Australian National University

Institute for Water Futures

Strategic foresight for water and natural resource management in Queensland

Final report submitted to the Queensland Water Modelling Network

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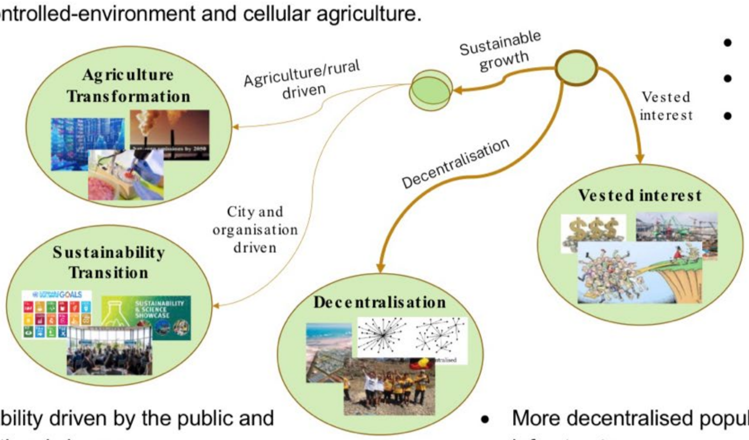
Executive Summary

Foresight is a systematic and participatory process for looking to, thinking about, and debating the future. It is not a way to predict the future; rather it is a way to uncover perspectives on the many different futures that could happen. These perspectives can used to inform decisions made today and provide a greater ability for planning to be more adaptive to manage uncertainties into the future. The Queensland Water Foresight project was established to develop processes and tools to support the joint creation of possible futures for Queensland's water resources and related ecosystems (Phase 1), and to identify opportunities and interventions to move towards desirable outcomes for water and associated resources (Phase 2). The Mary River Basin and South East Queensland (SEQ) region were used as the case study to ground the project activities.

The project drew participants together from a range of government, industry and catchment management organisations to identify key drivers and develop storylines for four scenarios: *Agricultural Transformation*, *Sustainability Transition*, *Decentralisation* and *Vested Interest*. The scenarios reflect different societal, environmental, political, economic and technological changes, as well as different levels of influence of such drivers on the governance of water in the future. The scenarios were intended to facilitate open conversations about how water management might look like in 2050 for the scenarios, including consideration of the competing demands for water between agriculture, environment, urban and other sectors.

- Strong water and carbon credit markets.
- Drier and more volatile climate drives transformation
- Rise of controlled-environment and cellular agriculture.

- Economic growth drives decision making
- Distrust in science
- Big grey infrastructure
- Resource inequity, environmental degradation and social conflicts



- Sustainability driven by the public and organisational change
- Strong acceptance of science
- Collaborative, integrative and proactive water management

- More decentralised population and infrastructure
- Water management focuses on local interests and community participation.

Phase 2 of the project examined the use of the scenarios for: 1) testing the robustness of current strategies; 2) identifying intervention pathways from *status quo* towards desired futures of water management; 3) improving system understanding relating to the futures of water management; and 4) identifying gaps in data and science to support decisions.

In the *Strategy* workshop, participants examined the threats and opportunities posed in the context of the scenarios to some strategies in the Water Plan (Mary Basin) 2006 or the SEQ Water Security Program (2017). Modification of water allocation and trading rules in the statutory Water Plan (Mary Basin) 2006 was a key concern to the participants if the strategic reserve proved not to be viable under climate change and population growth. Considering the SEQ Water Security Program (2017), the implications of significant shifts in the agriculture sector were seen as not yet having received sufficient consideration. Both the statutory Water Plan (Mary Basin) 2006 and the SEQ Water Security Program (2017) have mechanisms to be reviewed and revised with new information including on emerging trends in water availability and demand. Workshop participants recognised that demand-management solutions are recognised as more robust and resilient to future uncertainties than supply-focused solutions, and both need to be considered together to further strengthen and support both plans.

The *Three Horizons* workshop facilitated dialogue about transformative change in Queensland water management in relation to the future scenarios. Key areas of actions identified during the workshop were: 1) education and training in various competencies across stakeholder groups, including farmers, consumers, politicians and decision makers; 2) research and development (R&D), particularly improved monitoring capacity to support more responsive decision making; 3) community engagement, and enabling stronger community influence; 4) roles of markets such as water trading; 5) legislation, including strengthening compliance and enforcement; and 6) organisational capacity in systems and futures thinking.

The final (*Information needs*) workshop centred around the information requirements needed to anticipate how the future may unfold and develop robust water interventions. Participants identified a future state of water management that they wanted to address and selected focal actions from the *Three Horizons* and *Strategy* workshops. The choice of actions and their purpose(s) were discussed, as well as their order of implementation over time and the type(s) and source(s) of information to track changes and the performance of the strategy. The implications of disruptive scenarios and wildcard events on the strategies were then considered.

Transformation of the energy sector emerged as a critical consideration in water planning and management into the future. By 2030, the Queensland Government has committed to a 50% renewable energy target and envisions being at the forefront of energy renewable hydrogen production. The opportunity exists to bring together representatives from Queensland Government, water entities, the renewable energy industry, and local councils to use the scenarios developed in this project as a basis to explore the interconnectedness and implications of future transformation of energy sector and water management on both sectors.

This project highlighted the criticality of collaboration and nexus thinking in water planning and management into an uncertain future. Strong collaboration, coordination and foresight capabilities are required within (and between) government, industry and other stakeholders across sectors. Together with other foresight and scenario planning activities conducted across the State and internationally in recent years, the project offers practical approaches and learnings to foster a shift to a norm of collaborative future-oriented science and planning processes for catchment and water management.

Acronyms

ANU	Australian National University
CRC	Cooperative Research Centre
DAF	Department of Agriculture and Fisheries
DES	Department of Environment and Science
DNRME	Department of Natural Resources, Mines and Energy [1]
DRDMW	Department of Regional Development, Manufacturing and Water
EHMP	Ecosystem Health Monitoring Program
EU	European Union
GBR	Great Barrier Reef
HLW	Healthy Land and Water
IWF	Institute for Water Futures, ANU
MAR	Managed Aquifer Recharge
MERS	Monitoring, Evaluation and Reporting Strategy
MRCCC	Mary River Catchment Coordinating Committee
NRM	Natural Resource Management
PESTLE	Politics, Economics, Social, Technology, Legal, Environment framework
QFES	Queensland Fire and Emergency Services
QWMN	Queensland Water Modelling Network
SEQ	South East Queensland
WSS	Water Supply Schemes
WPSP	Water Planning Science Plan
WSUD	Water Sensitive Urban Design
WWTP	Wastewater Treatment Plant

[1] Now split into DRDMW and Department of Resources

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1 Introduction

1.1 Background

Current water and riverine ecosystem monitoring and modelling approaches are useful for providing insight into past and emerging trends in water and riverine ecosystems, and exploring “what-if” scenarios. However, they are ill-equipped to predict how the environment and society will respond to a wider range of possible dynamics and accelerating changes in the future. Placing too much emphasis on past, quantifiable, linearly extrapolated datasets or models can stop the identification of innovative ways to co-envision and navigate through an uncertain future. Foresight studies have been proposed as a way to address the limitations of traditional approaches to water management that tend to rely on historic data and short-to-medium planning cycles (e.g. up to 10 years). Foresight is a systematic and participatory process for looking to, thinking about, and debating the future. It is not a way to predict the future; rather it is a way to uncover perspectives on the many different futures that could happen and to use those perspectives to make decisions today.

1.2 Development and use of futures scenario in water-related studies

In the scientific literature for water-related studies that employ future scenarios, the most cited (or intended) use of the scenarios is to support decision making or strategy development, such as developing transition strategies to desired futures (Hoolohan et al., 2019), stress testing current river basin management (Henriques et al., 2015), and exploring management options such as low-regret solutions (Gerlak et al., 2021). In addition to strategic planning, scenarios were also used to increase understanding of the social-ecological system and develop futures knowledge, such as future water demands (Drakes et al., 2020), future ecosystem service changes (Malinga et al., 2013), and stakeholder perspectives of changes in wellbeing across diverse futures (Kiatkoski Kim et al., 2022). As well as product outcomes, some studies focused on the process outcomes of scenarios, and highlighted the use of scenarios for stakeholder collaboration (Faysse et al., 2018), and cross-sectoral and intergenerational exchange (Rangecroft et al., 2018). The most common target users of future water scenarios are policy makers, decision makers, agricultural industry and water managers. Some studies also targeted broader stakeholders such as local communities (Blancas et al., 2018), scientists/researchers (Schneider and Rist, 2014), NGOs and think tanks (Hoolohan et al., 2019).

1.3 QWMN Water Foresight project

This Queensland Water Foresight project was funded by the Queensland Water Modelling Network (QWMN) and the Institute for Water Futures (IWF) at the Australian National University (ANU).

The QWMN was established in 2017 to improve the State’s capacity to model its surface water and groundwater resources and to improve the quality of models used to support policy development and water management. The QWMN provides tools, information and collaborative platforms to support best-practice use of water models, and the uptake of their results by policy makers and natural resource managers. QWMN also aims to build the capacity of the water modelling and use sector, encouraging a collaborative culture of engagement between modellers, end-users, researcher, among others. While foresight approaches have been used in the State, it had not been applied to broader land and water management issues with cross-sector collaboration. The benefits of foresight were recognised by leadership groups in the Queensland Government, but capacities to design and undertake foresight activities were seen to be limited.

Initiated in 2020, the project aimed to:

- develop processes and tools to support the joint creation of possible futures for Queensland's water resources and related ecosystems, and
- identify opportunities and interventions to move towards desirable outcomes for water and associated resources.

The scoping and design framework implemented for this project encompasses three components: objective design, method design and dissemination design (Figure 1). The objective design incorporated design elements relating to the definition and clarification of objectives (Figure 2) and was informed by project scoping workshops and engagement with the project Steering Committee. The method design considers four elements relating to the selection and refinement of methods over the life of the project. The dissemination design considered communication and evaluation elements for each of the workshop series and the overall project.

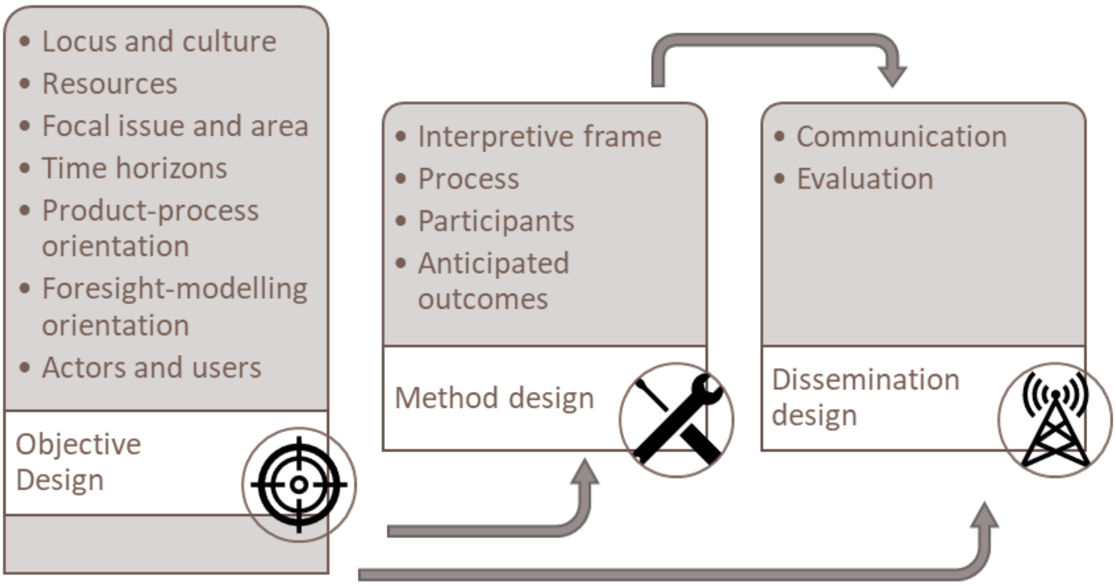


Figure 1. Scoping and designing framework for integrated foresight-modelling projects

The first project phase, completed in 2021, focused on developing multiple plausible scenarios for the Queensland water resource management. Phase 2 commenced in late 2021, was completed in October 2022 and focused on the use of these scenarios.

Locus & culture	• QWMN established to improve water models and modelling capacity • Management approach has both participative and regulatory elements • Water system planning considers regulation *and* natural resilience
Resources	• *Existing resources for rural landscapes and urban regions:* expert knowledge, water data, models and spatial information systems. • *Project resources:* Funding for project lead (0.4 FTE); in-kind contributions from ANU project team, Steering Committee and workshop participants
Focal issue & area	• *Broad focal issues:* 1) water supply, 2) water quality and related ecosystem protection and improvement. • *Area:* the Southeast Queensland catchments (SEQ); Mary River catchment
Time horizon	• 2030 and 2050 align with many existing strategies both internal and external to government. • 2050 is suitable for development of plausible scenarios and the 2030 interim timeframe may set the pathway for the longer 2050 horizon.
Product-process orientation	• *Product outcomes:* future trends/events, scenarios and intervention pathways. • *Process outcomes:* challenging assumptions in modelling and policy development, and building foresight culture in organisations
Foresight-modelling orientation	• Support policy development with better data and evidence • Improve models, modelling approaches and modelling paradigms
Actors and users	• *Actors:* the project team and steering committee. • *Users:* policy and program representatives from Queensland Government, NRM organisations, water utilities and consultants

Figure 2. Characteristics of the project's objective design

1.4 Report Structure

This report documents the methods and processes employed by the project team and the key outputs and implications of the work. The case study region is introduced in Section 2, followed by an overview of the overarching project methodology in Section 3. Section 4 describes the activities and outputs from Phase 1 of the project culminating in a description of the four future scenarios co-developed with workshop participants. The application of these scenarios across three workshops is documented in Section 5. The discussion in Section 6 outlines progress towards project objectives and then addresses three key themes that emerged from the project workshop discussions: the need for water management to embrace a transformation from silo-approaches to approaches that embrace integration and nexus thinking, the imperative of governance to support the development of a foresighting culture across agencies and stakeholders, and the opportunity to coordinate and learn from the growing body of foresight projects across water, agriculture and related fields in Queensland, Australia and globally.

2 Case study overview and water management context

2.1 Mary River

The 9595 km^2 Mary River system (Figure 3) is the southern-most catchment that impacts upon the Great Barrier Reef (GBR) [2]. The 310 km long Mary River ranges from fresh through to saline in the estuary reaches adjacent to Fraser Island. With its warm temperate climate, high intensity cyclonic rainfall events can occur on the very steep slopes in the catchment. Average annual rainfall exceeds 1500 mm in the south-eastern headwaters of the catchment and drops to below 1000 mm in the north-western reaches.

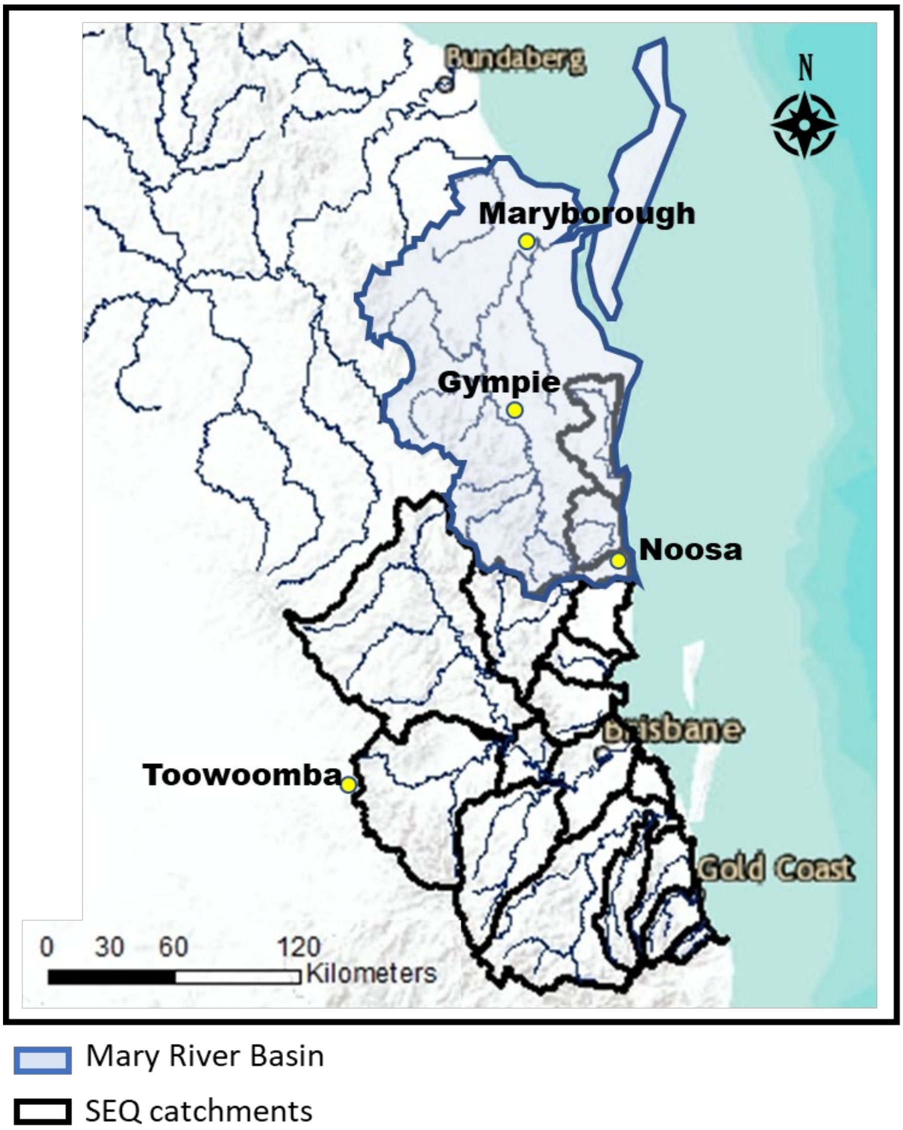


Figure 3. Mary River Basin and South East Queensland (SEQ) catchments

The catchment has experienced major changes in land use, increased competition for resources, and, being close to both the Sunshine Coast and Hervey Bay, rapid population growth [3]. More than 200,000 people live in the catchment with the largest

[2] https://mrccc.org.au/aims/, accessed 12 October 2022
[3] https://mrccc.org.au/aims/, accessed 12 October 2022

urban centres being the towns of Maryborough and Gympie. The diverse local economy includes dairying, beef, forestry, fishing, horticulture, mining, sugar, farm forestry, tourism, sand and gravel extraction, small industry and cottage arts and craft.

Six water supply schemes (WSS) exist within the catchment servicing irrigation and industrial users: four operated by Seqwater (Baroon Pocket, Cedar Pocket, Lower Mary River, and Mary Valley) and two by Wide Bay Water (Teddington Weir and Wide Bay) [4]. The Mary River also supplies towns in the catchment with urban water and water is supplied out of the catchment to urban areas of the Sunshine Coast. Water shortages are an issue that have been raised in the media as recently as October 2020 where unprecedented zero flows occurred in the Mary River [5].

Increasingly developed from the 1800s, the cumulative impacts of land clearing, industrialisation, sand and gravel extraction and increased water supply (rural and urban, and within the catchment and to the Sunshine Coast), led to the Mary River being labelled as one of the east coast's most degraded rivers by the early 1990's. Poor catchment health and associated water quality has serious implications for the sea grass beds of Wide Bay (southern GBR) and also Great Sandy Straits, which adjoin Fraser Island.

In 1991 the Mary River Catchment Coordinating Committee (MRCCC), with representatives from government, industry, farmers, landcare and community organisations, was established to develop strategies and actions aimed at improving catchment health. Much of the riparian restoration that has been undertaken in the catchment has been guided by the MRCCC through their implementation plan to carry out the works needed to achieve actions in the Mary Catchment Strategy, as well as the Mary River and Tributaries Rehabilitation Implementation Plan. Being a catchment that impacts upon the GBR, the MRCCC has received funding from Federal Government Reef Programs to carry out restoration works with landholders. Funds from Queensland Department of Environment and Science (DES), Seqwater and the Sunshine Coast, Gympie, Noosa and Fraser Coast Councils contribute to water quality improvement projects, the community Waterwatch networks and smaller projects [6].

2.2 South East Queensland (SEQ) region

The region of South East Queensland (SEQ) covers 22,672 km^2 and extends from Noosa in the north down to the Queensland-New South Wales border in the south and west to the Great Dividing Range (Figure 3). The region includes the local government areas of Brisbane, Gold Coast, Ipswich, Lockyer Valley, Logan, Moreton Bay, Noosa, Redland, Scenic Rim, Somerset, Sunshine Coast and (part of) Toowoomba (Healthy Land and Water, 2021).The SEQ region catchments encompass a diverse landscape ranging from mountain ranges, hills and valleys, to floodplains, coastal bays and islands. Much of the SEQ landscape drains into Moreton Bay, an internationally significant Ramsar wetland. The SEQ region has a sub-tropical climate, with a long-term average annual rainfall of just over 1000mm (total area-averaged). However, the region has experienced below average rainfall in recent times, including for six

[4] https://www.business.qld.gov.au/industries/mining-energy-water/water/catchments-planning/water-plan-areas/mary-basin, accessed 12 October 2022
[5] https://www.abc.net.au/news/rural/2020-10-15/water-shortage-mary-river-gympie/12769224, accessed 9 November 2020
[6] https://mrccc.org.au/about-the-mrccc/, accessed 12 October 2022

consecutive years from the 2014-15 to 2020-21 [7], and more recently high rainfalls and repeated flooding [8].

The region's population, which is mostly concentrated within 50 km of the coast, is expected to grow from 3.7 million (Queensland Government, 2020) to 5.3 million by 2041 (Queensland Government, 2017). The region is responsible for more than 60% of Queensland's gross product and 70% of the state's employment. SEQ has a diverse economy, supporting various agricultural, manufacturing, tourism and commercial enterprises (Queensland Government, 2017). Rural areas comprise ~85% of SEQ land, with grazing the dominant land use (51% of total SEQ land area), and horticulture and intensive animal production also important agricultural activities.

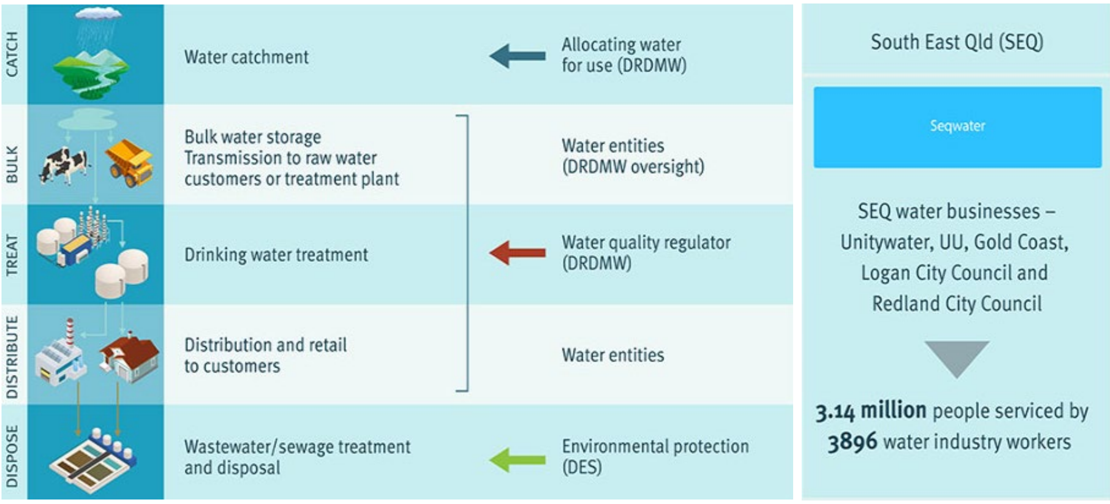
Water supply in SEQ is delivered by Seqwater, with most of the region's drinking water sourced from its 26 dams. The major dams include Wivenhoe Dam on Brisbane River, Somerset Dam on Stanley River, Hinze Dam on Nerang River and North Pine (Lake Samsonvale) on North Pine River. The Gold Coast Desalination Plant also produces 46 GL/year. The Western Corridor Recycled Water Scheme was built over a decade ago as a climate-resilient source of water in response to the impact of the Millennium drought, although it is currently not producing water, it can be recommissioned as required (www.seqwater.com.au). Water security remains one of the top priorities going into the future particularly given the context of the forecasted population growth and climate change (Queensland Government, 2017).

Population growth and climate change, in addition to land use change and water quality have been highlighted as some of the key threats to SEQ's aquatic and marine environments (Queensland Government, 2017). The health of Moreton Bay is under threat from a range of issues – those most relevant to the SEQ catchments include the high sediment and nutrient loads associated with storm water runoff from the major river systems (Saeck et al., 2019). For over two decades, significant investment has been made to reduce nutrient (particularly nitrogen) and sediment inputs to the Bay. The 'South East Queensland Natural Resource Management Plan 2009-2031' [9] set out a large number of targets across various asset themes including water. The regional water targets relate to environmental flows, groundwater levels and quality, groundwater dependent ecosystems, high ecological value waterways, and the maintenance, enhancement and restoration of waterways. Progress towards these set targets is being evaluated by the NRM organisation Healthy Land and Water (HLW), as the current coordinator of the Ecosystem Health Monitoring Program (EHMP) which provides an annual regional assessment of the health for each of the major catchments, river estuaries and Moreton Bay zones in the SEQ [10]. HLW was established in 2016 (through the merging of Healthy Waterways and SEQ Catchments) and works with the local communities, Landcare and other organisations and regional bodies, as well as government agencies to improve and protect SEQ's landscapes and waterways [11].

[7] http://www.bom.gov.au/water/nwa/2021/seq/index.shtml, accessed 17 October 2022
[8] https://www.qra.qld.gov.au/2021-22-Southern-Queensland-Floods, accessed 7 December 2022
[9] https://hlw.org.au/download/south-east-queensland-natural-resource-management-plan-2009-2031/, 17 October 2022
[10] https://hlw.org.au/project/ecosystem-health-monitoring-program/, accessed 18 October 2022
[11] https://hlw.org.au/, accessed 19 October 2022

2.3 Water management in the Mary Basin and SEQ

The *Water Act 2000* establishes the regulatory framework for the management of water resources in Queensland. The Queensland Government, through the Department of Regional Development, Manufacturing and Water (DRDMW) plays a key role in specifying catchment water allocations, regulation of drinking water treatment and the oversight of the storage and distribution of water (Figure 4). Infrastructure to store, treat and transport water is typically owned and operated by Seqwater in South East Queensland and Sunwater elsewhere in the State. These entities are responsible for bulk water storage and provision of bulk water to local councils (Sunwater) or, across the 11 local council areas of the SEQ, to the providers of water and sewerage services (Seqwater). Seqwater is also responsible for long term water supply planning in the region.



(Source: Adapted from [12])

Figure 4. Roles in Queensland water resource management and the SEQ

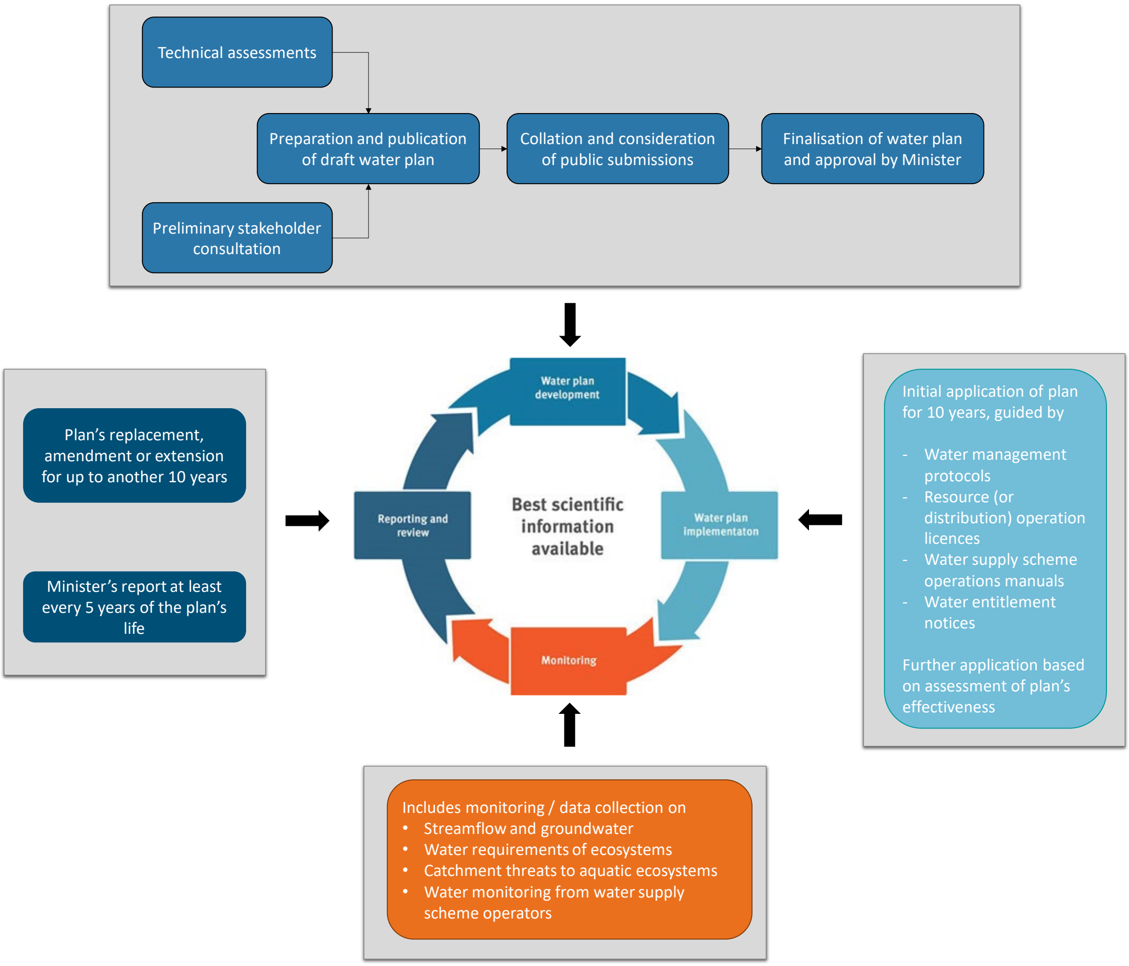
A schematic of the development, implementation and review process for water plans developed for areas in Queensland is shown in Figure 5 [13]. The technical assessments that underpin the development and review of water plans comprise

- ecological modelling using data collected on the flow requirements of ecosystems,
- hydrologic assessments using models which draw on long time series of historic flow data, and the
- identification of water related social, economic and cultural values.

These assessments are used to define in the water plan the amount and type of water that can sustainably be made available to support the needs of water users (towns, agriculture and other industries and the environment) and identify strategies to include in the plan that aim to manage climate-related risks. Further detail on the science underpinning water plans care provided in the Water Planning Science Plan (WPSP) 2020-2030 (DRDMW, 2020).

[12] https://www.rdmw.qld.gov.au/water/how-it-works, accessed 9 January 2023

[13] https://www.business.qld.gov.au/industries/mining-energy-water/water/catchments-planning/planning, accessed 9 January, 2023



(Source: Adapted from [14])

Figure 5 Queensland statutory water plan process.

Of relevance to this project is the Water Plan (Mary Basin) 2006, the expiry date for which has been extended to 28 May 2024 [15]. This decision was taken to allow the Queensland Government to complete technical assessments and undertake consultation to address current and emerging issues within the water plan area prior to replacement of the water plan. Information is available from Business Queensland website on how water is managed in the area, the water supply scheme (WSS) operators and how water can be accessed through water entitlements, water allocation trading or seasonal water assignment [16]. Seqwater operates three schemes within the Mary Basin water plan area – Baroon Pocket WSS, Cedar Pocket WSS and Mary Valley WSS.

Distinct from the statutory Water Plan (Mary Basin) 2006 is the Seqwater Water Security Program (2017). Last revised in 2017, the plan outlines how Seqwater will provide the regions drinking water into the future, taking a 30-year timeframe [17].

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[14] https://www.rdmw.qld.gov.au/water/how-it-works, accessed 9 January 2023
[15] https://www.rdmw.qld.gov.au/water/consultations-initiatives/mary-basin-water-plan, accessed 9 January 2023
[16] https://www.business.qld.gov.au/industries/mining-energy-water/water/catchments-planning/water-plan-areas/mary-basin, accessed 9 January 2023
[17] https://www.seqwater.com.au/what-were-doing, accessed 11 January 2023

Seqwater research indicates that the current water grid can supply the region with enough water until about 2040, except if there is a severe drought or a significant change in supply or demand; post-2040 new water sources will be necessary to meet demand [18]. Low, medium and high demand forecasts are used as different growth scenarios to prepare for whatever population change happens over time in the region and to support Seqwater to take decisions on where, when and how to invest in water infrastructure in response to changing conditions. The plan sets out triggers for implementing different water security options as well as for reviewing and changing the Water Security Program over time.

The science and research underpinning the statutory Water Plan (Mary Basin) 2006 and the Seqwater Water Security Program (2017) both recognise and consider the complexity of the water system in the region and the challenge in managing finite water sources now and into the future to achieve ecological, social and economic outcomes. In this Queensland Water Foresight project, the foresight approach taken embraces a broader future-oriented lens to uncover different perspectives on the many different futures that could happen in the Mary Basin and SEQ. The scope is necessarily broader than the statutory and water security plans and was intended to explore the implications of societal, climate and environmental change on water planning and management now and into the future.

[18] https://www.seqwater.com.au/sites/default/files/2019-09/FACT_SHEET_-_Water_Security_Program.pdf, accessed 9 January 2023

3 Overarching Methodology

3.1 Project scoping

A systematic scoping exercise was undertaken in late 2020 to refine the project scope and inform the project design summarised in Figure 1 and Figure 2. A scoping workshop was held to discuss two main questions with the project team, steering committee members and representatives from some of the primary target user groups (Queensland Department of Environment and Science [DES], Department of Agriculture and Fisheries [DAF] and the then Department of Natural Resources, Mines and Energy [DNRME]):

- What contribution should the foresight project make within the QWMN modelling pipeline? [19]
- What should be the scope of the future scenarios?

A pre-workshop survey was sent to all participants to provide a snapshot of their current understanding on the potential uses of foresight information and their preferences on the project scope (Box 1). The completed surveys were used to structure the workshop breakout and plenary sessions to discuss the project scope, namely the critical time horizons and the potential case studies that the project should target.

***Box 1.** Pre-workshop survey questions*

- Which is a more important outcome from the foresight activities (policy support or improving modelling)?
- Rank the list of key contributions foresight should make to support policy making/modelling
- Who should be the target users of the foresight outputs?
- What are the most useful time horizons?
- What are the main water-related issues the project should target?
- What is the organisation's capacity to affect change in Qld water and related ecosystems?

The key outcomes of the scoping workshop were around use of foresight information, case studies and time horizons. In terms of the use of foresight information, the participants identified the most important product-related outcomes: future trends/events, scenarios and intervention pathways. The most important process-related outcomes are challenging assumptions and building foresight culture in organisations. The Burnett River catchment and SEQ region were identified as potential case studies; after the workshop the participants proposed the Mary River catchment instead of the Burnett system. The time horizon of most interest was 2050 which aligned with several existing strategic plans and scenarios, and was considered appropriate for infrastructure planning for water given the long lead-in times for infrastructure approval and construction. 2030 was seen as important for identifying intervention pathways, towards the 2050 'end point'.

[19] Information on water modelling pipeline can be found at https://watermodelling.org/news/qwmn-forum-2020-to-explore-water-modelling-pipeline (Accessed 29 September 2022)

3.2 Project design and workshop flow

Drawing on the project scoping activities with the Steering Committee and primary target user groups, a two-phase project design was developed. Both phases constituted a series of workshops supplemented with synthesis activities undertaken primarily by the ANU project team (Figure 6). An overview of the project workshops is given in Table 1.

Phase 1 developed scenarios that represent multiple plausible futures (for the year 2050) for Queensland water resource management. Potential uses of the scenarios discussed by the stakeholders engaged during this phase informed the workshop design for Phase 2. These uses were: (1) testing the robustness of current strategies, (2) identifying intervention pathways from *status quo* towards desired futures of water management, (3) improving system understanding relating to the futures of water management, and (4) identifying gaps in data and science to support decisions in the face of future uncertainties.

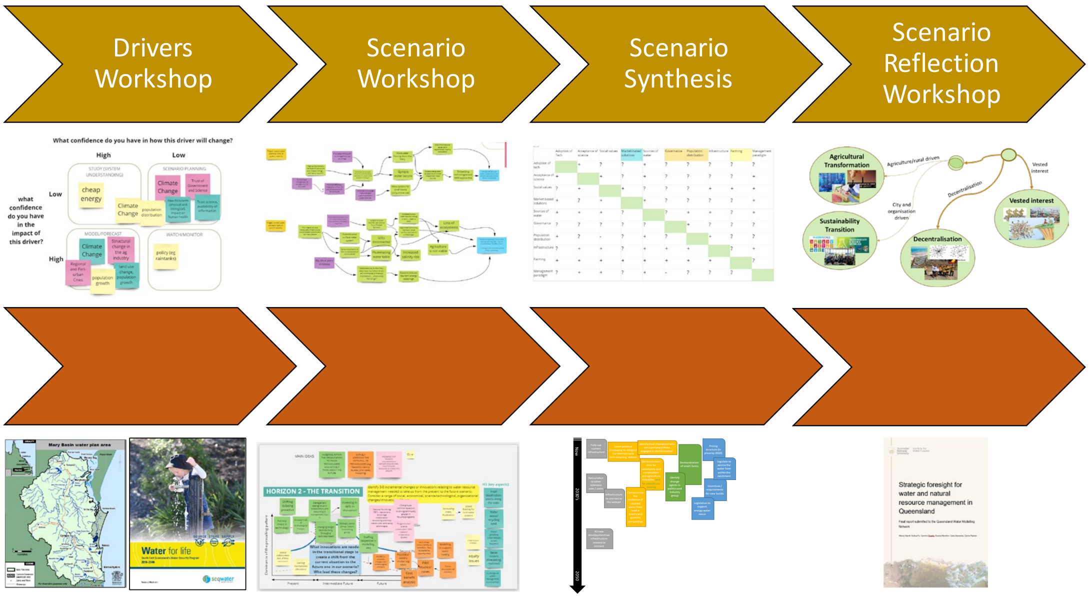


Figure 6. Series of workshops and syntheses implemented in the Foresight project.

3.3 Workshop format and participants

Due primarily to the COVID-19 pandemic, all workshops except the *Information Needs* workshop were undertaken online. Online meeting durations were constrained to three or less hours to minimise 'Zoom fatigue' and used Miro boards to facilitate and capture discussions. The *Information Needs* workshop was conducted as a full day in-person workshop.

Table 1. Overview of the project workshops

Workshop	Purpose	Format	# of participants [1]	Participant organisations
Drivers of Change (March 2021)	To identify critical drivers of change that could shape the futures of Queensland water management in 2050 and the uncertainties associated with these drivers.	3-hour online workshop using Miro	17 *[13]*	Alluvium An independent consultant ANU DAF Department of Resources DES Moreton Bay Council MRCCC NRM Regions Queensland QFES Queensland Water Directorate Southern Gulf NRM Sunwater Walpark
Scenario (May 2021)	To create scenario storylines around water in 2050 for the Mary River and SEQ region	3-hour online workshop using Miro	12	
Scenario Reflections (August 2021)	To evaluate the scenarios developed based on discussions from the Drivers and Scenario workshops	1.5-hour online workshop using live polling	15	
Strategy (October 2021)	To test components of the Water Plan (Mary Basin) 2006 and SEQ Water Security Program (2017) against the four future scenarios	2-hour online workshop using Miro	15 *[6]*	
Three Horizons (April 2022)	To identify opportunities and interventions designed to move towards the desirable future	3-hour online workshop using Miro	17 *[9]*	
Information Needs (September 2022)	To identify information requirements (data, policy and science) needed to support decisions in the face of future uncertainties.	6-hour in-person workshop	9 *[3]*	

[1] Number of post-workshop survey responses shown in brackets

3.4 Project evaluation

Evaluation was built in to the project design and implemented across all phases. The overall objectives were to evaluate whether (and to what extent) learning and future-thinking objectives had been achieved for each workshop and to inform the design and facilitation of future workshops. The approaches used to evaluate the performance of the workshops and triangulate findings included direct questions during plenary activities in the middle and at the end of each workshop, reflections of the workshop facilitators on the group activities, and post-workshop surveys to elicit participant perspectives. Participant feedback during plenary and group activities was captured through audio recording, outputs created by the participants (e.g. post-it notes) and facilitator notes capturing the discussions. The feedback and findings from each workshop were discussed by the ANU project team after the workshops and documented in post-workshop reports which were circulated to the workshop participants for their comment.

Post-workshop surveys consisted of a mix of closed-ended and open-ended questions to gauge participants' learnings, their feedback on the process, activities and facilitation, and their needs and aspirations for future workshop process and content. Completing the surveys was not compulsory and took generally between five to ten minutes for the participants to complete. It is important to note that the discussion of the participants' feedback in this report captures only the opinions of those who took the surveys.

Separate to the evaluation process implemented in this project, an inductive thematic analysis of the overall QWMN Foresight process is being led by Caroline Rosello that draws on the project reports, post-workshop surveys, and consideration of contextual events influential on the project team's decisions when designing the workshops. This analysis is expected to help identify different barriers and enablers for building participants' capability to think about possible futures. This analysis will be documented in a journal article that is in preparation as of the date of this final report.

4 Phase 1: Scenario development

Minkkinen et al. (2019) defined six interpretative frames based on the level of perceived unpredictability and level of pursued change (Figure 7). In this figure, the planning and predictive frames assume the dynamics of the systems can be understood sufficiently for probabilistic forecasting and rational planning to be feasible and appropriate. The visionary and scenaric frames assume the assessment of probabilities is problematic and thus uncertainty is best addressed by considering plausibility; this level of unpredictability was considered appropriate for the SEQ and Mary River water resources. The transformative and critical frames consider the uncertainty so high that, rather than focusing on futures, they focus on uncovering present assumptions and opportunities without defining future outcomes. Some foresight practitioners may not consider the last two frames as foresight. However, it can be argued that like other foresight frames, the transformative and critical frames also involve structured exploration and anticipation with a view to influence strategic thinking.

For this project, multiple interpretative frames were considered particularly relevant:

- *Planning frame:* focusing on identifying trajectories, barriers and opportunities, and adapting emerging modelling approaches and paradigms to suit future needs.
- *Critical frame:* focusing on discussing and challenging assumptions about future changes and water models.
- *Scenaric frame:* focusing on understanding multiple plausible futures of water systems and demands in policy and modelling. it is possible to have one or multiple interpretive frames (e.g. from different stakeholders).

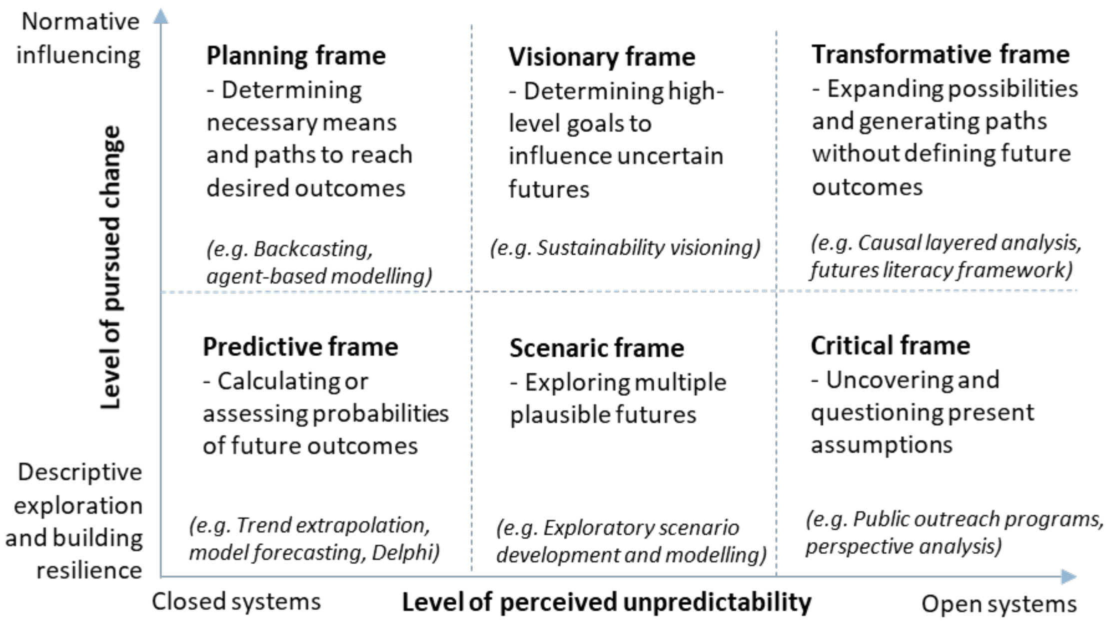


Figure 7. Six foresight frames and example foresight-modelling methods associated with each frame (Adapted from Minkkinen et al., 2019).

4.1 Drivers workshop

4.1.1 Methods

The *Drivers* workshop focused on identifying critical drivers of change that could shape the future of Queensland water management in 2050, and uncertainties associated with these drivers.

Prior to the workshop the project team used the Politics, Economics, Social, Technology, Legal, Environment (PESTLE, De Boer et al., 2018) framework to compile a list of drivers and trends considered relevant to the Queensland water context. Fifteen drivers that may have direct or indirect impacts on water and related ecosystems were identified, including climate variability, natural disasters, water use and exploitation, land use, soil health, pollution and urbanisation (see Appendix 1 for details). In this project, a wide range of water 'users' are considered including agriculture, cultural, domestic, ecosystems, energy, industry, leisure and transport. Drivers of Change Cards (Figure 8) were developed for 12 PESTLE drivers and these were distributed to the participants of the Drivers Workshop prior to the workshop.

In the online workshop, participants were assigned to one of three break-out groups with 5-7 participants and a facilitator. The groups were each assigned a 'user' role: rural water users, the environment and urban water users. There were four breakout activities and a plenary case study discussion. Firstly, each group was asked to identify and prioritise the main goals of their 'user' role and associated water objectives *(Activity 1)*. Then each group discussed the potential impacts of the Drivers of Change (as described in the cards) on the water objectives identified in *Activity 1* and selected 6-10 drivers (from the cards and/or alternate drivers identified by the group) they considered most important for their respective role *(Activity 2)*. Each group then voted on a subset of about 3-5 important PESTLE drivers *(Activity 3)* to consider in the following activity. In *Activity 4*, each group deliberated on the level of confidence they had in how each driver will change and the impact of each driver (Figure 9). In Figure 9, low confidence in both how the driver will change in the future and the impact of changes in the driver indicates high uncertainty. The workshop concluded with an overview of the SEQ and Mary River catchments by two of the participants with local knowledge followed by a plenary on if and how the drivers might differ between the two case study areas.

4.1.2 Outputs

Seven key drivers of change were shortlisted by the workshop participants.

1) *Climate change* was recognised as leading to more frequent extreme events such as floods, droughts, fires and cyclones, and more permanent decline in catchment runoff due to change in temperature and evapotranspiration. While the groups disagreed on the levels of uncertainty associated with climate change (see Figure 9), most participants agreed that the long-term policy and socio-economic effects of climate change, either as step-changes or responses to shocks, was underexplored in the Mary River and SEQ regions.
2) *Trust in science* was conceptualised as driven by information availability, communication, information equity, uncertainty literacy, media and social media influences. The current trajectory identified by participants was an increasing distrust in science but they noted that radical change (shocks) may be possible in the future. The potential policy and socio-economic impacts of trust in

science was considered to be highly uncertain (i.e. low confidence in both questions in Figure 9; top right panel).

3) Future *population growth* and *population distribution* will drive water supply and demand, infrastructure development and water pollution sources. The effect of future population distribution on water and water management in the case study regions were considered to be uncertain.
4) *Land use change* driven by structural shifts in the agriculture sector and climate policy (e.g. biodiversity credits) could lead to more trees in the catchments, altering the spatial and temporal water demand and usage in the system. The direction of change and the nature of the impacts was considered to be more certain than other key drivers in this list (i.e. high confidence in both questions in Figure 9; bottom left panel).
5) *Cheaper energy* will have ripple effects on the transformation and adoption of technologies such as water transfer, water treatment, desalination, monitoring, atmospheric water harvesting, automation in transportation and factory-based agriculture. While the direction of change (cheaper) was considered to be quite certain, the effects of cheaper energy on water resources was considered uncertain. The impact on water demand of energy generation using water dependant schemes such as pumped hydropower or hydrogen was not considered at this stage, although the water requirements of hydrogen generation was raised as a concern later in the project (see Section 5.3).
6) The detection, impacts (including on health) and treatments of *new physical and biological pollutants* was identified as highly uncertain.
7) *Policy and governance,* which is driven by numerous external and internal factors, can have several direct and indirect impacts on water resources. Potential uncertainties identified by participants included those associated with: centralised vs decentralised decision making, ‘prevention & preparation’ vs ‘response & recovery’ paradigm, and policy flip-flops.

Discussions on the potential impacts of these drivers centred on four broad water-related objectives: water supply, water demand, water and ecosystem health and human safety and wellbeing. Many drivers were identified as important for both systems although there were some differences in their priority or impact pathways. For example, agriculture in the Mary River is highly dependent on unsupplemented or unregulated water resources, so might be more vulnerable to climate change than agriculture in the SEQ, which relies more on regulated water sources. In terms of impact pathways, population growth and urbanisation trajectories could plausibly differ between the two regions. Nonetheless, these discussions highlighted the interconnectedness of the Mary River and SEQ region, with water supply in the Mary River driven by water demand in SEQ, and the importance of the project activities to consider the region as a whole. The discussions on water demand include human and nature and highlighted the tension in supply-demand.

Figure 8. Drivers of change cards developed for the Drivers Workshop

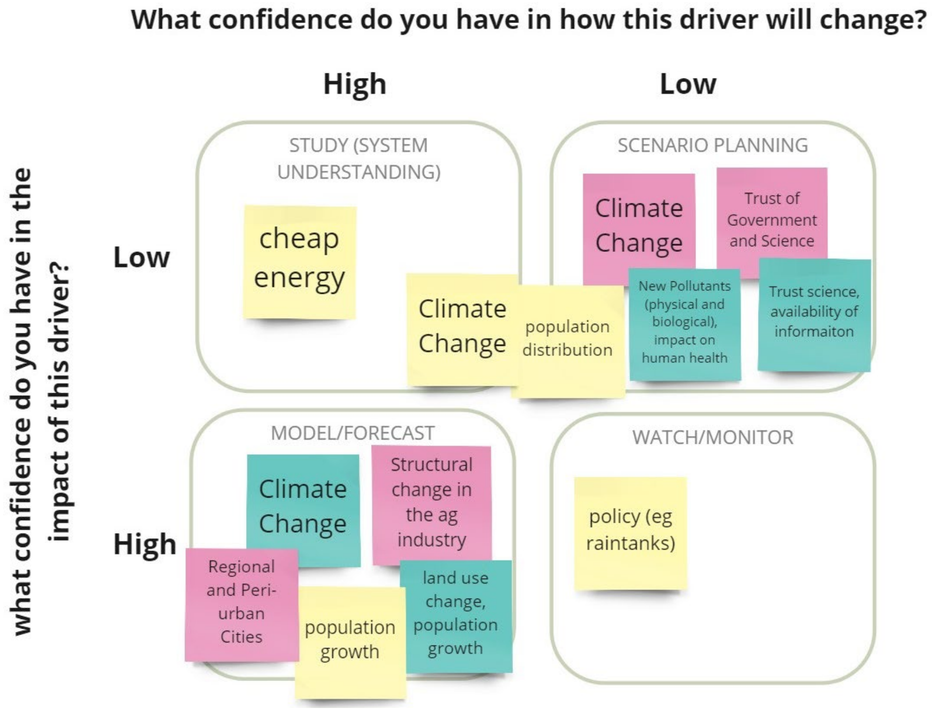


Figure 9. Compiled critical drivers of change from three breakout groups (Pink: rural user; Green: the environment; Yellow: urban users).

4.2 Future Scenarios

4.2.1 Scenario development

Scenario workshop: The Scenario Workshop aimed to create scenario storylines around water in 2050 for the Mary River and SEQ region. With seven drivers of change identified in the Drivers Workshop as being critical to the futures of water management, the traditional deductive approach that defines future scenarios based on a structured framework (e.g. Four Quadrant based on two drivers; Ramirez and Wilkinson, 2014) was not appropriate; these approaches are hard to use with such a high number of drivers. Instead, an inductive approach (Van der Heijden, 2011) to scenario development was adopted whereby scenarios were created by brainstorming events and creating storylines around these events. The participants were split into four break-out groups each with 4-5 participants including a facilitator. Each group was assigned a set of four drivers of change to initiate their discussions (selected from those listed in Section 4.1.2). The structure of the workshop activities is shown in Figure 10.

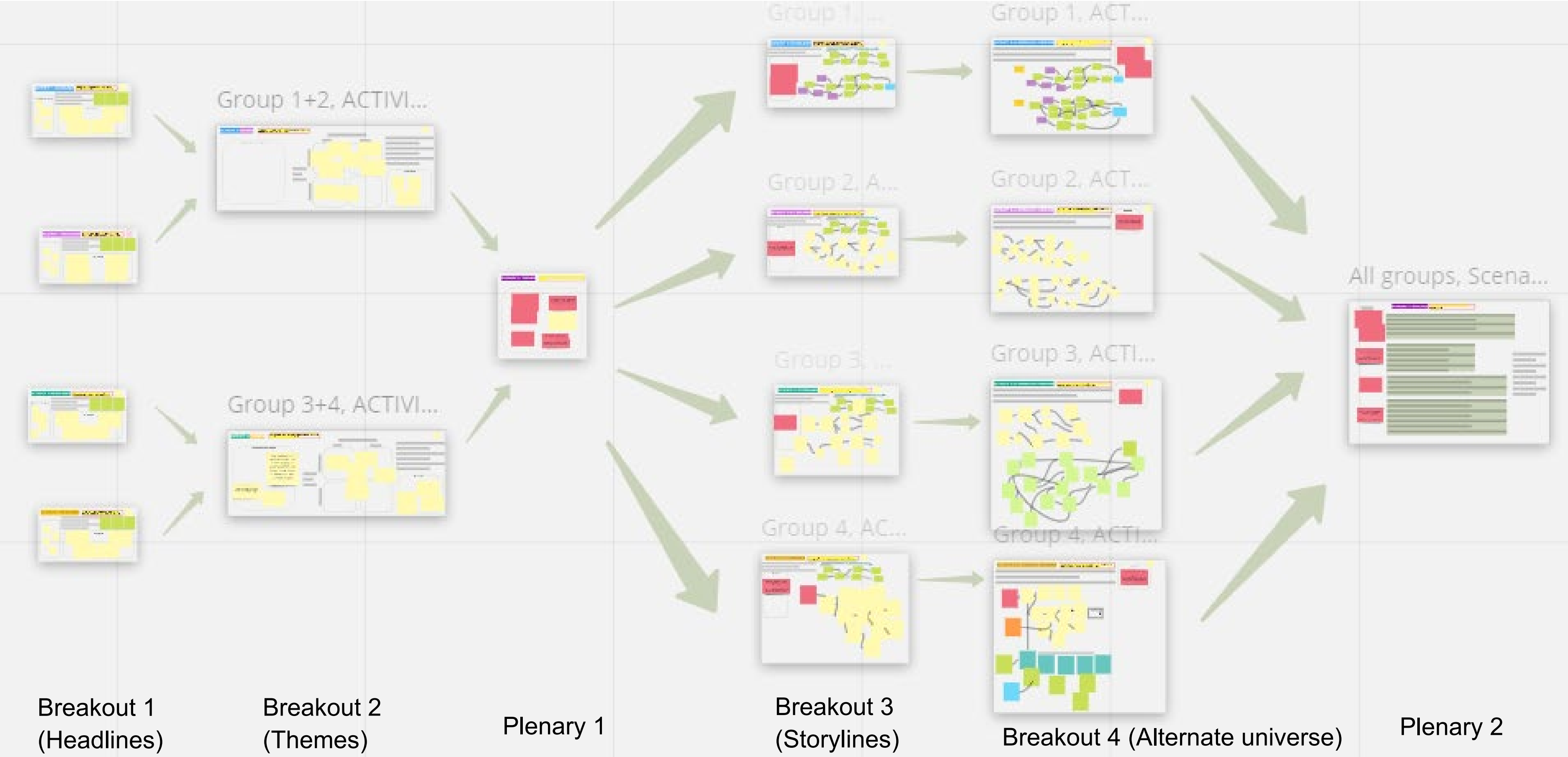


Figure 10. Overview of the Miro boards, showing the divergence-convergence nature of the workshop design.

First, the four breakout groups constructed speculative ‘headline scenarios’ for the Mary-SEQ region based on their set of four drivers *(Breakout 1)*. The headlines included a brief outline about how a shock or trend may influence water systems for the Mary-SEQ region, linking one or more shock or driver to a consequence. Participants were encouraged to consider plausible events and tipping points.

The groups were then merged into two larger groups to discuss the headlines and select two or three to develop into detailed narratives *(Breakout 2)*. The selected headlines from the two groups were discussed in a plenary session with participants to identify four scenario themes to develop into storylines *(Plenary 1)*. The final themes were selected based on three criteria: they point to distinctly different futures; they are important to consider when thinking about future strategies; and they should present either the greatest challenges to water and water management or the most promising opportunities for interventions.

Participants then returned to their original group and developed at least one storyline (or scenario pathway) of how the scenario may unfold in the future *(Breakout 3)*. The purpose of the storylines is to explore ideas and pathways of potential consequences of future shocks, in order to understand key areas of concern and perceived vulnerabilities. These storylines were then assigned to another group who developed an alternative and distinctly different storyline to that developed by the previous group *(Breakout 4)*. The purpose of this exercise is to explore the consequences of different assumptions on scenario pathways.

The workshop concluded with the facilitators from the breakout groups providing a summary of the scenarios developed by their group and a reflection by participants on the scenarios. The storylines emerging from this workshop are included in Appendix 2.

Scenario synthesis: One challenge with the inductive approach is that the storylines that emerge may not have a clear relationship to one another. Identifying the overall framework for scenarios often requires additional thinking and reshuffling of ideas generated from the discussions (Van der Heijden, 2011). This was exacerbated in this project where the shift to online Zoom meetings due to the COVID-19 pandemic constrained the length of meetings to less than three hours. Inductive approaches often employ in-person full or multiple day workshops which allow participants the time to reflect on and synthesise the scenarios.

To create distinctively different scenarios, multiple lines of enquiry were undertaken by the project team. Firstly, the drivers and pairs of causal relationships between drivers and outcomes were extracted from both the *Drivers* and *Scenario* workshops and synthesised by the project team. These driver axes were then used in a cross-impact matrix to identify correlations between the drivers to try and systematically identify how each driver may affect other drivers, and to expose new causal relationships that were not raised in the workshops. Lastly, the archetype method was used to create future scenarios by linking generic images of the future (i.e. archetypes) with the local contents derived from the workshops and synthesis activities. This latter exercise drew on the six meta-archetypes that Boschetti et al. (2016) identified from their review of more than 1000 scenarios addressing different issues over several decades (Figure 11). A *local focus* type scenario was not defined because a future where the Mary and SEQ region would become less connected with other Queensland regions and fend for itself was not considered plausible. We also excluded a *technology drivers* type scenario as the pathways to any future scenarios will involve some level of adaptation of technologies and so different types of technologies were instead embedded in each of the scenario narratives.

A first draft of four narratives were sent for discussion and validation to the participants. Some aspects of the scenarios were initially perceived to be implausible, mostly related to uneven paces of changes between ecological systems on the one hand and political and societal changes, scale dependencies, missing context in the narratives that would explain transitions over time and space, or scepticism about some of the events described, notably a decentralised future. The narratives were revised into four scenarios: *Agricultural transformation*, *Sustainable transition*, *Decentralisation* and *Vested interest*. These four scenarios were evaluated in the *Scenario reflections* workshop.

Scenario reflection workshop: In this workshop, participants evaluated the four archetypal scenarios developed by the project team based the *Drivers* and *Scenario* workshop discussions. This was achieved through live polling for four scenario evaluation questions (Appendix 3) based on three criteria:

1) The developments in the scenario should be **logical**; the causal relationships between events needs to make sense;
2) The scenarios content needs to represent **considerable change** to the current situation. It should not provide a most likely future, but explore the limits of what could happen;
3) The scenarios aim to demonstrate **different** future pathways that could happen. The set of scenarios needs to capture a **range** of relevant uncertainties for thinking about future developments in Mary and SEQ water resources and management, and make decisions about policies and research strategies.

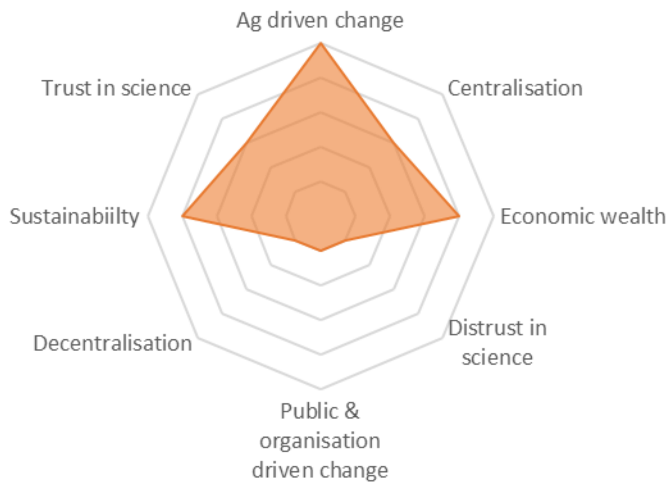
Discussions following each poll were used to refine the scenarios (Appendix 3).

Figure 11. Scenario meta-archetypes identified by Boschetti et al. (2016)

4.2.2 Final Scenarios

The final four scenarios are described in the following subsections. The spider diagrams differentiate the primary and secondary drivers for each scenario. The four axes represented are: agriculture-driven change vs public and organisation-driven change, centralisation vs decentralisation, economic wealth vs sustainability, trust in science vs distrust in science.

Agricultural Transformation:



Water and carbon markets, as tools to manage water resources and respond to climate change, respectively, have gained broad acceptance across all levels of government, agriculture and other water-dependant industries, and urban and water entities. The legislative environment has been designed to achieve equitable and efficient water and carbon markets that prevent monopolising resources and price-setting. Projections of future supply and demand of water resources and carbon credits, including their uncertainties, are transparently communicated to existing and potential investors.

Drier climate, significantly higher water prices, and more frequent extreme events make some agricultural farms less economically viable. At the same time, the world, including Australia, commits to net-zero emission targets by 2050. Australia's transformation to net zero-emission is spearheaded by Brisbane's Olympic Games 2032, as the state Government pledges that South East Queensland (SEQ) will be Australia's first zero-carbon region.

Subsequently, significant private and public investments accelerate the development and adoption of renewable energy and decarbonisation technologies in an effort to transition to low-carbon economy. Some landowners in the region see the opportunity to transform from food producers to renewable energy or carbon credit providers. Large parcels of rural land are diversified to non-food production (Grundy et al. 2016), such as renewable energy or carbon farming [20]. Carbon credits are exported as part of the global carbon trading scheme. In addition, carbon credit projects are integrated with management where reduction in dry-season large-scale bushfire emissions earns landholders carbon credits. Effective controlled burning practices, including cultural burning, also reduce the impact of uncontrolled fires on water quality.

In the agriculture sector, the challenges of increasingly frequent extreme weather events, such as intense droughts, storms, heatwaves and floods, accelerate the adoption of controlled-environment agriculture (Benke and Tomkins, 2017) such as vertical farming. Lab-grown meat becomes more acceptable to consumers,

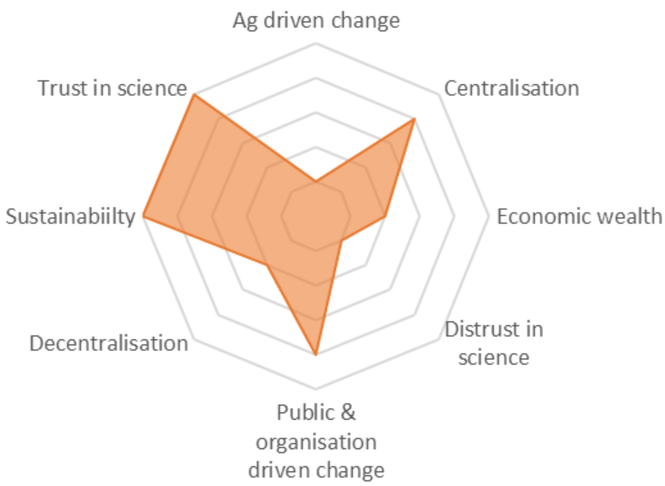
[20] https://www.qld.gov.au/__data/assets/pdf_file/0020/101693/ernst-young-qld-zero-net-emissions-economy-agriculture.pdf, accessed 12 October 2022

accelerating the growth of cellular agriculture. Powered with cheap renewable energy and being located closer to dense population centres and export ports, these new agriculture businesses increasingly become important players in food production.

The rise of urban agriculture places ever-increasing pressure on urban water supply and treatment. As a result, new centrally located desalination plants are built to provide some relief in water supply. New technologies that convert the highly concentrated brine into useful chemicals are adopted to make the desalination process more efficient and reduce the adverse effects of waste brine on coral reef and marine life.

Conventional land-based agriculture adapts to higher water costs through growing high-value crops, precision and/or regenerative farming to reduce water demand, and/or through innovations such as managed aquifer recharge that support the conjunctive use of surface and groundwater resources.

By 2050, the transformation of land and agriculture, driven by markets and climate change, reshape water management in the Mary and SEQ region.



Sustainability Transition: Sustainability and integrated water management paradigms are adopted by the communities, government agencies, businesses and industries as the guiding principles of water management and use in the Mary and SEQ region. Environmental, societal and economic considerations are balanced in pursuing an improved quality of life for all in the region. Events, such as the listing of GBR as "in danger" as a World Heritage Site and the global sustainability movements, accelerate the broad acceptance of these paradigms.

Spearheaded by rapidly advancing sensor technologies, artificial intelligence and faster internet speeds, real-time water information and long-range water resource projections become available and accessible by decision-makers and communities. Significant advancement in sciences and modelling, effective communication of science-based outputs and high level of trust in science by the communities lead to shared understanding of challenges in water resources management, including climate change. However, significant gaps remain, such as dealing with uncertainties, social conflicts and decisions that create winners and losers.

In urban areas, water sensitive urban design (WSUD) and integrated management of water infrastructure are norms. Smart utility meter [21] technology that monitors water uses and promotes water-saving behaviours are adopted by the businesses, residents and visitors in the region, significantly reducing urban pressures on water demand. Urban intensification (Allen et al. 2018) is used to manage the environmental footprint

[21] https://www.smart-energy.com/industry-sectors/smart-meters/how-smart-utility-meters-help-households-make-better-choices, accessed 12 October 2022

of a growing population by maximising the use of infrastructure capacity while improving urban liveability. Nature-based solutions such as the sponge city concept (Chan et al 2018) are adopted to increase climate resilience.

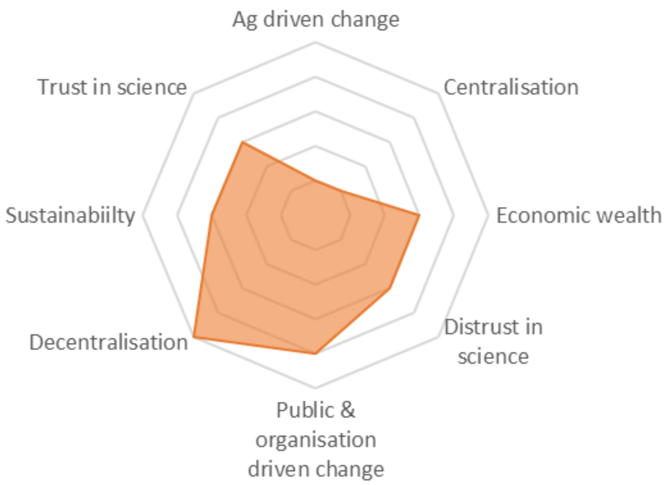
In rural areas, water conservation technologies and best practices in soil and runoff management are widely adopted. Powered by cheaper renewable energy and advanced water treatment technology, recycled water [22] becomes a significant water source for irrigation. In addition, societal demand for sustainable produces [23] accelerates the active transition to regenerative agriculture which improve soil health, water cycle and biodiversity.

Disaster risk management focuses on corrective activities initially, and proactive activities throughout. Corrective activities involve retrofitting critical at-risk infrastructure and relocating exposed populations such as those living on high-risk flooding areas. Development of disaster-resilient water infrastructure and land use planning prioritising the avoidance or mitigation of natural hazards are used to address future disaster risks.

While progress to significant water law reform for First Nations Peoples (Godden et al 2020) has been slow and patchy, their knowledge and influence in water management is increasingly recognised and valued. Consultative approaches to environmental flow management result in better flow regimes and noticeable ecological systems recovery.

Visible benefits of good management practices and planning decisions reinforce the population's trust in science-based decisions and foster broad commitments to apply ongoing good water use practices. By 2050, the region's sustainability- and efficiency-driven water resources management is recognised, allowing for the exportation of water management expertise and the achievement of resilient and vibrant societies.

Decentralisation: The region's population [24] has grown by 75%, from 4 million in 2021 to 7 million in 2050. Digital technologies and internet connectivity have advanced significantly, enabling a virtual presence for work, study and other activities. This regional lifestyle is supported by affordable digital health care [25], on-demand and



[22] https://globalwaterforum.org/2020/05/11/potable-water-reuse-the-next-megatrend/, accessed 12 October 2022
[23] https://www.weforum.org/agenda/2021/05/eco-wakening-consumers-driving-sustainability/, accessed 12 October 2022
[24] https://www.qgso.qld.gov.au/statistics/theme/population/population-projections/regions, accessed 12 October 2022
[25] https://nationalstrategy.digitalhealth.gov.au/about, accessed 12 October 2022

affordable transport [26] greater acceptance of credible remote learning [27] certificates and micro-credentials, and quicker and more streamlined freight services [28]. Automation technologies take care of routine manual tasks allowing most workers to focus on providing knowledge and services. Subsequently, the need for physical presence in the workplace or classroom is reduced. Most workers have more flexibility in where and when they work and benefit from shorter workdays to focus on personal wellbeing and community services. As a result, a growing number of people choose to live in regional centres over expensive and crowded cities.

Decentralised water technologies (Quezada et al. 2016) play a crucial role in the regional centres to support water supply and treatment and improve climate resilience. High capital expenditure on new infrastructure has placed an initial strain on government budgets. However, the ongoing operating costs are reduced by more efficient and connected systems. Combined with decentralised energy systems [29], these flexible and sustainable options replace the need to build large water delivery and treatment infrastructure. The costs associated with new infrastructure mean the rollout is not uniform across the region, with faster-growing areas benefiting ahead of others.

With more people living in the regional centres, growing numbers of people became engaged in regional issues and demanded change in how decisions are made. A system of transparency, clarity and acceptance of decision-making between institutions of governance at the central, regional and local levels is established, and participatory decision-making becomes the norm. Supported by increased local revenues and participatory budgeting [30], local councils and NRM bodies develop strong partnerships with communities, industries and research institutes to develop and support holistic development goals. This shift from coalitions around political lines to coalitions around issues still presents challenges associated with conflicting values and priorities. However, communities are empowered to engage in water management and negotiate positive outcomes at local scales.

Disaster risk management focuses on community-based activities such as community assessments of hazards, vulnerabilities and capacities, and their involvement in planning, implementation, monitoring and evaluation of local action for disaster risk reduction.

With socio-economic and ecological improvements, new decentralised industries and services emerge in the region, attracting a seasonal and perennial population around the regional centres.

By 2050, a more decentralized and collectively empowered society emerges in the Mary and SEQ region.

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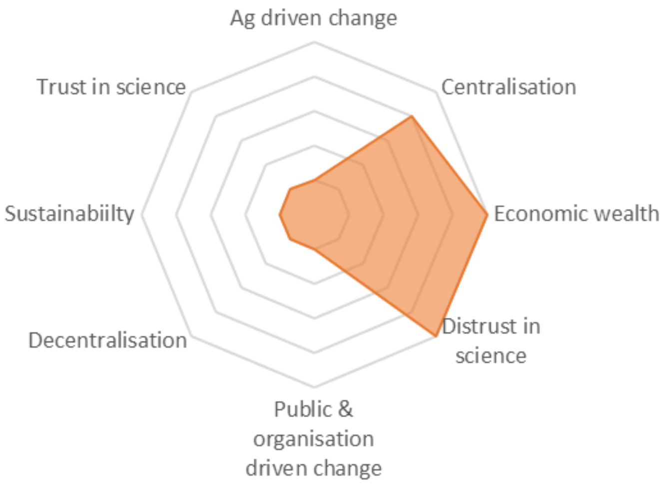
[26] https://www.tmr.qld.gov.au/-/media/communityandenvironment/Planning-for-the-future/Queensland-Transport-Strategy/time-travel-report-0619.pdf?la=en, accessed 12 October 2022
[27] https://www.weforum.org/agenda/2016/09/is-online-learning-the-future-of-education/, , accessed 12 October 2022
[28] https://www.freightaustralia.gov.au/what-are-we-doing/scenario-planning, accessed 12 October 2022
[29] https://www.qld.gov.au/__data/assets/pdf_file/0022/101695/ernst-young-qld-zero-net-emissions-economy-energy.pdf, accessed 12 October 2022
[30] https://www.bettertogether.sa.gov.au/planning-tools/engage/participatory-budgeting, accessed 12 October 2022

Vested Interest: As alternative realities perpetuated by media and social media become entrenched in people's daily lives, water management becomes further politicised and the foci for disinformation [31] campaigns. These campaigns, by individuals or groups, aim to heighten public mistrust in science [32] or influence policies or decisions (e.g. the type and location of new water infrastructure or water allocation policies) for commercial or political gain. This disrupts and paralyses sustainable and strategic policy development in the water space. Efforts of scientists to communicate the severity of environmental issues, or feasible solutions to them, fall on deaf ears.



Driven by the separation of water and land entitlements, and ongoing scarcity, water becomes a precious asset and enters the stock exchange. Following the lead from California's water futures market [33], investors are permitted to buy water entitlements during wetter years when water is cheaper, and hedge towards drier years when the prices are higher. With limited water market regulation, large corporations or water investment companies purchase the majority of water entitlements [34]. Speculation by these more prominent players sees record prices set whenever conditions are dry.

As a result, water resources become too costly for smaller farms and disadvantaged communities to purchase. Farmers resort to reducing agricultural production or selling their water entitlements to large corporations. The high cost of water reduces the volumes of water that can be purchased for the environment, meaning that ecosystems in the region become irretrievably degraded, with only a few small assets able to be protected. Increased cyclones and flooding lead to increased casualties and infrastructural damages in floodplain/high-risk areas, increasing population distress and property insurance premiums, and reducing property values. Economic and social inequality widens.

Inequality breeds public distrust in government, resulting in frequent changes in state government leadership and policy flip flop. Local councils become more sceptical of the effectiveness of higher decision-making levels and start to consider their own solutions. Mistrust between decision-making levels worsens coordination and communication, preventing effective environmental monitoring and provision of feedbacks to water management and planning.

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[31] https://globalwaterforum.org/2019/12/17/waves-of-fake-news-in-transboundary-waters-the-need-for-communication-resilience/, accessed 12 October 2022
[32] https://www.abc.net.au/news/2017-07-31/the-four-ways-distrust-of-science-has-infected-political-agendas/8759194, accessed 12 October 2022
[33] https://pacinst.org/implications-of-californias-water-futures-market/, accessed 12 October 2022
[34] https://www.accc.gov.au/system/files/Murray-Darling%20Basin%20water%20markets%20inquiry%20-%20guide%20to%20the%20final%20report.pdf, accessed 7 December 2022

With less water in storages, investments are made in grey infrastructures and water transfers from the Mary River system to SEQ, leading to increased conflicts between Mary and SEQ, and visible damage of reduced water resources available to water users in the Mary River system. Ecologically, the impact is severe with the degradation of the Mary River ecosystem and Great Barrier Reef. The unique Australian lungfish disappears from the Mary River system.

With no long-term commitment to disaster preparedness, disaster risk management largely relies on response and recovery activities, coupled with financing instruments such as national contingency funds and insurance.

By 2050, the region suffers from less affordable and limited freshwater resources, continued degradation of ecosystems and associated services, and increasing economic and social inequality. Neither people nor nature are thriving.

5 Phase 2: Scenario Use

Four potential uses of the scenarios were discussed by the stakeholders in Phase 1:

1) testing the robustness of current strategies (Section 5.1);
2) identifying intervention pathways from status quo towards desired futures of water management (Section 5.2);
3) improving system understanding relating to the futures of water management (Sections 5.1 to 5.3); and
4) identifying gaps in data and science to support decisions in the face of future uncertainties (Section 5.3).

The three workshops described in the following subsections were designed to explore the utility of the scenarios against these uses.

5.1 Strategy workshop

5.1.1 Methods

This *Strategy* workshop was designed to test components of the Water Plan (Mary Basin) 2006 (Queensland Government, 2006) and SEQ Water Security Program (Seqwater, 2017) against the four future scenarios. Following consultation with Seqwater and the RDMW, six strategies were selected as the foci for the discussions (Table 2). Two breakout groups – one for the Mary River and the other for the SEQ – were asked to reflect on:

1) the threats/opportunities to the strategies under three future scenarios: *Agriculture Transformation* (Mary), *Sustainability Transition* (SEQ), *Decentralisation* (Mary and SEQ) and *Vested Interest* (Mary and SEQ), and
2) how could (or have) the implications of the threats/opportunities be(en) examined in the planning process.

Given time constraints, this workshop was not intended to provide a comprehensive analysis of the scenario implications for the plans and selected strategies.

5.1.2 Scenario implications

Three common themes emerged from the discussions regarding the futures of water management strategies in the Mary and SEQ region:

1) concern around the implications of the lack of flexibility of the statutory and water security plans under future climate and demographic change;
2) demand-management solutions (e.g. farm-turned-tourism to support ecosystem services, household water demand management) are recognised as more robust and resilient to future uncertainties than supply-focused solutions, and both need to be considered together to further strength and support the water plans; and
3) effective communication and capacity building of organisations, industries and communities are a critical part of the solutions in all future scenarios.

Table 2. Focus strategies considered in the Strategy Workshop.

Plan	Strategy	Description
Water Plan (Mary Basin) 2006	Specification of ecological outcomes	The Water Plan (Mary Basin) 2006 specifies ecological outcomes for particular parts of the plan area, such as the Noosa River (and coastal streams), Mooloolah River, Mary River (upstream Mary River barrage pondage), Six Mile Creek, Tinana Creek Obi Obi Creek and Burrum River. However, no ecological objective is provided for the Great Sandy Strait. The mechanisms to meet the outcomes include the operational and environmental management rules in the Mary Basin Water Management Protocol (RDMW, 2021)
	Specification of trading zones	The Mary Basin Water Management Protocol (RDMW, 2021), commenced in 2016, implements the Water Plan (Mary Basin) 2006 (Queensland Government, 2006). For the Lower Mary River area, the Protocol specifies the types of water allocations (i.e. high/medium priority) in the Lower Mary River Water Supply Scheme (WSS), and how water can be traded. Currently, there is only one zone for the Lower Mary River WSS. The allocations in this zone can only be traded with the one zone in the Teddington Weir WSS.
	Strategic reserve	Under the Water Plan (Mary Basin) 2006 (Queensland Government, 2006), unallocated water is held as a general, strategic or town water supply reserve. A certain amount of strategic water reserve (which will be reviewed in the MBWP replacement currently underway) is put aside for significant project, or infrastructure identified in the SEQ regional plan or regional water security program.
SEQ Water Security Program (2017)	Purified recycled water	There are two pathways to this new supply option: 1) indirect potable reuse, including recommissioning the Western Corridor Recycled Water Scheme (capacity up to 182 ML/day) to produce recycled water, which is more expensive than treating surface water sources; and 2) direct potable reuse, which reduces costs by not relying on storage (e.g. dam) and less pumping. The second reuse option is currently not considered viable due to lack of legislation support for direct portable use.
	Desalination plant	The second strategy involved building a new northern/central desalination plant near the coast to significantly increase water supply that is not reliant on rainfall. As a gauge, the current Gold Coast Desalination Plant can supply 133 ML/day of water. Current projected medium total bulk water demand for the SEQ region in 2046 is about 1400 ML/day, which is an increase of about 600 ML/day from the 2015-16 demand.
	Water saving measures	A range of water demand/saving measures are considered in the Program, including water saving devices, household greywater structure and use of water pricing to provide incentive for increasing water use efficiency.

Agricultural Transformation: This scenario highlights the shift in the agriculture sector in the Mary region towards high value crops, which demand more reliable (and year-round) quantity and quality of water supply. The workshop participants considered that the current supply system (run-of-the-river system, no dam) would leave that agriculture transformation vulnerable to increasing risks from climate change and variabilities. Supporting sustainable transformation of agriculture would require those involved in water management, and future development of implementation of the Water Plan (Mary Basin) 2006, to get ahead of expected growth in population and agriculture change, and start to think about the change in water demand, seasonally and spatially, that will occur over the next 30 years. Potential foci to consider, individually or in combination, are shown in Figure 12. The modification of water allocation and trading rules was considered especially important if strategic reserve proved not to be viable under climate change and population growth. Many risks associated with the infrastructure development pathway were identified especially in the context of the *Vested Interest* scenario.

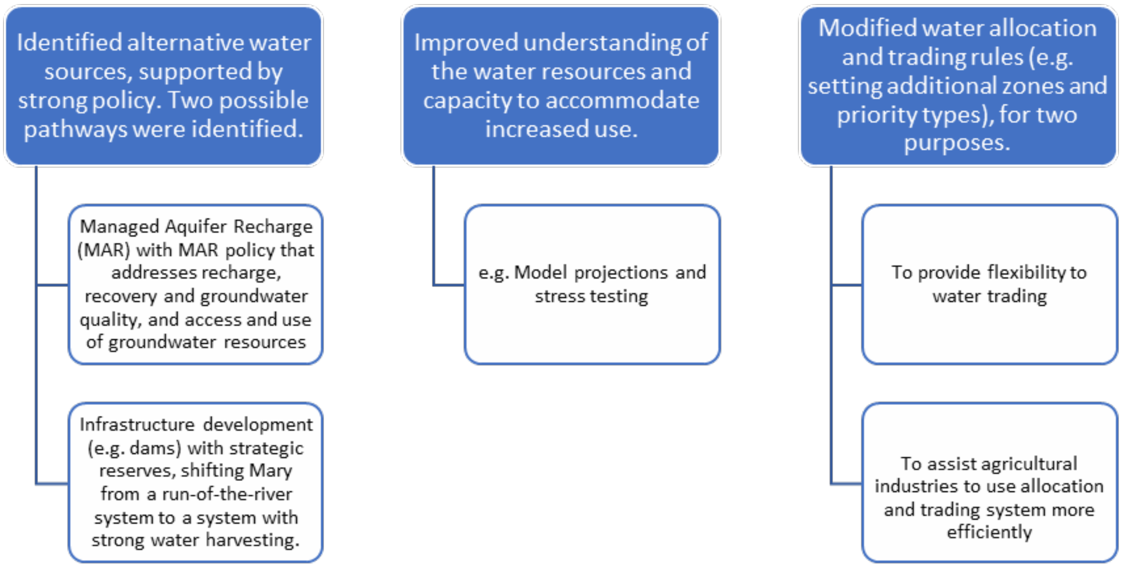


Figure 12. Key considerations needed to support the sustainable transformation of agriculture

Sustainability Transition: This scenario highlights the paradigm of integrated water management. Technical challenges and tensions between water users associated with population growth are important issues to address.

The group identified a lack of holistic regional water consideration in the Seqwater water security program and identified ways to redress this. For example, the purified recycled water scheme could be used to support dam levels and be used by irrigators, especially if the prices become more acceptable. The implications of a potentially significant shift in the agriculture sector (*Agriculture Transformation* scenario), such as water use efficiency associated with controlled-environment agriculture, has not been given significant consideration in the Seqwater strategy.

This scenario assumes a strong support (or good will) from the communities in terms of transitioning to sustainable practices. The participants identified that this support or good will needs to be backed up by strong (two-way) communication between Seqwater and the communities to support the uptake of technologies associated with the strategies (e.g. recycled water technologies). This may involve allowing the communities to check what they use is safe or that the implementation of technologies is of a high standard, and to provide feedback to Seqwater about what does or doesn't work. There might be opportunity to consider and strengthen two-way communication strategy in the Seqwater water security program to obtain effective feedbacks from communities. In the future, new technologies such as sustainability monitoring may help collect data on water uses and add new layers of sustainable accountability to urban spaces.

Decentralisation: The Decentralisation scenario describes a future with more regionalised population distribution aided by technological advances and societal changes.

From the Water Plan (Mary Basin) 2006 perspective, a potential threat under this scenario is increased competition between agricultural and town water supplies, placing further pressure on high priority water and so increasing the cost of water. The current legislations and water planning process focuses on rural and urban areas but there has been little consideration of how to deal with urban sprawl. The participants felt that the Plan in its current form was not flexible enough to cope with the changes implied by this scenario.

Potential strategies may include:

- Towns adapt to utilise more medium priority water (this is already occurring at Gympie).
- Examine more holistically the potential sources of water (e.g. groundwater, MAR, infrastructure, piped sources from other catchments, dams, recycled water)
- Regulate/encourage new developments to undertake more intensive water harvesting (other than water tanks) and reduce reliance on Mary River water, and encourage/assist homeowners to develop their own ‘demand management’ strategies and reduce per capita water usage.

The strategic reserve will be less relevant under this scenario because this will be even more expensive under a decentralised scenario and harder for proponents to argue for a “significant project”.

In terms of the SEQ Water Security Program (2017), the flexibility of the three strategies were assessed by the participants. In general, the consumer-based water saving measures were considered most flexible/robust under the *Decentralisation* scenario. Desalination plants may to some extent support the more decentralised demand given they are located in different regions. Mitigation strategies for inflexible strategies may be considered in the Seqwater water security program. For example, while the Western Corridor Recycled Water Scheme was considered most inflexible, it may be mitigated by more decentralised Wastewater Treatment Plant (WWTP) schemes. The SEQ group identified that a decentralised population and a diversification of water supply systems are likely to result in the provision of diverse quality of services and subsequently water prices for different regions and institutional needs. More complex price structures and quality control of services may be needed, which are not yet considered in the plan. Policy changes, appropriate governance system and community engagement will be critical to support the implementation of different quality of services and price structure. Increased regional development associated with this scenario may also have significant effects on water quality in dam water supply and strategies to monitor and mitigate water quality will be critical.

Vested Interest: This scenario describes a future where economic growth and vested interests drive decision making. Environmental flow objectives are locked into legislation and cannot be easily changed so are considered robust to this scenario. However, the policy flip-flops described in the scenario may prevent meaningful proactive changes to protect the environment or water security for the broader community. A lack of trust in science (e.g. behind ecological outcomes) could lead to planning delay or policies being vulnerable to lobbyists and conflicts, thereby reducing evidence-based decision making and impacting all catchment and water planning processes. Ongoing efforts in communication, transparency and dealing with disinformation is needed, including continued investment in people, skills, resources to support engagement around planning. The participants from the Mary group raised the idea of “positive vested interest” whereby one industry that required good water quality (e.g. water-based tourism) pushed back against other industries that consume or pollute water. However, this idea was not discussed in detail by participants who concentrated on measures to counter negative vested interests.

The participants from the SEQ group identified that the consumer-based water saving measures can be the key to counter vested interests and safeguard water equity under this scenario, highlighting the high level of human agency in this strategy. Water scarcity created by vested interests may provide strong incentives for the uptake of consumer-based water saving measures, and drive innovations in this space. The Seqwater security program can enhance strategies to educate and empower the community in water saving measures.

5.2 Three horizons workshop

5.2.1 Methods

The *Three Horizons* workshop aimed to identify opportunities and interventions for moving towards a desirable future. It applied the Three Horizons framework (Sharpe et al., 2016) to facilitate dialogue about transformative change. The framework represents three different patterns (Figure 13): an established first horizon (red dashed line) giving way over time to an emerging third horizon (e.g. a desirable future) (green dashed line), via transitional activity in the second horizon (black dashed line). The framework has been used to support transformative thinking in many fields such as military technology (Jordan, 2021), sustainability transformation (Fazey et al., 2020) and population health (Wicks and Jamieson, 2014).

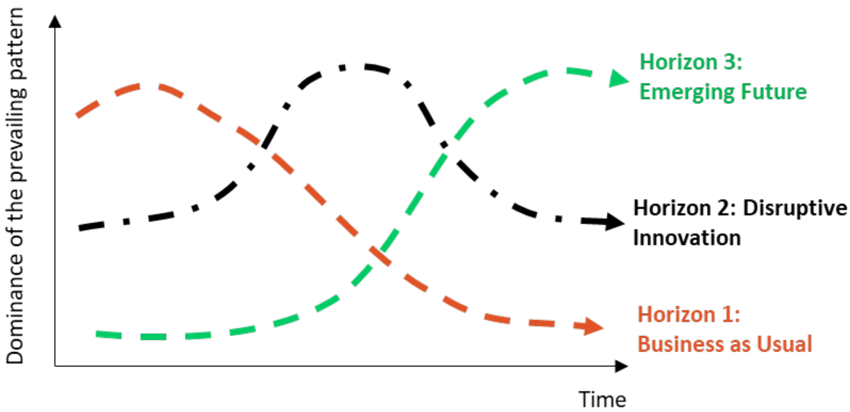


Figure 13. Three horizons framing used to identify opportunities and interventions to move towards desirable future(s).

The participants were split into three working groups to discuss the horizons based on one of the future scenarios: *Agriculture Transformation*, *Sustainability Transition* and

Decentralisation. The *Vested Interest* scenario, the "Decline" archetype scenario (see Figure 11) that is not seen as a desirable outcome, was not considered in this workshop. Commencing with Horizon 1 (the present) in the first activity, the participants were asked to identify aspects of water management that are prevalent today but will become less relevant or useful for their given future scenario. They then discussed Horizon 3, namely 1) how could water resources be managed differently in the future scenario and 2) what emerging changes/innovations are already happening today that can be taken to that particular future scenario. In the Horizon 2 (the transition) session, participants were asked to identify innovations or interventions that are needed in the transitional stage to create a shift from the current situation to their future scenario, and what actor or institution would lead these changes.

5.2.2 Outputs

The workshop discussions included the identification of vulnerabilities in current water planning and management practices under each scenario and descriptions of possible water planning and management practices in 2050. A common vulnerability across the three scenarios was the silo approach considered to be the current state of water planning and policy; by 'silo' the participants felt that there was insufficient integration across water, agriculture, energy and other sector planning processes. Other issues were more specific to the type of scenario (Table 3) but translate to the common needs of improving data availability and knowledge inclusion to inform flexible water planning and policy decisions. In terms of future planning and management needs, common to the three scenarios was the adoption of more integrated and nexus thinking approaches to water planning and management, more coordinated planning across sectors, building on knowledge inclusion, greater community influence on decision-making, data availability, and more flexible water policies and practices (Table 4).

The key types of actions identified during the workshop to support transitions from current to future practices were: 1) education and training, 2) research and development (R&D), 3) community engagement/influence, 4) market and water trading, 5) legislation and 6) organisational capacity. These are summarised in Table 5. All groups identified the importance of education and training, albeit with a focus on different groups reflecting the scenario they were assigned. Improved monitoring capacity (R&D) to support more responsive decision making was a common theme across all scenarios and groups, as was strengthening the capacity of water managers and scientists to influence community. Various top-down and bottom-up approaches to influence community were identified. Market and water trading were discussed by the *Agricultural Transformation* and *Decentralisation* groups, with the former placing emphasis on market equity and expanding the concepts of water and carbon markets to include water quality and biodiversity. The latter focused on the structure of water trading mechanisms needed to support flexible and dynamic water management under the *Decentralisation* scenario. Actions related to legislation were most discussed by the *Agricultural Transformation* group, although stronger compliance with, and enforcement of, regulations was also raised by the *Sustainability Transition* group (Table 5). The absence of actions across these categories (e.g. regulation under the Decentralisation scenario) does not necessarily mean it was considered irrelevant; rather, it may not have discussed in detail by the group participants perhaps for lack of time.

Table 3. Vulnerabilities of current water management identified by participants in the Three Horizons workshop

Agriculture Transformation	Sustainability Transition	Decentralisation
Planning/policy environment • Silo approach • Partly regulated • Issues around compliance	Planning/policy environment • Silo approach • Limited compliance • Short-term planning is the norm • Limited inclusion of knowledge in planning, especially First Nations	Planning/policy environment • Silo approach • Limited inter-basin transfers and conjunctive water use • Rigid water allocation & pricing mechanisms • Top-down consultation
Immature carbon and water markets; agriculture industry has 'set-and-forget' approach to market	Nature-based solutions for flood mitigation and water sensitive urban design more the exception than the norm	
Manufacturing water often a "last resort" option; current paradigm largely assumes single use of water	No voice for the environment; politically environmental needs are not considered equally important as economic needs	Large centrally managed water infrastructure not suited for decentralised populations
Misalignment between water quality standards and types of uses	Political interference in decision-making processes, preventing sustainable decisions (e.g. focus on grey infrastructure for flood management when ecological-based solutions offer potential)	Real-time water information and forecasting is needed for monitoring and to inform water allocations and demand management decisions
Agriculture is primarily focused on production	Real-time water information and forecasting is needed for monitoring and to inform water allocations and enforcement of water regulations.	

Table 4. State of catchment and water management in 2050 envisioned by participants during the Three Horizons workshop

Agriculture Transformation	**Sustainability Transition**	**Decentralisation**
Integrated planning/policy environment • Water-energy-agriculture nexus • Fully regulated system • Outcome-focused • Effective compliance • Conflict management and litigation	Integrated planning/policy environment • Water-energy-agriculture nexus • Effective compliance • Long-range future scenario planning is the norm • First Nations knowledge recognised and embedded in planning	Integrated water management • Options co-designed & co-led by local communities • Considers inter-basin transfers and conjunctive water use
Mature & integrated biodiversity, carbon and water markets; agriculture industry act as carbon and biodiversity stewards	Nature-based solutions for flood mitigation and water sensitive urban design	Water trading mechanisms support flexible and dynamic water supply
Multiple use of water and water manufacturing the norm for agriculture (rural and urban) and households	Environment equally valued with other water users	Localised urban water supplies established along the coast (and within catchment)
Widescale uptake of precision agriculture	Community influential in ensuring political accountability and strongly support politicians who call for sustainable water management	Real-time water information and forecasting supporting organisations, business and community adapt and improve efficiency of their water use
Single water market for Mary-SEQ and movement of water to highest-value uses *(not necessarily monetary value)*	Real-time monitoring of water use and greater investment in stream gauges	

Table 5. Actions identified during the Three Horizons workshop to support transitions from current to future practices

Category	**Agriculture Transformation**	**Sustainability Transition**	**Decentralisation**
Education /training	• Target farmers: carbon farming, holistic agriculture • Target consumers: water (incl. quality), carbon, biodiversity footprints of products	• Target current/future politicians: water and sustainability literacy	• Target decision makers: future literacy
R&D	• Improve monitoring to support real-time decision making • Unpacking the "value-chain" of water • Precision agriculture technology • Review/revise legislations to improve their flexibility and adaptability to changes, and accountability	• Improved monitoring to support real-time decision making • Nature-based solutions	• Improve monitoring to support real-time decision making • Tracking technology advancement (horizon scan) • Pilot studies to test new technologies (e.g. MAR, smart development initiatives, decentralised technologies)
Community engagement/ influence	• Bring in First Nations knowledge on agriculture and water management • Community driven sustainable and ethical investment agriculture	• Value diversity of views over elite voices • Knowledge sharing with community leaders	• Water Futures CRC that brings together public/private sector and community groups
Market and trading	• Water market supported with equity protection • Expand markets to carbon, water quality, biodiversity		• Stock-exchange like water trading mechanism that offers more flexible and dynamic water supply
Legislation / operations / allocations	• All water resources regulated • Outcome-focused policy with guidelines that ensure accountability and incentivise innovation • Stronger standards and compliance measures	• Stronger enforcement of regulations	
Organisational capacity	• Improve systems/nexus thinking, futures thinking	• (More) coordinated sectoral planning • Futures thinking & long-term planning • Systems/nexus thinking	• Having a team or staff members with skills in future forecasting, disruption and other long-term thinking
Demand management	• Water recycle and reuse • Water sensitive urban agriculture design • Precision agriculture technology	• Water saving measures • Grey infrastructure • Water pricing	
Water supply / infrastructure	• Water recycling / manufacturing • Infrastructure to move water to highest value	• Water recycling / manufacturing	• Water recycling / manufacturing

5.3 Information Needs workshop

5.3.1 Methods

The approach for this *Information Needs* workshop built on the Three Horizons method and aimed to identify relevant sources of information and data and knowledge necessary to anticipate and manage different uncertainties according to how the future may unfold.

The 6-hour in-person workshop, conducted on 14 September 2022, commenced with a session that synthesised the key objectives, policy and practice levers and critical uncertainties – in the context of the four scenarios *Agricultural Transformation*, *Sustainability Transition*, *Decentralisation* and *Vested Interest*. The breakout activities and plenary discussions that followed centred around the information needed to anticipate how the future may unfold and to support the development of robust water interventions (e.g., infrastructure, community programs and/or policies) (Figure 14).

The breakout activity saw two groups work with a specific scenario (*Agricultural Transformation* and *Sustainability Transition*) for 90 minutes. The participants identified a future state of water planning and management that they wanted to address and actions identified from the *Three Horizons* and *Strategy* workshops to build their strategy. The choice of actions and their purpose(s) were discussed, as well as their order of implementation over time and the type(s) and source(s) of information to track changes and the performance of the strategy to achieve a future planning state. Findings from the two groups were presented in plenary and discussed among the participants. The two last activities were plenary discussions that considered the implications of disruptive scenarios (*Decentralisation* and *Vested Interest*) and wildcard events [35] on the strategies developed by the breakout groups.

5.3.2 Workshop Outputs

Reflections on prior workshop outputs: Participants reflected upon the outcomes in the context of how the water management landscape has changed since the commencement of the project and also in relation to similar projects in Queensland or globally. Energy has been a game-changer over the last year in terms of influencing water-related decisions and driving (e.g. hydropower) investments by the Queensland Government. The emphasis given to redressing the 'silo-approach' to water management raised in the *Three Horizons* workshop was again highlighted, with participants feeling that insufficient consideration was made to water planning processes when political decisions are taken in relation to major water infrastructure.

The syntheses of workshop discussions resonated with participants from the water industry who have gone through similar foresight or planning exercises. The scenarios and key themes from those were largely consistent with this project. Energy has also been front of mind for the water industry, particularly in response to choices around recycled water and desalination plants. Ongoing engagement and education are critical to building water literacy across the community and industry sectors as well as creating

[35] Wildcards are low probability but high impact and consist of rapid, surprising event(s) as opposed to gradual change

advocacy and community activism to enhance acceptance of water interventions. Community education provides demonstrable benefits when done well, with examples cited in media coverage and responses to surveys around recycled water uses and acceptability. There is a need to improve knowledge inclusion and shift to involving people in water plans and programs, especially younger generations who are often excluded from any consultation (whether deliberately or accidentally. Another point raised is the rapid changes we are seeing (climate change and others) will have massive implications on water security and operations which means the review of plans and programs will need to be done more frequently, supported by an adaptive management process.

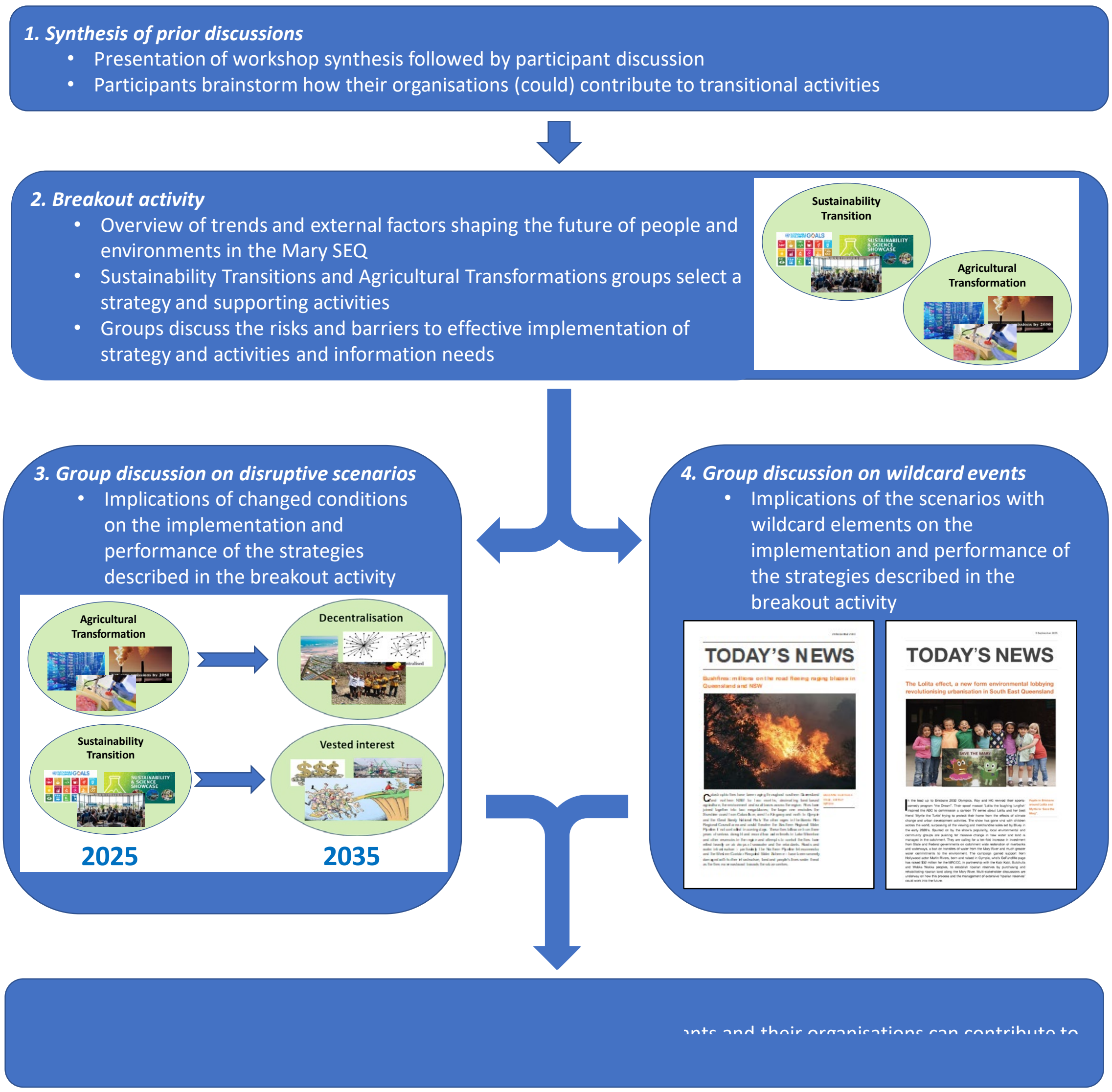


Figure 14. Structure of the Information Needs workshop

The outputs from preceding project workshops were largely consistent with those from other foresight activities in Queensland that workshop participants were familiar with, as well as literature from other countries and the early stakeholder engagement activities of the One Basin CRC (especially the emphasis on education and knowledge inclusion). Future-thinking approaches were noted by the groups to be in a more advanced stage in Europe (Portugal case study) where there are examples of water planning using integrated scenarios and foresight workshops with risk management elements.

Organisation contributions to effective catchment and water management: The participants identified how their respective organisations could contribute to future changes in water management. The types of changes identified were:

- technical contributions such as modelling and technical advice,
- resources including networks, trained staff with local knowledge or funds,
- education and training contributions such as water literacy programs and facilitation/mediation skills,
- advocacy roles that support (e.g.) engagement of vulnerable groups, forums, negotiation skills in consultation processes, and
- institutional support for engagement and capacity building programs

Barriers to operate for most participants related to networks and inclusion of knowledge, funds and partnerships, and leadership will and commitment. Improved connection to higher decision makers was considered critical for local practitioners and community. Other issues, mostly for water operators, are access to resources, time, effective legislation, maintenance of knowledge and skills within organisations, open mindedness and knowledge to support innovations and creative thinking, future thinking and anticipation practices, effective communication and transparency of decisions, training and education, and computing capability.

Water demand management in the context of Sustainability Transition: One breakout group examined water demand management activities in the context of the *Sustainability Transition* scenario. They identified the current limitations of water management and planning, future objectives, and supporting activities and strategy related actions to achieve that future state. Medium- and longer-term activities defined in Figure 15 recognise that some activities, namely water pricing, require acceptance from the population in order for them to succeed. Overall, the process to support both the change of mindsets and trust building necessary to implement effective water pricing and achieve a sustainable future in terms of water management in 2050 was considered to be underpinned by effective community engagement and education. ‘Crises’ are a key driver for changing mindsets and water managers across organisations need to be prepared to support communities at these times. The critical risks to achieving the sustainable water future objectives through implementing the water demand activities: a governance environment that can greatly affect momentum of change; deafness to the youth who will bear the impacts of decisions made now; misinformation and disinformation to undermine the process of change; and implications of energy transformations on water consumption and the performance of water schemes.

Elements of the *Vested Interest* scenario imposed as disruption to the *Sustainable Transition* scenario – namely disinformation campaigns, disbanded independent bodies and a shift from public good to private interests – were seen as current issues that need to be addressed. Enabling communities to act as ‘activists’ will be key and good data, trustworthy information and education will remain important over time. A focus on prevention and pro-activity over reactivity is important, which will need change in mindsets in organisations, funds, and skilled staff.

Current limitations of water planning and management

- Limited community inclusion and engagement of vulnerable groups (First Nations, youth)
- Queensland with the most expensive water in Australia
- Water is an essential service, forgotten and not mentioned in regional plans
- Oblivious of water as limited
- Limited water saving technology
- No knowledge of who should be responsible to implement changes
- Voiceless environment and water
- For operators, debts related to legacy issues and dependence on water operations and service to address it
- Aging assets and workforce
- Skills shortage
- Limitations of the frequency of water plan reviews
- Lack of trust in Government and in science

Activities and actions needed to shift from 2022 practice to 2050 state

Short term

- Reviews of water plans to improve the valuation of the environment.
- Funding research and support technological innovation
- Support multi-level governance through the development of education and communication platforms or forums, among examples, also inclusive of the Youth voice around water issues

Medium term

- Engagement programs, including politicians
- Ongoing monitoring and review
- Funding WSUD
- Repurpose of assets
- Community awareness and education
- Provide correct and accessible information
- Skills training and staff retention/succession planning

Long term

- Water pricing

Future objectives for a sustainable water future in 2050

- Community influential on decisions
- Environment equally valued
- Trust equilibrium

Figure 15. Activities and actions defined for water demand management under the Sustainable Transition scenario

Water recycling in the context of Agricultural Transformation: One breakout group examined activities to support the widespread use of purified recycled water in the context of the *Agricultural transformation* scenario. Recognising the significant political and social risk to the implementation of recycled water schemes, the types of activities focused on related to community engagement, education and training, and legislation. The activities and their indicative timing identified by the group are in Figure 16. Key threats to the mainstreaming of recycled water were collapse of the power grid, reduced demand for change during times when other components of the water system are not stressed, and a lack of (or inadequate) legislations to catalyse change across industries (construction and agriculture).

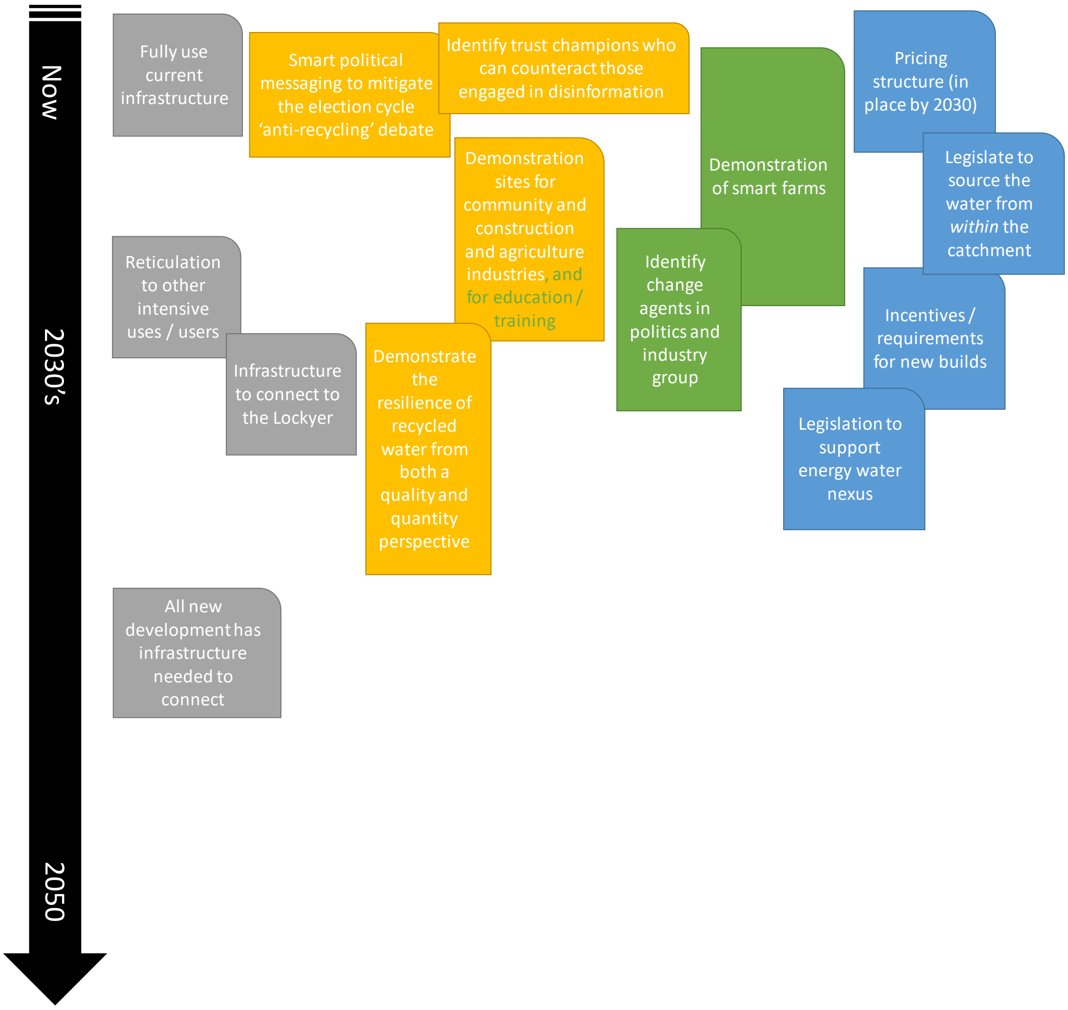


Figure 16. Activities to mainstream water recycling under the Agricultural Transformation scenario

The information needs discussed by the group were:

- ways to monitor community sentiment to water management, specifically recycled water, and to track how and if misinformation or disinformation is occurring;
- water use and water cost information that demonstrates the relative value of recycled water and which is in a form that supports engagement with community and industry;
- the identification of who might be the 'trust champions' who could communicate with community and industry ('not the normal suspects') and help build an environment that breaks through mistrust and supports the translation of science and policy messages; and
- early indication on climate and growth trends/events that will support the triggering of intensive messaging about the value of recycled water in times of (e.g.) drought.

The power grid was considered to be the key vulnerability of the recycled water scheme and in fact the whole water system (less so gravity-fed systems). The group identified that in the short-term, a lot of work is needed to align and codesign these activities and there is a need for 'gatekeeper staff' to engage with community and industry and support communication across governance levels.

Recycled water was considered a resilient strategy, more so than other strategies (e.g., vertical agriculture) under the imposed disruption scenario, *Decentralisation*. If the connection of the Lockyer to recycled water schemes by 2030 is on track then community should be able to adapt and implementation of activities continue under decentralisation. However, if the shift to a decentralisation started in the next few years, then it could pose a large disruptor to the activities outlined in Figure 16 associated with disinformation risks and changes in R&D priorities.

Wildcard activity: Two scenarios with elements of wildcard were considered by the group: a bushfire scenario and the 'Lolita effect' scenario (Figure 17).

Under the bushfires scenario, with its widespread damage to infrastructure, the current paradigm of rebuilding the same infrastructure in the same place was considered more likely than using the disaster as an opportunity to implement an alternate approach to water management. The need to have water resources (an essential service) back online quickly will contribute to decisions to replace infrastructure like-for-like but also is linked to demand management and the need for population literacy around water challenges. Water regulations will be critical to ensure safe water resources and uses given the water quality impacts from such large fires as well as the impacts on water operations, treatment plants and accessibility to water infrastructure. Impacts that are harder to envision include what implications the mental health issues and stress induced by the fires might have on people leaving communities and subsequent changes in community patterns. There needs to be more talk amongst decision-makers in Queensland about landscape implications under bushfires and connection to water resources.

The Lolita effect scenario described a chain of events leading to widespread lobbying from local community and environment groups to transform how land and water is managed in the Mary River catchment. The situation described in the scenario was seen as similar to what happened with the proposed Traveston Crossing Dam and the community push to prevent large water infrastructures. Other elements also mirrored the Millennium Drought which resulted in community pressure driving changes. Whilst value was seen in social media campaigns adapted to specific age groups and audiences that could influence connections, and bring the whole community along, the sustainability of this was questioned. The group noted the tendency for community short-term memory following such events, where activism and momentum decline as the crises and initial response or recovery is over or as community patterns change.

The session concluded with a brief discussion of other wildcard events that have (or could have) a large impact on water in the region. For water operators, COVID-19 led to a reduction in water demand during the pandemic (the opposite was expected). Demand is still below pre-COVID levels and monitoring is ongoing to understand the impacts of COVID on water demand. For water treatment and delivery of chemicals to treat water, closing the borders have had impact on water quality and service delivery. Hydrogen plants have gained much attention lately but participants were concerned there was little thought given to where the water to create this energy will come from and how much it would cost. Lyssavirus getting into water systems could have big implications on water resources and use, as could prolonged cyberattacks on water infrastructure.

28 November 2030

TODAY'S NEWS

Bushfires: millions on the road fleeing raging blazes in Queensland and NSW

A bushfire near Coles Creek, north of Gympie.

Catastrophic fires have been raging throughout southern Queensland and northern NSW for two months, decimating land-based agriculture, the environment and rural towns across the region. Fires have joined together into two mega-blazes; the larger one encircles the Sunshine coast from Caboolture, west to Kingaroy and north to Gympie and the Great Sandy National Park. The other rages in the Scenic Rim Regional Council area and could threaten the Southern Regional Water Pipeline if not controlled in coming days. These fires follow on from three years of serious drought and record low water levels in Lake Wivenhoe and other reservoirs in the region and attempts to control the fires have relied heavily on air drops of seawater and fire retardants. Roads and water infrastructure – particularly the Northern Pipeline Interconnector and the Western Corridor Recycled Water Scheme – have been severely damaged with further infrastructure, land and people's lives under threat as the fires move eastward towards the urban centres.

5 September 2035

TODAY'S NEWS

The Lolita effect, a new form environmental lobbying revolutionising urbanisation in South East Queensland

Pupils in Brisbane around Lolita and Myrtle to "Save the Mary".

In the lead up to Brisbane 2032 Olympics, Roy and HG revived their sports-comedy program "the Dream". Their spoof mascot 'Lolita the laughing lungfish' inspired the ABC to commission a cartoon TV series about Lolita and her best friend 'Myrtle the Turtle' trying to protect their home from the effects of climate change and urban development activities. The show has gone viral with children across the world, surpassing all the viewing and merchandise sales set by Bluey in the early 2020's. Spurred on by the show's popularity, local environmental and community groups are pushing for massive change in how water and land is managed in the catchment. They are calling for a ten-fold increase in investment from State and Federal governments on catchment wide restoration of riverbanks and waterways, a ban on transfers of water from the Mary River and much greater water commitments to the environment. The campaign gained support from Hollywood actor Marlin Rivers, born and raised in Gympie, who's GoFundMe page has raised $32 million for the MRCCC, in partnership with the Kabi Kabi, Butchulla and Wakka Wakka peoples, to establish riparian reserves by purchasing and rehabilitating riparian land along the Mary River. Multi-stakeholder discussions are underway on how this process and the management of extensive 'riparian reserves' could work into the future.

Figure 17. Wildcard scenarios discussed by the workshop participants.

6 Discussion and recommendations

The objectives for the project were to 1) develop processes and tools to support the identification of plausible scenarios of Queensland water systems, 2) explore opportunities and intervention pathways to move towards desirable outcomes for water, associated resources and society and the environment. This section commences with a discussion of the progress towards these objectives and a reflection on the project (Section 6.1). This is followed by discussion in Section 6.2 of three key themes that emerged from the project workshop discussions: the need to embrace approaches to water management that embrace integration and nexus thinking, governance to support the development of foresight culture across stakeholders involved in water management and coordination of futures-thinking activities across agencies organisations. The section concludes with pragmatic recommendations for progressing strategic foresight in Queensland water science and management, drawing on priorities identified by project participants (Section 6.3).

6.1 Progress towards project objectives

In the scoping workshop (see Section 3.1), the key outcomes to target were both product-related (future trends/events, scenarios and intervention pathways) and process-related (challenging assumptions and building foresight culture in organisations). Progress towards these outcomes are discussed in relation to the two project objectives: development of future scenarios (Section 6.1.1) and identification of opportunities and intervention pathways to move towards desirable futures (Section 6.1.2).

6.1.1 Processes and tools to co-create plausible future scenarios

The project successfully co-designed plausible scenarios for Queensland water systems, with some caveats and limitations noted in Appendix 3.

The project drew participants together from a range of government, industry and catchment management organisations to identify key drivers and develop storylines for the scenarios. The *Drivers*, *Scenario* and *Scenario reflections* workshops drew on the knowledge and perceptions of participants and the supporting collation and analysis of drivers, megatrends and scenarios from Queensland, national and international studies. One participant at the *Drivers* workshop saw the benefit of the workshops being the opportunity to step away from normal activities and challenge themselves

> *"It is very easy to get caught up in the cycle of only thinking about the things you are familiar with, a project like this is great because you can be opened up to new perspectives, ways of thinking, and thought processes. Also, in many organizations people are still very reactive and getting them to set aside the time to be proactive is hard. Attending a workshop like this sets aside that time to start thinking in that way."*

However, the S*cenario reflections* post-workshop survey highlighted the tension faced by some participants between broadening perspectives through the 'cross-fertilisation of ideas' and working in a space that at times seemed 'generalised and non-specific' and highly uncertain.

“Long-term scenario planning is almost by definition guess work and difficult. We don't know what we don't know. There is a practical resource limitation of time that prevents us from teasing out subtleties or "sub-set scenarios" of the starting set.”

With COVID-19 forcing all Phase 1 workshops to be conducted online and constrained to sessions no longer than three hours, the intended degree of scenario codesign was not fully realised. Actively including participants in the design of the scenario narratives – preferably in the form of in-person and full-day workshop(s) – might have streamlined the elicitation of the scenario elements and their transition over time, built greater trust in and ownership of the scenarios, and better articulated the differentiation between the scenarios. Whilst incorporating a cluster analysis of driving factors with the participants and/or experts into the project methodology might have been useful to validate different relationships between critical factors and potentially reduced the perceived overlap between the scenarios (see Appendix 3), the scenarios did produce distinct differences in outputs from the scenario use workshops (see Section 5).

6.1.2 Opportunities and intervention pathways to desired futures

The *Strategy* (see Section 5.1) and *Three Horizon* (see Section 5.2) workshops helped set the scene about factors that could prevent or support the implementation of different water supply and demand management actions and achieve desirable futures in terms of water planning and management. The subsequent *Information Needs* workshop explored the implications of different futures and emerging events the effectiveness of these plans and actions in achieving progress towards the desirable future (see Section 5.3).

Overall, the scenario use (Phase 2) workshops helped participants’ think about different opportunities and intervention pathways. Building on the findings from the *Strategy* and *Three Horizons* workshops, participants at the *Information needs* workshop were able to identify how they or their organisations could:

- contribute to change and build on their experience to think about future pathways and opportunities,
- develop a planning strategy with identifying key interventions, their approximate timing, and sources to track different indicators of change, and
- reflect on the implications of disruptive and wildcard scenarios on their planning strategy.

Across the scenario use workshops, the critical barriers to thinking about opportunities and intervention pathways were the time for participants to understand and get involved in the activities and the occasional ambiguity about the project’s expectations from participants and how they can contribute to future changes.

Another use case for the scenarios, which was raised by a participant in the *Information needs* workshop, was to use them in conjunction with strategic risk analyses. They cited the work of Luís et al. (2021), who ‘fused’ strategic risk and futures methods to inform long-term strategic planning of a water utility in Portugal. The process employed by the authors started with a baseline analysis of the risks associated with the utility’s strategic objectives and priorities. Scenario analysis was used to identify a broad range of situations that would stress-test the risks, allowing reassessment of the risks. Outputs from this phase were then used in strategy development aimed at managing risk and uncertainty. This approach could potentially be adapted for use with the QWMN Water Foresight scenarios, albeit more likely applied within organisations with focus on their respective objectives and priorities (rather than the multi-organisation focus of this project).

6.1.3 Reflections

The online sessions seemed to have insufficient time to support more in-depth discussions amongst participants (with varied domain and institutional knowledge) about such a complex system as water and water management is in the Mary River and SEQ region. Other challenges with the online setting – such as technical issues, the inability to see all other participants and pick up the 'energy of the room' or (in)direct disturbance of discussion flows by the facilitators – could have further obfuscated the participants' ability to discuss the implications of different futures. That said, the online setting was convenient and timesaving for those who were not located in Brisbane (including the ANU project team), and an appropriate response to the pandemic, and some discussions in the in-person *Information Needs* workshop were also curtailed by time.

As noted in Section 1.3, prior foresight activities in Queensland have not encompassed broader land and water management issues with cross-sector collaboration. Taking such a broad scope in this project has highlighted the general consensus that integrative, collaborative and nexus-thinking paradigms are needed to sustainably manage water into the future (discussed further in Section 6.2). Overall, the workshop process was seen as beneficial to connect people and discuss water issues; a similar approach was considered applicable for fostering conversations at both smaller and larger geographic scales than considered in this project. The process was seen as useful to build capacity and capability around water challenges, as well to identify commonalities between participants (in objectives, values and or operational challenges) and opportunities to collaborate in the future. The broad scope and the project resources, however, did mean the application of the scenarios in this project, and the discussions about them, should not be considered comprehensive or complete, or in a form that can immediately inform the strategic planning of organisations represented in the workshops.

One process-related outcome identified as important in the project scoping activities was the building of a foresight culture in organisations involved in the management of, or knowledge generation around, water. This project, and other foresight and scenario planning activities conducted across the State, are contributing practical knowledge on the benefits and challenges achieving this cultural change. It is acknowledged, however, that a transformation to future-thinking organisations will take considerable time and commitment from decision-makers and all levels of government.

6.2 Emergent themes

6.2.1 Foresight to support nexus thinking and integrated planning

Throughout the workshop series, participants argued that there was the need to shift to a water science, planning and management paradigm that holistically manages across water sources (surface, groundwater, regulated, unregulated, etc), issues (water supply, flood management, water quality etc) and sectors (agriculture, energy, urban, etc) *and* in doing so explicitly tackles the 'energy-water-food-environment-nexus'.

The Queensland Government increasingly recognises that an integrated approach to water science and policy is critical for achieving water security and environmental outcomes. For example, the Water Planning Science Plan (WPSP) 2020-2030 (DRDMW, 2020), has a broader scope on science and knowledge generation than the previous version and now explicitly includes cultural, economic, and social values. Reflecting this, workshop, participants in the scoping workshop suggested that this Queensland Water Foresight Project should provide a different lens that supports the discussion of current (and often naïve) assumptions in models and policy about future demands in trends in water availability, climate and markets (for example) and implications for community, industry and environment. Consequently, the water (and related) system considered in the scenarios and participants discussions was broader than the current focus of water science, models and planning.

Although raised in the early workshops, the concern about the implications of energy transformation on the water system increased over the project. In the *Drivers* workshop (Figure 9, Section 4.1.2), the 'Urban' breakout group identified energy as a key driver to consider in the development of future scenarios. While confident that energy would become cheaper – and that there would be implications for transportation, water source options (e.g. desalination) and water transfers – there was low confidence in what the extent and nature of impact of this driver would be on water resources and dependent systems. The transformation of the energy sector towards widespread adoption of renewables was an element built into the *Agricultural transformation*, *Sustainability transition* and *Decentralisation* scenarios, albeit with different storylines about the nature of the transformation (Figure 18). The implications of energy transformations considered in the *Strategy* workshop, focused on the *Decentralisation* scenario and uncertainty around how the critical energy needs to support decentralisation in the SEQ (e.g. digital transformation, high speed transport infrastructure and wide uptake of electric cars) would be met. Batteries and green hydrogen were seen as options to reduce associated energy costs and emissions.

In the *Three Horizons* workshop, all breakout groups identified the water planning and policy was undertaken in a 'silo' environment, where system connections to energy, land use and agriculture were not strong. The *Agricultural transformation* group envisioned (by 2050) that commitments to reach net zero would see a water-energy nexus approach drive water policy and agricultural transformation; this would involve a holistic / integrated approach to legislation that explicitly understood and accounted for feedback and linkages between urban and rural water consumption and the energy sector. They identified several innovations or incremental changes needed to transition to this future, including revision of water legislation and policy, expanded scope of markets (water, carbon, biodiversity, water quality), interventions to drive ethical and sustainable investment in markets, economic modelling and technical innovations to support transformation of agriculture and water planning (Figure 19). Similar discussions were had by the *Sustainability transition* group, minus the market discussions and with a greater emphasis on building community water literacy and futures-thinking orientation of decision-makers. Nexus considerations were raised further in the *Information needs* workshop, with energy a critical factor to be considered in water infrastructure investments (e.g. choices around recycled water and desalination plants [see Section 5.3.2] or the water requirements if there was a shift towards Hydrogen-reliant energy systems).

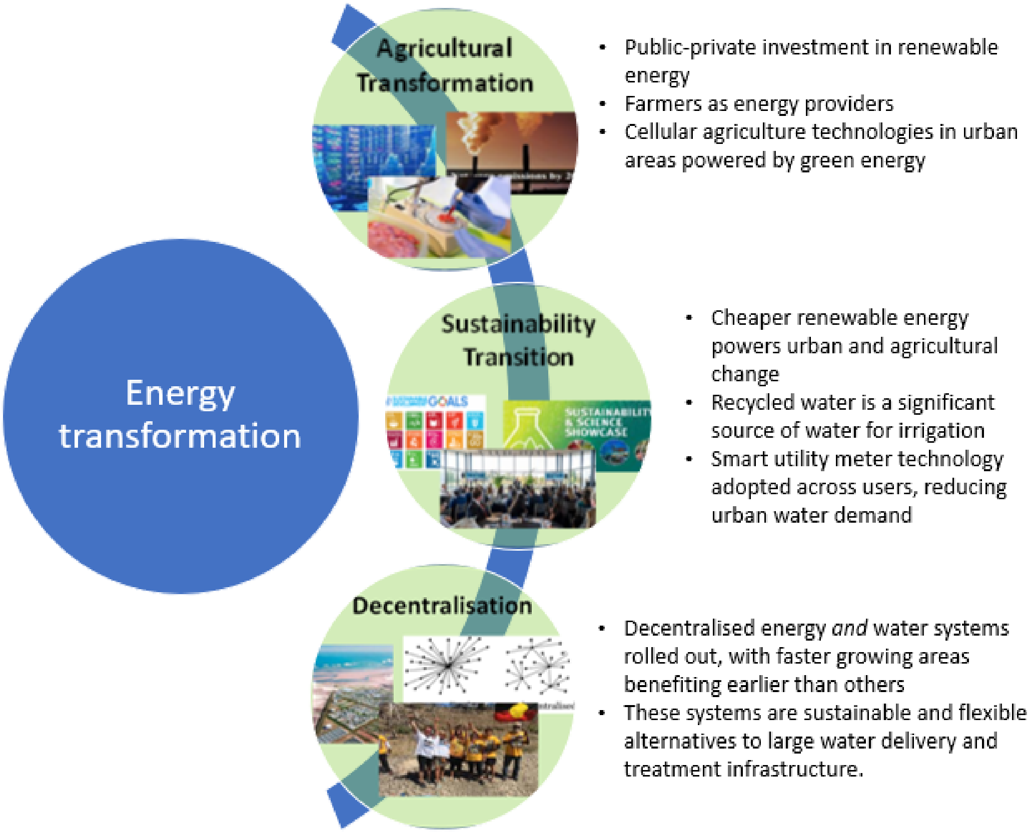


Figure 18. Reference to energy transformation across the scenarios (see Section 4.2.2 for scenario descriptions).

Participants in this project were acutely aware of system complexity and interconnectedness of energy and water system, but also recognised the considerable uncertainty around the implications of rapid transformation of the energy sector. With the Queensland Government having committed to a 50% renewable energy target by 2030 [36], and a vision of (in the same timeframe) being at the forefront of energy renewable hydrogen production [37], the opportunity exists for future activities building on this foresight project to bring in representatives from Queensland Government, the renewable energy industry and local councils to explore the interconnectedness and implications of future transformation of energy sector and water management on one another. Taking this collaboration further by operationalising the nexus approach would involve harmonising broad social policy goals and strategies across the sectors (Rasul and Neupane, 2021), and necessitate effective and integrated governance (Märker et al., 2018).

[36] https://www.epw.qld.gov.au/about/initiatives/powering-queensland, accessed 7 November 2022
[37] https://www.statedevelopment.qld.gov.au/__data/assets/pdf_file/0018/12195/queensland-hydrogen-strategy.pdf, accessed 7 November 2022

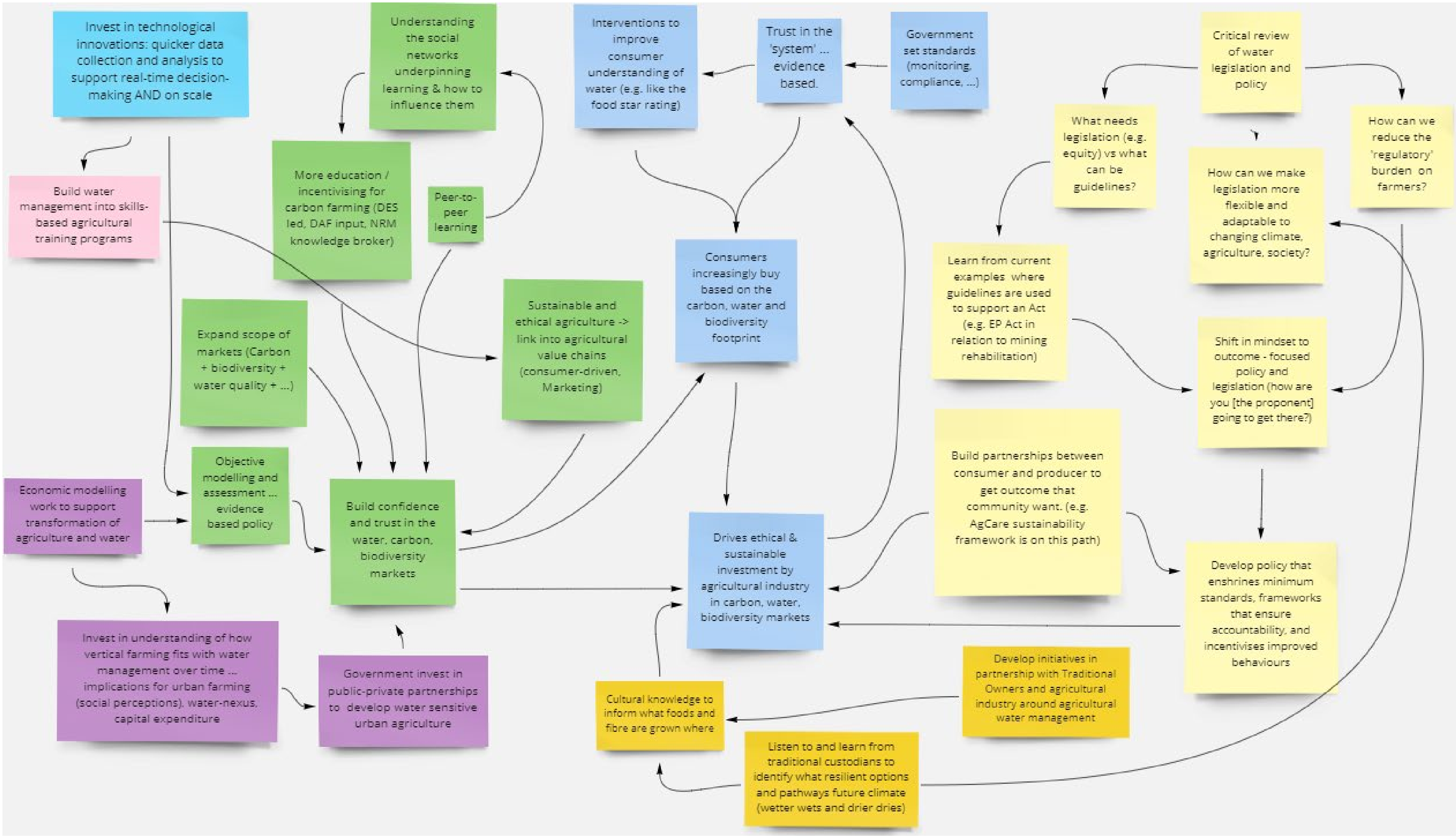


Figure 19. Innovations or incremental changes proposed to transition to 2050 water management (Agricultural Transformation scenario).

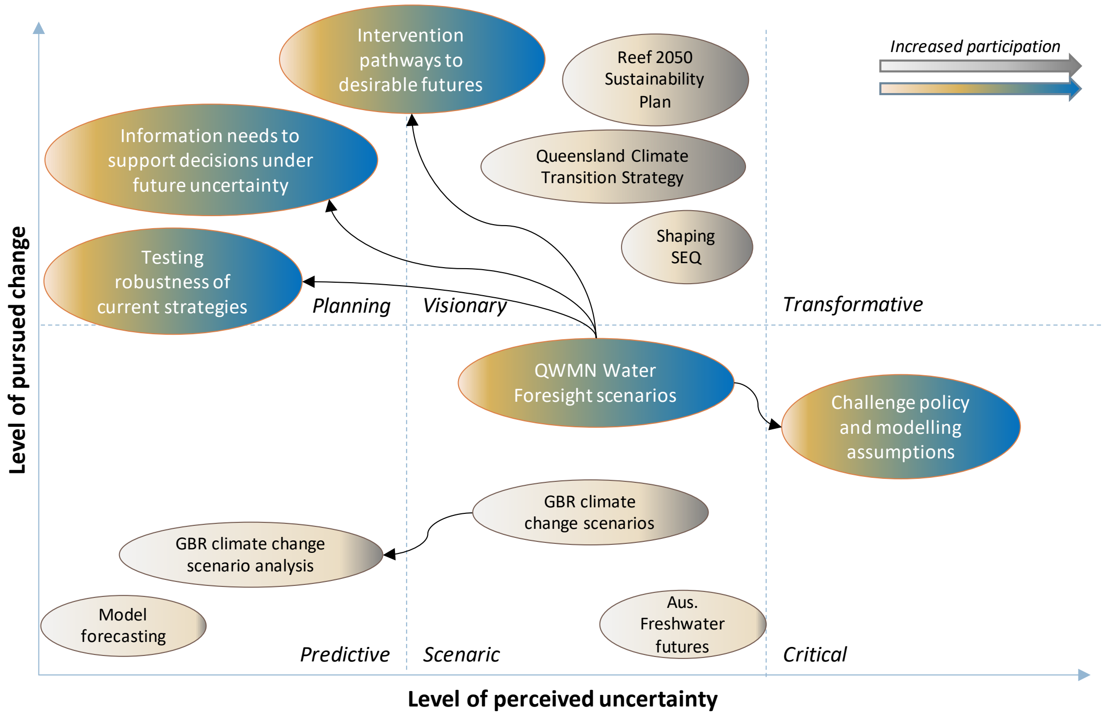
6.2.2 Governance to drive foresighting

Many participants saw the benefit of collaboration between government departments, private sector and community – this includes joint activities such as the Queensland Foresight Project workshops as well as more ongoing forums such as cooperative research centres (CRCs). Multi-stakeholder collaborations, including across decision-making levels, were identified as critical for supporting change in the context of achieving water security. In particular, dialogue between different stakeholders in the foresight workshops and other settings enables participants to be exposed to new ideas and perspectives, helping to spur innovations and learning. With the exception of issues related to the Murray Darling Basin, participants expressed the lack of opportunities to collaborate outside of their own team with different stakeholders and departments, due to a lack of time and resources as well as collaborations not seen as a priority within their organisation. Participants in the *Information Needs* workshop identified the opportunity to learn from international examples of the development of foresight culture within organisations.

The European Union (EU) was seen by workshop participants as a leader in the development and application of foresight and scenarios to water management. The European Commission (the executive arm of the EU) see foresight as integral to the setting of priorities around research and innovation policy and action (Burgelman et al., 2014). A perspective on the contribution of foresight to good governances, as well as a history of foresight and the evolution of its application within the European Commission, is given in Burgleman et al. (2014). It is notable that a number of foresight projects in the published literature are a direct result from the EU Water Framework Directive, widely regarded as the most substantial and ambitious piece of European environmental legislation, which led to calls for futures studies to support participatory river basin management across the EU (Van der Helm, 2003). The Directive establishes a framework for achieving and maintaining “good status” objectives for water bodies throughout the EU, which requires systems thinking and futures thinking to anticipate and plan for problems in future water use, availability and quality. Examples of foresight studies stemming from this legislative environment include Iital et al. (2011) and Carter and White (2012).

6.2.3 Coordinating future scenarios and learning exercises

The Queensland Water Foresight Project was initiated in 2020 to develop future scenarios for Queensland’s water quantity, quality and related ecosystems, and identification of opportunities and interventions to move towards desirable outcomes for water and associated resources. The development and use of the scenarios, employed multiple frames. However, other Queensland water scenarios have been and will continue to be developed for different context and purposes. In Queensland, a limited number of foresight studies have been undertaken in the water resource space. Of those shown in Figure 20, most used a stand-alone frame in a single project, the exceptions being two investigations into the GBR climate change scenarios which employed sequential sequence (Bohensky et al., 2011, Bohnet et al., 2008). Not shown in Figure 20 are recent (as yet unpublished) scenario planning and foresight activities undertaken in the water and agricultural spaces by water entities (e.g. Seqwater and Sunwater) and government agencies (e.g. DAF).



Legend and sources: Great Barrier Reef climate change scenarios (Bohensky et al., 2011, Bohnet et al., 2008), Reef 2050 Sustainability Plan (Australia, 2018): Australian Freshwater Futures (Lake and Bond, 2007); Queensland Climate Transition Strategy (DEHP, 2017) and Shaping SEQ (Government, 2017).

Figure 20. Interpretive frames of this project and examples of prior foresight efforts related to Queensland water resource issues or the Mary River and SEQ region.

Currently, there are no guidelines or toolkits (or formal 'communities of practice') that support robust scenario development and use processes in the State, although the UK Government has developed a toolkit for futures thinking and foresight which was used in the scoping and methodological design of this QWMN Water Foresight Project [38]. Information and knowledge (such as trends and drivers) relevant to Queensland future water scenarios tend not to be shared (formally at least) among users and between 'developers', and efforts in scenario development tend not to be coordinated (in part due to organisational sensitivities). Given foresight approaches will increasingly be used in future-oriented water planning, there is value in establishing guidelines and knowledge repositories on Queensland scenarios to support ongoing foresight activities across the water sector and broader nexus. Principles and guidelines might be structured around several topics including: 1) scoping scenario projects; 2) selection of process and methodology; 3) evaluation methods and metrics; 4) stakeholder engagement; 5) communicating scenarios; 6) scenario uses; 7) reuse of existing scenarios; 8) capacity building. A repository could offer publicly accessible, organised information on data (or sources of data) on drivers, trends, wild cards, signposts, and scenarios relating to water resources management and planning, as well as a collection of scenario development methods, uses and case studies

During the life of this project, regular meetings were initiated by Seqwater with ANU, Arup, SUNWATER and participants from other organisation to brief each other on

[38] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/674209/futures-toolkit-edition-1.pdf, accessed 21 November 2022

scenario planning and foresight activities being undertaken in the water space. These emerging relationships, and feedback from workshop participants, show there is a growing community of practitioners (across government, water entities and catchment management groups) and researchers with an interest in building collaborations and communities of practice around foresight and collaborative scenario planning. Whilst not overlapping the geographical area of the SEQ and Mary Basin, strategic foresight is seen as a critical part of the recently established OneBasin CRC [39], and there may be opportunities to draw on the resources of the CRC to continue developing foresight capabilities in Queensland.

6.3 Recommendations

Stemming from the project activities and outcomes, four recommendations are described below.

Continued co-investment in the development of a foresight culture within the Queensland government, water and associated industries, and catchment management organisations. As noted in Section 6.2.3, this project is amongst several foresight and scenario planning activities conducted across the State in recent years. All offer practical learnings for scaling shift towards capable and confident organisations that embrace uncertain futures in their water science and planning. The QWMN has an explicit goal to *"build a state-wide network with national influence to deliver transformative change"* and have cultivated strong collaborative relationships and networks between model practitioners, end users and research institutions over the years. QWMN is thus well-placed to facilitate the collaborations and conversations that workshop participants want to see continue (see Section 6.1.3). The Queensland Water Directorate (QLD Water), as the 'central advisory and advocacy body' for urban water industry in the State, might also be key given their industry networks and activities.

Avenues for future projects building on this QWMN Foresight project include:

- *Facilitating/mainstreaming foresight in water governance:* The European Union (EU) was seen by workshop participants as providing learning opportunities on the organisational change needed to mainstream foresight for Queensland government and water (and related) industry (see Section 6.2.2). Government-led foresight has also been studied beyond the EU (Calof and Smith, 2010, Janzwood and Piereder, 2019); synthesising and workshopping (with the Queensland Government) the learnings from these international efforts to develop public sector foresight programs could provide a path forward for institutionalising foresight across all levels of government. Buy-in from 'higher levels' of government and decision-makers were seen by workshop participants as key to the acceptance of foresight approaches and future-oriented water planning and governance.

- *Hearing from the 'unheard voices':* The workshop series emphasised how critical collaborations are to support change and that building multi-stakeholder

[39] https://onebasin.com.au/foresight-decisions-program, accessed 11 November 2022

collaborations needs to be a focus point for Queensland water security. Fostering trust-building, broader (and more inclusive) collaborations and drawing from multiple knowledges was seen as essential to effectively influence future water management and societal change.

Workshop participants were primarily from government agencies, water entities and catchment management organisations, representing a fairly small range of stakeholders in terms of world-views and backgrounds. The voices and perspectives of youth, Traditional Custodians and broader community from the Mary and SEQ region were not heard in this project. Beyond the technical, institutional and resource contributions that workshop participants identified their institutions could make to future water management, education and advocacy contributions were seen as critical (see Section 5.3.2). The need for education and engagement efforts tailored to youth as the 'inheritors' of the impacts of decisions made now and into the future was recognised.

From a practical standpoint to foster conversations with industry and community, adapting the QWMN Foresight approach to small geographical areas or looking at strategic focus areas where industry and community buy-in or change is needed (e.g. recycled water use). The QWMN has been investing in collaborative projects that consider traditional knowledge and cultural values in water models. Guidance from these project teams would be beneficial if there is interest in the future use and development of the scenarios to foster discussions about water planning and management with Traditional Custodians in the Mary Basin and SEQ region. Another idea raised by the workshop participants was that events similar to the Water Connections Week run between 2010-2019 [40] could be a vehicle for introducing foresight and the QWMN scenarios to a broader audience to facilitate the conversations needed to sustainably manage water into an uncertain future.

- *Invest in coordination and shared learning across Queensland foresight activities.* The meetings initiated by Seqwater to bring together practitioners and researchers working on water foresight projects identified the need for guidance and tools to robust scenario development, use and communication that will foster a shift to future-oriented planning as the norm for government and industry (see Section 6.2.1).

Conduct cross-sectoral workshops with representatives from Queensland Government, the water, renewable energy and agriculture industries, and local councils to explore the interconnectedness and implications of future transformation of energy and water sectors. Participants in this project's workshops identified the need for greater integration across the water, agriculture and energy sectors, given the accelerating transition toward renewable energy and zero emissions. The scenarios developed in this project and their application to look at transformation of water sector, could be used to initiate cross-sectoral discussions using the Mary Basin and SEQ as an initial case study.

[40] https://qldwater.com.au/Water_Connections_Week, accessed 30 November 2022

State government to explore the use of the QWMN Foresight Scenarios in conjunction with strategic planning activities. As the opportunity arises, government or other organisations could adapt the scenarios for use in supporting strategic risk analyses. This was identified as an explicit use of the scenarios by participants at the Information Needs workshop (see Section 6.1.2). For example, futures scenario methodologies might offer potential to support the Monitoring Evaluation Reporting and Strategy (MERS) process, described in the Water Planning Science Plan (WPSP), for a given water plan area. The scenarios might provide a mechanism to explicitly build futures thinking into the Water Plan review process (integrating across the WPSP themes [41]) through their use as a tool in conjunction with the review and planning phases of the MERS process. The current WPSP (DRDMW, 2020) extends until 2030 and the expiry of the Water Plan (Mary Basin) 2006 has been postponed to May 2024 [42]. This may provide an opportunity for Queensland Government and stakeholders to use the Mary Basin as a test case to determine whether there is any merit in adapting and applying the scenarios developed in this project to support the integration of futures thinking and scenario approaches into Queensland water planning.

Develop conceptual diagrams as tools to support scenario communication or future integrated model development. During the project mid-term review (December 2021), it was suggested that the future scenarios might be used to promote better system conceptualisation and provide a pathway to future integrated modelling to address water risks and opportunities. Initially, *the Information Needs* workshop was being designed around the use of future scenarios and conceptual diagrams to improve system understanding related to the futures of water management. The ANU teams' efforts to develop initial conceptual model of the scenarios, which the workshop activities would build on, indicated the complexity of this task would prove to be too much for a one-day workshop. Nonetheless, visual depictions of the scenarios, developed for example using the Integration and Application Network (IAN) tool [43], could prove useful communication tools. The IAN tool has been used to communicate various water related threats to catchments [44] and receiving water bodies [45] in Australia. Systems diagrams, showing hypothesised causal relationships, could provide a first step to develop semi-quantitative integrated models to explore interrelationships between energy, water and agriculture sector in the context of the scenarios.

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[41] Themes in the current WPSP are: Ecological asset requirements and threats, Landscape ecohydrology, Understanding groundwater systems, Catchment threats, Hydrological modelling and monitoring, Cultural values, Socio-economic values, Assessment and evaluation

[42] https://www.business.qld.gov.au/industries/mining-energy-water/water/catchments-planning/water-plan-areas/mary-basin, accessed 29 November 2022

[43] https://ian.umces.edu/media-library/symbols/, accessed 30 November 2022

[44] https://www.chiefscientist.qld.gov.au/publications/understanding-floods/what-factors-contribute, accessed 30 November 2022

[45] https://ian.umces.edu/media-library/diagram-showing-features-of-and-threats-to-darwin-harbour/, accessed 30 November 2022

7 Synthesis

The Queensland Water Foresight Project adopted a participatory approach whereby stakeholders from government departments (DAF, DES, and FES), water entities (Seqwater and Sunwater) and local catchment management groups co-designed, tested and evaluated a set of future water scenarios for Queensland. This foresight process engaged participants in a series of workshops, where they deliberated on the risks, opportunities, and interconnections related to a wide range of future and current drivers of change related to water in the SEQ region and Mary River Basin. The workshop activities guided discussions around the criticality and uncertainty of drivers, the assumptions underlying policies and modelling, and the interventions needed to move towards desirable outcomes for society and the environment.

The key product-related outcomes from the project are the Drivers of Change digital cards (Figure 8) and the four 2050 water scenarios (Section 4.2.2). The Drivers of Change cards described a diverse set of 15 drivers that may influence Queensland water in the future, ranging from climate change, future water markets, to inequalities, and First Nations water rights. In the project, these digital cards were used to prompt discussions about potential impacts of the drivers, and to identify important drivers for the case study areas; these cards can be used to facilitate other conversations about future changes related to water. The four co-designed water scenarios represent four alternative futures envisioned to emerge from the present day to 2050:

1) ***Agriculture Transformation*** – a future with strong water and carbon credit markets. Significantly drier and more volatile climate leads to the transformation of agriculture sector, including the rise of controlled-environment and cellular agriculture.
2) ***Sustainability Transition*** – a future driven by the public and organisational change towards sustainability. Strong acceptance of science and collaborative, integrative and proactive water management are the norm.
3) ***Decentralisation*** – a future with more decentralised population and infrastructure and where water management focuses on local interests and community participation.
4) ***Vested Interest*** – a future where economic growth drives decision making. The features of this scenario are: distrust in science, big grey infrastructure, resource inequity, environmental degradation and social conflicts.

The scenarios reflect different societal, environmental, political, economic and technological changes, as well as different levels of influence of such drivers on the governance of water in the future. As demonstrated in the Phase 2 workshops (Sections 5.1 to 5.3), these scenarios can be used to assess the robustness of management strategies, identify intervention pathways, and facilitate discussions and learnings about the futures of water and their systems.

The 2050 water scenarios were used to assess several water management strategies from the Water Plan (Mary Basin) 2006 and the SEQ Water Security Program (2017), with workshop participants examining potential threats and opportunities of selected strategies under those four alternative futures. The assessment of these strategies highlighted three main points: 1) concern around the implications of the lack of flexibility of the plan under future climate and demographic change; 2) demand-management solutions are recognised as more robust and resilient to future uncertainties than supply-focused solutions, and both need to be considered together to further strength and support the water plans; and 3) effective communication and capacity building of organisations, industries and communities are a critical consideration under all future scenarios.

In another workshop, participants examined the scenarios using the Three Horizons framework, which involved describing the innovations and interventions needed to create a shift from the current situation to the future scenarios. This identified key areas of actions: 1) education and training in various competencies (e.g. water, sustainability, futures, etc depending on scenario) across stakeholder groups, including farmers, consumers, politicians and decision makers; 2) research and development, particularly improved monitoring capacity to support more responsive decision making; 3) community engagement, and enabling stronger community influence; 4) roles of markets such as water trading; 5) legislation, including strengthening compliance and enforcement; and 6) organisational capacity in systems and futures thinking.

Process-related outcomes from the project related to building capacities of participants in systems and futures thinking, using scenarios for supporting strategic planning, and assessing assumptions in policies and modelling, as well as building stronger cross-sectoral collaborations. The project is an initial and small (but potentially significant) step forward that highlighted the importance collaboration and nexus thinking in water planning and management into an uncertain future. Foresight and scenario planning are promising approaches but for maximum value are dependent on stronger collaboration, coordination and investment in developing foresight capabilities within (and between) government, industry and other stakeholders in the water sector (and between the water sector and other key sectors such as energy and agriculture).

Ethics Approval

The research described in this report was granted ethics approval by the ANU Human Ethics Committee (protocol number 2021/110).

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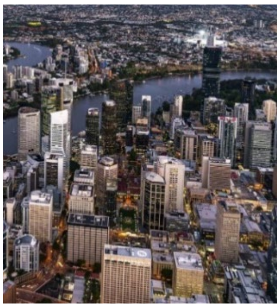
Appendix 1. Fifteen drivers relevant to water management in Queensland

Climate change: Queensland is hotter and drier and with higher climate variability. By 2050, the mean temperature rises by 1.5 to 2 °C. Heatwaves, bushfires, droughts, storm surges, tropical cyclones, flooding, water-borne diseases are likely to intensify. As a result, infrastructure such as water, sewerage, stormwater, transport and communications is increasingly under threats, from flooding in the coastal areas to bushfires inland. Agricultural productions and biodiversity are exposed to greater risks. Human health and livelihoods, especially in the rural, regional and remote communities, are significantly impacted, aggravating inequities.



Population growth and distribution: In Queensland, the population is projected to grow from 5 million in 2021 to 8.5 million in 2050 (Australian Bureau of Statistics, 2018). Nearly 90% of this growth is expected to be located in the SEQ region. This growth places significant demand for water, food and energy consumptions in the SEQ and surrounding regions, and presents challenges in the futures of infrastructure, housing and services to maintain liveability.

Regional and peri-urban cities: Growing house prices make city living increasingly unaffordable. On the other hand, automation technologies take care of many manual routine tasks, allowing most workers to focus on the provision of knowledge and services. Digital technologies and internet connectivity advance significantly, enabling a virtual presence for work, study and other activities. This regional lifestyle is supported by affordable digital health care, on-demand transport, greater acceptance of remote learning credentials, and effective freight services. As a result, a growing number of people choose to live in regional centres over expensive and crowded cities.

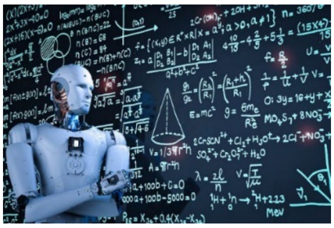
Future water market and trading: Driven by population growth, the demand for water grows by 50% by 2050. Water scarcity, accelerated by climate change, is widespread. Water becomes a commodity, and platforms to support water market and trading become mature. Water can be traded in futures markets where investors can hedge against higher prices in the drier month.

Precision agriculture: Precision agriculture uses technology to improve the ratio between agriculture outputs (e.g. food) and inputs (e.g. land, energy, water, fertilisers, pesticides). It involves the use of sensors to identify precisely (in space or time) the needs of crops or livestock, so as to maximise the productivity of each plant and animal while minimising wastes of water resources.

[Why you should be using data for your farm business - Farmers Weekly (fwi.co.uk)]

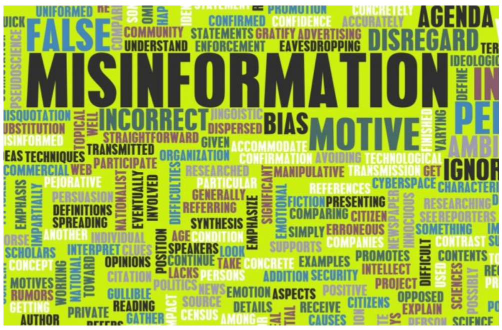
Controlled-environment and cellular agriculture: Food production is supported by automated controlled environment and is not land-dependent. Crops are protected from extreme or variable weather and pests. Agriculture production may be brought into cities, reducing emissions, reliance upon land and water resources, and transportation expenses, increasing economic autonomy for cities and communities. Examples of controlled environment agriculture include micro-greens, vertical farming, hydroponics and aquaponics. In addition, biotechnology supports cellular agriculture, where a stem cell factory could produce cellular products, such as plant-based milk, eggs, lab grown meat, leather, and fur.

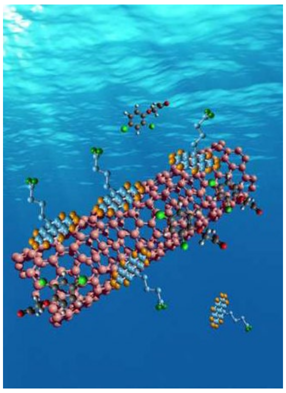
Artificial intelligence for science: Artificial intelligence (AI) and high-performance computing are used to study complex water problems. Quantum computing is significantly faster than regular computers while also being able to store more information. Combining artificial intelligence and quantum computing allows us to perform highly complex problems such as advanced climate, water and decision support modelling.



[AI Pitfalls and the Hidden Value of the 'Citizen Data Scientist' (enterpriseai.news)]

Trust of government and science: As alternative realities created by media and social media become further entrenched in people's daily lives, water management becomes further politicised and the foci for disinformation campaigns by individuals or groups for commercial or political gain. These campaigns aim to build support for policies or decisions that favour them and increase public mistrust in science. This disrupts and paralyses sustainable and strategic policy development in the water space. The efforts of scientists to communicate the severity of environmental issues, or feasible solutions to them, fall on deaf ears.





Nano-materials: New technology such as engineered nano-materials can have many uses, including in health and environmental remediation. These new materials and chemicals may end up in the water ways, with unknown environmental impacts. For example, nano-biopesticide is composed of active ingredients diluted in nano-emulsions and existing bio-pesticides such as neem. Their particles can cover a broader surface area and increase bio-pesticides molecule solubility and stability. However, its environmental impacts such as on the waterways are largely unknown.

Biotechnology: Biotechnology could change our tools and values related to land and the natural environment. If demand shifts away from some traditionally produced raw materials (e.g. agriculture and forestry products), their resource prices may soften, resulting in land use changes. Industrial districts may rise in value at the expense of agricultural land, while areas of particular biodiversity may gain new value and significance if they offer data, ecological services, and raw materials for bioprospecting.

Sustainability movement: Driven by the global sustainability movement, societal value of water increasingly focuses on environmental sustainability as opposed to economic development (Wei et al., 2017). Consciousness in water use efficiency at individual and community levels drives change in water demand by the consumers. Sustainability and ethics information of products, produce and services, such as their water use and environmental footprints, can be more accessible.

Autonomous sustainability monitoring: This involves combining AI and precision tools such as satellites and sensors to help collect data on social and environmental impacts and identify solutions to enhance sustainability practices. This technology can elevate the intelligence with which we manage water resources, understand and deal with pollution and integrate different actors for more sustainable practices. In combination with other technologies and systems such as blockchain and the internet of things, these initiatives could spread in smart cities and add new layers of sustainable accountability to urban spaces.

First Nations water rights: Rivers, wetlands and other waterways are considered by the First Nations People as crucial to maintaining their cultural and spiritual identity, life and livelihoods. The Australian Government has ratified a number of international human rights instruments, thus has an obligation to the First Nations people to protect and fulfil the rights contained within them including the right to water. A legal mandate to the First Nations water rights allow the First Nations People to take ownership of the water and how it should be managed. Local and catchment-based programs and initiatives can be co-designed with the First Nations People and local communities.

Inequalities: The ways people connect with, value and use water vary greatly. Socially advantaged communities used water for leisure and luxury while disadvantaged communities struggled to meet their health and wellbeing. A social gradient in water use influences the types of sustainability and levels of resilience and liveability people can achieve in cities. For example, advantaged communities have greater access to blue (e.g. ponds, lakes, rivers) and green (e.g. parks, trees) infrastructure that mediate exposure to extreme heat, cooling and flooding events, greater technical water use knowledge and financial capacity to afford water saving technologies. Inequalities that exist around access and use of water affect the design and implementation of water management programs and initiatives.

Legal rights for rivers: Rivers in New Zealand, Australia, India and Colombia and Bangladesh have been granted legal rights since 2017, where rivers are recognized as legal persons or living entities. Legal rights for rivers allow us to rethink our relationships with rivers, shifting from what we want *from* the river to what we want *for* the river and how do we get there *with* the river. It is considered as a new and more radical way of protecting natural resources and a pragmatic way in which First Nations People can manage rivers through guardianship. The rights include having "trustees" looking out for rivers' best interests, and going to court if the rivers have to protect their own interests.

Appendix 2. Initial scenario themes identified in the Scenario workshop

Four scenario themes were identified by the participants:

1. *Sustainability theme:* proactive integrated water management with sustainable demand management, alternative and climate resilient water supplies, water sensitive design for extreme events.
2. *Infrastructure theme:* ambitious high cost infrastructure as solutions to our problems. High environmental costs and poorer consequences for rural water users.
3. *Market theme:* farmers and environment lose out as water markets mature. Social conflicts erupt.
4. *Science theme:* improved trust in science and technology leads to enhanced uptake of model outputs and changed behaviour.

Through the development of alternative storylines for each scenario themes, sequences of causal effects were explored. A brief summary of the storylines is provided below.

Sustainability theme: Proactive infrastructure development, cheaper energy and societal push for urban water use efficiency decrease urban reliance on freshwater resources. In addition, improved knowledge in groundwater systems and their sustainable use provide more options for small towns in terms of conjunctive use of surface and groundwater resources. These leads to more flows available for the environmental systems than otherwise, meeting ecological needs and agreements, reinforcing social acceptances to sustainability. The end point is climate resilient region with capacity to grow sustainably.

The alternative storyline under this theme describes a future where without proactive water management, there is inadequate infrastructure, overallocated water and too many people. Reactive solutions such as bigger dams, exploitation of groundwater and desalination plants in Noosa without proper treatment of the salt lead to serious environmental consequences, societal conflicts and high economic costs.

Infrastructure theme: The storylines under this theme centred around investment in different types of infrastructure. A "negative" future was developed based on grey infrastructure such as pipelines pumping water from the region’s north (the Mary River catchment) to the SEQ region. This results in significant water stress in the northern catchments, and high environmental impacts on biodiversity, fish population and water quality. Subsequently, there are substantial declines in riparian and salt marsh habitats and the ecosystem services they provide. Less water in the northern catchments also leads to less water for the agricultural industry such as macadamia and sugarcane. The decline in water quality results in further degradation of the Great Barrier Reef systems, leading to international "shame" from losing the world heritage site. The end point is increased divide between the communities from the Mary River and SEQ.

The alternative storyline under this theme looks at investment in green infrastructure (nature-based infrastructure to capture and filter water), driven by a key shift in how the ecosystem serves are valued and recognised in policy. The scenario results in positive environmental impacts, but also disruption to industry during a transition to new green industries. Innovation to new industries and new training to the workforce is required to support the transition. Indigenous knowledge is a key input into the green infrastructure design. As landholders put more water into the river systems, they receive environmental stewardship payments.

Market theme: The initial storyline under this theme describes a future where water markets was determined as the most efficient way to management water, while regulation is limited. This results in corporations holding water until premium prices are reached. Many farmers are unable to afford water, and have to rip out their crops or sell their water, significantly affect the farming communities. Higher water price also leads to less water available to the environment, leading to fish kills and environment destruction.

The alternative storyline under this theme assumes legislation is well established to ensure water markets are used as intended. With proper monitoring and enforcement, water is being used sustainably. Water markets are used to buy environmental water, such as through philanthropic grants.

Science theme: With advanced science and modelling on the water resources, proactive science communication and engagement, people are more receptive to the insights the models provide. The communities use these insights to adjust their water use decisions or invest in water markets.

The alternative storyline describes a future where vested interests undermine science to support their own interests, leading to control of water prices by large corporations and increased social conflicts. Lack of trust in science and modelling by the general population leads to lack of trust in the effectiveness of policy and investment decisions.

Appendix 3. Summary of workshop evaluations

Drivers: The post-workshop survey sought feedback on the process and discussions from the Drivers workshop and participant. The level of agreement with statement in Figure A indicates that the 13 participants who submitted the survey felt that the workshop was valuable although would have appreciated more time for discussions.

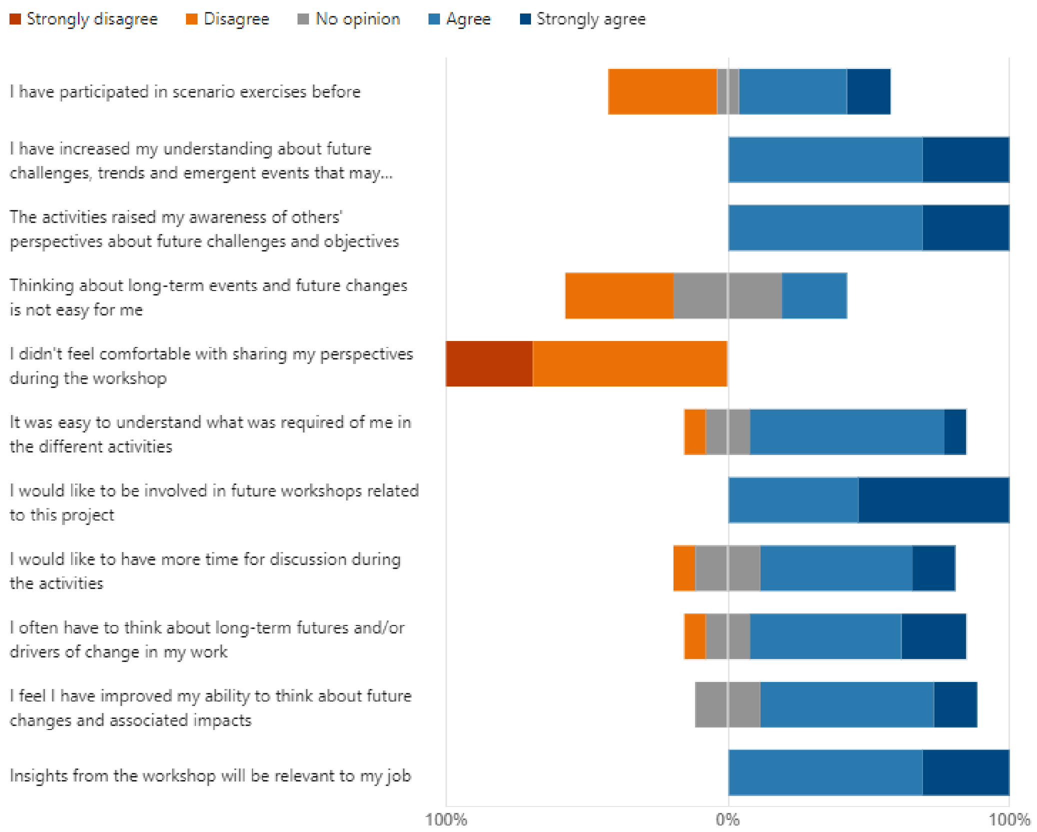


Figure A. Level of respondent agreement with statements.

Respondents were asked what barriers they face in their work when thinking about the future. Key barriers related to the time, funding, data availability and at times the direction and lack of support from within departments or organisations to support staff's collaborations beyond those needed for operational short-term issues. This project was seen as providing a space that would help participants build connections with others working in the region and open them up new perspectives, ways of thinking, and building *"subject matter literacy, community and indeed personal literacy on subjects that require us to think beyond the short and immediate term"*.

Respondents were asked to elaborate on aspects that they learned or found surprising in the workshop. Hearing from people from other organisations and parts of the SEQ and Mary Basin region, and understanding their perspectives and common or disparate challenges was seen as a key learning, as was broadening individuals understanding of the region and the high degree of connectedness between the SEQ and Mary Basin. One respondent noted that it was interesting that all groups had different perceptions on how climate would change would by 2050 and the impact of this change (see Figure 9) despite it being considered the most critical driver during the workshop.

Scenario development: The four archetypal scenarios developed by the project team based on the Drivers and Scenario workshop discussions were evaluated by the Scenario Reflections workshop participants through live polling for four scenario evaluation questions, listed in Table A.

Table A. Evaluation questions used in the Scenario Reflection Workshop

Q1: Does the scenario provide a logical sequence of events? **(Very logical, somewhat logical, not very logical, not logical)**
Q2: Is the scenario extreme (but still plausible) enough? **(Much too extreme, a bit too extreme, right balance, could be a bit more extreme, not extreme enough)**
Q3: Is the range of scenarios wide enough to support policy and research/modelling strategies? **Too limited, rather limited, appropriate range, too wide, much too wide**
Q4: Are the scenarios distinct enough from each other to chart unique pathways? **Too similar, some overlap, sufficiently different**

Whilst all draft scenarios were considered by most participants to be logical (Figure B [right]), there was more variations in whether or not participants considered the scenarios to be extreme enough but still plausible. The *Agricultural Transformation* and *Sustainable Transition* scenarios were considered to have the 'right balance' for over 65% of workshop participants (Figure B [right]). This contrasted with the *Decentralisation* and *Vested interest* scenarios where the percentage who thought these scenarios were well-balanced was below 40%. The components and interactions described in the *Vested Interest* scenario were considered plausible but the described outcome as potentially too extreme. Although some participants noted that this scenario reflected the current situation, by 2030 it was seen that there would be a change away from this 'Business as usual scenario'. The *Decentralisation* scenario seemed to jar with participants mental models with much of the discussion providing argument for centralisation rather than decentralisation. Additional concerns raised about the scenarios were the overlap between the *Agricultural Transformation* and *Sustainable Transition* scenarios, the small timeframe (30 years until 2050) for considering the implications of outdated water infrastructures, and the need for more holistic details (e.g., environmental conservation; decreased material/economic aspects of life) and nexus thinking in the scenarios. Agreed actions to revise the scenarios after this workshop are given in Table B.

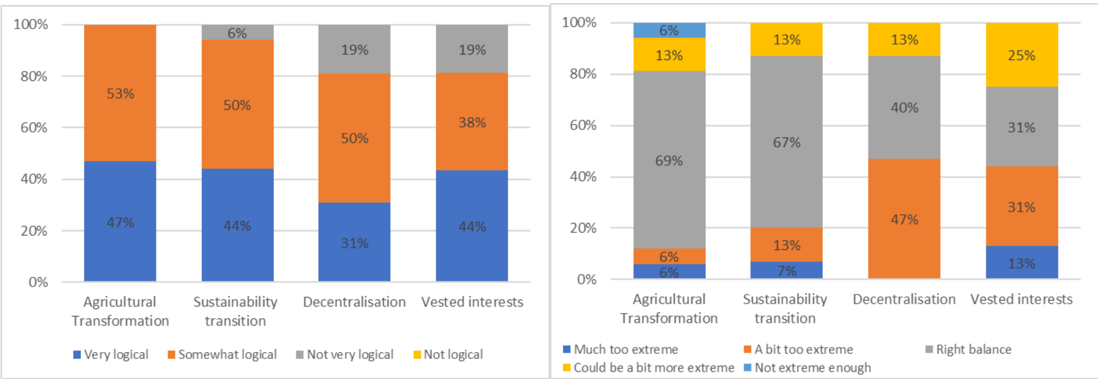


Figure B. Distribution of responses on how logical (left) and extreme (right) the draft scenarios were.

Table B. Action taken to revise scenario based on Scenario Reflection discussions.

Scenario	Action
Agricultural Transformation	No major change needed
Sustainability Transition	Updates will highlight drivers of this scenario and describe gaps and setbacks. First Nations rights to water will be strengthened in the scenario.
Decentralisation	The argument for centralisation will be included in the *Sustainable transition* scenario. This scenario will be strengthened by adding other drivers for decentralisation of population and decision making. The negative impacts of decentralisation will be highlighted as will elements describing the transparency of decision making and the challenges posed by the presence of coalitions around issues.
Vested Interest	Scenario name changed from Unbridled growth to Vested interest.

While scenarios do not have to be mutually exclusive, their differences need to be clear and well documented and understood, and draw on different sets of challenges across one or more key drivers [46]. The radar plots shown in the final scenario descriptions (see Section 4.2.2) differentiate the primary and secondary drivers for each scenario, conceptualised in terms of the actors driving change, (de)centralisation, motivations or mindset underpinning the transition (e.g. sustainability), and (dis)trust in science. Notwithstanding the different drivers of change, the *Agricultural Transformation* and *Sustainability Transition* scenarios were seen by some as compatible with one another and aligned with thinking around how agriculture and water management could transition into the future; others saw them as distinct scenarios. Illustrating this are two quotes from participants of the *Scenario Reflection* workshop, noted in the post-workshop survey, in response to a question on the contexts in which they saw themselves or their organisation taking the scenarios forward.

> *"Overall scenarios 1 [Agricultural Transformation] and 2 [Sustainable Transition] align with the sustainable production approach DAF maintains for the sector generally. It aligns to the triple bottom line outcomes for Reef as well as other high priority projects like DAF's Drought and Climate Adaptation Program and emerging strategies like Growing for Qld and our low emissions work."*

> *"Only in terms of continuing to work towards scenario 2 [Sustainable transition], in the face of many different forces driving events towards scenario 1,3 and 4 [All other scenarios]."*

Strategy: Participants were asked to evaluate the scenario use process through a post-workshop survey. Noting that only six of 15 participants completed the survey, the scenarios seemed to be useful tools to stimulate thinking and reflection on current plans and their adaptability, robustness and resilience under potential future threats and pressures. They could push people out of their comfort zones; one respondent, for example, noted that they typically keep to the 'science/engineering' and considering the implications of vested interests on plans was new to them. Another participant noted that the different interpretations that people had of the scenarios added a richness to the discussions. The potential use of similar scenario exercises within the

[46] https://thinkinsights.net/strategy/scenario-planning/, accessed 31 October 2022

participants organisations was seen to be to integrate such exercises into options assessment and/or strategy development workshops; the opportunity to achieve buy-in is when new strategies and plans are being developed. The main barriers to apply such an approach within organisations were identified as the time, tools and skills needed to implement the exercises and record outcomes in a way that is 'robust for decision-making', and has the buy-in and trust of the people signing off on any decisions.

One key challenge faced by workshop participants when identifying future threats and opportunities and their implications for the plan that they evaluated was the limited time in the workshop to 'bounce ideas' between each other and discuss how the plan strategies 'meshed' with the scenarios; multiple people noted that discussions were 'getting going' at the end of the session. A short online workshop needs a clear structure, hands-on facilitation and well-defined tasks, and the survey responses suggested that this exercise might have benefited from a longer workshop. Other challenges identified related to the difficulty of looking far ahead (to 2050) and reimagining the water plans. This was expressed in two ways, that the changes to plan settings being considered by the group were 'perhaps not radical enough in the context of the scenarios' or that 'it is difficult to apply some certainty to the scenarios … it's probably because I deal with analysis that is quite defined'.

Three Horizons: Nine of 17 participants completed the post-workshop survey; they generally found the Three Horizons approach to be an effective method for bringing together a large volume and diverse opinions, with sufficient time allocated for discussions (Figure C). The transition towards the future of water and water management envisioned by the breakout groups will require a proactive government and senior management pushing for longer term thinking (beyond the political cycle). It was noted by some participants that the discussions focused heavily on the political landscape which is not easily influenced by the sectors and organisational roles represented by participants. The importance of leveraging on disruptions (e.g. catastrophic events or technology advances) to create a mindset change was noted.

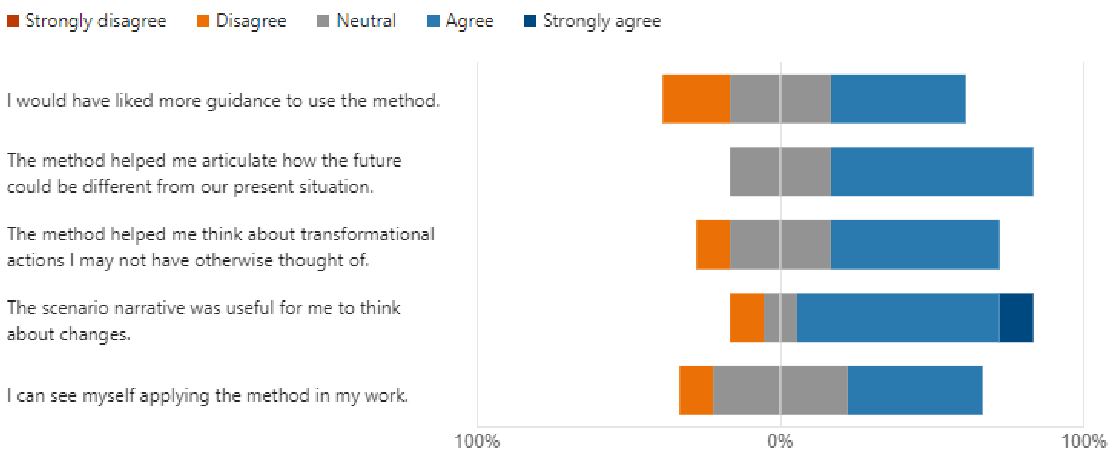


Figure C. Participant reflections on the Three Horizons method

Information needs: Three (of nine) participants took the post-workshop survey. Noting this limited data, the workshop activities were seen as useful activities that the respondents were able to contribute effectively to (Figure D). Although a small group, it's diversity and the willing contributions of the participants were noted as a positive; it highlighted possible future collaborations and the 'common goal' of participants despite the many difference between their organisations. Time limitations meant discussions on the 'disruptive' and 'wildcard' scenarios were constrained with the latter exercise seen by one responded as an aspect that could have been expanded:

> *"Maybe more on the wildcards. It seems with issues we are having now they come in multiples e.g. severe drought, followed by severe fire, followed by COVID. Maybe they are not true wildcards, and could be considered more as impact of multiple external impacts. We used to do this a bit with our drought simulation events. eg implementing drought response but then the desalination plant has to shut down for a week due to a fault, then one of the council areas decides they had a little rain in their catchment so they are not going to implement water restrictions anymore, etc. It really gets people thinking. But it is also the reality of what happens, as we have seen over the last few years. Anyone in Health would agree with that, from COVID, to mask and other PPE availability, to vaccination hold ups, to availability of breathing support machines, etc. The list just goes on. Who could have thought that all of that would happen in normal planning. It isn't until you do these wildcard activities that we get some insight."*

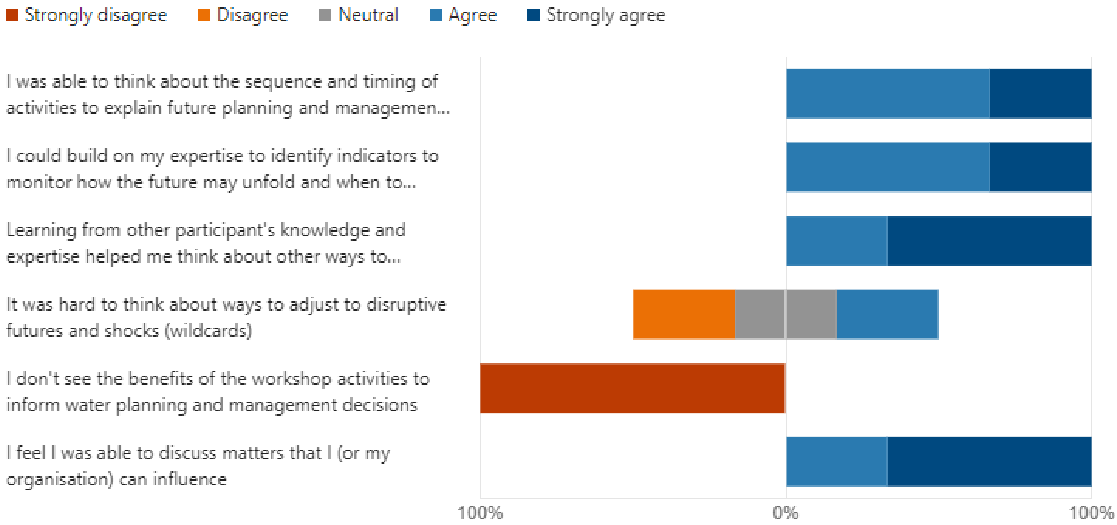


Figure D. Participant learnings from the Information Needs workshop.