

# Planning for uncertain water futures

## Using strategic thinking to rehearse uncertain futures in the water sector

M Dawson, L Uthayakumaran, L Maunsell, S Davies, S Cook, M Moglia, S J Cork

### ABSTRACT

Cities, their citizens and service providers are being challenged from multiple fronts – population growth, technology, societal and environmental challenges.

We are also faced with an intersection of two groups of thought – future or strategic thinking to create awareness and preparedness for future challenges, and data-driven actions and decisions. Although not contradictory, combining these perspectives poses challenges to those wanting to improve long-term infrastructure and service planning and strategies.

Sydney Water has been working with the CSIRO to develop a set of possible future scenarios for Sydney and a framework to integrate them into our planning and improve our resilience in an uncertain future.

**Key Words:** Futures, Scenarios, Planning, Uncertainty, Strategy, Scenario Planning, Strategic Thinking

### INTRODUCTION

Australia is one of the most urbanised countries in the world, with about 90% of the population living in towns and cities. Nearly two out of three Australians live in only eight capital cities. Most of Australia's future population growth is expected to occur in cities. Based on current projections, the population of Sydney Water's area of operations is expected to exceed 8.5 million, an increase of 75%, by 2060.

Rapid urbanisation presents both opportunities and risks. How this change plays out in future cities will shape the livelihoods and wellbeing of Australians, and the ability of future populations to live within the earth's carrying capacity. Sustainability, liveability and resilience of the nation depends on our capacity to build and manage cities that will meet the needs of the future through a time of significant uncertainty.

To successfully plan for sustainable, liveable and resilient cities, we need to accept that the future is both uncertain and complex. The path to that future is dynamic and a system of interconnected parts can influence the behaviour and outcomes of individual components.

Water plays an important role in enhancing the liveability of cities through the integration of water sensitive principles into city planning, delivering value through economic, social, and environmental benefits. In particular:

- Economic benefits through the optimisation of infrastructure investment across water, land use and transport planning while providing world-class water services. It provides opportunities for significant waste recovery of water, energy and nutrients and sets the cities' water infrastructure in a new sustainable direction.
- Encouraging quality housing through water and drainage infrastructure that promotes excellence in housing developments and surrounding environments as Sydney grows.
- Supports healthy communities by linking parks, cycleways and other community infrastructure to water features such as wetlands and streams, giving communities beautiful natural places to live and be active. Integrated water solutions can keep parks and open spaces green and provide attractive green infrastructure to keep Sydney cool and communities safe from heat-related illness.

- Better governance co-ordination, the implementation of strategic pollution control, stormwater harvesting, water recycling, and the use of water for irrigation can enhance and help rediscover the iconic waterways of Sydney.

As planners of future water, wastewater, and stormwater services we are required to develop forecasts and projections about the future. eg. what will be the demand for water over the next 5, 15, 30, and 50 years and how will it be provided? What will be our future energy needs and how should we meet them? What will future customers expect/need from a water utility and how can those needs be best met? To best answer these questions, utilities and other service/infrastructure providers need to acknowledge

that they are one component within a complex system. We are not able to control all factors influencing the future outcome and there are limitations on using past events and data to future possibilities. As such, utilities and other service/infrastructure providers have a role in both shaping and monitoring the transition of a city from its current to future state.

As illustrated in Figure 1, use of scenarios and scenario planning approaches is one way of moving beyond forecasts and predictions when working with complex and uncertain systems.

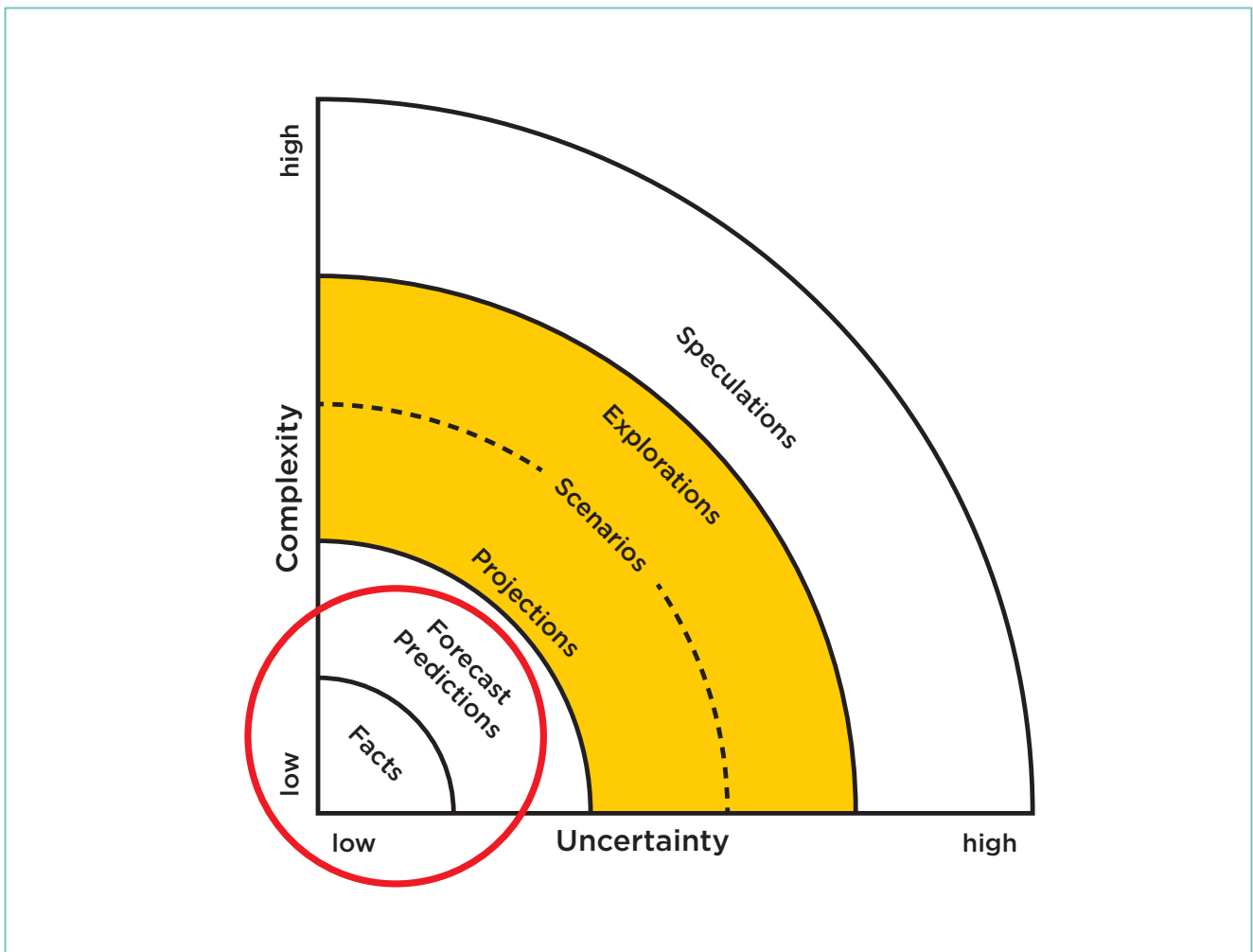


Figure 1: Role of scenario planning in managing complex and uncertain futures (Zurek and Henrichs, 2007)

Scenario planning is a well-accepted method used in business to expand the thinking about possible future challenges and opportunities, with the aim of proactively developing coordinated strategies to address emerging problems and improve preparedness for unanticipated shocks. The same benefits that can be achieved for businesses through the application of scenario planning can also be realised in the strategic planning of water infrastructure and services for cities and regions. Using a scenario planning approach, we can identify plausible futures that embed key critical uncertainties facing urban and rural areas. Scenarios can be used to test the resilience of our strategies and plans under a range of varied plausible future states. They help to understand future risks and opportunities and how we can build resilience into our plans. Another benefit is that scenarios can form a framework from which a range of potential outcomes can be quantified and analysed.

In developing a range of plausible futures, we broaden our thinking beyond what we have seen in the past, and what we know is true now. Future events that are currently unpredictable may trigger divergences from current plans, strategies and thinking. These unrecognised trends or shocks can cause the future trajectory of the system to change, with the result being a completely different future state developing. As it is not possible to predict the future, scenario planning prepares us for a future that is different than now.

## APPROACH

The future scenarios currently being integrated into Sydney Water's business and infrastructure planning processes have been developed considering cross-dependencies and the interactions between water and broader national and regional factors.

The scenarios aim to identify the potential impact of broader global/regional trends and other potential disruptions to the industry, both within and outside the control of Sydney Water. It assists in providing reasoning and justification for strategic and planning decisions, particularly those that may challenge current business practices.

The approach also provides a common language and framework, under which all stakeholders discuss future challenges, assumptions and options. This provides a solid foundation for co-design and other forms of collaborative planning.

The 'strategic conversation approach' as described below, has been applied to develop the scenarios. This is similar to the approach used by the CSIRO to develop scenarios for other Australian cities (Moglia et al., 2018).

### Step 1: Stakeholder interviews, survey and horizon scanning

A series of background interviews and an online survey were undertaken with relevant stakeholders to identify appropriate input dimensions for the scenarios as well as potential uses for the scenarios. This was supported by a horizon scan of potential market drivers, key trends, emerging technologies and potential disruptions that could impact the region in the future. The objective of the horizon scan was to stimulate thinking among workshop participants and give them some sources they could draw on before, during and after the workshop.

### Step 2: Scenario development

Workshopping is an effective way to develop scenarios. Attendees should be those who are able to promote diversity of thought. People from different disciplines, a mix of ages and cultures enable traditional thinking to be challenged.

The scenario development workshop was facilitated according to the strategic conversation approach (Van Der Heijden, 1996). This is a type of approach that allows participants to explore different visions and in the process of doing so, they develop a shared appreciation of challenges and opportunities (Rohrbeck and Schwarz, 2013).

The workshop was also intentionally facilitated to eliminate blind spots by challenging dominant mental models of how a city works (Godet 2012). Specifically, a 'political foresight' approach was adopted after Stewart (2008); i.e., consideration of multiple plausible futures. Scenarios were developed from discussions organised along a two-by-two matrix (Figure 2).

Selecting appropriate dimensions for the scenario matrix is essential to ensure that a range of plausible futures can be created. The UK Foresight Futures project (Office for Science and Technology 2002), found that using the dimensions representing societal mood (individualist vs. collectivist) and institutional culture (collaborative vs. fragmented) that the largest plausible differences across key challenges for humanity were able to be produced.

The reason for the choice of these uncertainties to guide further conversation is that it is recognised that humans and their actions are the key drivers within the emerging era of the Anthropocene (period of significant human impact on the Earth's geology and ecosystems). Within each of the

quadrants, there is some consistency in the drivers for technological progress, for protection of environmental and social values, and for collaboration or conflict within regions and between nations.

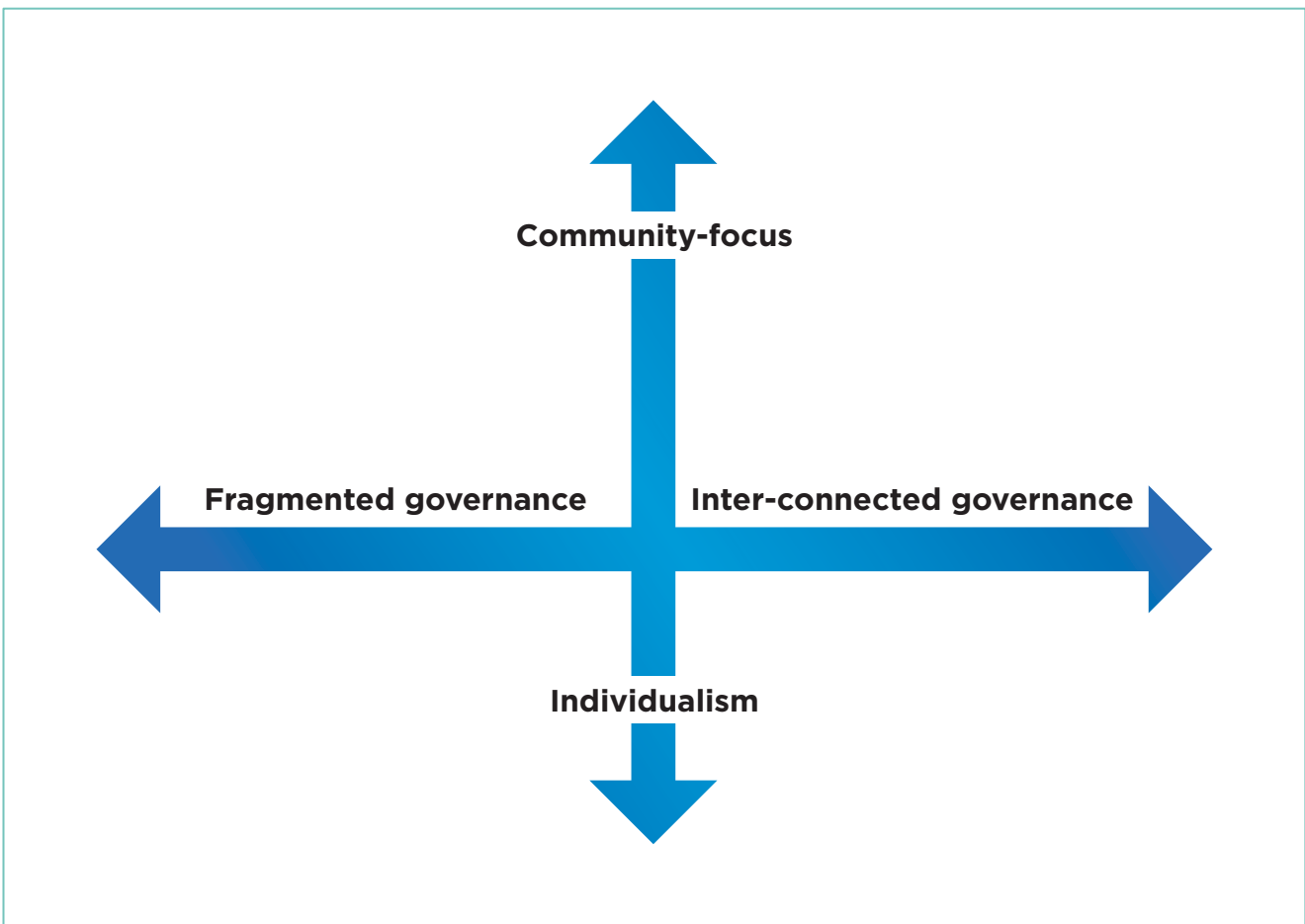


Figure 2: Two critical uncertainties – chosen axis to frame scenario conversations.

Each scenario includes a detailed narrative and key settings on important uncertainties. By focussing on very divergent and different futures we were able to explore the broad range of challenges and opportunities that arise within them. As well as considering the implications of each future separately, we also explored how a scenario may transition to another and what the early warning and thresholds are.

**Step 3 – Identifying key datasets and signposts for monitoring trajectory**

To ensure the scenarios are usable and integrated into infrastructure planning, key datasets and signposts need to be considered. Identification of signposts and monitoring changes in observed conditions over time is critical in understanding the trajectory on which we are progressing towards the future.

This enables the scenarios to be modelled and a range of potential future outcomes to be quantified for critical business themes. This, in turn, enables plans and strategies to be 'wind-tunnelled' against the scenarios. Testing how proposed plans and strategies cope under a range of scenarios can assist in the identification of the strengths and weaknesses of each plan or strategy. It can also uncover existing biases and assumptions built into existing processes.

## CRITICAL UNCERTAINTIES FOR WATER IN SYDNEY

The following critical uncertainties were identified during the scenario development process:

- **Population growth** – the volume, speed and the location of growth, due to its impact on demand for water services, new development and services, economic growth as well as on the environment.
- The nexus of **urban form and land-use**, infill growth vs more urban sprawl. The uncertainty of how this will play out over time and the implications of this has on the planning of water services, the nature of water demand and protection of the environment and heritage.
- **Climate change**, in particular, its impact on sea level rise, heat island effects, environmental degradation, food supplies, will increase the risk of natural hazards and need for effective climate mitigation and adaptation.
- The widespread **technological change** was considered to have potentially large impacts. Changes that were mentioned were self-service water related service provision, automation and the impacts of virtual reality on the future of work and transport. **Cyber-crime** was mentioned as a key risk here.
- **Future community** – the level of social cohesion, community attitudes, perceptions, values and resilience, due to its impact on the demand for services, efficient use of resources and their expectations for products and services.
- The nature of future **service provision** because water-related services may be delivered differently in the future. This can be impacted by changing governance, regulation, licencing, competition, technological innovation, and changing community expectations.
- Growth in or development of **new demands for water** to support the city. eg non-residential, green space and cooling.
- The composition of **future water supply sources** and its connectedness to the broader water cycle

## WATER SCENARIOS – OVERVIEW

A summary of each scenario developed at the workshop and refined to ensure plausibility and justifiable logic paths is provided below. Each scenario is provided in a narrative format and the critical uncertainties in each can be compared using the settings shown in Figure 3.

	S1	S2	S3	S4
<b>Population</b>	▲	●	▼	●
<b>Equality</b>	▲	●	▼	●
<b>Innovation</b>	●	▲	▼	●
<b>Greenhouse gases</b>	▼	●	▲	●
<b>Climate impacts</b>	▼	●	▲	●

▲ High   ● Mid   ▼ Low

Figure 3: Key uncertainty settings for each scenario

### Scenario 1: Community Focused – Interconnected Governance

Sydney communities and governance have become more interconnected. Sydney prospers allowing citizens to enjoy a high standard of living, while strong government revenue enables public investment in green infrastructure improving liveability environmental outcomes. Public investment in technology innovation develops cost-effective approaches to decentralised water treatment.

With better access to data, information and a community push to think more holistically, there is a strong focus on the quantification of externalities. Water is valued and water services are critical to improve and sustain liveability. Enabling the consideration of externalities (social, environmental and economic) in investment decisions improves public good and long-term planning outcomes. With explicit consideration of social and environmental values organisations are able to proactively respond to challenges such as financial crises and climate change.

Key scenario drivers:

- community pressure to address environmental and social dilemmas

- a new economic paradigm, along the lines of doughnut economics (Raworth 2017)
- organisations look to improve further the stability of financial markets, public health, social inequality, and the environment
- globalism, free-trade, international collaboration and the relatively free flow of people and ideas

### Scenario 2: Individualist – Interconnected Governance

Sydney has a collaborative governance model focussed on delivering public good outcomes, but the community has become more fragmented. There is increased reliance on technology which enables more individualised water services. Cheap energy enables improved water security through use of local water treatment. Private companies and individuals now can operate more efficiently in the water market.

Technology disruptions, such as artificial intelligence, automation and remote working, fundamentally shift the way people go about their lives at work, home and play. Existing regulatory and policy environments struggle to keep up with the advancement of technology and community expectations.

Improvements in technology and continuing resource constraints, there is a desire to achieve extreme resource efficiency. Smart city concepts are adopted to provide coordinated solutions to complex problems.

Key scenario drivers:

- automation and other technology advancements lead to disruption of the economy
- market-mechanisms as a driver of change rather than government intervention
- ongoing depletion of a range of resources leads to a focus on resource efficiency
- with the evolution of market-mechanisms and technology climate change mitigation and adaptation and resource recovery are enabled

### Scenario 3: Individualist – Fragmented Governance

The ability for governments to influence outcomes reduces as individualism rules. It is a chaotic period, and government plays a smaller role in the management and regulation of essential services, like water. Private companies increasingly provide services on a for-profit basis. Within the community, there is a rise of the 'individual', with individuals looking after themselves with less consideration of the community as a whole. With more reliance on local resources, some individuals and communities are disadvantaged due to a lack of access to resources and traditional services. Big global issues, like climate change

impacts, water security, wastewater management are not addressed as well as they had been historically. The ongoing pressure from these bigger threats resulted in the community banding together to drive change for a better future.

Key scenario drivers:

- rapid and unplanned change in fundamental assumptions and standards
- limited ability to proactively adapt to large-scale threats and shocks.eg climate change, financial crisis
- lower than expected population for Sydney and the world
- innovation is driven by large corporations
- extreme user pays mentally, with limited baseline support available

### Scenario 4: Community Focused – Fragmented Governance

As a result of technology disruption, community rejection of large corporations, some larger water utilities lose their effectiveness to deliver services and infrastructure. Community focused and more localised providers look to fill the gap leading to a more 'village focused' paradigm. With the growth in local entrepreneurship and self-sufficiency, each village trades their local resources and skills to achieve their own localised aspirations. A more fragmented approach to policy, regulation and service provision leads to variation in the quality of services. To manage large-scale issues experienced across 'villages', such as public and waterway health, coordination and negotiation is required between 'villages'.

Key scenario drivers:

- community distrust in large organisations
- growth in small businesses producing custom-made products and services
- decline in large-scale manufacturing
- a drive by large parts of the population to be self-sufficient and 'off-grid'
- limited ability to proactively adapt to large-scale threats and shocks.eg climate change, financial crisis.
- lower than expected population for Sydney as the difference between city and regional living declines

## COMMON BLIND SPOTS

Analysis of the workshop outcomes and the scenario refinement process flagged the following blind spots that are currently not well understood.

### Technology as a double-edged sword

Technology is often assumed to be the saviour to our future challenges, yet it is often forgotten that technology tends to carry with it unintended consequences. It can lead us on an uncertain path where the outcome and its flow-on effects are unknown.

In three of the four scenarios, the fairly well-known risks associated with fossil fuels and artificial intelligence and the potential disruptive impacts of the fourth industrial revolution played a significant role in the outcome of the scenario. The path and speed of technology development and adoption in these scenarios had the potential to cause massive changes to the nature of work and disrupt the current social fabric of society, governance and tax systems.

It is also clear that future changes in the nature of work present challenges for the provision of infrastructure and services, as a major shift in employment, could fundamentally alter the business model of utilities. However, the specific risks or appropriate responses are not yet well-understood.

Interestingly, the scenarios demonstrated that one key mechanism for achieving a positive future with strong technology development and adoption is the ability to ensure desired social and environmental outcomes through adequate governance.

A common topic raised when discussing future plausible scenarios was trying to understand the implications of technological innovation. Although many agreed that technology would have a significant impact on the future, the exact nature of this impact was not as certain.

Overall, technology can be used in many different ways and the impacts will vary depending on how they are used. We can't necessarily predict how new technology can be used, unless we know something about the socio-economic and cultural context and the regulatory environment under which the technology is implemented (Figure 4). If we know those factors, then we are in a better place to make predictions about the use and impact of technology. This also provides an opportunity to shape the impact and use of technology. A key insight for the water sector is that technological progress is not sufficient for change without overcoming the implementation barriers as well. A good example of this is in the case of Sustainable Urban Water Management (Marlow, Moglia et al. 2013).

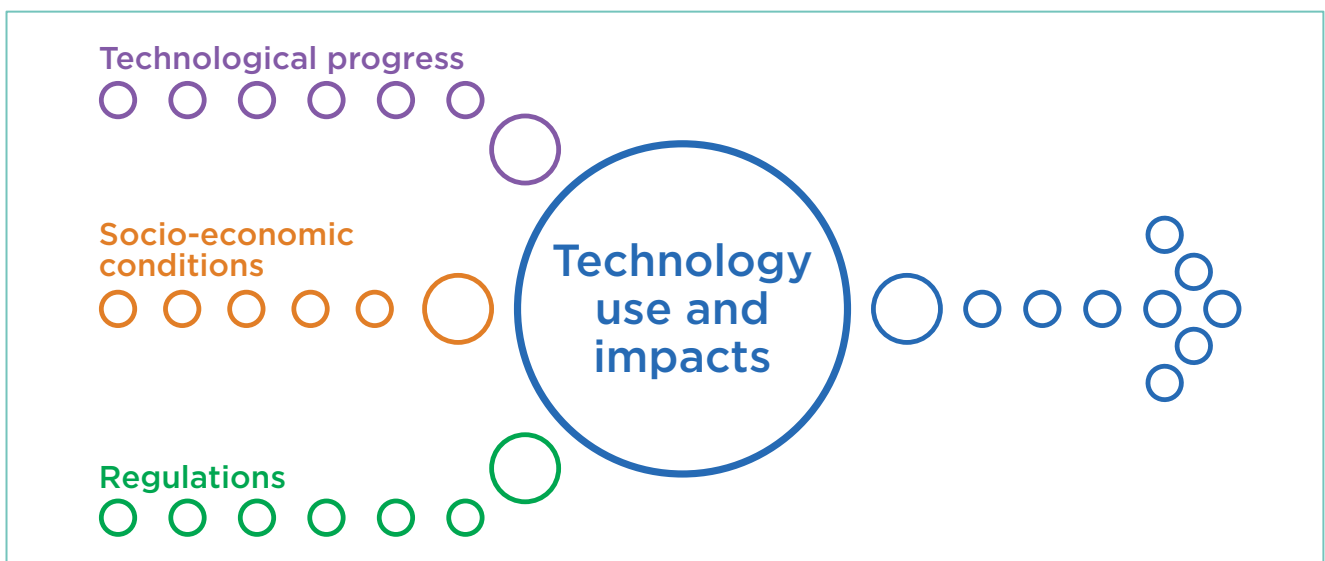


Figure 4: Fundamental relationship to allow us to understand technology use and impact

### Variability in land-use futures

The urban form in Sydney is currently changing with an increase in apartment and smaller lot development, combined with reduced large-scale industry. It is possible that the current urban form of Sydney will continue to change, which could shift spatial and temporal patterns for the demand of infrastructure and services, such as water use. This may raise the possibility of stranded or no longer fit-for-purpose assets, where the infrastructure is inappropriately sized, located in an area with no demand or provides an obsolete service.

These possibilities reinforce the importance of allowing for flexibility in adapting to changing circumstances and, given the immense uncertainties involved with supply and demand for urban services, to avoid lock-in infrastructure decisions. To deliver this, an adaptive planning approach to infrastructure investments and/or investment in scalable modular services that can be up-scaled or downscaled according to changing needs is required.

### Uncertainties of climate change

As the scenarios are meant to challenge current plans and thinking, three of the four scenarios experience median to high impacts from climate change. However, the key to this is the adaptive capacity of society to respond to climate change impacts and minimise its impact on fundamental services and standards of living. The scenario development process identified large-scale geoengineering in one of the four scenarios (Scenario 2), and cheap and accessible fusion power appeared in two of the scenarios (Scenario 1 and Scenario 2), thus allowing for a rapid transition to clean and cheap energy. However, in Scenario 3 and Scenario 4, climate change had a disruptive impact on the economy, and in Scenario 2 there were large-scale inflows of climate refugees. Suffice to say that climate change loomed large in all scenarios, but that the societal response to the impacts varied considerably, and thus creating uncertainty in terms of impact.

The outcome of this uncertainty or our ability to adapt is critical, particularly in its potential to disrupt or impact on the security of water supply and providing reliable and resilient water, wastewater and stormwater services in cities.

### Uncertainties of population growth

The volume, distribution and timing of population across the city is a fundamental driver in the future Sydney and the delivery of services.

Population growth is front of mind to infrastructure and service planners. However, the potential for a stabilisation or declining population is not. Scenario 3 explored the possibility and impacts of a serviced population significantly lower than currently projected. Current trends suggest population, on the whole, is likely to continue to grow rapidly, driving many of the current questions around the ability for existing infrastructure to cope with such rapid change. However, it is more important to consider how population trends may play out and capacity of infrastructure to meet demand at a more localised level.

### The customer of the future

Another blind spot that will influence the success of our planning and strategies will be the expectations, values and attitudes of customers of the future. It was acknowledged that we currently have little understanding how customer or social wants and needs will change or remain the same over the long term. We have seen the shift to more customer-centric services, and it is assumed that this will continue into the future. There is additional uncertainty on how utilities may adapt to this changing paradigm.

## CHALLENGE OF IMPLEMENTING SCENARIOS

The development of scenario narratives are only the first step in the scenario planning process. The biggest challenge is in their implementation.

To support the integration of scenarios into business processes, a toolkit has also been developed. This provides a process to review the scenarios, track trends and also starts to quantify key uncertainties for each scenario.

With this guidance, scenario planning approaches can be embedded to improve the resilience of Sydney Water's long-term strategies and planning processes by:

- providing an engaging, common framework and language which enables multi-disciplinary and community groups to collaborate and co-design proactive plans for prosperous, liveable and resilient places
- improving awareness and information sharing on interdependencies between planners
- providing a process to acknowledge 'built-in' assumptions and biases and challenge them
- starting the conversation on which assumptions and impacts are truly important to quantify and assist in the prioritisation of research, analysis or other work to inform long-term strategies and plans
- informing forecasts by enabling the consideration of disruptions, uncertainties and other non-linear trends, and



- enhancing business resilience and understanding the risks of current strategies and plans by testing their robustness against multiple possible futures

## CONCLUSION

The scenario development process creates an environment for ongoing dialogue about inherent uncertainties and the assumptions behind strategies, policies and plans. Scenarios enable water utilities to engage actively with government agencies, the community and the private sector to consider long-term outcomes and resilience of their strategies, plans and decisions on the long-term resilience of a city.

The scenarios provides a common language and framework for collaboration with all stakeholders to discuss future challenges, as well as to identify and to challenge current assumptions embedded in strategies and plans. Sydney Water is now using these scenarios to 'resilience' test their strategies and plans for the future and identify priority focus areas for research and analysis.

## REFERENCES

- Marlow, D. R., M. Moglia, et al. 2013. Towards sustainable urban water management: A critical reassessment. *Water Research* 47(20): 7150-7161.
- Moglia, M., S. J. Cork, F. Boschetti, S. Cook, E. Bohensky, T. Muster and D. Page (2018). Urban transformation stories for the 21st century: Insights from strategic conversations. *Global Environmental Change* 50(May 2018): 222-237.
- Raworth, K. 2017. Meet the doughnut: the new economic model that could help end inequality. Viewed October 2017, <<https://www.weforum.org/agenda/2017/04/the-new-economic-model-that-could-end-inequality-doughnut/>>.
- Rohrbeck, R. and J. O. Schwarz. 2013. The value contribution of strategic foresight: Insights from an empirical study of large European companies. *Technological Forecasting and Social Change* 80: 1593-1606.
- Van Der Heijden, K. 1996. *Scenarios. The Art of Strategic Conversation*. Chichester, John Wiley & Sons.
- Zurek, M. B. and T. Henrichs. 2007. Linking scenarios across geographical scales in international environmental assessments. *Technological Forecasting and Social Change* 74(8): 1282-1295.

## THE AUTHORS



**Marcia Dawson**

Marcia Dawson, Principal Analyst at Sydney Water using analytics and research to inform strategic infrastructure planning and policy decisions. She is intrigued by the challenge of merging strategic thinking and data driven approaches to drive change.



**Luther Uthayakumaran**

Luther Uthayakumaran, has approximately 20 years of experience in multiple industries in strategy, innovation and analytics, and has been working in the water industry for the last three years.



**Lucinda Maunsell**

Lucinda Maunsell is a strategic manager of technical teams and environmental engineer with over 20 years experience in the water industry. She has proven track record in high level strategic planning and problem solving, underpinned by technical analysis.



**Sharon Davies**

Sharon Davies, Sydney Water-Urban strategy and Infrastructure planning specialist. Recently completed projects with Greater Sydney Commission and Infrastructure NSW to better integrate water and land use planning in Greater Sydney.



**Stephen Cook**

Stephen Cook is a Senior Research Scientist working within CSIRO Land and Water. Stephen is an environmental scientist with more than 15 years' experience in the urban water sector.



### **Magnus Moglia**

Dr Magnus Moglia is a Melbourne-based Principal Research Scientist at CSIRO Land and Water and an Adjunct Associate Professor at Swinburne University. His current research includes Futures Thinking,

Scenarios and complex systems modelling to explore pathways and system levers for making our cities more sustainable.



### **Steven Cork**

Steven Cork, BSc, PhD, is an ecologist and futurist. He is the Principal Consultant of *Ecolnsights*, a director of the private sustainability R&D organisation Australia21, and teaches environmental policy and communication as an Adjunct Professor in the Crawford

School of Public Policy at the Australian National University.