needs to be 'translated' when passed on to other jurisdictions. This is often not a straightforward process. As the underlying code or data quality can differ manual intervention is required to standardise data formats and quality. For real-time data from new technologies to be useful these barriers to interoperability need to be removed allowing for better data-sharing.

KEY MESSAGE

Developing and implementing technologies to streamline data management, integration, and transfer — including in real or short timeframes — will allow water managers to efficiently analyse quality data and use that information to make the best possible evidence-based decisions.

3. Technologies for data use

The quality of analysis by water data managers often depends on the quality of the data used. A major barrier to implementing emerging technologies is the underlying availability and quality of the data, as outlined in the first two broad themes.

It is difficult to develop technologies to make best use of data inputs that aren't to the necessary quality or provided in the correct formats. There are many aspects of water modelling that could be improved across Australia by using higher quality data or data that is standardised, for example:

- **A whole-of-basin approach**, compared to the current approach of combining a 'patchwork' of different models or technologies across a river system.
- **Interconnected modelling** to connect data from freshwater system with marine dynamics.
- **Modelling to simulate climate change impacts**, demand and management rules more flexibly.
- **Dealing with floodplains**, including incorporating better linkages with surface-groundwater models.
- **Monitoring and accounting** for both levels of extraction and inputs across systems.
- **Resolving discrepancies** between actual and modelled flows suggests better process understanding or more recent/relevant data may be needed to improve models and address model errors.

Using timely, real-world data from the water sector as inputs to modelling is not always possible due to the limitations in data gathering and management, however, it could be possible if more efficient data collection and sharing technologies could promptly standardise and share data formats.

KEY MESSAGE

Designing modelling technology that can handle imperfect data, in real time, to provide clear information in usable outputs should be a priority for future technology development. Providing clear information and outputs from data analysis will increase the likelihood these are used in evidence-based decision making for a range of end users.

UNDERSTANDING THE BARRIERS TO NEW TECHNOLOGIES

There are several potential barriers to the development or adoption of new technologies for Australia's water sector:

- **Cost and regulation** often limit the adoption of new technologies, especially for systems combined with renewable energy sources. Reducing regulatory boundaries for technologies that improve sustainable water use, especially those that incorporate renewable energy, could incentivise the uptake of new technologies.
- Modelling technologies provide good predictions for water flow and usage which can guide decision making but may require commensurate **increases in field measurements for more precise modelling**. Additional technologies for gathering robust, timely field measurements can ensure data fed back into water management models will improve their accuracy and further refine decision-making.
- Access to emerging technologies like remote crop sensors and water use sensors is improving as costs fall. However, **water managers also need access to these technologies at scale. Without the means to support such a network, and the data analytics skills to interpret their information, the benefits of this technology are greatly limited**.
- More social science research is needed to understand **community expectations and implications of changes in water management** use across a catchment.
- Expectations for transparency of water management planning and decision-making are increasing, given the public interest in sustainability and climate change issues. However, **improved access to evidence to inform decisions requires the implementation of technologies to measure, assure and then communicate water management data** in an accessible way. Increasing information acquisition may have to anticipate a commensurate capability to curate and share that information.

Practical translation and implementation of any new technology must be equal across the jurisdictions working with each other, to allow these challenges to be addressed holistically, and with the end users in mind, to allow Australia's entire water sector to advance.

CONCLUSIONS

Understanding how much water is in a catchment, how it flows and is used across the catchment and the water demands by the environment, industry and population are key challenges to regional water management in Australia. Technologies that collect water data – and create useful information from it – are therefore critical to guide decision-making in Australian water management as shown in Figure 1. As shown in the figure, the flow of information and understanding from data is not unidirectional. The gained knowledge may indicate gaps in the data collected. As a result, an actionable insight could be to adjust how data is collected or transformed into information to better fulfil user demands.

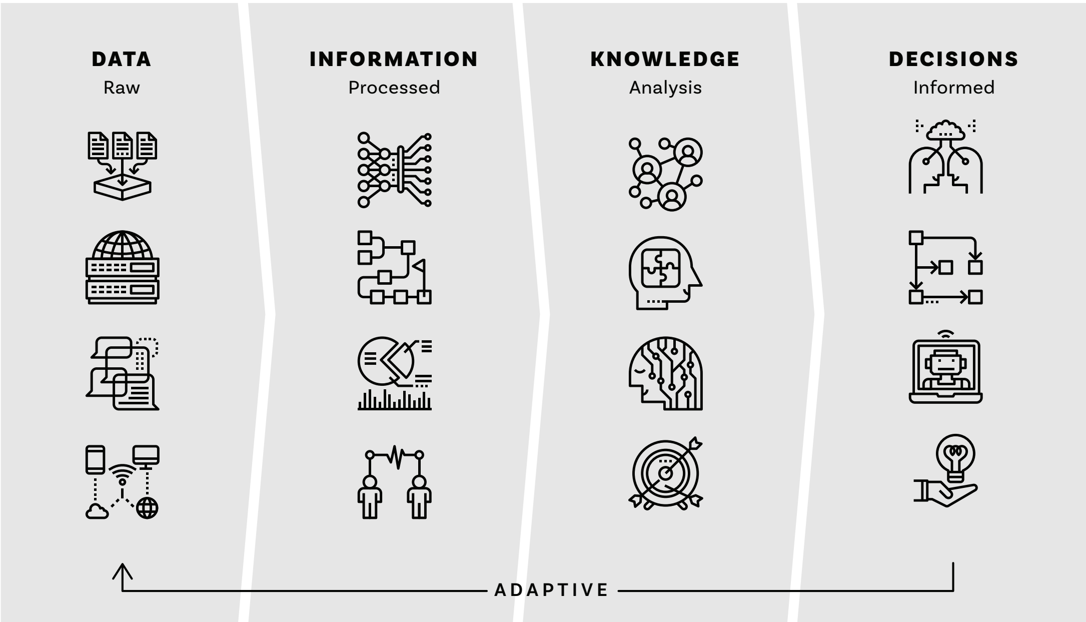


FIGURE 1 From data to decisions

As emerging monitoring technologies – including sensors and IoT technologies – are further developed and deployed to gather water data around Australia, the frequency, quality, and interoperability of data collected will likely be improved. To ensure these technologies also gather the necessary depth of data, they must be designed to also capture metadata or contextual information. This is a critical task for on-the-ground hydrologists and ecologists who currently take many of Australia's water data measurements in the field.

With this increase in data availability, sufficient improvement is also needed in technologies that can manage, interpret, and create useful information from data in close to real-time. Speed and accuracy of management technologies that can use perfect or imperfect data will be essential to ensure evidence-based decisions about water management can be made efficiently.

Finally, consideration must be made about what the various end users want from the information derived from data about water. While technologies to improve the breadth and depth of data collection could provide more, higher-quality inputs for models and other predictive tools, understanding what the end users want to use that information for is critical to ensure new technologies provide useful information to guide effective decisions. Engaging closely with end users of water information - like traditional custodians, farmers, ecologists, local councils and utility water managers – will help scientists and policymakers better understand how technologies that gather, manage and analyse water data can be designed for maximum efficacy that guides the best outcomes for making water management decisions.

ATSE

Australian Academy of Technological Sciences & Engineering

atse.org.au