Decision support systems and tools for water resources policy and management

An Australian Perspective

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About the Authors
Since its inception in 2005, the International WaterCentre (IWC) has played a vital role in the global water sector in building relationships between Australian water experts and the international water sector. The IWC does this through an offering of world class professional education and training, capacity development, and applied research services, which promote integrated and whole-of-water cycle approaches to policy, planning, and management. For more information, visit watercentre.org.

The Alluvium Group was established in 2006 as a niche, employee owned consulting firm focused on the sustainable management of catchments, rivers, and cities. Alluvium delivers a broad range of services into the Asia-Pacific region with a focus on small to large-scale water resources planning, water sensitive urban design and strategy, water resources modelling, environmental flows management, climate change adaptation, and catchment planning and management. For more information, visit alluvium.com.au.

eWater is an Australian Government owned not-for-profit organisation providing capacity building, modelling tools, technical support services, and a community of practice to support integrated water resource management and water management governance, within Australia and internationally. eWater leads the ongoing development and adoption of eWater Source, Australia's National Hydrological Modelling Platform. For more information, visit ewater.org.au.

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Contents

1 Introduction 3

1.1 Asia Australia Learning Week 3

1.2 Capturing the generated knowledge – the purpose of this publication 3

2 Why use Decision Support Systems and Tools 4

2.1 Defining decision-making 4

2.2 What are Decision Support Systems and Tools? 4

2.3 Why use Decision Support Systems and Tools in decision making? 5

3 How Decision Support Systems and Tools are used in the Australian water resources sector 6

3.1 Improving water information and knowledge 7

3.2 Community, Traditional Owner and stakeholder inputs 10

3.3 Transforming water allocation and management 12

3.4 Improving environmental water management 16

3.5 Reforming water pricing 19

3.6 Modernising institutional arrangements 20

4 Using Decision Support Systems and Tools – Principles for success 22

5 References 24

Figures

Figure 1. Decision making stages adapted from Simon (1960) 4

Figure 2. Sample of possible entry points for DSSTs in the decision-making stages 5

Figure 3. Objectives and elements of water reform in Australia over the past 30 years (Doolan, 2016) 6

Figure 4. Australia's water information website 9

Figure 5. Core components of the Paddock to the Reef program 11

Figure 6. Burrinjuck Dam, by WaterNSW 14

Figure 7. ACT Water Decision Support System and Tools 15

Figure 8. Reef planning and investment tool dashboard 18

Figure 9. SCADA system interface, by Goulburn-Murray Water 21

1 Introduction

1.1 Asia Australia Learning Week

Asia Australia Learning Week was held in 2019 to bring together Australian water sector staff from the Asian Development Bank (ADB) and their developing member country governments. The event aimed to provide participants from 14 countries with a broad range of professional backgrounds an opportunity to exchange knowledge across the water sector.

The theme of this event was 'Decision support tools to guide water policy development, investment planning and on-ground management of water resources', and aimed to build participants' understanding of:

- Decision Support Systems and Tools (DSSTs) and their role in advancing the water sector in Australia
- policy, planning, management, and practical considerations of applying DSSTs across different geographical scales, governance structures, institutional levels, and water users
- transition pathways for the enhanced use of DSSTs, including the overall history, current situation, and future directions in the Australian water sector, with a focus on the South Eastern Australian experience of water resources allocation in highly regulated systems.

Case studies that showcased the adoption and utility of Decision Support Systems and Tools at both regional catchment and local scales provided practical examples of experiences with DSSTs, and the adaptive management principles that unpinned their use and refinement. The focus was on both the rural and catchment context (dam operations) and the urban context (water and wastewater utilities).

1.2 Capturing the generated knowledge – the purpose of this publication

The event brought together a range of Australian experts who contributed to framing an understanding of how DSSTs are used in Australia and developing practical case studies from the Australian context. Given the knowledge and case studies generated during the Learning Week, it was recognised that documentation of key outputs would be valuable. This publication therefore aims to draw on the information and discussions developed to document the Australian perspective and experience of DSSTs. This perspective largely draws on the Southeastern Australian experience in water resources allocation in highly regulated systems.

2 Why use Decision Support Systems and Tools

2.1 Defining decision-making

Although there are several definitions of what decision-making is, the work done by Herbert Simon in the early 1960s is the most relevant and served as a baseline for the concept of decision support systems later developed by Gorry and Morton (1989). Simon (1960), who focused on organisational decision-making, defined decision making as a three-stage process (Figure 1).

Stage 1 refers to gathering 'intelligence' to formulate the problem and to develop solutions. **Stage 2** focuses on the development or 'design' of potential solutions to the previously identified problem, which then go through evaluation and selection, or 'choosing', in **Stage 3**.

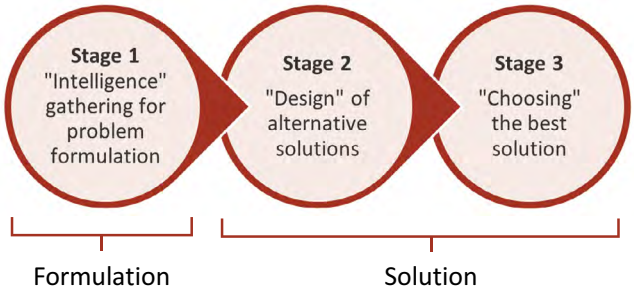

Figure 1. Decision making stages adapted from Simon (1960)

This simple articulation of decision making, i.e. deciding what the problem is, and how to solve it, can be applied to how water sector organisations make strategic, planning, or operational decisions to address water related issues. Issues range from making decisions on allocating water between users, designing water supply systems or estimating environmental flow requirements, to dealing with water scarcity, managing flooding events or reforming the sector's governance structures.

2.2 What are Decision Support Systems and Tools?

Decision-making in the water resources sector is often complex. Decision makers rely on available knowledge, or generate knowledge through predictive tools, to build an understanding of a problem and decide how to solve it. However, the complex nature of water-related issues, which involves multidimensional relationships, impacts, and diverse stakeholders, often means that available knowledge may be uncertain and/or the understanding of the problem and potential solutions contested. This type of complex decision-making context hinders the capacity of decision makers to produce rational, transparent, and efficient decisions. If there is disagreement or misunderstanding in any of the stages of the decision-making process, it can lead to poor decision-making or a lack of any decision making at all, and consequently to poor or perverse outcomes.

It is from this complexity in decision making that the need for Decision Support Systems and Tools (DSSTs) arises. DSSTs use available information and data to generate and visualise structured knowledge and analysis for decision makers, aiding them in producing decisions more efficiently, and with improved quality, consistency, and transparency. Decisions can then be better explained, re-produced and critiqued (McIntosh et al., 2011).

DSSTs are often considered as separate components, decision support systems—the overall support context in which decisions are made—and decision support tools—the specific instruments that are utilised. In the context of this report, for simplicity, we use the term DSSTs to include both components of decision support.

Today, DSSTs commonly take the form of computer-aided mechanisms developed to support one or more decision-making phases where either the problem formulation and/or the solution generation are arguable (McIntosh et al., 2011). Box 1 outlines common types of DSSTs used in the water resource sector. These generally include DSSTs such as models, visualisation tools, geographical information systems (GIS), artificial intelligence, and data management systems (Denzer, 2005).

Box 1. Examples of DSSTs used in the water sector (adapted from Serrat-Capdevila et al., 2011)

- GIS and other visualisation tools to better interpret and present data.
- Tools to help understand the costs and effects of infrastructure alternatives.
- Operating tables or predictive models that prescribe actions to perform given a set of condition rules.
- Simulations to understand the consequences of different operating policies, scenarios, or management alternatives.
- Flood forecasting systems.
- Smart device applications (apps) that provide data and information to the public to inform decisions.
- Conceptual models and frameworks.

2.3 Why use Decision Support Systems and Tools in decision making?

As the interface between science and decision makers, DSSTs have three distinct benefits for supporting the decision-making process (Giupponi & Sgobbi, 2013) (see Figure 2, note that multiple entry points are not represented here, these are just a sample):

1. **Data and information collation, analysis, interpretation, and visualisation:** DSSTs provide a framework for the organisation of data, information and knowledge and their clear and succinct communication.
2. **Scenario analysis:** DSSTs support decision making by allowing for analysis of the impact of possible management strategies/actions, commonly referred to as scenarios.
3. **Participation and engagement:** DSSTs enable participation by various stakeholders by providing opportunities to engage and interact with data and information for considering values, preferences, and priorities.

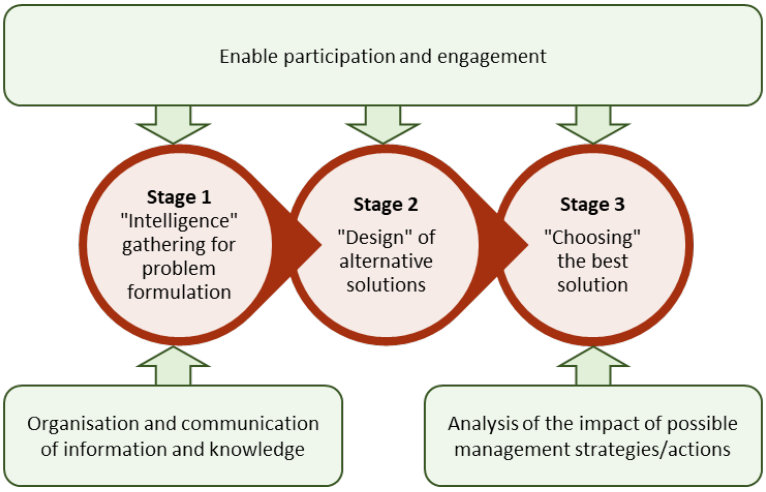

Figure 2. Sample of possible entry points for DSSTs in the decision-making stages

3 How Decision Support Systems and Tools are used in the Australian water resources sector

Over the past 30 plus years of water reform in Australia, there have been six key overarching areas that were consistently pursued through State government reform programs, the collective Murray-Darling Basin program, as well as nationally. With a focus on the Murray-Darling Basin and regulated systems, these are:

- improving water information and knowledge
- community and stakeholder inputs
- Traditional Owner and First Nations inputs
- improving environmental management
- transforming water allocation
- reforming pricing of water services
- modernising institutional arrangements (refer to Figure 3) (Doolan, 2016).

Each of these areas were supported by a range of policy and legislative reforms, including the development and application of DSSTs to inform decision-making (partially represented in Figure 3 by the cross-cutting and underpinning area of improving water information and knowledge). In this section, we explore examples of how DSSTs have informed decision-making under each of these areas and at various scales.

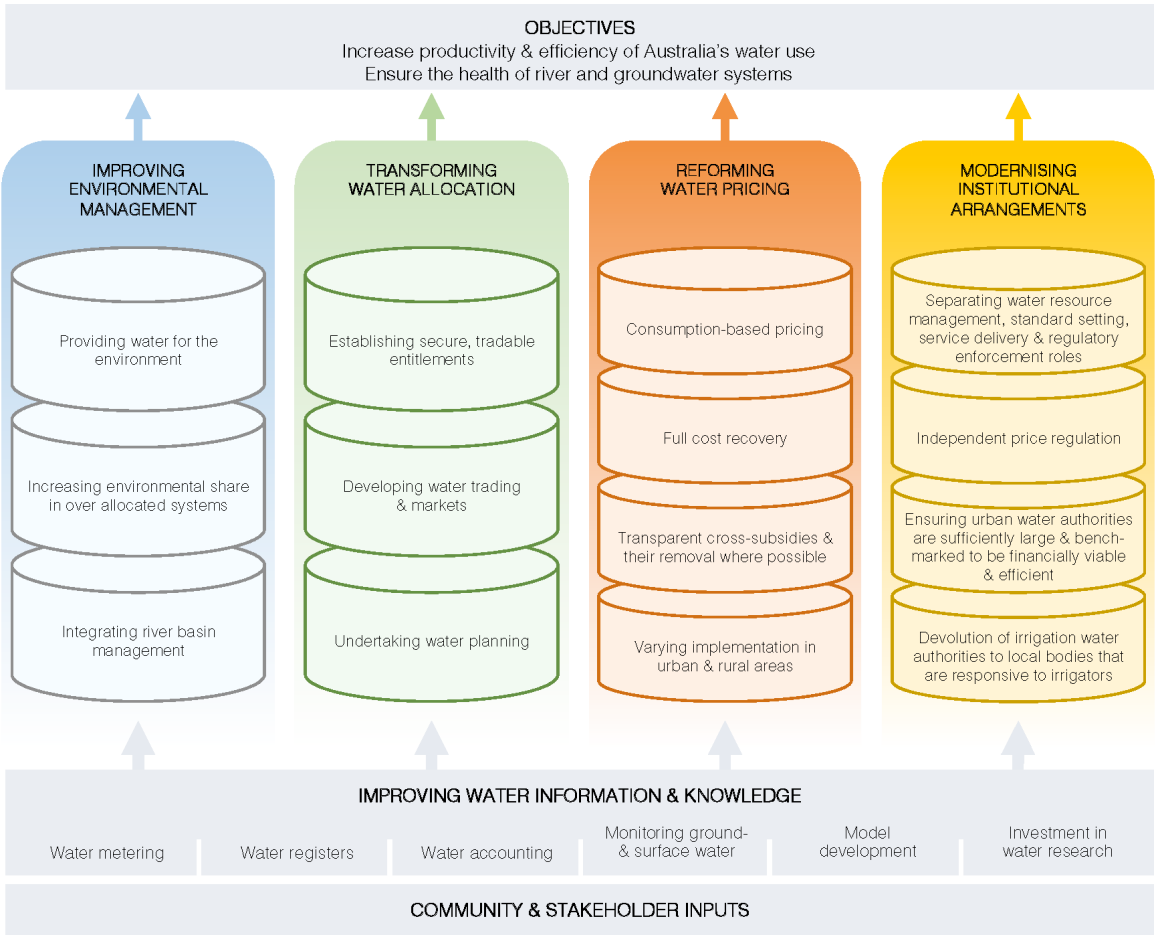

Figure 3. Objectives and elements of water reform in Australia over the past 30 years (Doolan, 2016)

3.1 Improving water information and knowledge

Improving collection, processing, availability, and use of water information has underpinned Australia's water reforms. Water information provides the evidence base for water planning, water trading and the operation of water markets, environmental management, water service delivery, compliance, and community engagement (Doolan, 2016). As Australia's water reforms have been implemented, the use of water information and knowledge has evolved with improvements in the information base, modelling tools, and water managers' capacity to utilise the information (Doolan, 2016).

In Australia, DSSTs have been part of and supported this process in a range of ways, for example:

- introducing and improving water metering to understand water use;
- improving monitoring of surface and groundwater resources;
- modelling to underpin planning and operational decision-making;
- developing State and National water accounts to show where water is being used and for what purpose;
- improving understanding of water environments and their environmental flow requirements under different climatic scenarios; and
- making water information more useful and publicly accessible (adapted from Doolan, 2016).

Case studies 1 and 2 below illustrate how DSSTs have informed the development of improved water information and knowledge in Australia.

3.1.1 Case Study 1: National level platforms that support the management of Australia's scarce water resources

This case study draws on presentations by eWater staff during the Asia Australia Learning Week 2019 as well as on the AWP Knowledge Product titled WaterTools: A Guide to three national level platforms that support the management of Australia's scarce water resources (Carr et al., 2019).

As Australia has progressed through complex water reforms, the tools adopted to support these reforms have become necessarily more complex. Three key national level platforms have resulted from this progress: i) the eWater Source model; ii) the Bureau of Meteorology's Water Forecasting Tools and the associated Australian Water Resource Information System; and iii) Geoscience Australia's Digital Earth Australia and Open Data Cube technology for organising remotely sensed information into analysis-ready forms to identify water availability. Each of these tools was developed to be adaptable, to meet a wide range of needs, and to work across Australia's diverse range of climates, natural and built environments, and government boundaries. The legalisation driving the development of the eWater Source model and the Bureau of Meteorology (BoM) forecasting tools and how they are used as DSSTs is outlined further below.

The 2011 update of the Commonwealth Water Act 2007 was a key driver for the development of the three national level tools. The Water Act gave the BoM functions for collecting, holding, managing, interpreting, and disseminating Australia's water information. The Act also required the BoM to provide regular forecasts on the future availability of Australia's water resources and committed funds for the BoM to deliver these additional functions. The BoM's role in data management is discussed further in Case Study 2: Providing a national data platform.

In response to the requirements of the Commonwealth Water Act 2007, the BoM developed water forecasting services that provide short-range streamflow forecasts up to seven days—updated daily—and seasonal streamflow forecasts up to three months—updated monthly. The BoM's forecasting tools are utilised as DSSTs to manage water allocation. For example, seasonal streamflow forecasts are used by WaterNSW, the largest water supply authority in the Australian State of New South Wales, to support operations and management in the Murrumbidgee River. The streamflow forecasts of flows into the reservoirs of the catchment help water managers predict how reservoirs will behave over the main winter-spring filling period and, therefore, inform reservoir release decisions to ensure downstream water demands are met, whilst ensuring sufficient water is stored in the reservoirs for later use (see more detailed in Case Study 5: Informing infrastructure operations for Burrinjuck Dam).

The Commonwealth Water Act 2007 also requires the Murray-Darling Basin Authority (MDBA) to develop, in consultation with the States, an integrated water model for the Murray-Darling Basin. Subsequently, a National Hydrological Modelling Strategy was developed, and it recommended the adoption of a single hydrological modelling platform capable of meeting Australia's current and future water management needs. The Strategy recommended the eWater Source model to be adopted (Source's use as a DSST within the Murray-Darling Basin is outlined in Case Study 3).

eWater Source is now utilised as a DSST for water resource planning and river operations as well as urban and bulk water supply within the Murray-Darling Basin and across Australia. As a planning DSST, eWater Source enables water managers to understand the available water resources in a catchment and then to test different policy or management scenarios of this water resource (e.g. reliability of allocations under different development scenarios or how changes to allocation rules affect different water user groups). As a river operations DSST, Source enables river managers to plan for operations under a range of scenarios and to simulate the potential impacts of operational decisions, on a daily or seasonal basis (e.g. allocating water to users according to water sharing rules). As a DSST for urban and bulk water supply, Source models are being used to determine individual water allocations and optimise system operations.

More recently, the growth in computing power and availability of accessible data has led to the creation of Australia's Digital Earth Australia (DEA) and Open Data Cube (ODC) technology. The technology is designed to organise, store, and analyse satellite data into an analysis-ready form. DEA contains, for the whole of Australia, more than 30 years of pre-processed and accessible satellite data, taken every two weeks at a 25 squared metres resolution (currently being updated to every five days at a resolution of 10 squared metres). DEA can then be used to develop products that can inform water resources management decision-making. The tools have been developed to provide (Carr et al., 2019):

- the percentage of time surface water has been observed in Australia since 1987 to the present, which can inform understanding of water availability, historical flood inundation, and environmental needs
- quantification of the amount of surface water, which can inform drought assessments
- monitoring of water quality, which can help the identification and response to pollution events
- tracking the flow of water over the landscape, which can inform flood warnings, evaluation of environmental flow events, and tracking compliance with water extraction rules.

More information on the three national level platforms is available at: ewater.org.au/products/ewater-source/; bom.gov.au/water/ssf and ga.gov.au/dea

3.1.2 Case Study 2: Providing a national data platform

This case study draws on a presentation made by BoM staff during the Asia Australia Learning Week 2019.

Pre-2007, water-related data in Australia was spread across multiple agencies across multiple jurisdictions. Due to the disbursed data and responsibilities for collecting and managing it, there was no central data repository that could help answer questions such as how much water is available, allocated, used, lost, or traded.

Recognising that "you cannot manage what you don't measure," the Commonwealth Water Act 2007 gave the Bureau of Meteorology (BoM) responsibility for collecting, holding, managing, interpreting, and disseminating Australia's water information. In addition to the collection, storing and making data available, the task included the development of water resource reports, forecasts of future water resources availability, national water accounting, and national water information standards.

To develop a suite of DSSTs, the BoM had to modernise the institutional arrangements for water data collection in Australia. This involved four key steps: i) standardising definitions; ii) standardising formats; iii) managing large quantities of data and interpreting it into high quality and useful information; and iv) making the information widely available through a publicly available website.

The resulting publicly available data website (Figure 4) presents raw data as well as interpretation and visualisation of data on river water levels (4,110 sites) and discharge (3,885 sites); water storage levels (530 sites) and volumes (500 sites); water quality parameters such as electrical conductivity (1500 sites), turbidity (700 sites), pH (600 sites) and water temperature (2,000 sites); and rainfall (1,500 sites).

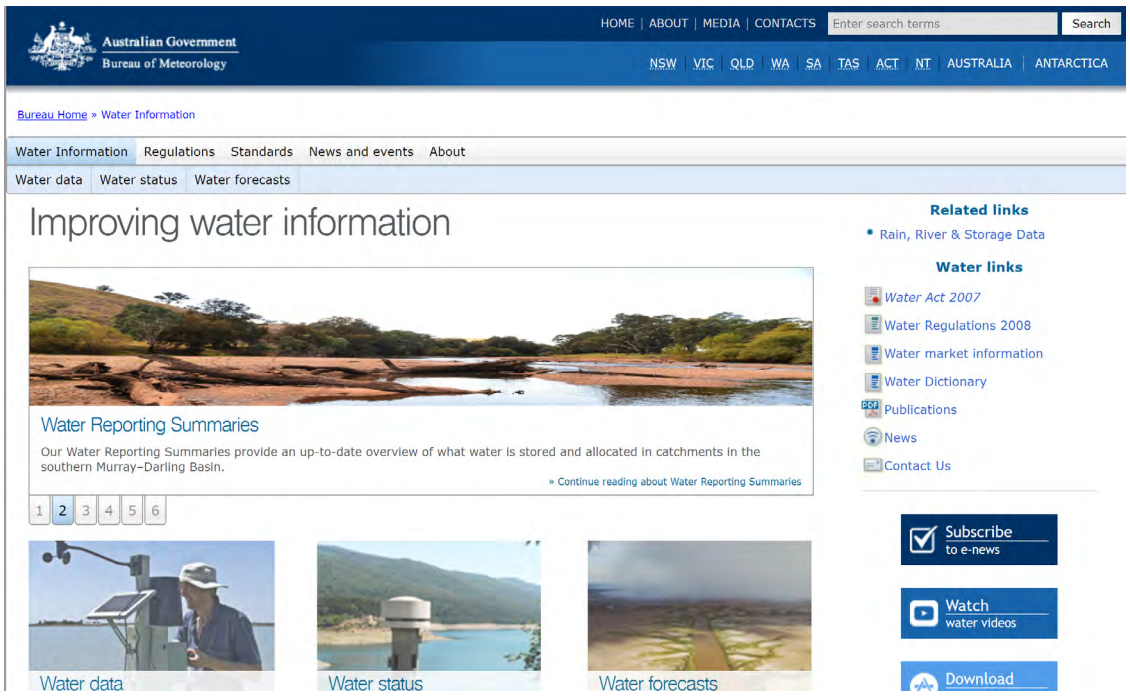

Figure 4. Australia's water information website

This information is utilised by a broad range of users—federal, state, and local government, universities, private sector—to support a wide range of decision making related to understanding flow conditions, optimising reservoir operation, informing water trade decisions, planning infrastructure development, and managing groundwater usage.

More information on Australia's water information platform is available at: bom.gov.au/water

3.2 Community, Traditional Owner and stakeholder inputs

Community and stakeholder engagement has been a fundamental component of Australia's water reforms. Community, Traditional Owner and stakeholder engagement is critical as water management inherently involves trade-off decisions that have impacts on individuals, industries, communities, their local environments, and regional economies. Engagement helps water decision makers to understand user and community needs and to manage these in the most equitable manner possible. Resolving trade-off challenges can only occur through achieving negotiated outcomes between key stakeholders, communities, and governments (Doolan, 2016). If stakeholder engagement is done well and built on a common understanding, it can build support for planning and making regulatory and management decisions.

In Australia, DSSTs have supported this process in a range of ways, for example:

- Informing and making clear the trade-offs in who gets water when, and how different water uses are prioritised in allocation decision-making, e.g. water entitlements, allocations, and trade.
- Making water information more useful and publicly accessible.

In addition, stakeholder engagement has been integrated into many of the DSSTs used throughout Australia's water reform journey. Case Study 3 provides an example of how DSSTs have enabled community and stakeholder engagement in Australia.

3.2.1 Case Study 3: Paddock to Reef – bringing together experts, governments, researchers, and landholders to improve water quality outcomes for the Great Barrier Reef

This case study draws upon information provided by Queensland Department of Natural Resources, Mines and Energy staff.

The Paddock to Reef Integrated Monitoring, Modelling, and Reporting Program (Paddock to Reef program) started in 2009 as a joint initiative of the Australian and Queensland governments to report on water quality improvements resulting from investing in improved land management practices. Improving the quality of water leaving properties by reducing pollutant run-off is critical to support the health and resilience of the Great Barrier Reef. The program brings together industry bodies, government agencies, natural resource management bodies, landholders, and research organisations.

The program provides a framework for evaluating and reporting progress towards the Reef 2050 Water Quality Improvement Plan targets. It integrates monitoring and modelling information on management practices, catchment indicators, catchment loads and the health of the Reef at the paddock, sub-catchment, catchment, regional, and whole Great Barrier Reef scales (Figure 5). The program evaluates management practice adoption, management practice effectiveness (in terms of water quality benefits and economic outcomes), catchment condition, pollutant run-off, and marine condition.

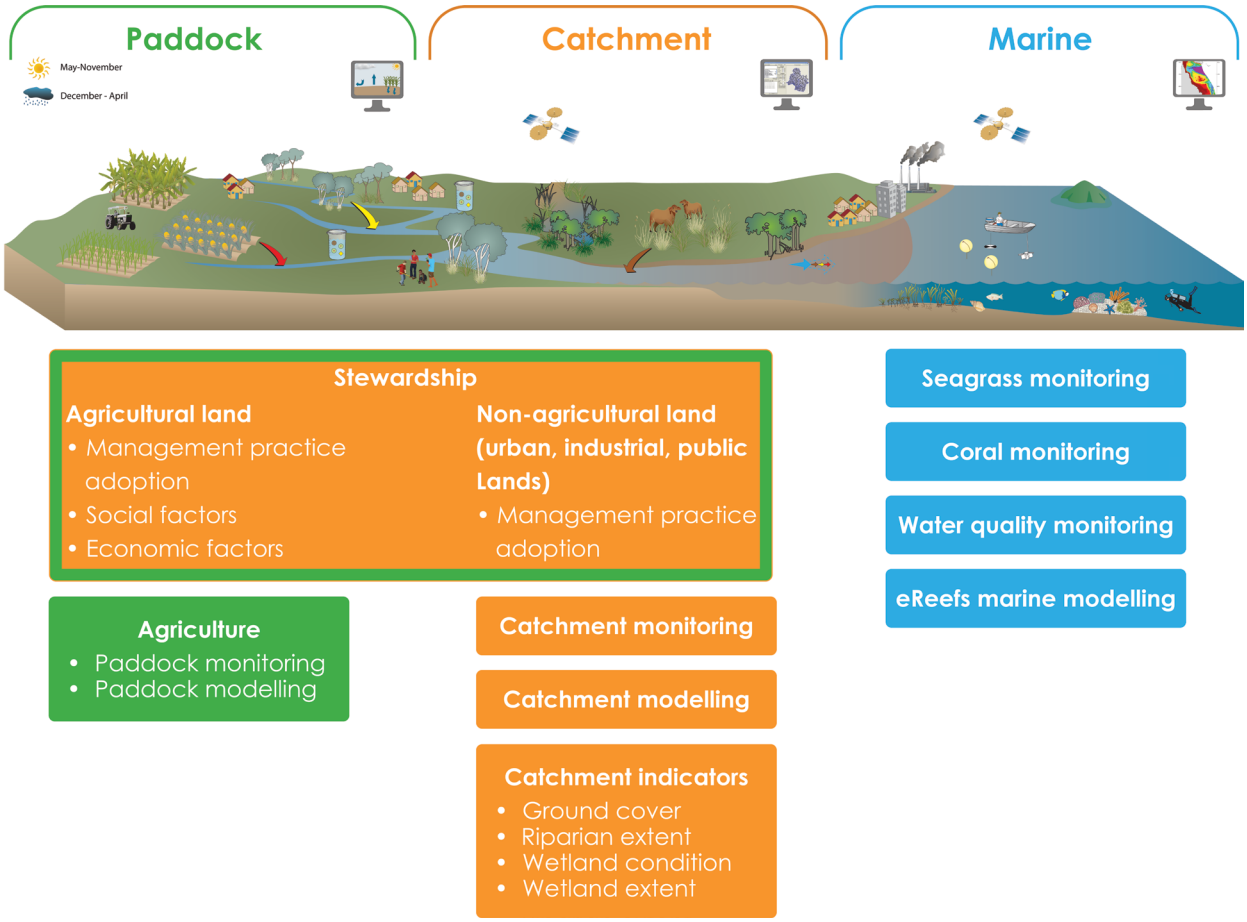

Figure 5. Core components of the Paddock to the Reef program

The catchment modelling is based on the Source platform, with customised plug-ins developed by the Queensland Government to provide additional water quality functionality. A range of other purpose-built data collection and reporting tools have also been developed to support the program. These include interactive maps to show pollutant generation rates and priority investment areas.

The models are primarily used to report on annual progress towards the Reef water quality targets as a result of investment in improved land management practices. Secondly, model outputs are used to determine priority areas for investment and to assess possible outcomes from different scenarios, such as different rates of adoption of improved practices. The catchment models also provide inputs for the marine models.

Many of the actions required to achieve the water quality targets need to be undertaken by farmers and other land managers. To support greater uptake of the required actions, the Paddock to Reef program has been designed to share technical information in a way that can be easily understood and used. It also incorporates the local knowledge of land managers. Program features include:

- Multiple lines of evidence to inform progress towards the targets.
- Technical experts are based in the regions, giving them a good understanding of the local environment, issues, and the effectiveness of management actions. This also helps build relationships with local land managers.
- Ongoing refinement of the models and other tools to incorporate new knowledge, data, and methods.
- Results are presented online through an interactive reporting system to cater for the broad range of stakeholders interested in the results from the general public to scientific experts.

- Data is made available to support other programs, for example regional report cards, regional natural resource management bodies, and local government investment decisions.
- 'Cut-down' models to provide locally specific tools to assess individual projects and prioritise local investment.
- Peer review, continual improvement, and validation are critical elements for any modelling program. The Paddock to Reef catchment modelling program undertakes an external review every three years. The program is supported by a Great Barrier Reef-wide pollutant load monitoring program, which provides data to validate and calibrate the catchment models and increase confidence in the models over time.

More information on the Reef 2050 Water Quality Improvement Plan is available at:
reefplan.qld.gov.au/tracking-progress

3.3 Transforming water allocation and management

In Australia, State and Territory governments can allocate water entitlements to water authorities and other parties, enabling them to extract and use water for a range of purposes. In allocating water entitlements, governments must ensure that water is allocated and used to achieve social and economic outcomes in an environmentally sustainable way. For the holders of water entitlements, the right to extract, use, and trade water comes with the responsibility to use it in accordance with conditions set by government (Doolan, 2016).

DSSTs have supported this process in a range of ways, for example:

- Enabling system understanding through development of water resource models (e.g. the eWater Source model).
- Assessing allocation scenarios/performance efficacy through the use of water resource models (e.g. the eWater Source model).
- Forecasting streamflows to inform operational planning and allocation decisions (e.g. Bureau of Meteorology streamflow forecasting tools).
- Informing operational decisions for dam management to meet the requirements of water allocations and associated plans.
- Putting water market information into the hands of entitlement holders to make informed trading decisions.

Case studies 4 to 6 provide examples of how DSSTs have informed decision-making in transforming water allocation in Australia.

3.3.1 Case Study 4: Tools for water resource planning and management in the Murray-Darling Basin

This case study draws on presentations by Murray-Darling Basin Authority staff during the Asia Australia Learning Week 2019.

The Murray-Darling Basin is a critical asset for Australia. It is home to 2.6 million people including 40 Indigenous nations; supports an AU$24B agriculture industry, in addition to a AU$8B tourism industry; and is home to 120 waterbird species, 46 native fish species, and 16 internationally recognised and protected wetlands.

Increasing crises have occurred in the Murray-Darling Basin from the 1950s, including increasing salinity, disconnected wetlands and floodplains, and closure of the Murray River mouth. These crises led to a series of reforms that culminated in the development of the Murray-Darling Basin Plan. The Plan outlines how water is shared—or allocated—between the basin States and water users.

The Murray-Darling Basin Authority (MDBA) is responsible for monitoring and enforcing compliance with the Basin Plan, and it uses a range of tools including DSSTs to do this.

Data underpins the key functions of the MDBA, including evaluating water resource plans, Basin Plan evaluation, compliance, and river operations. The MDBA collects data and utilises DSSTs to undertake investigations, understand systems, and understand change in systems. Interestingly, the MDBA does not collect data itself, it is reliant on State partners to collect and provide data through an automated online system.

The data is then utilised to deliver MDBA's modelling functions. The MDBA plays an independent role in modelling the shared waters of the Murray River and Lower Darling River with the aim of sharing information and knowledge between States, and in providing oversight on modelling activities undertaken by States within the basin.

The MDBA utilises a DSST for planning, prediction, and auditing. The DSST is comprised of an eWater Source model of the River Murray and Lower Darling that simulates a range of processes, including interstate water sharing, assessment of available water resources, water allocation, demand modelling, operation and management rules, flow and salinity routing, and water accounting.

The MDBA uses the DSST to improve understanding of hydrology and responses to climatic variability, inform development, implement and audit policies, design operating policies for management of infrastructure, and inform water sharing and accounting.

An important role of the DSST is to establish policy baselines for water reform initiatives in the basin, and model scenarios to measure the change from baselines to inform policy design and assess policy effectiveness. Using the DSST model to run water sharing and allocation scenarios is an effective and cost-efficient method to evaluate likely outcomes of change.

More information on tools used for water resource planning and management in the Murray-Darling Basin is available at: mdba.gov.au/managing-water/water-resource-modelling

3.3.2 Case Study 5: Informing infrastructure operations for Burrinjuck Dam

This case study draws on a presentation by WaterNSW staff during the Asia Australia Learning Week 2019.

WaterNSW is a State-owned water corporation with responsibility for operating New South Wales rivers and water supply systems. Burrinjuck Dam, owned and operated by WaterNSW, is the main water storage for the Murrumbidgee irrigation scheme (Figure 6). The dam is the first major dam built in New South Wales for irrigation and hydropower generation purposes. Secondary purposes of the dam include to provide water for towns, river flows, and stock, as well as for flood mitigation and recreational use.

Figure 6. Burrinjuck Dam, by WaterNSW

WaterNSW has the authority to decide on releases from the dam subject to the Water Sharing Plan for the Murrumbidgee Valley, which outlines the process for sharing water or water allocations between users. Within WaterNSW, a River Operations Water Unit team is responsible for setting dam release targets.

Core to informing the release decisions of the River Operations Water Unit team is real time data collection and analysis. There are four upstream gauging stations and one downstream gauging station. Each gauge sends live water levels and flow rates directly to a WaterNSW Live Water app, which can be viewed by operators and planners through their phones or computers. In addition, operational staff undertake daily weather readings that are entered directly into the BoM database (this database is described in more detail in Case Study 2). Operators also calculate daily discharge from valves, hydropower, and spillways using rating curves, and estimate daily inflow using storage data and upstream gauges. All this data is passed to the River Operations Water Unit team.

Using a custom DSST tool, the River Operations Water Unit team combine the data collected at the reservoir site with water allocation rules, weather forecasts, irrigation requirements, and environment flow requirements to develop a flow release target. The target is then fed back to the dam operators to ensure the release target is met.

All dam and river data, including release data, are made available to the public through the internet on the WaterNSW home page and the BoM website.

More information on tools used for managing Burrinjuck Dam is available at:
waternsw.com.au/supply/visit/burrinjuck-dam

3.3.3 Case Study 6: Planning for Canberra's water needs

This case study draws on presentations from the Australian Capital Territory Environment, Planning and Sustainable Development Directorate staff during the Asia Australia Learning Week 2019

Like many cities around the world, Canberra, Australia's national capital, faces the challenges of meeting the needs of a growing population with highly variable water resources, managing the impacts of urbanisation on water quality and waterway health, and adapting to a hotter, drier and more variable climate. In response, the Australian Capital Territory (ACT) *Water Strategy 2014–44: Striking the Balance* (2014), seeks to achieve three outcomes:

- healthy catchments and waterbodies;
- a sustainable water supply used efficiently; and
- a community that values and enjoys clean, healthy catchments.

Integrated water resources management underpins the Water Strategy. To support this, the ACT is implementing a DSST that integrates monitoring data, research and supporting information, hydrology models with visualisation, and reporting tools (Figure 7).

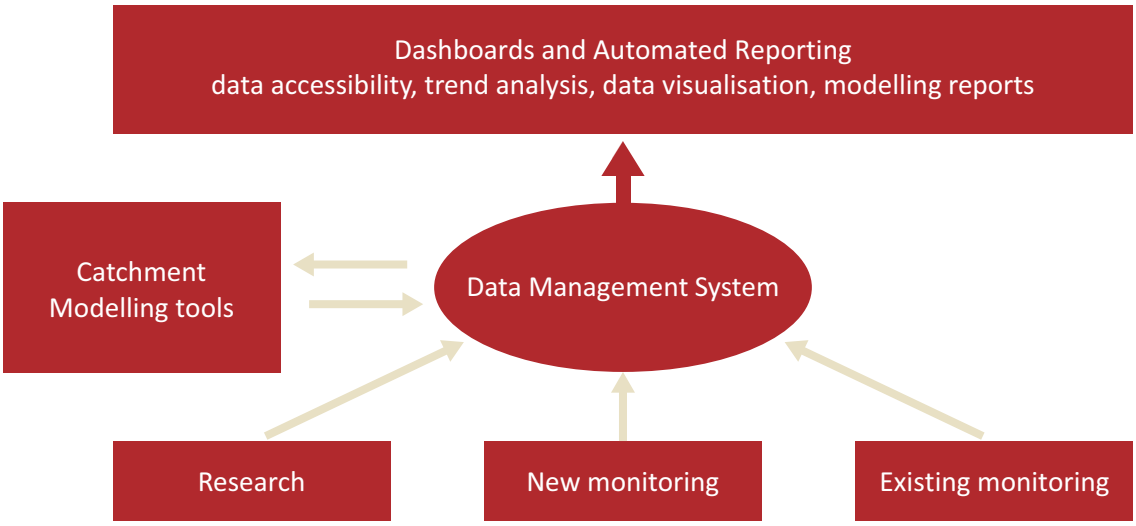

Figure 7. ACT Water Decision Support System and Tools

The DSST ensures that modelling is based on the best available information and provides a platform for analysing and presenting data and modelling results. The platform supports the integration of different modelling tools to work together to allow the whole water cycle to be modelled and managed. In this case:

- an eWater Source model provides regional scale information on catchment and river system water quantity and quality, as well as opportunities for demand management and alternative water supplies;
- MUSIC (Model for Urban Stormwater Improvement Conceptualisation) model provides information on urban water quality impacts and management options;
- site, neighbourhood, and suburb scale options for water supply demand management are investigated with the eWater Source plug-in for estimating urban water demands.

More information on water management in the ACT is available at: environment.act.gov.au/water

3.4 Improving environmental water management

Australia's water allocation mechanisms are based on the core principle of sustainable water resources management. In its water reform process, Australia recognised that arresting, and where possible, reversing the decline in environmental conditions was essential to secure a sustainable water resource base. This required three key actions: providing a legally recognised share of water to the environment; increasing the environment's share of water in over-committed systems to improve environmental health; and managing water within an integrated river basin management context (Doolan, 2016; Aither, 2018).

In Australia, DSSTs have supported this element of Australia's water reform through:

- Improving understanding of environmental condition, such as river condition, and prioritise management responses (e.g. Waterway Health Report Cards: An Australian Perspective)
- Improving understanding of environmental flow and other requirements (e.g. FLOWS assessments).
- Enabling water to be allocated to the environment within planning models (e.g. within the eWater Source model).
- Enabling understanding of the environmental impact of changes in flow (e.g. the Murray Flow Assessment Tool described in Case Study 9).
- Guiding investment decisions to maximise intervention benefits in terms of flood mitigation, biodiversity, water quality, and waste assimilation (e.g. the building catchment resilience project).

Case studies 7 to 9 provide examples of how DSSTs have informed decision-making to improve environmental water management in Australia.

3.4.1 Case Study 7: Evolution of environmental flows Decision Support Systems and Tools

This case study draws on a presentation by CSIRO staff during the Asia Australia Learning Week 2019.

The Commonwealth Scientific and Industrial Research Organisation (CISRO), Australia's national scientific research agency, has been developing and evolving a suite of environment flows DSSTs to meet changing requirements from decision makers over the past 20 years.

In 1999, CSIRO was commissioned by the Murray-Darling Basin Commission to develop an Environmental Flow Decision Support System (EFDSS). The EFDSS was a software tool designed to assist communities and government agencies to jointly explore the relationships between flow regimes and environmental condition in regulated rivers.

Although the EFDSS was never used to inform decision-making in the basin, in 2003 it was used as the basis for the Murray Flow Assessment Tool to inform understanding of the likely impacts of retrieving water for the environment. The Murray Flow Assessment Tool was utilised to inform the Living Murray Initiative, a joint initiative funded by State and Commonwealth governments, coordinated by the Murray-Darling Basin Authority (MDBA), that aims to restore the Murray River through environmental flows. The Murray Flow Assessment Tool software tool was used within the Living Murray Initiative to inform environmental flow interventions by predicting the ecological benefits/impacts of different flow scenarios along the River Murray system.

The EFDSS was also utilised in 2007–2008 as part of the suite of Sustainable Yields projects. The Sustainable Yields projects aimed to provide a comprehensive scientific assessment of current and future water availability in major water systems across Australia through a consistent framework for water policy decisions and investment. The projects had an ecological component that re-used the EFDSS method.

In 2015, revived and improved, the EFDSS again formed the basis for and was adapted to provide the ecological response component of the Sustainable Diversion Limit Adjustment method. The Sustainable Diversion Limit Adjustment method aims to provide a consistent and robust process to assess the impact of potential changes to the Sustainable Diversion Limits set for the Murray-Darling Basin. The Sustainable Diversion Limits place a cap on the amount of water that can be removed from the river, ensuring that sufficient water remains for the environment.

Finally, in 2017, the EFDSS helped inform the creation of an architecture to provide the forecast of a range of likely ecological impacts under climate and hydrology changes in the Murray-Darling Basin. This forecast architecture, termed trajectory modelling, has informed MDBA decision-making to manage multiple risks associated with planning for water resources under uncertainty and variability.

More information on tools used for planning for ACT's water needs is available at:
clw.csiro.au/publications/technical99/tr11-99vol-1.pdf;
and clw.csiro.au/publications/technical99/tr11-99vol-2.pdf

3.4.2 Case Study 8: Analysing investments scenarios for improved water quality in the Great Barrier Reef

This case study draws on a presentation made by Alluvium Consulting staff during the Asia Australia Learning Week 2019 as well as the project report titled Effective and efficient pathways for investments in improved water quality in the Great Barrier Reef (Alluvium, 2019).

The Australian Great Barrier Reef (GBR) is a national treasure. It is one of Australia's most important and unique ecological sites, as well as being World Heritage-listed and internationally recognised for its natural beauty,size, and biological diversity. It also brings economic benefit to Queensland as it is a popular recreational destination for domestic and international tourists. Protecting the environmental, social, and economic value of the GBR is therefore a top priority of the Queensland Government with support from the national Government.

Yet the Reef is under threat. Climate change and water quality degradation associated with catchment land use changes, contaminant runoff, coastal development, and extreme events, are two of the most significant threats impacting Reef health. Therefore, improving water quality flowing to the Reef is one of many priority actions identified to protect the GBR World Heritage Area. With funding of more than AU$443M from the Australian Government (as at 2019), as well as additional funds from a range of other investors, the Great Barrier Reef Foundation (GBR Foundation), a non-government organisation, is playing a key role in reducing water quality impacts on the Reef.

As part of the efforts in addressing water quality issues affecting the Reef, the GBR Foundation funded the Investment Pathways Project. The Project developed a DSST to help inform the GBR Foundation's five-year investment strategy and annual work plan on water quality improvements. The DSST provides a quantitative assessment comparing the most cost-effective catchment management actions in 46 reporting basins within the Reef catchments, and a data visualisation tool to support the comparison of the investment scenarios.

The DSST includes ten collaboratively identified management intervention approaches focussed on three primary pollutants—nutrients, fine sediments, and pesticides. Each of the management intervention approaches were modelled across 46 reef catchments, to allow comparisons of cost-effectiveness between options and to establish efficient investment pathways. The final project output was a visualisation tool that translates the outputs of the detailed modelling of management interventions into

a user-friendly interface to assess user-defined investment scenarios (Figure 8). These scenarios have now been used to inform development of the GBR Foundation's five-year investment strategy and annual workplans for their water quality work, thus informing the investment of more than AU$140M to improve the condition of the GBR.

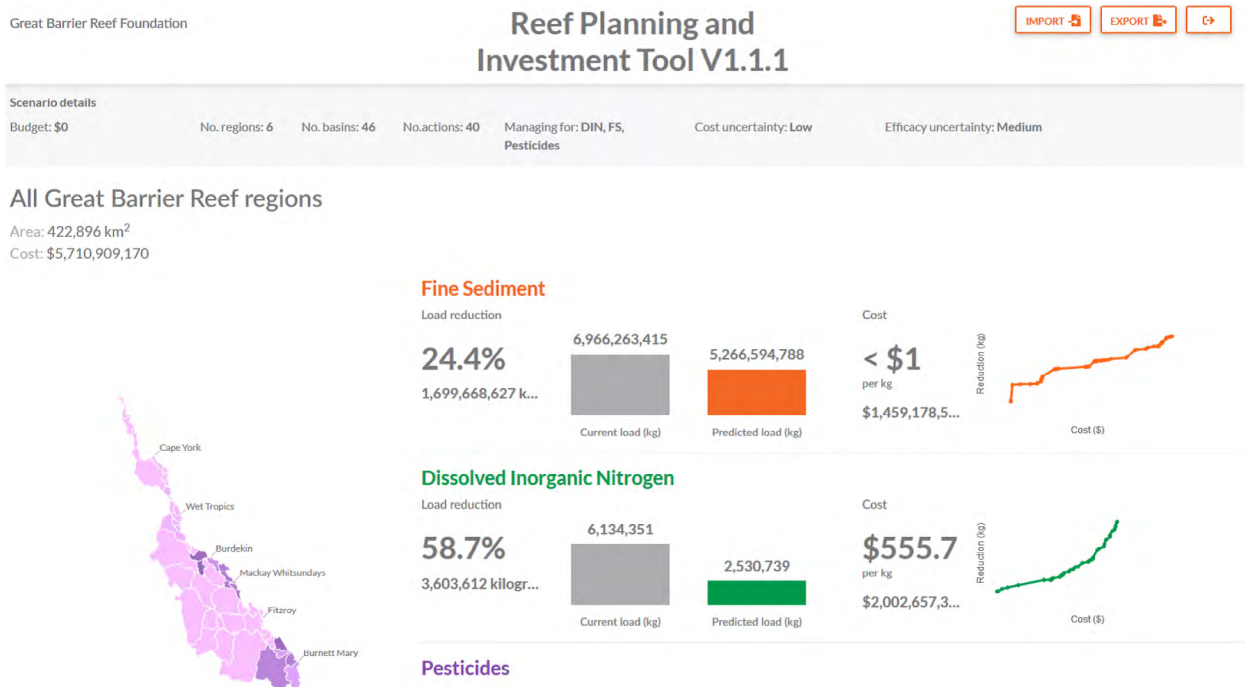

Figure 8. Reef planning and investment tool dashboard

More information on Great Barrier Reef Investment Pathways Project DSST is available at: barrierreef.org/uploads/Alluvium-2019-Effective-and-Efficient-Pathways-for-Investment-in-Improved-Water-Quality-in-the-GBR-Web-1.pdf

3.4.3 Case Study 9: Using streamflow forecasting to improve environmental outcomes and reduce adverse social impacts

This case study draws on a presentation made by BoM staff during the Asia Australia Learning Week 2019 as well as the AWP Knowledge Product titled WaterTools: A Guide to three national level platforms that support the management of Australia's scarce water resources (Carr et al., 2019).

Environmental water releases in the Goulburn River need to be timed to ensure a gradual rise and fall in river levels. If rapid water level rise and fall occur, it can adversely affect environmental outcomes as well as impact private property, businesses, and other infrastructure bordering the river. Therefore, the environmental water manager of the river needs to time releases when there is not going to be significant rainfall or a natural flow event in the Goulburn River or in the downstream Murray River.

The environmental water manager of the Goulburn River previously timed releases based on expert judgement of when river flows may increase. Now they utilise BoM's seven-day streamflow forecasts for the Goulburn and Murray Rivers. Using the seven-day streamflow forecasts gives the environmental water manager more information on which to base release decisions and higher confidence that a large event will not coincide with releases, thus reducing the risk of poor environmental and social outcomes from environmental flow releases.

3.5 Reforming water pricing

Reform of water pricing was a critical component of Australia's water reforms. The goal was to introduce new pricing regimes in urban and rural systems that established consumption-based pricing and full-cost recovery principles. Water pricing reform promotes efficient and sustainable use of water resources and water assets, enables investment in infrastructure, ensures that water businesses remain financially viable, provides adequate revenue streams for service delivery, and facilitates the functioning of water markets (Doolan, 2016).

In Australia, DSSTs have supported this element of Australia's water reform through:

- economic tools informing the balance of financial sustainability of irrigation authorities against financial sustainability of their customers; and
- scenario analysis for investment in new irrigation schemes and other infrastructure (e.g. Multi Criteria Decision Analysis).

Case Study 10 provides an example of how DSSTs have informed decision-making in reforming water pricing in Australia.

3.5.1 Case Study 10: Waterflow™ – a water market application

This case study draws on Waterflow™, an independent source of water market information supported by the Commonwealth Government's Business Research and Innovation Initiative.

Water markets are a key component of Australia's water pricing reforms. Markets allow water to be reallocated from lower to higher value uses. In Australia, buyers and sellers are free to trade water allocations or entitlements—legally defined property rights to water[1]—subject to water trading rules established and enforced by agencies. Irrigators are the main participants in Australian water markets as well as urban water utilities, environmental water managers, and investors.

Waterflow™ is a DSST developed to improve the transparency and reliability of water market information in Australia. Through a website or phone application, Waterflow™ compiles and provides information on buy and sell listings from various water market intermediaries, brokers, and exchanges. This information, available to the public, enables potential water buyers and sellers to be better informed and compare their options, and thus make more informed water trade decisions.

More information on Waterflow™ is available at: waterflow.io

1 In Australia, a water access entitlement is an ongoing right to an exclusive share of water from a water resource whilst a water allocation is the right to access a volume of water for use or trade in a given year.

3.6 Modernising institutional arrangements

Institutional reform was critical to Australia's water reforms. The aim was to develop organisations that were financially viable and capable of providing services to communities efficiently within environmental constraints. Steps to achieve this included separating roles for water resources management, setting service standards, introducing regulatory enforcement, and devolving operational responsibility to local bodies (Doolan, 2016).

In Australia, DSSTs have supported or resulted from this area of Australia's water reform through:

- BoM's organisational changes to become the primary data hub for the Australian water sector;
- ensuring water services are delivered as efficiently as possible; and
- benchmarking performance of water corporations/utilities.

Case Study 11 provides an example of how DSSTs inform decision-making in modernised institutional arrangements in Australia.

3.6.1 Case Study 11: Goulburn-Murray Water – how a modernised institution uses DSSTs

This case study draws on a presentation made by Goulburn-Murray Water staff during the Asia Australia Learning Week 2019.

Goulburn-Murray Water is Australia's largest rural water corporation and manages Australia's largest irrigation delivery network. As a rural water corporation, its role is to provide water services for irrigation, domestic, and stock purposes. These services include water supply, drainage, and salinity mitigation. The corporation also provides services such as flood mitigation, groundwater management, facilitating hydropower generation, and providing public recreational activities.

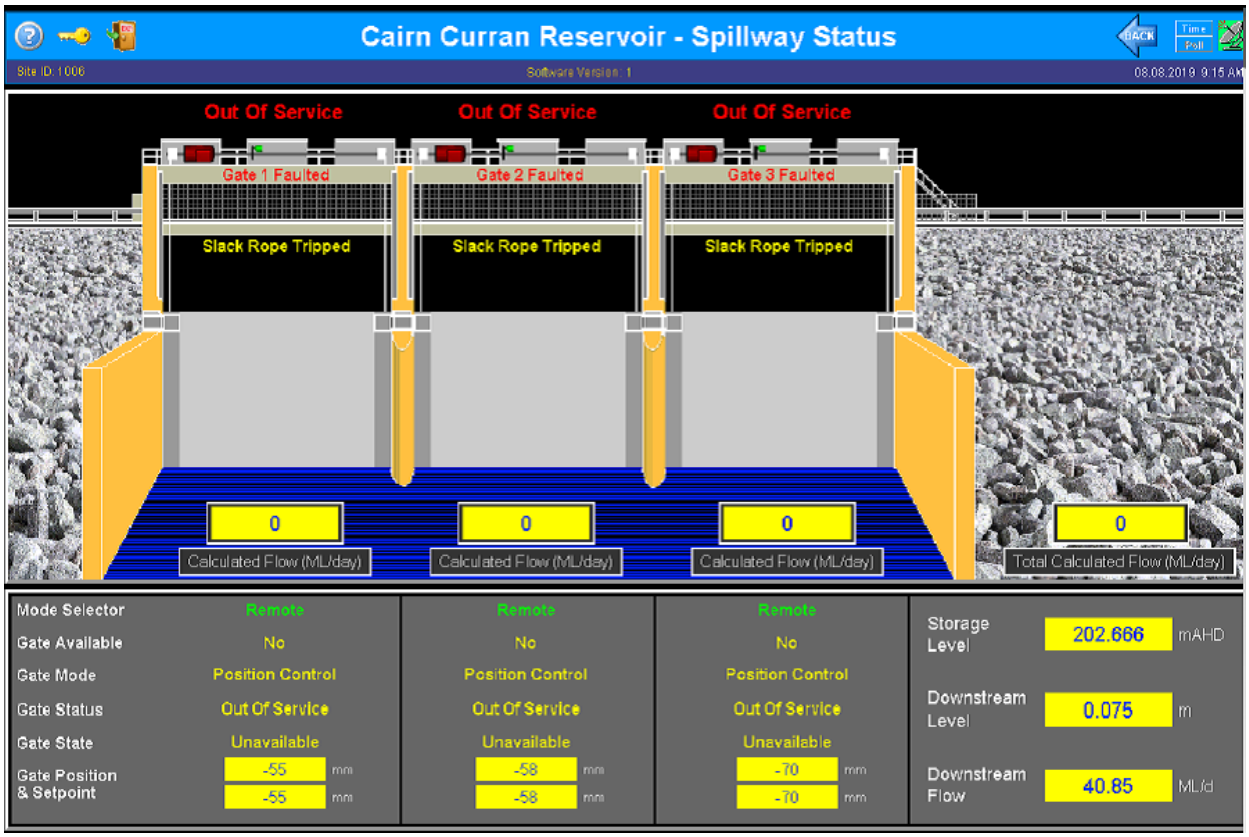

Figure 9. SCADA system interface, by Goulburn-Murray Water

To support these services, Goulburn-Murray Water owns and operates a large water storage and delivery system. This scheme is comprised of dams to store large amounts of water, weirs to store smaller amounts of water closer to the user, and channels and rivers to deliver water to users. Goulburn-Murray Water also plays an important role in managing water entitlements, including calculating seasonal allocations.

In modernising during Australia's water reforms, Goulbourn-Murray Water adopted the use of four DSSTs: i) a SCADA (supervisory control and data acquisition) network; ii) demand planning; iii) a stream gauge network; and iv) desktop tools.

For example, Goulbourn-Murray Water's SCADA network enables real-time communication with infrastructure including meters, regulators, and monitoring sites. This allows Goulbourn-Murray Water and customers to understand and control water delivery in real time (Figure 9). Initially used for just data collection and control of a few key regulating sites, it is now used across the whole irrigation scheme. The network allows customers to adjust water flow and they see the change within minutes, whereas it has previously taken days for the water flow adjustment to occur as a staff member had to manually open gates (Goulburn-Murray Water, 2016).

More information on Goulburn-Murray Water DSST is available at:
g-mwater.com.au/water-resources/managing-water-storages

4 Using Decision Support Systems and Tools – Principles for success

Reviewing Australia's journey over the past decades in the successful, and in some cases, unsuccessful adoption of DSSTs to inform water resources decision making reveals the identification of ten key principles for success.

Collaboration

1. **Trust, collaboration, and engagement is essential:** Australia's efforts to drive inter-institutional coordination and clarity of roles, engage various stakeholders, and generate trust, are key building blocks for effective data collection, information generation, and decision making.
2. **Common conceptual models can help gain a common understanding:** It is useful to gain a common understanding through engagement with a broad number of stakeholders using conceptual models, to then develop a more complex model. A 'black box' tool is less useful as stakeholders struggle to understand the inner workings, and therefore may not place trust in it.

Enabling environment

3. **Sector integration is critical for data collection, management and sharing:** Australia takes a unique nation-wide approach with regards to data and DSSTs, such as having centralised data collection and sharing platforms (e.g. BoM), standard modelling practices (e.g. eWater Source), and transparent and clear data sharing processes. This avoids the common issue of poor data access that occurs across many countries in the Indo-Pacific. The value of data increases when it is shared as it avoids data 'silos,' which hide the complete picture.
4. **Legislation can help drive DSSTs development and application:** Australia's water reform process explicitly recognised the importance of data and DSSTs. Enshrining a national data platform and common modelling platform into policy gives legitimacy, increases trust, and long-term funding certainty for data platform and model development.

Data

5. **DSSTs are only as good as the inputs to them:** DSSTs are only as good as the data they use and the questions they try to answer. If poor information is input, or scenarios are not well framed, then DSST results may be unreliable or useless.
6. **The importance and value of data:** Australia has a long track record in data collection and management. Having strong historical records—the systems to capture high levels of data resolution and quality in real-time and the structures to store and access it—gives Australia a unique strength for informing decision-making. Data can be expensive to collect, but if managed well, it can provide a very high return on investment.

Adoption and use

7. **DSSTs need to respond to end user and decision maker needs:** An expensive and complex DSST is useless if it is unable to meet the requirements of end users and decision makers. Therefore, there is a need for a participatory DSST development process that embraces end users and stakeholders throughout the design and development process. In addition, a DSST needs to be able to evolve to meet the changing requirements of decision makers.
8. **DSSTs need to present information in a clear and coherent way that speaks to the decision maker:** Decision makers are rarely scientists or modellers, so communication needs to be clear and coherent, in a way that speaks to their world understanding. This may mean presenting results spatially, visually, framed as economic impacts, or communicated in short policy briefs.
9. **The power of interconnecting DSSTs at multiple scales:** DSSTs can be utilised at multiple scales from basin scale to site scale. These DSSTs can be linked between scales, for example, the hydrological models used to plan for water allocations can inform the operation decisions for the releases of a specific reservoir.
10. **Recognise that decision-making is a negotiated and often political process:** DSSTs provide information to make decisions—they do not make decisions themselves. This is because water management decision-making is inherently a value-driven, negotiated, and political process.

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