Department of Climate Change,
Energy, the Environment and Water

# Steps required to undertake a cost-benefit analysis

Extracted from the Water conservation cost-benefit analysis guidelines

September 2024

The *Water conservation cost-benefit analysis guidelines* have been developed to provide a framework to undertake cost-benefit analysis of urban water conservation options. These guidelines will assist utilities to consider the broad range of costs and benefits of water conservation initiatives. Their purpose is to encourage utilities to consider and evaluate water conservation initiatives on an equal basis with supply side measures that improve water security.

For ease of use, the full *Water conservation cost-benefit analysis guidelines* have been broken into the following sections to guide utilities through the analysis process:

- **About the *Water conservation cost-benefit analysis guidelines*** – Summary of the purpose, background and process for conducting a cost-benefit analysis.
- **Undertaking a cost-benefit analysis** – Describes the steps involved.
- **Valuation methodologies** – A successful analysis will assess economic, social, environmental and cultural costs and benefits.
- **Case study A** – Water conservation cost-benefit analysis in a metropolitan coastal community with a large population.
- **Case study B** – Water conservation cost-benefit analysis in an inland community with a small population.
- **Case study C** – Water conservation cost-benefit analysis in an inland community with a mid-size population.

Visit **water.dpie.nsw.gov.au** to download these documents or a copy of the full *Water conservation cost-benefit analysis guidelines*.

# Contents

# Getting started

3

### Tips and tricks

**DO** focus on being clear about the need, objective, or driver for the decision and the broad spectrum of options to achieve this need.

**DON'T** focus on the availability of detailed cost information on the options or any non-monetary social and/or environmental values.

## 3.1 What are the key steps involved in a cost-benefit analysis?

There have been developments in recent years in analytical techniques used to monetise social and environmental outcomes and evolving expectations when considering risk and resilience in water conservation. But the key concepts and steps involved in a CBA remain broadly unchanged and the water industry still uses them.

These include setting out the objective or business need for the investments (or non-investments), the range of potential options for achieving this objective, and the transparent and objective process for valuing and ultimately comparing these options.

As shown in **Figure 8** (and discussed in more detail in the remainder of these guidelines), undertaking a CBA involves the following steps:

- **Step 1:** Define the problem or business need (the objective).
- **Step 2:** Define a base case and range of alternative options. In most cases, the base case and options should achieve the objective.
- **Step 3:** Identify and value, where appropriate, the incremental economic, social, and environmental costs and benefits of the options. This is relative to the base case.
- **Step 4:** Compare the costs and benefits of the options, compared to the base case, to identify the expected NPV and BCR.
- **Step 5:** Account for key risks and uncertainties that could impact the economic, environmental, and social costs and benefits of the options.
- **Step 6:** Undertake distributional analysis to identify who benefits and who bears the costs of the options.

These guidelines are consistent with best-practice approaches to undertaking CBA and draw on a range of state and commonwealth guidelines.[30]

30 See for example: NSW Treasury, TPG23-08 NSW Government Guide to Cost Benefit Analysis, 2023; NSW Department of Planning and Environment, Regulatory and assurance framework for local water utilities, July 2022.

**Figure 8: Overview of cost-benefit analysis**

## Framework for undertaking cost-benefit analysis

### 1 Define the problem and business need (the objective)

**Examples of objective**

**Objective** – Provide water services to area/customer within timeframe, consistent with regulatory obligations

### 2 Define a base case and alternative options that achieve the objectives

- 0 Base case (BAU or do minimum)
- 1 Water-efficient appliances
- 2 Leakage detection

### 3 Identify and value (where appropriate) incremental costs and benefits of the options

**Examples of costs and benefits**

- Economic costs and benefits
- Social costs and benefits
- Environmental costs and benefits

### 4 Compare the cost and benefits to identify the ENPV and BCR

| ENPV < 0 and BCR < 1 | ENPV = 0 and BCR = 1 | ENPV > 0 and BCR > 1 |
|---|---|---|
| **Does not maximise** society's wellbeing | Society is **indifferent** | **Maximises** society's wellbeing |

### 5 Account for key risks and uncertainties

**Examples of uncertainties**

- Lower and higher costs
- Climate change
- Discount rate
- Risk of drought
- Demand

### 6 Identify the high-level distribution of costs and benefits across the community

**Examples of relevant parties**

- Local community (incl. developers)
- Customers
- Water utilities
- NSW community

# 3.2 What level of resourcing and effort is required?

CBA is the preferred approach for evaluating all decisions, but the valuation of costs and benefits requires resources, time, and effort. The appropriate degree of analysis will vary from one project to another and should match the size, complexity, level of risk, and estimated cost on a case-by-case basis.

While proponents have flexibility in making assumptions, the rules about which benefits and costs to include in a CBA and approaches to valuing them are straightforward and well established.

As discussed in more detail below, in many cases, the decision and choice of option will have limited impact on the community or may be of limited interest to stakeholders. If so, a simple CBA (similar to a cost-effectiveness analysis – CEA) may be appropriate (see **Box 5**).

In other cases, the project(s) can be considered “of significance” to one or more parties and may therefore warrant a more detailed CBA. If so, users of these guidelines may require further technical guidance and specific expertise to assist in developing or reviewing key aspects of the CBA.

## Box 5: Cost-benefit analysis vs cost-effectiveness analysis

Cost-effectiveness analysis (CEA) aims to identify the option that achieves the specified objective(s) at least cost (**Figure 9**). In this example, it is clearly option A (base case). Options B to E all involve additional costs to the base case, that is, positive incremental costs. We have not displayed Option A on the chart because the graphic represents the additional costs of Option B to Option E, compared to Option A.

CEA involves undertaking many similar sets of steps, applying similar principles, and using similar evidence as CBA. But non-market costs and benefits are typically not quantified and valued. Unlike CBA, CEA identifies the least-cost option and cannot indicate whether the preferred option provides a net benefit or “value for money” to the community (**Figure 10**).

**Figure 9: CEA identifies Option A as achieving the specified objective(s) at least cost**

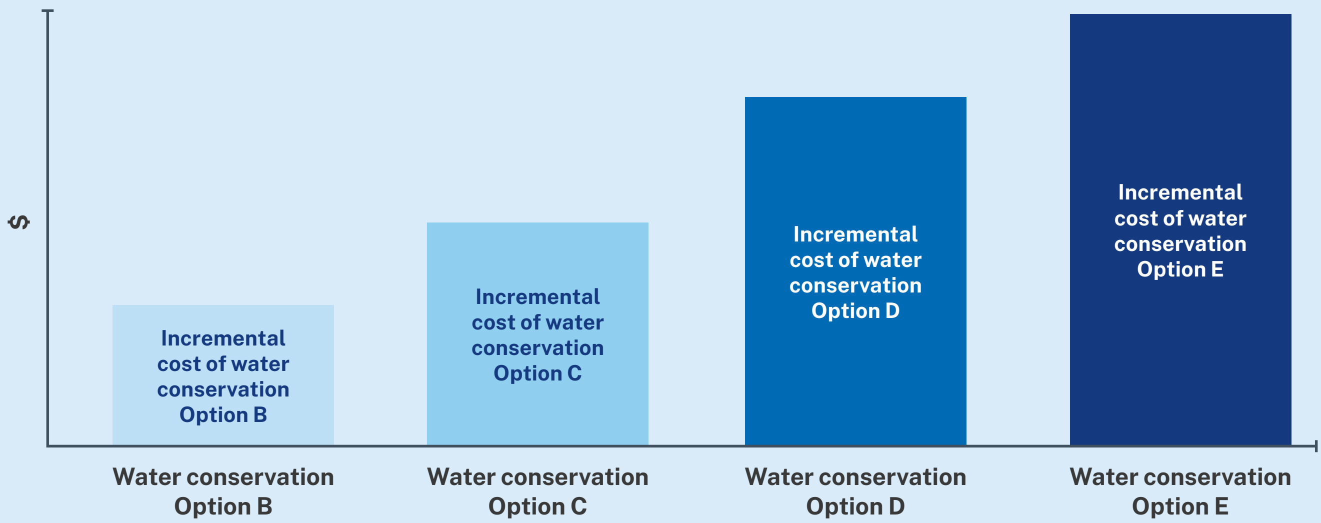


**Figure 10: Cost-benefit analysis identifies Option C as achieving the specified objective in a way that maximises welfare or value for money for the community**

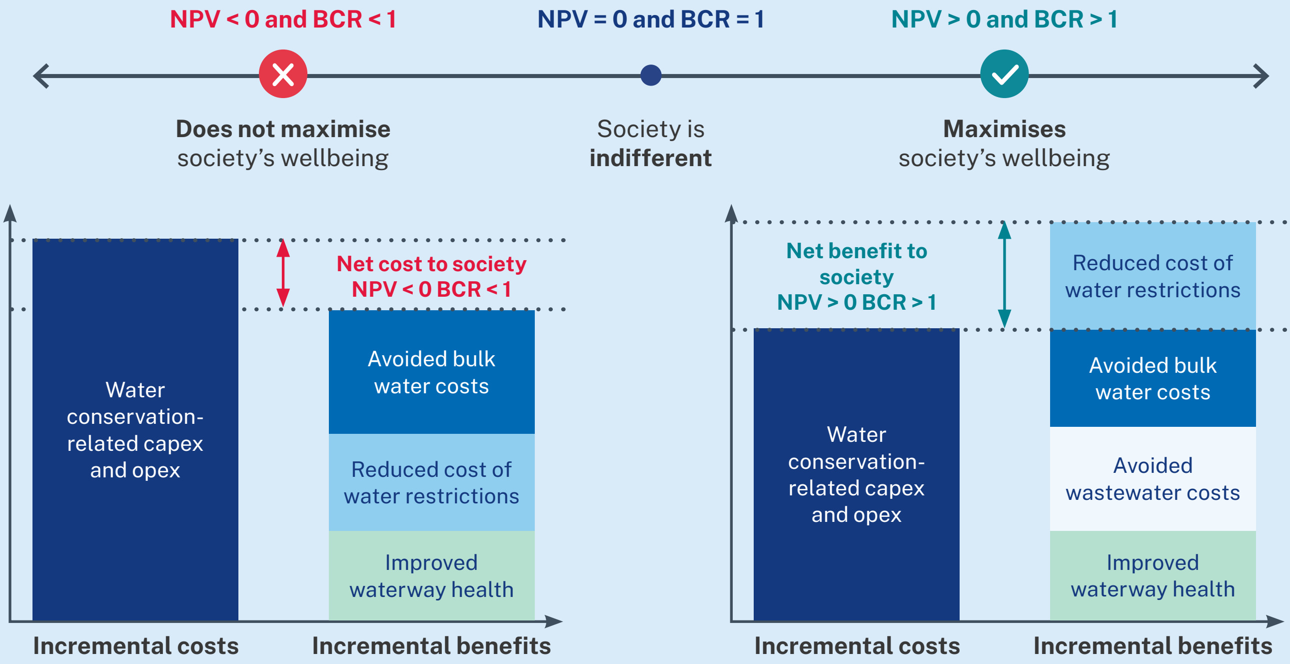



**Table 2** and **Table 3** provide guidance on considering whether the project(s) is "of significance" and the implications for the level of resourcing and effort required in different circumstances. **In short, answering "yes" indicates that elements of a detailed CBA may be warranted**.

Common sense should guide the degree of analysis – that is, the extent to which a simple or detailed CBA is warranted. This is particularly so when assessing benefits or costs that are difficult to quantify, and the level of risk and resilience analysis required.

**Table 2: Getting started: Identifying the analytical effort required for a detailed cost-benefit analysis**

| Guiding principle | Implication | Example | Effort and resourcing required |
|---|---|---|---|
| **Is the project associated with significant non-monetary impacts?** | May be significant environmental or social impacts. | Impact on likelihood, or cost, of running out of water. | May require gathering and valuing site-specific outcomes. |
| **Would the project impose significant financial costs to the NSW community?** | May involve lifecycle expenditure over $10m. | Portfolio of supply side and demand side investments to deliver water security over the long term. | May require more complex risk and resilience analysis and distributional analysis. |
| **Is the project subject to significant risk and uncertainty?** | Community value may differ significantly depending on future states of the world. | Implementation of infrastructure solutions that have effects on uncertain outcomes such as drought. | May require more complex risk and resilience analysis, such as expected NPV or real options analysis. |
| **Is the project subject to cost-recovery risk and/or require co-funding?** | May need to demonstrate value and distribution of benefits to sections of community (for example, to access co-funding). | Investments that involve multiple parties such as water utilities, government, and households. | May require, more complex risk and resilience analysis and distributional analysis. |
| **Is the project of significant community interest?** | May need to demonstrate value and distribution of benefits to sections of community. | Demand side investments as part of the broader water security planning process. | May require gathering and valuing site-specific outcomes and distributional analysis. |

### Table 3: Getting started: Practical differences in level of effort and resourcing required

| Step | Simple CBA | | Detailed CBA | | Key differences |
|---|---|---|---|---|---|
| | Summary | Example | Summary | Example | |
| **1 Defining the business need and objective (that all options must achieve)** | Objectives are typically the set of outcomes to be achieved, although you can also use CBA to determine the value of different levels of service or performance (different outcomes). | Maintaining provision of water services to the community that meet obligations, levels of service, and expectations. | As per simple CBA | As per simple CBA | N/A (both involve identifying the objective that all options must achieve). |
| **2 Defining options (including a base case and at least 2 alternative options)** | Identifies the range of possible options to achieving the objective. A "do nothing" base case will only be appropriate in some (but not all) circumstances. | The base case could be a business-as-usual (BAU) approach to the provision of water services (which may involve limited water conservation). | As per simple CBA | As per simple CBA | N/A (both involve identifying options, including a base case, that achieve the objective). |
| **3 Identifying and valuing benefit and costs** | Likely to only include economic costs (expressed in financial dollar terms), and so won't require valuing non-monetary social and environmental impacts. | Operating and capital of managing growth in water demand and/or wastewater (for example, LRMC estimates) for a given utility (and catchment). | Likely to involve valuing broader economic, social, and environmental outcomes (some of which are non-monetary), using site-specific information. | Benefit to the community of reducing the likelihood of incurring drought-related costs (such as restrictions) and risk of supply shortfalls. | Detailed CBAs are more likely to involve the valuation of broader economic, social, and environmental costs and benefits that accrue to broader community. |
| **4 Comparing the value of the options** | Calculates NPV and BCR to compare economic costs across the options. | Similar to least-cost analysis (also known as cost-effectiveness analysis). | Calculates NPV (or expected NPV) and BCR to compare economic, social, and environmental costs and benefits across the options. | Detailed CBA that values the broader economic, social, and environmental outcomes. | While both can involve calculating the NPV and BCR, simple CBA is more likely to resemble a least-cost analysis/CEA. |
| **5 Accounting for risks and resilience of options** | Likely to involve simple sensitivity analysis of key assumptions (at least 9 combinations of sensitivities). | Three discount rates combined with 3 cost scenarios (low, central, and high). | Likely to involve more detailed sensitivity, scenario analysis, and/or real options analysis. | The use of real options analysis to identify the value of adaptive decision-making in response to a water shortage event or drought. | Simple CBA is likely to involve much simpler sensitivity analysis (for example, varying a few key assumptions). |
| **6 Identifying high-level distribution of costs and benefits** | Likely to involve limited distributional analysis if costs and cost savings (avoided costs) are shared "evenly" across community. Likely to be qualitative. | Network leakage reduction that reduces unbilled water for the benefit of all users. | Likely to involve more detailed distributional analysis (broader range of parties) to inform potential co-funding.<br><br>Likely to be quantitative. | Water conservation measures for specific users, which leads to benefits for all water customers. | Simple CBA is likely to have a smaller range of impacted parties and likely to be qualitative. |

# 3.3 What information do I need and where is it available?

Regardless of the resources, time, and effort available, all CBAs will follow a basic "framework" or process for organising the available information in a logical and methodical way to support decision-making.

There is a minimum amount of information required to get started on a CBA (see **Table 4**). However, CBA is an iterative process. If more information becomes available, you can introduce it into the CBA. It is common for the analysis to evolve as more information becomes available about the nature of the decision and the options, associated costs and benefits, and risks and uncertainties. **The trick is to find a "way into the problem" without getting stuck on identifying all potential options or final cost information and/or other detailed assumptions.**

**Table 4: Getting started: Cost-benefit analysis information requirements**

| Information required | How the information is used | Where I can find this information | Example |
|---|---|---|---|
| **Need, objective and driver of the decision** | To ensure all options meet the same minimum standard (an "apples with apples" comparison). | **Step 1** (Chapter 4) | Providing water services in a way that meets the level of service. |
| **Base case and at least 2 alternative options** | To compare the broad range of options to achieve the objective. | **Step 2** (Chapter 5) | BAU approach to renewing an existing water asset, compared to increased investment in rainwater tanks or increased investment in leakage management. |
| **Modelling period** | For calculating the stream of costs and benefits. | **Step 3** (Chapter 6) | 30 years |
| **Lifecycle costs** | For the stream of costs and benefits. | **Step 3** (Chapter 6) | Capital costs, operating and maintenance costs, renewals. |
| **Information on site-specific outcomes** | For measuring the change in economic, social, and environmental outcomes. | **Step 3** (Chapter 6) | Volume of water conservation that offsets potable water demand or wastewater volumes, change in river health. |
| **Information on values from project site or a similar site** | For valuing the change in economic, social, and environmental outcomes. | **Step 3** (Chapter 6) | Long-run marginal cost (LRMC) of water, carbon price, willingness to pay for improved waterway health. |
| **Information on valuation methodologies** | For valuing the change in economic, social, and environmental outcomes. | **Step 3** (Chapter 6)<br><br>**Appendices 2, 3, and 4** | Value avoided potable water demand (or wastewater use) by multiplying the LRMC of water (or wastewater) with the volume of water saved (or wastewater discharged). |
| **CBA model** | To calculate NPV and BCRs to compare the value of options. | **Step 4** (Chapter 7)<br>Supporting excel model of case studies | N/A |
| **Discount rate** | To compare costs and benefits over time. | **Step 4** (Chapter 7) | 5 per cent |
| **Information on how outcomes change under alternative states of the world** | For comparing the value of options under uncertainty. | **Step 5** (Chapter 8) | Three discount rates combined with 3 population growth rates and low, medium, and high lifecycle cost estimates. |
| **Impacted parties (that is, who benefits)** | To understand the high-level distribution of impacts across the community. | **Step 6** (Chapter 9) | The local community, developers, nearby councils, and the broader NSW community. |

# Step 1: Defining the problem, business need, and cost-benefit analysis objective

4

The first step in a cost-benefit analysis is to clearly define the problem. Why does it need addressing and what is the resulting project objective that responds to this need? That is, why is this decision being sought, and what outcome are we seeking?

In instances where you are developing a business case, this step typically draws on previous work done in the "strategic case for change" stage of the business case.

**STEP 1** **Defining the problem, business need, and objective – tips and tricks**

- **DO** focus on the immediate drivers – service and compliance obligations – and measurable outcomes.
- **DON'T** express the objective in terms of volume of water conservation delivered. Water conservation is a means to an end. For example, delivering water security or managing wastewater volumes rather than an objective in and of itself.
- **DON'T** include overly broad drivers that may not assist in focusing on the specific outcomes. The extent to which options achieve these broader considerations can still be captured as part of identifying and valuing the incremental economic, environmental, and social outcomes in **Step 3**.
- **DON'T** include prescriptive inputs and outputs unless there is some form of requirement for these actions (for example, compliance with a strict regulatory obligation).
- **DON'T** include ill-defined outcomes that could potentially result in analysing many very different options. For example, when there is no clear level of service the options are required to deliver.

# 4.1 Defining the problem and business need/driver

Typically, a problem or business need could relate to several interrelated drivers, including the need for the following:

- **Meet a service obligation** – such as providing water services and/or wastewater management services in a way that fulfills obligations and community expectations regarding levels of service. This can include maintaining service provision to a certain standard (for example, the number of outages, or pressure levels) or level of service related to water security (likelihood of restrictions, supply shortfalls) or servicing a new area/customer. It could also relate to evaluating the value of changes to service obligations or levels of service.
- **Respond to evolving customer expectations** – such as increasing customer interest in water conservation, the circular economy, and environmental outcomes related to waterway health and/or carbon footprint.

Importantly, as discussed in more detail below, for the purposes of the CBA, insufficient water conservation is not an appropriate problem or business need/driver. Water conservation is a means to an end rather than an objective in and of itself. For example, it is a method of contributing to water security or assisting in wastewater or stormwater management. Take care to express the problem as an outcome rather than a means.

### 4.1.1 The challenge of answering multiple questions at once

Often a decision on water conservation, commonly supported by a business case, will be responding to multiple needs with multiple potential decisions being sought. For example, as part of broad water security planning processes, decisions are often sought on the level of service to be delivered (which informs system yield) and on the appropriate supply and demand mix to deliver that level of service.

However, this context creates the risk that the CBA will seek to optimise across too many variables (or answer too many questions at once). That is, there are too many drivers and moving variables the options seek to address (see **Step 2**). Answering too many questions at once can create challenges in understanding the drivers of value and the solution that delivers the greatest benefit to the community.

If this is the case, one option may be to undertake a sequential analytical process:

- **First, analyse the level of service.** What level of service or level of compliance maximises net benefits to the community? How frequently should you impose water restrictions on the community?
- **Second, analyse the interventions to achieve this level of service.** What set of interventions designed to meet this level of service maximises the net benefits to the community?

The clearer the need and resulting objective, the more you can target the CBA to answer the "right" questions in the "right" order.

## 4.2 Establishing the cost-benefit analysis objective

A related step is to then define a clear outcome that each of the project options will need to achieve – the CBA objective.

This is a critical step. It is worthy of close consideration before proceeding to the next steps given business case reviews often raise concerns around methods for defining objectives. Getting the objective "right" can reduce the risk of undertaking an evaluation of options that may not identify the "best" intervention, that is, the largest net benefit.

For this reason, you can use a range of principles to help guide the selection of the problem/ opportunity and objective. These include the objective appearing as the following:

- Clearly stated in terms of welfare outcomes and outputs (ends rather than means), and not in terms of the completion of a process (what is to be built or delivered). For example, in most cases, the objective should be to deliver a certain level of service, rather than a certain volume of water conservation.
- Broad enough to allow the exploration of a range of innovative alternatives, but specific enough to ensure the analysis reveals reliable and relevant information to decision-making.
- Separable, unless several interdependent outcomes are being addressed through a single initiative, that is, where there are synergies between projects.

The standard SMART (specific, measurable, achievable, relevant, and timely) principles should apply when establishing the CBA objective.

For example:

> ... the objective is to provide water security (that is, balance yield and demand) to xx customers in the service area of LWU xxx by 20XX. This is consistent with the level of service agreed with the community (that is, water restrictions no more than 5 per cent of the time, and the likelihood of running out of water is no more than 1 in 100,000).

# Step 2: Defining the options

5


A cost-benefit analysis is a comparison between a base case option and an alternative set of options.

The second step in a cost-benefit analysis is to clearly define the credible set of options, including a base case, that could achieve the objective. In instances where a business case is being developed, this step typically draws on previous work done in the "strategic case" stage of the business case.

## STEP 2 Defining the base case and options – tips and tricks

- **DO** combine measures into a portfolio if a single measure is insufficient to achieve the objective.
- **DO** ensure the base case represents what is realistically likely to happen without the specific project or investment.
- **DO** ensure the base case and alternative options are defined across the water cycle and across time.
- **DO** ensure the broad range of water conservation options are considered.
- **DO** ensure the base case and options are forward looking and consider the costs and benefits with and without the intervention.
- **DO** consider a broad range of technically feasible options to achieve the objective – policy, regulatory, investment.
- **DON'T** define a base case or options on the basis of whether funding is or isn't committed.
- **DON'T** rule out feasible options as part of the long-listing process on the basis of broader considerations the CBA should capture.

# 5.1 Defining the base case option

The base case consists of a "real-world assessment" of what would occur in the absence of implementing an alternative option. The base case should represent what is realistically expected to happen without the specific project or investment. The base case may represent a:

- **"do nothing" case** if this is sufficient to achieve the objective
- **"do minimum" case** if this is sufficient to achieve the objective
- **"business-as-usual" case** where there is an existing pathway or paradigm for achieving the objective.

In most situations – but not all – the base case will be a **"do minimum"** or **"business-as-usual" case**. The reason being it often has to meet a clear compliance, service, or customer expectation. For example, in the case of water security planning that has to meet a clear level of service, the base case could involve maintaining the historical level of water conservation, that is, no further additional investment in new water conservation measures. Investment in supply side measures such as additional desalination or groundwater access would meet any future water demand.

However, where there are genuinely realistic options, or when evaluating different targets or standards, then a "do nothing" case or "do minimum" case may be appropriate. Realistic options include potentially taking on added risk from poor performance and/or not meeting expectations. Evaluating different standards would include setting the objective to optimal level of service.

Alongside **Step 1**, a well-established base case is critical to a robust and informative CBA. It provides the foundation for identifying the incremental value of alternative options. Getting the base case "right" reduces the risk of misreporting the incremental value of alternative options.

## 5.1.1 Defining the base case across the water cycle and across time is a must

A CBA ultimately involves comparing the incremental costs and benefits of an option to the base case. Water conservation can have impacts across the water cycle and over time, for example, in times of water surplus and in times of water scarcity. To identify these incremental differences and ultimately the incremental costs and benefits, it is crucial to define the base case in terms of the actions that will be taken:

- **The water system in response to growth** – What supply side and/or demand side measures or investments deliver value for money to balance supply yield with water demand in line with community levels of service?[31] Answering this question typically involves drawing on a utility's long-term water security plan.
- **The water system in response to drought or other potential shortfall events** – What supply side and/or demand measures or investments are required to manage drought or other low-probability shortfall events? Answering this question typically involves drawing on a utility's drought-management plan.
- **The wastewater system** – What supply side and/or demand side measures or investments are required to manage wastewater volumes? Answering this question typically involves drawing on a utility's wastewater management plan.
- **The stormwater system** – What measures or investments are required to manage stormwater volumes? Answering this question typically involves drawing on a utility's development servicing plans.

Clearly defining this base case is critical. The incremental costs and benefits of additional water conservation measures are compared to this base case. This highlights that water conservation measures form part of a broader portfolio of measures to manage water security and/or other aspects of the water cycle.

31 Level of service is typically defined in terms of likelihood and frequency, duration, and severity of water restrictions (primarily related to drought) and likelihood of supply shortfall events (both in and outside of drought).

# 5.2 Defining the alternative options

After defining the base case, you must identify and document a range of realistic alternative options that incorporate the use of water conservation and achieve the objective. As discussed above, for the purposes of these guidelines, water conservation is defined as measures including the following:

- **Demand management and water efficiency** – using grey (efficient appliances) and green infrastructure (vegetation in open spaces that reduces water needs) and behavioural change, including waterwise rules and education programs, to reduce consumption.
- **Leakage management** – managing leaks in water supply on the utility and customer sides of the meter to reduce utility-supplied water and/or billed water.
- **Small-scale supply and reuse** –using on-site supply solutions, including rainwater tanks and "on-lot" recycling (greywater) to reduce utility-supplied water.

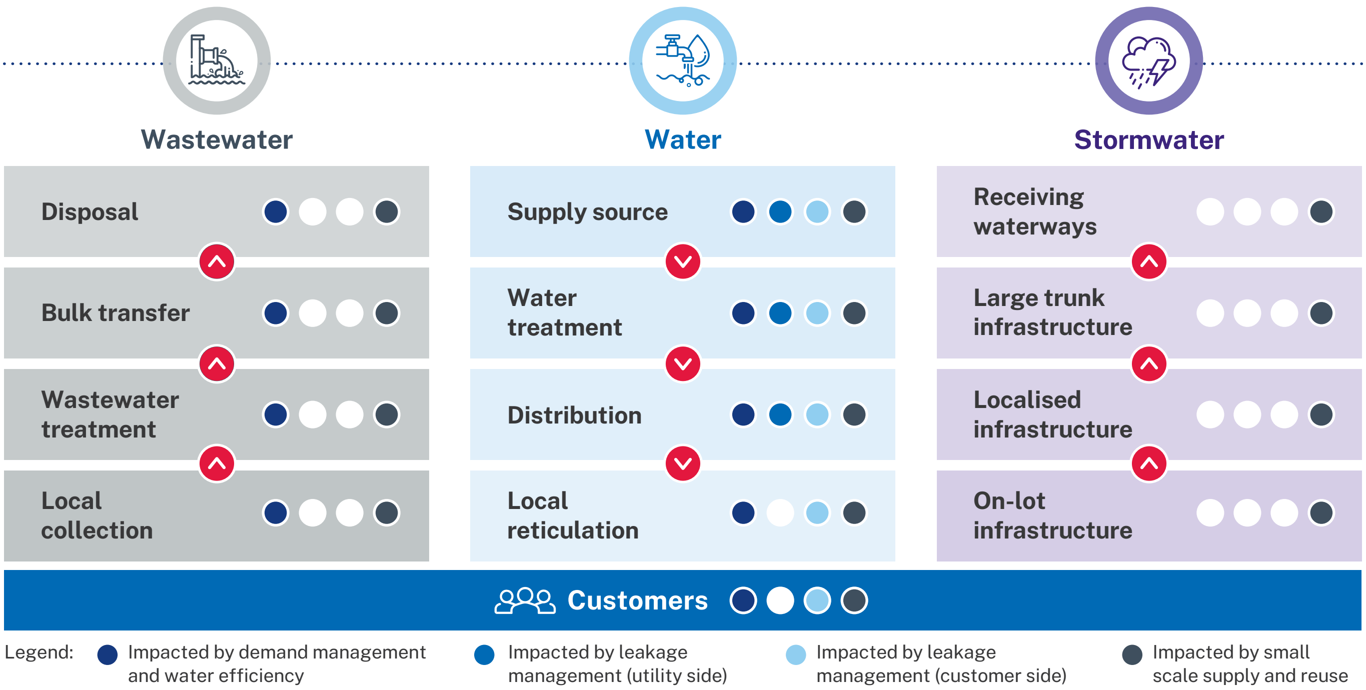
When developing alternative options for inclusion in a CBA and considering their costs and benefits (such as avoided costs), you should also consider the driver of the investment and the impact the measure has on the water cycle.

**Figure 11** shows the following in terms of impacts on the water cycle:

- Demand management and water efficiency can have impacts on the water, wastewater, and stormwater networks, but not always. Efficient indoor appliances such as washing machines or showerheads will reduce wastewater volumes, but more efficient outdoor "infrastructure" or practices (such as vegetation) can reduce stormwater volumes.
- In most cases, leakage management is likely to only have impacts on the water network.[32]
- Small-scale reuse can have impacts across the water cycle. In practice, reuse measures that involve reusing wastewater are likely to have impacts on the water and wastewater networks, while stormwater reuse and rainwater harvesting are likely to have impacts on water and stormwater systems.

The implications of these options in terms of calculating avoidable costs are set out in **Box 7** in **Section 6.1**.

**Figure 11: Identifying the impact of water conservation on the water cycle**




32 We note that customer side leakage management related to indoor tap or running toilets is likely to impact wastewater volumes.

Given these differences, **the appropriateness of a given water conservation measure and its potential inclusion as an option in the CBA, will depend on the objective of the CBA**. For example, consider the following:

- If the objective of the CBA is to manage wastewater consistent with the utility's regulatory obligations, water conservation measures that have no impact on the wastewater network, such as utility side leakage detection, are unlikely to achieve the objective. Therefore, they are unlikely to form part of a reasonable alternative option.
- Similarly, if the objective of the CBA is to manage stormwater consistent with the utility's regulatory obligations, water conservation measures that have no impact on stormwater volumes, such as demand management, are unlikely to achieve the objective. Therefore, they are unlikely to form part of a reasonable alternative option.

These differences will also drive relevant economic, social, and environmental costs and benefits (see **Section 6**), and therefore impact the ultimate value of the water conservation measure.

> **The cost-benefit analysis' objective will guide which water conservation measures should be included in the analysis.**

### 5.2.1 When the option involves a portfolios of measures

In some cases, a single measure or investment (small-scale recycling for example), may not be sufficient to achieve the objective (reducing wastewater volumes for example). In this case, package the measures into a combination or portfolio of actions. The **CBA will compare different combinations (or portfolios) of these individual measures**.

These guidelines focus on water conservation measures. But water conservation is one of a range of supply and demand side measures utilities can use to achieve an objective. In practice, CBAs of water conservation will also evaluate other non-water conservation measures. Examples follow:

- A CBA investigating alternative approaches to delivering water security could involve comparing a more traditional supply-side approach (for example, constructing desalination schemes or increasing groundwater access). The portfolio would combine these supply side measures with some water conservation.
- A CBA investigating approaches to managing wastewater constraints could involve comparing a traditional transport, treatment, and disposal approach to managing wastewater. The portfolio could combine small-scale reuse for some wastewater and traditional transport, treatment, and disposal of residual wastewater volumes.

# 5.3 Identifying the base case and alternative options

The options and the base case should meet a range of principles (see **Table 5**). This includes forward looking options (we can only change future action) and defining options in a way that enables measurement of costs and benefits "with and without" the intervention.

**Table 5: Step 2: Defining the project options for inclusion in a cost-benefit analysis – key principles**

| Guiding principle | Why? | Example | Potential issues |
|---|---|---|---|
| **Do the options achieve the objective?** | Enables "apples with apples" comparison. | If the aim of the project is to provide water security to the catchment area, it is not appropriate to include an option that does not achieve this objective. | Care should be taken when undertaking projects aimed at setting the standard/level of service and identifying the preferred option to achieve that standard.<br><br>As discussed in **Step 1**, in this case, one option may be to undertake a sequential analytical process whereby the CBA is used to set the level of service first and then consider options. |
| **Do the options, including the base case, consider the feasible range of approaches to achieving the objective?** | Ensures "all options are on the table" to identify the option that delivers the greatest benefit to the community. | If the aim of the project is to provide water security or wastewater management, it is not appropriate to only consider options relating to water conservation (that is, not considering traditional service options). | Care should be taken to consider the broad range of policy, regulatory, and build or non-build investment options, rather than focusing on a subset of potential solutions (that is, predetermining the solution before completing the analysis). |
| **Are the options technically feasible?** | Ensures all options can be implemented in practice, and therefore achieve the objective. | New technologies that have not been tested in practice are less likely to deliver the objective and/or there is uncertainty as to whether the technology can feasibly deliver the objective. | Care should be taken to balance considering the broad range of options with ensuring they represent practical solutions. |
| **Are the options forward looking?** | Ensures capture of changes that can be reasonably expected in policy, regulatory, or market factors. | The options and base case should not assume nothing will change over time. They should incorporate reasonably expected changes such as increase in population and urbanisation and the resulting impact on water conservation initiatives. | This requires considering future changes, for example, forecasting changes to demand over time, which can be challenging, especially in the case of biophysical changes. |
| **Do the options enable identification of the counter-factual?** | Identifies the value of intervention by comparing what would happen in the absence of the project. It compares the state of the world with and without the project. | A project that involves increased water conservation should compare the option of increased water conservation to the current level of water conservation, rather than with and without all water conservation. | This requires understanding what would happen in the absence of the option – the causal link between the option and outcomes – which can be challenging, especially for options that involve multiple steps in the causal chain. |

## 5.3.1 Identifying the appropriate number of options

It will depend on the objective and decision being sought, as well as the level of risk and uncertainty, but typically, utilities should shortlist between 2 and 4 **alternative options to the base case** for inclusion in the CBA.

The process for short-listing these options is a key component of the CBA and broader business case (see **Box 6**). For example, if the CBA is supporting a typical strategic business case, where the decision relates to potential pathways or business directions, then a larger number of broad options may be appropriate. If the CBA is supporting a final business case, where there is an investment decision, then a smaller set of options may be appropriate. They would likely cover differences in scope, timing, size, and location of investment.

### Box 6: Short-listing options for inclusion in the cost-benefit analysis

It is best practice to articulate the process for short-listing the options, such as the following:

- The long list of potential policy, regulatory, and build and non-build solutions, and a high-level discussion of:
  - the intended outcome and resources required. The early stages of identifying options may only require summary data. Later in the process and before committing significant funds, the confidence required increases and you should include additional detail
  - how, where, and when you will use these resources
  - how the intended outcome meets the needs of the community
  - broader considerations, including social and environmental impacts
  - any risks
- A shortlist that includes a base case and typically between 2 and 4 alternative options.
- The criteria used to short-list the options. For example, the long list of options was assessed based on whether they met a range of criteria, including:
  - the capacity of the options to meet the needs of the growing population (the key objective)
  - the capacity of the options to contribute to a range of other objectives
  - the feasibility of the options in practice
  - the consistency of the options with broader long-term resource planning and regulation
  - the extent to which solutions represented a least-cost approach to servicing customers, consistent with obligations.

It is critical that feasible options are not ruled out as part of the short-listing process, on the basis of broader considerations that should be captured as part of the CBA. For example, a conventional approach to wastewater management or stormwater management should not be excluded from the analysis because it imposes additional environmental costs. Rather, these environmental costs should be incorporated in the CBA alongside the other costs and compared to the benefits.

# Step 3: Identifying and valuing key incremental costs and benefits

6

The third step in a cost-benefit analysis is to identify the types of economic, social, and environmental outcomes that accrue to the NSW community from the options. The aim over the modelling period is to forecast and value in monetary terms (convert to a dollar basis) those outcomes most likely to materially differ between the base case and the alternative options. These are “the key incremental costs and benefits”.

This cost and benefit valuation step can often be the most resource, time, and effort-intensive. There may be key differences between a simple and complex CBA. The appropriate degree of analysis in this valuation step will vary from one business case to another and should be matched on a case-by-case basis to the size, complexity, level of risk, and community interest.

## STEP 3 Identify and value key incremental costs and benefits – tips and tricks

**DO** focus on incremental changes that accrue to the NSW community rather than just the utility or customer. They will result directly from the alternative options, that is, “moving away” from the base case.

**DO** focus on the most material costs and benefits. These are likely to relate to bulk water supply cost savings, wastewater management cost savings, and the avoided cost of drought-management measures and community impacts (financial and social costs).

**DO** consider the existing methodologies or approaches outlined in these guidelines for valuing key impacts in monetary terms. Review the Appendices for further detail on specific valuation methodologies. Or consider engaging supporting expertise to assist in applying existing, or if necessary, amended, or new methodologies for monetising key impacts. This includes:

- **Appendix 2** – further detail on valuing economic costs and benefits of water conservation
- **Appendix 3** – further detail on valuing social costs and benefits of water conservation
- **Appendix 4** – further detail on valuing environmental costs and benefits of water conservation

**DON’T** focus on whether the cost or benefit is classified as economic, social, or environmental. All costs and benefits are treated equally and have the same discount rate applied.

# 6.1 Identifying categories of costs and benefits

CBA captures economic, social, and environmental outcomes or impacts on community welfare. These are outcomes that accrue to the NSW community rather than simply customers or utilities:

- **Benefits relate to any *improvements* in economic, social, and environmental outcomes as a result of the options**. Examples are the avoided costs[33] from using the water supply, wastewater, and stormwater systems. This can include economic, social, and environmental impacts. More examples include the range of other affiliated avoided costs such as those relating to input products (energy use, detergent, or chemicals for water-intensive appliances) and associated greenhouse emissions (see for example **Box 7**).[34]
  - For instance, a $10m economic saving in the form of avoided or deferred water-related expenditure or a $10m social benefit in the form of reduced water restrictions. Both outcomes form part of the benefit side of the CBA "ledger" (see **Step 4** on incorporating these benefits into the BCR calculation and NPV calculation).
- **Costs relate to any *deterioration* in economic, social, and environmental outcomes as a result of the options** – for example, $10m in additional expenditure to deliver the water conservation measure. This outcome forms part of the costs side of the CBA "ledger" (see **Step 4** on incorporating these costs into the BCR calculation and NPV calculation).

Ultimately in a CBA it does not matter whether an improvement (or deterioration) in community welfare is in the form of changes to economic, social, or environmental outcomes. Don't focus on classifying into these categories. Unlike an multi-criteria appraisal where weights are attached to certain outcomes based on their categorisation, key changes in community welfare are valued in monetary terms (converted to a dollar basis) and summed over the modelling period. For this reason, **a $10m economic, $10m social, or $10m environmental benefit all provide the same value to the NSW community**.

However, distributional analysis considers recipients of benefits or costs (see **Section 9**), which could be a key consideration to decision-makers.

## Box 7: Avoided costs of water conservation

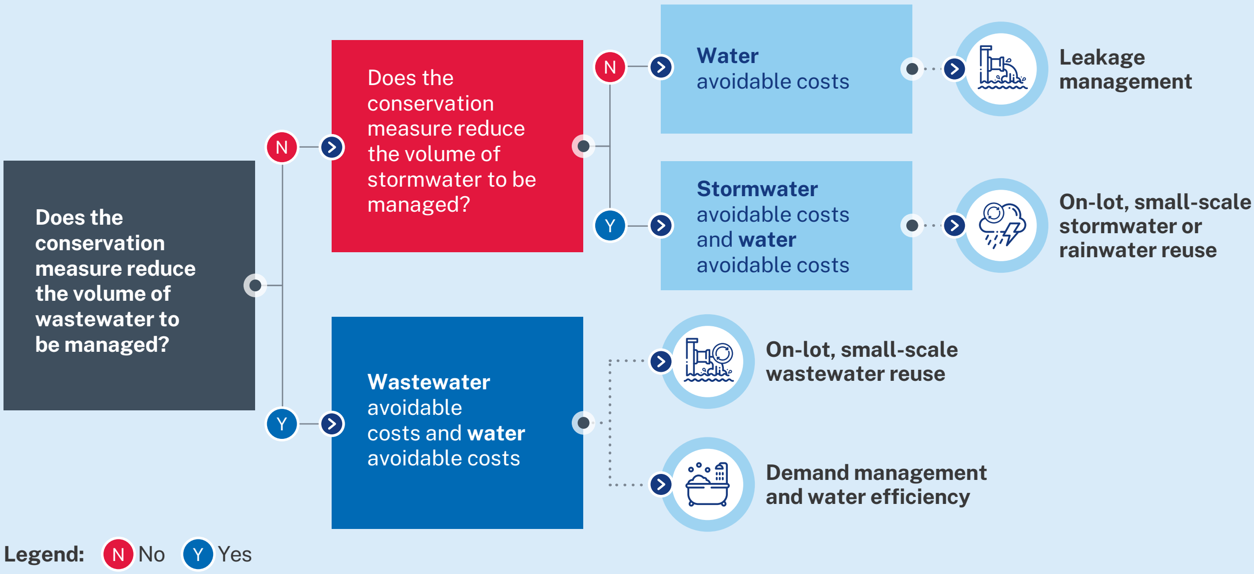
Growth in water, wastewater, and stormwater volumes can influence the need for expenditure, and potentially, timing of investments in the relevant network. Alternatively, a reduction in volumes from water conservation can defer or avoid the need for this expenditure, ranging from operating costs related to treatment through to capital costs related to augmenting capacity in constrained systems. This reduction in volumes can also avoid a range of social and environmental costs.

The cost savings associated with avoiding expenditure in the water, wastewater, and stormwater systems are known as "avoidable costs" and represent a benefit to the community, relative to the base case. Water conservation measures are often small-scale, but on a unit basis ($/kL) the avoided costs can be large, particularly in capacity-constrained networks. These are often the most significant benefit of water conservation measures.

The relevant network, and therefore the type of avoidable costs (water, wastewater, or stormwater costs) will vary depending on the water conservation measure (see **Figure 12**). However, the same valuation methodology applies albeit with different assumptions.

33 Costs that would have been incurred in the absence of water conservation i.e., from continued use.
34 This can include related consumptive materials from water intensive appliances e.g., electricity or gas to heat water, washing machine detergent, pool chemicals etc.

**Figure 12: Identifying the impact of water conservation on the water cycle**




Critically, avoidable costs are already expressed in dollar terms. It can therefore be simpler to estimate than the broader social and environmental benefits of water conservation, which are often non-market benefits.

Estimating the value of these avoidable costs involves drawing on information that decision-makers should have access to as part of their long-term planning. For example, long-term water-security plans and wastewater management plans. The major metropolitan utilities are required to publish key information on their water and wastewater systems. This is part of their operating licences that can be used to calculate the avoidable costs in their systems that result from water conservation.[35]

**Figure 13** below sets out some common categories of costs and benefits of water conservation that may be relevant in the CBA. These costs and benefits include the following:

- **Economic costs and benefits**
  - The upfront and ongoing costs of the water conservation measure. This could include the cost of constructing and operating small-scale reuse schemes or the costs of implementing education campaigns. These costs may be recurrent, that is, incurred more than once, over the modelling period.
  - The value of avoided costs to meet growth in water demand. This defers augmentation of the bulk water system or avoided operating expenditure relating to pumping/extraction, treatment, or transport.
  - The value of avoided capital and operating costs related to construction and operation of a drought response.
  - Avoided cost of administering water restrictions.
  - The value of avoided capital and operating costs related to the wastewater network.
  - The value of avoided capital and operating costs related to stormwater management.
  - The avoided cost of managing degraded water quality/managing a water quality event.
  - Other input costs of water-intensive appliances, such as cost of detergent from use of water-efficient appliances or avoided energy costs. These are separate to those captured in the avoided water, wastewater, and stormwater costs above.[36]

35 For example, information on Sydney Water's Malabar wastewater network indicates that growth is expected in the network over the next thirty years and significant investment is forecast to meet this growth (Sydney Water (2023), *Malabar wastewater network capacity report*, available at www.sydneywater.com.au/content/dam/sydneywater/documents/malabar-wastewater-network-capacity-report.pdf.)

36 This can include related consumptive materials from water intensive appliances e.g., electricity or gas to heat water, washing machine detergent, pool chemicals etc.

- **Social costs and benefits**
  - The avoided cost of water restrictions on the community.
  - The avoided cost of a shortfall (insufficient water supply) on the community.
  - The avoided infrastructure footprint. Water conservation can help manage water, wastewater, or stormwater constraints. It can also reduce or defer the need to construct measures to manage water, wastewater, and stormwater volumes, and therefore, reduce the footprint of land required for infrastructure, which could be used for other purposes
  - Amenity and recreation benefits arising from greater availability of irrigated open space. For example, some forms of water conservation can enable greater frequency of irrigation. This involves reducing the rate at which storages deplete, and therefore reducing the frequency and duration of water restrictions, which would prevent irrigation. In addition, some forms of water conservation, such as recycling, enables irrigation during periods of water restriction. Other forms, such as changes to vegetation, provide amenity benefits with less water.
  - Health benefits resulting from reduced inactivity, in the form of reduced mortality and morbidity.
  - Urban heat-related benefits from provision of irrigation, such as reduced energy distribution and generation infrastructure costs and reduced urban-heat related diseases.
  - Impact on reputation and/or goodwill in the community.
  - Impact on sense of community.
  - Impact on mental health outcomes, for example, as a result of reduced duration and extent of restrictions during a period of drought.
- **Environmental costs and benefits**
  - Impact on river and ocean health arising from reduced stormwater and wastewater discharge.
  - Avoided cost of wet weather overflows.
  - Reduced greenhouse gas emissions from energy use associated with pumping, treatment, or transport.

**Figure 13: Overview of commonly identified costs and benefits of water conservation-related decisions**

**Economic costs and benefits**

- Cost of water conservation
- Avoided costs to meet growth in water demand
- Avoided drought-response costs
- Avoided cost of administering restrictions
- Avoided wastewater costs
- Avoided stormwater costs
- Avoided costs of managing water quality events
- Input costs of water-intensive appliances

**Social costs and benefits**

- Avoided cost of water restrictions
- Avoided cost of a shortfall
- Avoided infrastructure footprint
- Amenity benefits
- Active and passive recreation benefits
- Avoided inactivity diseases and healthcare costs
- Urban cooling benefits
- Impact on reputation/goodwill
- Impact on sense of community
- Impact on mental health outcomes

**Environmental costs and benefits**

- Impact on river and ocean health
- Impact on cost of managing wet weather overflows
- Impact on greenhouse gas emissions

This list is a "conversation starter" rather than a "menu" from which to choose. Ultimately, any relevant costs and benefits incorporated into the CBA must meet the following key principles:

- **Costs and benefits should reflect changes in outcomes that the community ultimately values, rather than an input into the process**. For example, the community does not value a rainwater tank, but rather the benefits a rainwater tank provides. See the discussion of causal links below.
- **Costs and benefits should represent changes in "resource" outcomes** from the perspective of the NSW community, rather than financial costs and benefits from the perspective of the user.
- **Costs and benefits should directly result from the option with a clear and documented "causal link"** between the intervention and the outcome. A program logic approach can be useful to establish and document these causal links.
- **Costs and benefits should be measured on an incremental basis to the base case, that is,** changes in NSW community outcomes that result from "moving away" from the base case.

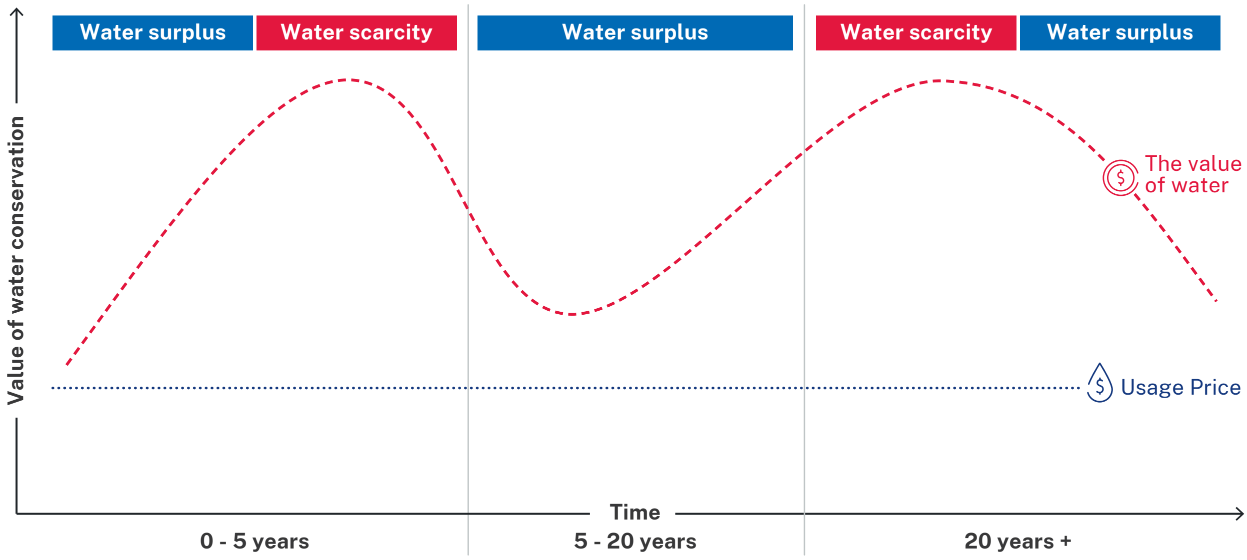
## 6.1.1 Identifying the value of water saved – an example

The value of water conservation will change over time (see **Figure 14**).

- It is highest during periods of low water availability (water scarcity) where the material benefit for water conservation is related to managing drought.
- It is lowest in periods of high water availability (for example, outside drought), where the material benefit relates to the avoided cost of meeting growth in water demand and the availability value.

Using the usage price as a proxy for the value of water is likely to understate the value.[37]

**Figure 14: The value of water conservation will vary over time**




Importantly, this relationship occurs whether the program has a life of one, 10, or 30 years. Every water conservation measure will deliver these benefit categories (the sum of these 3 benefit categories). The size of these benefits depends on supply and demand conditions and *value of water* in any given year within those modelling windows. Examples follow:

- A measure that has a life of a few years, such as a short-term education program implemented in times of water scarcity, can help reduce the rates at which storages deplete. This defers or reduces the need to incur drought-related costs such as water restrictions or constructing a drought-response measure. Although it is only a short measure, the value of the education program should capture **the sum of these 3 benefit categories**, including help deferring augmentation in the water system to meet growth in demand.
- A longer-term measure, such as an appliance efficiency program, will have an increased probability of covering periods of low and high-water scarcity. It will likely deliver similar types of benefits, with the value of water and size of the benefits varying over the modelling period.

Critically, the "availability value" of water conservation isn't a category of costs or benefits in and of itself.[38] Rather, it is a form of water conservation that you can evaluate using these methodologies and guidelines. The "availability value" of water conservation is its ability to further defer the costs of responding to drought (see **Box 8**).

37 This is because the usage price is typically set with regard to LRMC/reflects the cost of meeting growth in water demand.
38 The availability value of water is the value of baseline investment in water conservation that maintains capabilities and enhances the ability to scale up water conservation during periods of drought.

### Box 8: Valuing the "availability value" of water conservation

As outlined above, water conservation measures introduced in or outside drought can reduce the costs associated with a drought-response plan (an "avoidable cost" benefit).

However, in addition to these benefits, ongoing or baseline investment in water conservation that retains core skills, processes, and information that enhances the ability of utilities to scale up existing programs and/or introduce new programs, further reduces the costs of a drought-response plan. This includes times of water surplus. These ongoing investments further reduce the likelihood of triggering drought-response costs such as the social or administration cost of water restrictions, construction of drought-related investments, and the social cost of a shortfall should this occur.

Therefore, ongoing investment in water conservation, including in periods of higher water storages (outside drought) has *future benefits* for the community.

We outline a framework for quantifying the *net benefits* of ongoing investment in water conservation, which you can use as a proxy for its "availability value". This framework uses CBA and real-options analysis (see **Section 8.2.5**) techniques drawing on many of the same information, such as the value of water. It involves comparing a "with ongoing conservation investment" option to a "without ongoing conservation investment option". The aim is to:

- identify the difference in the time and effectiveness of scaling up programs during drought
- identify the difference in the dam depletion rates and probability of drought-related costs (same 4 categories of drought-related costs above)
- calculate the difference in the costs associated with a drought-response plan between the "with ongoing conservation investment" and the "without ongoing conservation investment" option.

The "availability value" of water conservation depends on the drought-management plan of the local water utility, and is therefore specific, so these guidelines do not include a generic framework for valuing this benefit. You should carry out further work to understand the site-specific value of this benefit.

## 6.2 Identifying the causal link between the option and the outcome

A key principle of CBA is the need for a clear causal link from the measures (inputs and actions) in the base case and alternative options to the products and services provided (intermediate outputs) and then to the changes in community welfare (economic, social, and environment outcomes). This ensures a clear explanation of the way in which an option will meet the CBA objective.

A "logic map" is a tool to ensure there is a clear causal link underpinning the CBA. It describes the links from an initiative's objective to the inputs, to the outcomes, and to the ultimate benefit it will produce.

Logic models can function as an evidence base and assist in identifying the data required to forecast and monetise economic, social, and environment outcomes. They ensure any business case provides a clear explanation of an option meeting the CBA objective. The extent of analysis should be matched on a case-by-case basis to the size, complexity, level of risk, and estimated cost.

As shown in **Figure 15**, using a logic map involves identifying the link between an option, inputs, outputs, and outcomes:

- **An option** – the investment, initiative, or measure being delivered.
- **An input** – the resources and actions through which the option transforms into outputs.
- **An output** – the changes attributed to the initiative that may manifest in the short, medium, or long term.
- **An outcome** – the changes in welfare associated with the output, that is, the change in economic, social, or environmental outcomes).

**Figure 15: Identifying the causal link is critical**

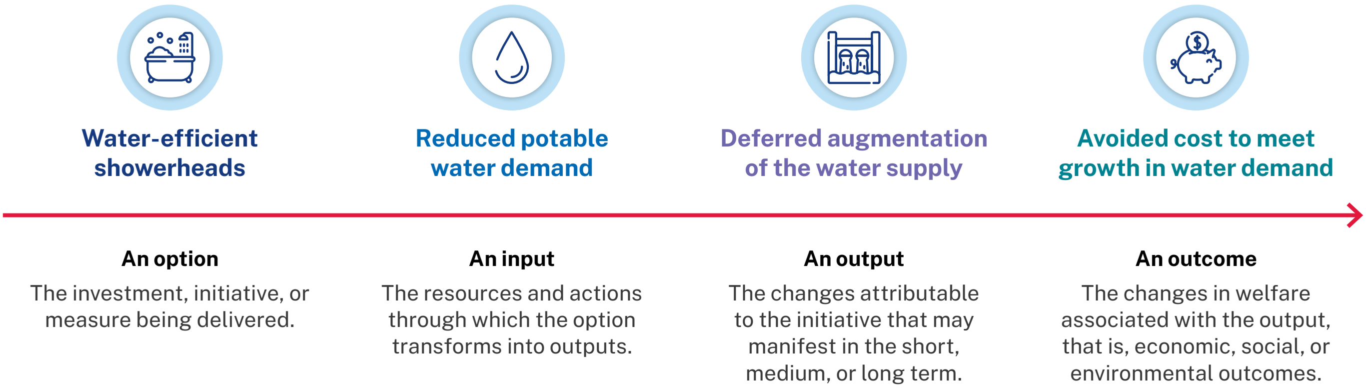



**Table 6** outlines some examples of common inputs, outputs, and outcomes.

**Table 6: Examples of common inputs, outputs, and benefits**

| Option | Input | Outputs | Outcomes |
|---|---|---|---|
| Reduced household demand for potable water | Investment in water-wise rules and/or water conservation education program. | Increased opportunity for regular irrigation of open space. | Amenity benefit. |
| Improve household water efficiency | Investment in water-efficient appliances (for example, washing machines, showerheads). | Reduced household energy demand associated with water consumption. | Avoided energy expense and household cost saving. |
| Improve leakage management on customer side of the meter | Investment in digital metering. | Slowed depletion of storage levels because of reduced leakage. | Reduced likelihood of and/or severity of water restrictions. |
| Improve leakage on utility side of the meter | Investment in additional leakage management. | Increased opportunity for regular irrigation of recreational spaces. | Reduced cost of inactivity disease burden on society. |
| Improve small-scale supply and reuse | Investment in rainwater tanks. | Reduced likelihood of wet weather overflow. | Reduced cost to manage wet weather overflows. |
| Trigger a drought response | Impose water restrictions on society. | Slowed depletion of storage levels because of a behavioural change. | Avoided economic, social, and environmental costs of a shortfall. |

It can be challenging to identify and articulate the causal link between the water conservation measure and the associated economic, social, and environmental costs and benefits the community values. It involves answering difficult questions, such as the following:

- **What degree of incremental or marginal change is caused by the water conservation measure and not by other factors?** This can be especially difficult for social and environmental outcomes that often involve a multi-step, causal chain, such as changes in the cost of water restrictions, or a shortfall.
- **What is the ultimate benefit the community values (rather than a step in the causal link process)?** CBA is used to place a value on changes in community outcomes (outcomes), rather than "inputs" to the process. The community does not value increased utility reporting requirements per se. Rather, the ultimate outcome the community values from utility reporting requirements (an input) is that it leads to improved transparency (an outcome), and ultimately, an improved level of service (a benefit).
- **What is the change in outcomes over long periods of time?** As some water conservation measures are often long-lived, outcomes may emerge and compound only into the longer term. This inevitably makes accurate measurement difficult as certainty reduces with time elapsed.
- **Which indicators or attribute variables should be measured to best capture the change in outcomes?** The variables chosen should be the best possible indicators of incremental changes in real social resources that arise because of the investment.
- **What dataset is needed and available to link the investment to the outcome and quantify the impacts of the investment?** Baseline scientific data to measure changes in outcomes due to the investment is essential. Without this, there is no baseline measure to convert to a dollar figure. In the best-case scenario, original research is undertaken as part of the investment evaluation project with the research parameters and scope tailored to the project at hand. But this rarely happens due to time and resourcing constraints.

# 6.3 Determining the appraisal period

You should forecast key costs and benefits over a period of time ("appraisal period"). This is to enable a robust comparison of the economic, social, and environmental outcomes of the options. Some may not occur until many years into the future.

Typically, the appraisal period is 30 years, however the choice of appraisal period will depend on several factors, including the following:

- **Nature of the intervention** including the economic life of any investments. In general, the longer the asset life, the longer the appraisal period. But where options involve differing assets and/or interventions, as is often the case when comparing water conservation measures to traditional "build" solutions), the appraisal period can use:
  - **a "residual value"** – representing the additional value provided by the investment beyond the appraisal period. An example is a pipeline with an asset life of 80-100 years, which is beyond the 30-year appraisal period. Or a specific option requires additional investment towards the end of the appraisal period.
  - **a "renewal value"** – representing the cost of renewal and replacement of assets with a shorter economic life. An example is education programs.
- **Ability to forecast key costs and benefits** over this period. This includes considering key factors that might influence outcomes over this period. Examples are population and demand, technological changes, climate change, and rainfall. In general, the more certainty regarding forecast key costs and benefits, the longer the appraisal period. However, where there are uncertainties impacting forecasts, you can address them through:
  - simple sensitivity analysis
  - more complex real options or adaptive pathway analysis (see **Step 5**).

As the stream of costs and benefits are discounted in **Step 4**, the "importance" attached to outcomes diminishes in the later years of the appraisal period. For this reason, the choice of appraisal period will be a balance between time, effort, and resourcing required to compile reasonable estimates of costs and benefits over the period, and additional value obtained from a longer period. Additional value includes differentiating the options.

Importantly, as discussed in **Box 9**, there is a difference between the appraisal period, an asset's life, and the long-term or short-term value of water. The life of the asset and the appraisal period should not influence the valuation approach.

## Box 9: The difference between appraisal period and the value of water saved

Critically, the life of the asset and the appraisal period should not influence the valuation approach. Under the same hydrological conditions, a kilolitre of water saved in year 1 should have the same value whether the modelling period is 5 years or 30 years.

For example, assume there are 2 water conservation projects being considered: Project 1 and Project 2. Both projects save 5ML of water per year. The only difference is that Project 1 lasts 5 years, while Project 2 lasts 20 years. There may also be different costs, but that is not the focus here.

Given both projects save 5ML per year in the first 5 years of the modelling period (under the same hydrological conditions), it can be assumed both projects provide the same value of water saved in the first 5 years of their lives.

It is not correct to assume the value of the shorter-term measure is the short-run value of water, whereas the value of the longer-term measure is the long-term value of water.

**Table 7: The value of water: Project 1 – an example of a project with a 5-year life**

| Years | 1 | 2 | 3 | 4 | 5 | 6 | ... | 20 |
|---|---|---|---|---|---|---|---|---|
| Volume of water saved (per year) | 5ML | 5ML | 5ML | 5ML | 5ML | 0 | ... | 0 |
| Value of water saved ("true value") | $0.5m | $1m | $2.5m | $1.5m | $1m | 0 | ... | 0 |

**Table 8: The value of water: Project 2 – an example of a project with a 20-year life**

| Years | 1 | 2 | 3 | 4 | 5 | 6 | ... | 20 |
|---|---|---|---|---|---|---|---|---|
| Volume of water saved (per year) | 5ML | 5ML | 5ML | 5ML | 5ML | 5ML | ... | 5ML |
| Value of water saved ("true value") | $0.5m | $1m | $2.5m | $1.5m | $1m | $0.5m | | $0.5m |

*Note: These values are indicative only.*

# 6.4 Valuing costs and benefits over the appraisal period

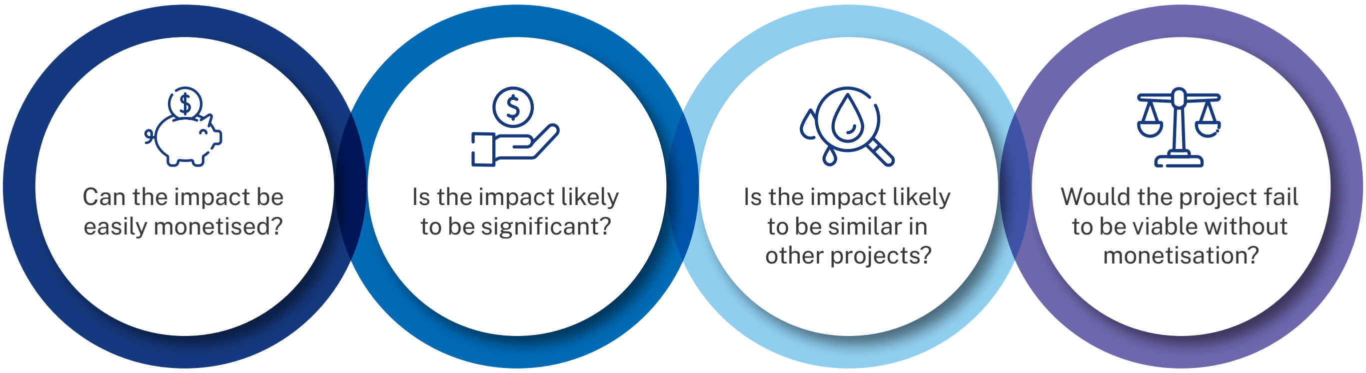
Forecasting and valuing the key incremental outcomes over the modelling period can be a resource, time, and effort-intensive process.

Importantly, a **CBA does not require the valuation of all relevant impacts**.

These forecasts may be straightforward and for many simple CBAs these economic outcomes may be the key differentiating factor between the options and the focus of the CBA. Where this is the case, or where the size and scope of the project does not justify the work entailed in quantifying other social and/or environmental costs and benefits[39], a simple CBA may be similar to a CEA (see **Section 3**). In this context, proponents should be confident that other key economic, social, and environmental outcomes are equivalent across the options or that valuing and including these non-market social or environmental outcomes would not materially impact the CBA or business decision.

As shown in **Figure 16**, where there are other material economic, social, or environmental outcomes that could differentiate the options, it is worth investing resources in valuing this change in outcomes. This could involve developing a forecasting and valuation method and may require input from specialists including environmental, hydrology, or economic experts.

**Figure 16: Principles for identifying the appropriate degree of monetisation**




Whether it is valuing the benefit of deferred infrastructure augmentation (avoided cost), avoiding pollution in a waterway, or the social benefit of reduced likelihood and duration of water restrictions, valuing these outcomes typically requires the same 3 key stages:

1. **Forecasting the change in likelihood of events from each option (ΔL)** – An example is the reduction in likelihood of triggering a drought response, water restrictions, or a shortfall after implementing a water-conservation measure. In many cases, there will be no changes in likelihood of events, and you can skip this step. This is often expressed as the "change in likelihood" term in the valuation formula.
2. **Forecasting the change in outcomes from each option (ΔQ)** – This is the forecast quantity or volume change in outcome you are trying to value. An example is the reduction in potable water demand (measured in kL), volume of wastewater discharged to a waterway (measured in kL), and reduction in brown energy demand or greenhouse emissions (measured in MWh or tonne $CO_2$). This is often expressed as the "change in quantity" term in the valuation formula.

39 That is, the cost and time involved in benefit valuation and data collection are not consistent with the scale or scope of the options being evaluated.

3. **Applying a monetisation technique to value this change (P)** – An example is the value of water conserved as a result of using rainwater tanks rather than potable water to meet demand ($/kL). This is often expressed as the "price" term in the valuation formula. The key valuation principle is that outcomes are valued at the dollar amounts that individuals or businesses are willing to pay for them. These techniques are typically classified as the following:

    a. ***Market valuations*** – where market prices reflect the value of the resources in alternative uses. This could include using costs associated with delivering water conservation measures derived from market contracts for these services.

    b. ***Non-market valuations*** such as:

        i. ***primary approaches*** – which involve undertaking site-specific analysis (such as surveys or hedonic pricing) to derive a value for a change in outcomes caused by an option (the price people are prepared to pay for a certain outcome)

        ii. ***secondary approaches/benefit transfer*** – which takes values from a pre-existing study, project, or piece of research and applies it to a new project or context (see **Box 10**).

## Box 10: Benefit transfer

Benefit transfer takes a value from a pre-existing study, project, or piece of research and applies it to a new project or context.

It is cheap and quick to undertake, relative to primary valuation studies. However, it relies on the existence of a bank of suitable primary non-market valuation studies from which unit values can be drawn. The less similar the study site is from the policy site, the more questionable is the use of benefit transfer. For benefit transfer to be suitable:

- the source study must be based on adequate data, sound economic methodology, and correct empirical techniques
- the magnitude of the change in the relevant variables measured and valued in the source study must be similar to the magnitude of the change at the target site
- the policy context and characteristics of the source and target site should be similar
- the market or households of the source and target site must have similar socio-economic characteristics
- the relevant outcome at the policy site (that is, the biophysical indicator or outcome to be valued) should be the same as the outcome of the study site.

Even where there are significant similarities between a study site and policy site, benefit transfer can require considerable judgment on transferring study site values.

## 6.4.1 Identifying the appropriate monetisation technique

- In simple terms, think of the 3 steps outlined in **Section 6.4** as components of an equation. As **Figure 17** shows, multiplying the change in likelihood of an event occurring (**ΔL**) (where relevant) by a change in an outcome (**ΔQ**) and the appropriate value or price associated with this change (**P**) will enable the calculation of the value of a given economic, social, or environmental cost or benefit.

**Figure 17: Valuing economic, social, and environmental costs and benefits**


- **Table 9** provides examples of relevant **P**, **ΔQ**, and **ΔL** for a range of benefits associated with water conservation. As noted, for some costs and benefits, the likelihood of the impact occurring does not change, and therefore, likelihood is not a relevant input into the valuation formula (marked with an N/A). The catalogue provides further detail on the relevant P.[40]
- The relevant **P**, **ΔQ**, and **ΔL** depends on the cost or benefit of interest, which in turn, depends on the information available as part of the CBA. In practice, it is possible to value a given change in outcomes the community values in multiple ways. For example, to value changes in waterway health arising from reduced stormwater discharge from the use of rainwater tanks, users may have access to information related to either outputs or certain outcomes that provide some insight into the change in community welfare. These could include:
  - the volume of nutrients discharged into the river (output)
  - the presence of indicator species (proxy for outcome)
  - the length of waterway in good health, swimmable days lost or gained (outcomes the community values).

While each of these metrics seek to estimate the change in the environmental outcomes related to waterway health, they use very different but potentially overlapping information on changes in biophysical outcomes. As discussed in **Box 11**, take care to avoid double-counting.

**Table 9: Valuing key costs and benefits – an example of information requirements**

| Cost or benefit | Change in outcomes (ΔQ) | Change in price (P) | Change in likelihood (ΔL) |
|---|---|---|---|
| **Value of avoided costs to meet growth in water demand** | Change in volume of water supplied/ volume of wastewater or stormwater reused. | Long-run marginal cost (LRMC) of bulk and non-bulk water supply.<br>Where LRMC is not available, the usage price can be a proxy. | N/A |
| **Value of avoided costs of investing and operating drought assets** | Number of drought- response measures constructed. | Cost of construction and operation of drought response (for example, construction of a pipeline, recycling scheme, or desalination scheme). | Likelihood of triggering construction of a drought response. |
| **Value of avoided cost of carting water**[41] | Volume of water carted (in kL). | Cost of carting water. | Likelihood of carting water. |
| **Avoided cost of water restrictions** | Volume of restricted demand under each level of water restrictions. | Community WTP to avoid water restrictions. | Likelihood of different stages of water restrictions. |
| **Avoided cost of a shortfall** | Size of the shortfall (in kL). | Community WTP to avoid a shortfall. | Likelihood of a shortfall. |
| **Value of avoided wastewater costs** | Change in volume of wastewater transported through the wastewater network/volume of wastewater reused. | Long-run marginal cost (LRMC) of wastewater management.<br>Where LRMC is not available, the SRMC of wastewater can be a proxy. | N/A |
| **Improved waterway health** | Kilometres of swimmable waterway. | Community WTP for swimmable rivers. | N/A |
| **Recreation opportunities** | Hectares of irrigated or unirrigated open space/visitors to open space. | Community WTP to engage in recreation (walk, run). | Likelihood of different stages of water restrictions. |

40 Department of Climate Change, Energy, the Environment and Water (2024), Catalogue of values for costs and benefits of water conservation.
41 Can be a form of a drought response.

## Box 11: Avoiding double counting of benefits

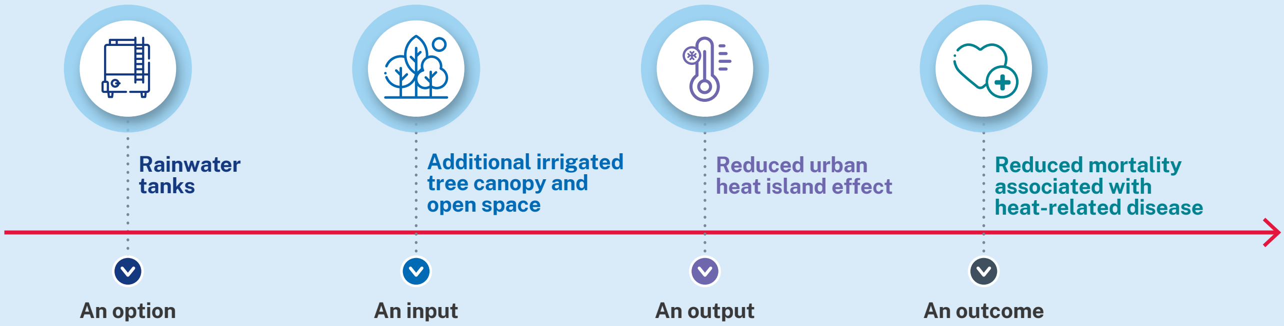
Double counting can occur in the following situations:

- **Valuing and monetising an output and an outcome**[42]. This often occurs when outcomes are imprecise and difficult to measure. For example, rainwater tanks can provide a source of water that leads to increased irrigation of open space and tree canopy. This may reduce urban heat. This means that reduced urban heat is an **output** of increased irrigation of tree canopy and open space (an **input**).

  As a result, it is inappropriate to value both the benefit of irrigation of canopy and open space (which would include its urban cooling benefits) and the benefits of reduced urban heat, without acknowledging the risks of double counting (see **Figure 18**).

- **Valuing multiple overlapping outcomes from the set of interventions**. Another example relates to amenity benefits and environmental outcomes. Studies often look at changes in house prices of dwellings in proximity to open space or healthy waterways to estimate the value of improvements in amenity. But depending on the characteristics of the study, this change in house prices can capture improvements in visual amenity (often categorised as a social benefit) and improvements in waterway health (an environmental benefit). In this case, it would be inappropriate to value the benefits of waterway health and this change in amenity.

**Figure 18: Example logic map**




These guidelines seek to identify a methodology to value each identified cost and benefit. However, users may be constrained by the data available to them and therefore in some cases may choose to use different metrics based on the data available.

For large-scale projects, users may have access to a wide range of information, including multiple metrics that value the same outcome. In cases such as these, users should seek to adopt the metric that matches the best available study (for example, one that meets as many of the principles of benefit transfer as possible).

In many instances (for example, smaller-scale projects), users may only have information on a single metric for each outcome of interest. In these cases, the available information will drive the choice of the appropriate price. For example, if the proponent only has information on time to catch a bass, the appropriate price must be based on a study that estimates the community's *willingness to pay for a reduction in time to catch a bass*.

In some cases, this study may not be based on the specific area of interest. In these cases, users should clearly document their assumptions (including why this specific study was adopted) and include sensitivity and scenario analysis to evaluate the sensitivity of the results to the benefit value applied.

42 The New Zealand Social Policy Research and Evaluation Unit (Superu) Guidelines provide further examples of the need to define inputs, outputs, and outcomes. See for example, Social Policy Evaluation and Research Unit (2017), *Making sense of evaluation: a handbook for everyone*, p.23. (Superu is a Crown entity).

Critically, CBA is an iterative process. You can introduce more information into the CBA as it becomes available. It is common for the analysis to evolve as more information becomes available about the nature of the business need and the options, the associated costs and benefits, and the risks and uncertainties. The trick is to find a "way into the problem" without getting "stuck" on identifying all potential options, final cost information, and/or other available detailed assumptions.

# 6.5 Applying the monetisation technique

The Appendices provide further detail on methodologies to value the key costs and benefits of water conservation:

- **Appendix 2** – further detail on valuing economic costs and benefits of water conservation, including valuing reduced energy costs, the avoided cost of drought-response measures, and water quality events.
- **Appendix 3** – further detail on valuing social costs and benefits of water conservation, including valuing the avoided social cost of water restrictions.
- **Appendix 4** – further detail on valuing environmental costs and benefits of water conservation, such as reduced greenhouse emissions.

Whether it is economic, social, or environmental outcomes you are forecasting and valuing, where possible:

- express them on an annual basis
- use well-accepted tools and techniques
- derive them from best available information and use common planning assumptions (where relevant)
- **express them in real dollars** (for example, $FY23 without the impact of inflation).

For example, as discussed below, you can estimate the value of reduced potable water demand from the use of water-efficient appliances by multiplying the long-run marginal cost of potable water with the change in potable water demand.[43]

## 6.5.1 Valuing avoided cost of expenditure to meet growth in water demand – an example

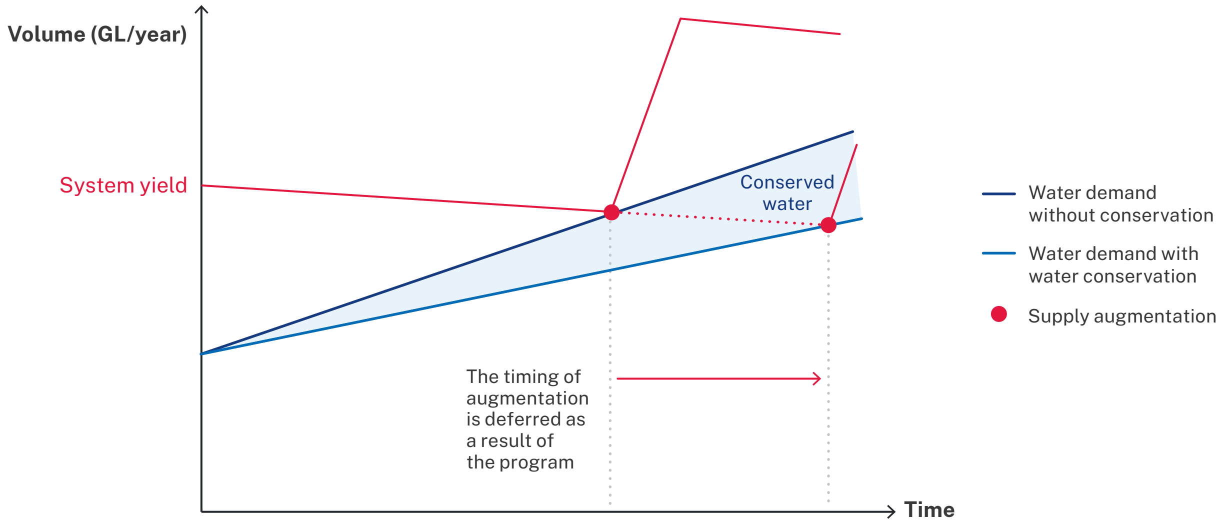
As shown in **Figure 19**, the use of water conservation, such as water-efficient appliances, can reduce the demand for water from the potable water system. In turn, this can defer or avoid the need to augment and/or operate key water supply assets (to increase yield) that would otherwise be required to meet growth in water demand (see **Figure 20**). The deferral of this expenditure represents an economic cost saving for the community (an "avoidable cost" benefit) relative to a base case.

**Figure 19: The link between water-efficient appliances and avoidable costs to meet growth in water demand**

| Impact on water demand | Impact on asset use/requirements | Impact on expenditure |
|---|---|---|
| Replacing appliances with more water-efficient versions (such as washing machines) can reduce the demand for potable water, compared to the base case. | Reduced demand for potable water will **defer or avoid the need to use and/or augment the potable water system.** | **The deferral or avoidance of use and/or augmentation reduces expenditure in the water system** (resulting in an "avoided cost" compared to the base case). |

43 In this example, as it relates to long-term water demand, there is no change in the likelihood, so L does not appear in the formula.

### Figure 20: The link between water conservation and costs to meet growth in demand

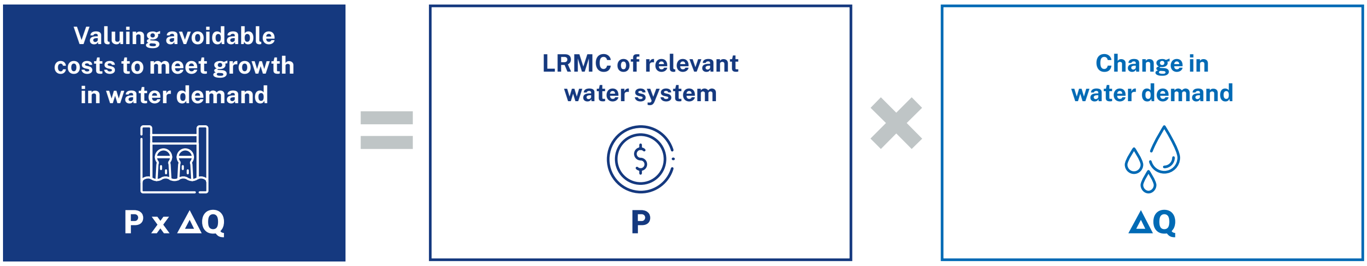



Importantly, short-term water conservation measures (that lead to short-term reductions in demand) and longer-term water conservation measures (that lead to prolonged reductions in demand) deliver this benefit. In other words, they do not need to be permanent water savings.

The present value of this upstream water operating expenditure and capital expenditure cost saving can be calculated by multiplying together:

- long-run marginal cost (LRMC) of water supply (**P**) and
- the change in water demand (**ΔQ**) over the modelling period.

### Figure 21: Valuing avoided costs to meet growth in water demand




In cases where an estimate of the LRMC of water supply is not available, use the usage price as a proxy until developing LRMC estimates. Importantly, for the reasons discussed above, the usage price is unlikely to be an appropriate estimate of the avoided costs to meet growth in water demand.

If you use the usage price in place of the LRMC, the results of the analysis should be subject to a "sense check" against the relevant planning documents, where:

- a low usage price implies there is sufficient capacity in the system, and therefore, it is likely the planning documents will indicate that no augmentation is required in the shorter term
- a high usage price implies there may be capacity constrains in the system, and therefore, it is likely the planning documents will indicate that augmentation is required in the shorter term.

# Step 4: Identifying the net present value and benefit-cost ratio

7

The fourth step in a cost-benefit analysis involves comparing the costs and benefits to report the overall net benefit to the community.

STEP 4

## Comparing the costs and benefits – tips and tricks

- **DO** categorise all monetised "positive" impacts as benefits, including avoided costs, whether they are economic, social, or environmental. Positive impacts are enhancements in society or community outcomes relative to the base case.
- **DO** categorise all monetised "negative" impacts as costs whether they are economic, social, or environmental. Negative impacts are deterioration in society or community outcomes relative to the base case.
- **DO** calculate the benefit-cost ratio and the net present value of the options using the social discount rate of 5 per cent for the central scenario, consistent with NSW Treasury guidelines.
- **DON'T** assume only additional capital and/or operating expenditure are the only costs unless satisfied that a simple cost-benefit analysis akin to a cost-effectiveness analysis is warranted. See **Box 5** for more detail on cost-effective analyses and the differences with cost-benefit analyses.

# 7.1 Calculating benefit-cost ratio and net present value

A CBA compares the economic, social, and environmental costs and benefits of different options to achieve the business need or opportunity (CBA objective). This involves aggregating the incremental costs and benefits relative to the base case that accrue over the modelling period into an overall single measure of net social benefit. There are 2 measures used to compare the overall measure of social benefit:

1. **Net present value (NPV)** – equal to the present value of incremental economic, social, and environmental benefits ***minus*** present value of incremental economic, social, and environmental costs over the period (**Figure 22**). This provides an estimate of community value for money of the options in ***absolute*** terms.
2. **Benefit-cost ratio (BCR)** – equal to the present value of incremental economic, social, and environmental benefits divided by present value of incremental economic, social, and environmental costs over the period (**Figure 23**).[44] This provides an estimate of community value for money of the options in ***relative*** terms.

Critically, BCR and NPV use the same information – the present value of incremental benefits and the present value of incremental costs – and provide important insights as to the value for money of the options.

44 We note that the latest version of the NSW Treasury guidelines defines denominator of the benefit cost ratio as the financial cost to government, rather than the cost to the community.

**Figure 22: Calculating net present value**

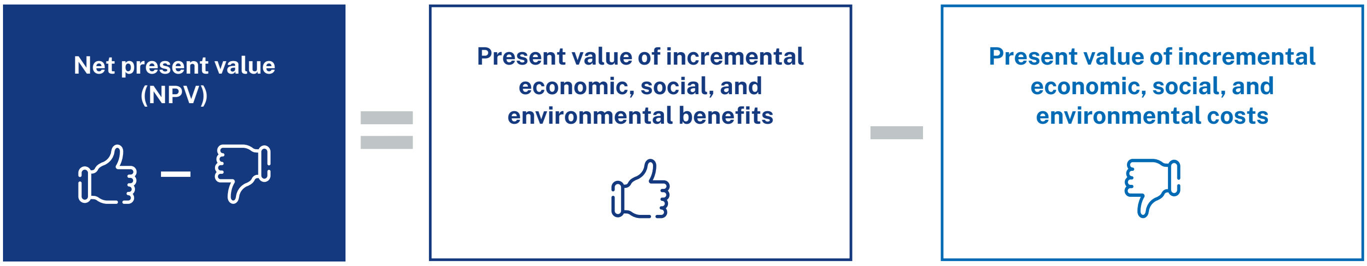
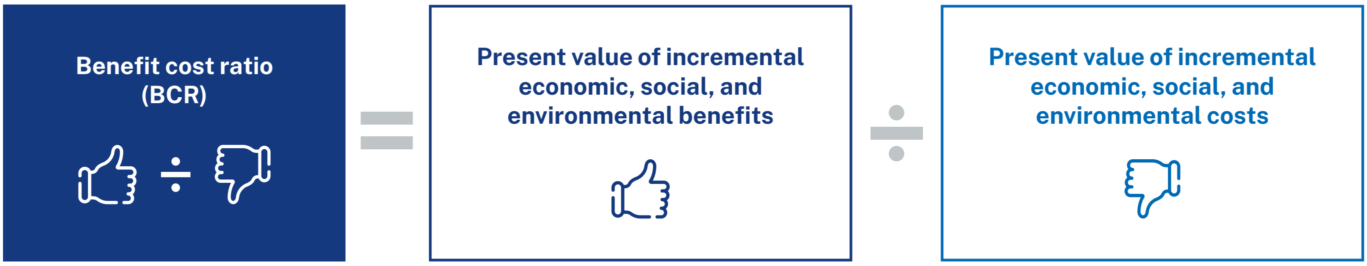



**Figure 23: Calculating benefit-cost ratio**




## 7.1.1 Categorising costs and benefits

NPV and BCR metrics are ways of identifying the size or ratio of the incremental benefits to the costs, so a key step is to ensure that costs and benefits have been categorised correctly. They must be on the correct side of the CBA “ledger”.

As discussed above, a BCR should represent the present value of all benefits (including avoided costs) divided by the present value of all costs (including disbenefits). The NPV represents the difference between the costs (including disbenefits) and benefits (including avoided costs). Examples follow:

- A $10m saving in the form of avoided or deferred capital expenditure should be treated in the same way as $10m in avoided greenhouse emissions. **They both represent an improvement in community welfare relative to the base case, that is, a benefit. They form part of the numerator in the BCR calculation and the first term in the NPV calculation.**
- An incremental cost to society represents any economic, social, or environmental change showing a deterioration in community welfare relative to the base case, that is, a disbenefit. It could be $10m in incremental capital expenditure or $10m in additional greenhouse emissions. They form part of the denominator in the BCR calculation and the second term in the NPV calculation.
- It is a common mistake to include any changes in infrastructure costs as costs. Changes might be an increase in expenditure or an avoided expenditure, but costs are the denominator in the BCR calculation.

**Box 12** provides a simple example of categorising monetised costs and benefits.

## Box 12: Simple example of allocation of impacts to cost and benefit categories

Take the example of a simple water conservation measure such as additional investment in water-saving showerheads (relative to the base case).

- **Upfront costs are an example of 1 (an incremental cost to the community)**. Additional water-saving showerheads are likely to involve additional upfront costs, compared to the base case.
- **Avoidable costs to meet growth in water demand are an example of 2 (an incremental cost saving or benefit to the community)**. Water-saving showerheads reduced water demand, resulting in avoided water costs to meet growth in demand, compared to the base case.
- **Avoided cost of water restrictions is an example of 3 (an incremental improvement in societal outcomes/benefit to the community)**. Water-saving showerheads reduced water demand and are likely to reduce the chance of water restrictions, compared to the base case.
- **Avoided energy and greenhouse emissions are an example of 4 (an incremental improvement in societal outcomes/cost to the community)**. Additional water-saving showerheads reduce water demand and decrease energy costs (utility and customer energy use) and greenhouse emissions, compared to the base case.

The overall net present value outcome of a given portfolio is determined by the **sum of 2 and 3, less the sum of 1 and 4** (incremental benefits less incremental costs). A net beneficial option is one where the sum of 2 and 3 exceeds the sum of 1 and 4.

| | | | |
|---|---|---|---|
| **01** | **Is quantified as a financial cost (for example, additional water-saving shower heads).** | Additional costs are a deterioration in societal outcomes compared to base case. | **Incremental cost** to society from that option |
| **02** | **Is quantified as a financial cost (for example, avoided water costs).** | Avoided costs are an improvement in societal outcomes compared to base case. | **Incremental benefit** to society from that option |
| **03** | **Is quantified as a social outcome (for example, avoided water restrictions).** | Avoided restrictions are an improvement in societal outcomes compared to base case. | **Incremental benefit** to society from that option |
| **04** | **Is quantified as an environmental outcome (for example, emissions).** | Avoided environmental costs are an improvement in societal outcomes compared to the base case. | **Incremental benefit** to society from that option |

# 7.2 Discounting costs and benefits

As discussed in **Box 13**, to compare costs and benefits that occur over different time periods, the costs and benefits must be discounted to current period dollars.

### Box 13: Why do we discount costs and benefits?

Discounting means that costs and benefits that occur in the future are given less weight than costs or benefits that occur sooner.

An intuitive justification for discounting is that there is a time value of money – we prefer to receive one dollar today than one dollar in a year's time.

To value a future cost or benefit in today's terms we discount the future cost or benefit using a discount rate that determines the present value. Present values allow for decisions to be made in the present about initiatives that have different costs and benefits in the future. It also allows for comparisons of interventions that may have a different sequence and/or time frame of costs and benefits over the same modelling or appraisal period.

The NSW Treasury guidelines states a CBA should include:

> "Central estimate of net present value (NPV) and benefit cost ratio (BCR) for each option relative to the base case, at the central real social discount rate (5 per cent).

> NPV and BCR results for each option in key sensitivity analysis, including the "high" and "low" discount rate sensitivities set in the Guide (7 per cent and 3 per cent, respectively)."[45]

This discount rate can be different to the weighted average cost of capital (WACC),[46] for example, of Sydney Water, Hunter Water, and Central Coast Council. Use the WACC when undertaking a financial analysis, separate to the CBA.

45 NSW Treasury (2023), *NSW Government Guide to Cost-Benefit Analysis, TPG23-08*, p. 38.
46 The WACC is the weighted average of debt and equity costs required for a benchmark efficient business to invest in necessary infrastructure (IPART, www.ipart.nsw.gov.au/Home/Industries/Special-Reviews/Regulatory-policy/WACC).

## 7.3 Reporting and interpreting results

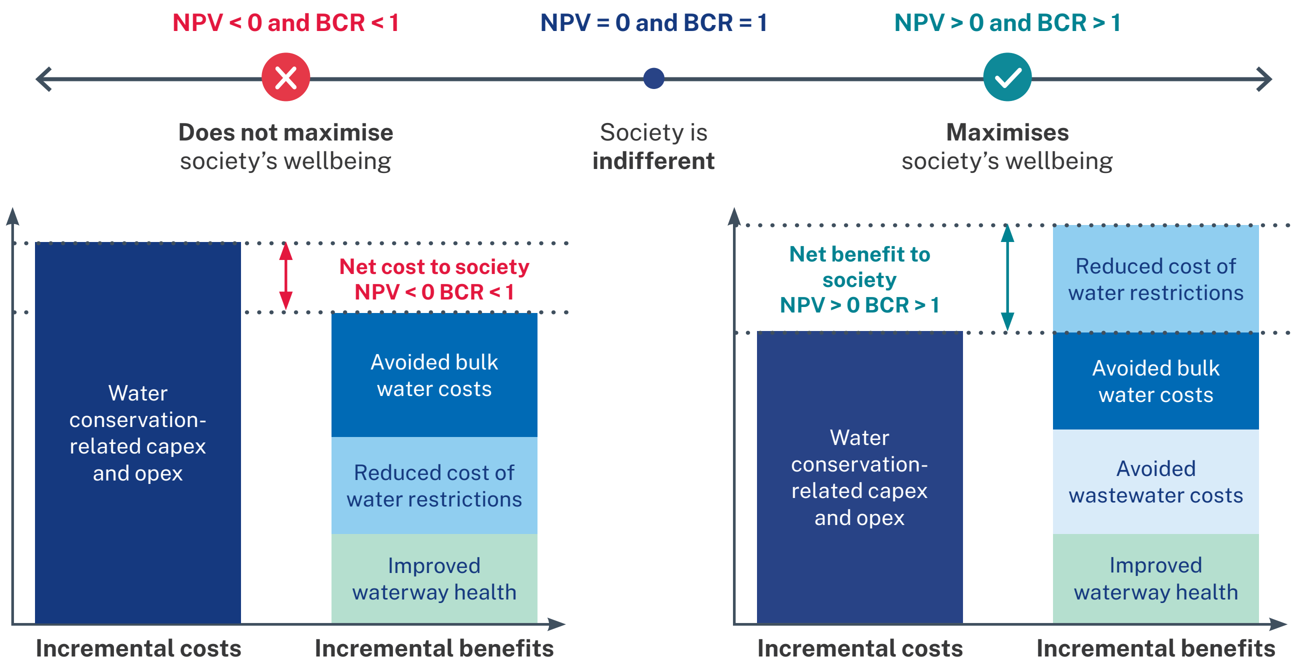
Present the CBA results in NPV and BCR terms.

As shown in **Figure 24**, the option with the largest NPV and BCR generates the largest incremental benefit to the community (compared to the base case). In particular:

- **NPV > 0 and BCR > 1 indicates the option results in a net benefit** to the community relative to the base case. That is, incremental benefits of the option exceed incremental costs.
- **NPV = 0 or BCR = 1** indicates the incremental benefit of the option exactly equals its incremental costs.
- **NPV < 0 and BCR < 1 indicates the option results in a net cost** to the community relative to the base case. That is, incremental costs of the option exceed incremental benefits.

BCR and NPV both provide important insights as to the value for money of the options. A BCR provides insights as to the value for money of the options in ***relative*** terms (that is, for every $ of costs), whereas NPV provides this insight in absolute terms.

**Figure 24: Cost-benefit analysis involves considering which options generate the highest net benefits – an example**




## 7.4 Considering qualitative costs and benefits

The quantifiable costs and benefits are the main part of a CBA, but in some cases quantification may not be practical. Impacts that cannot be quantified should be accounted for qualitatively.

To inform decision makers, the CBA should include a list of qualitative factors. This list should also include the anticipated direction of impact and likely significance. You should present these factors without subjective formal weightings. Even though these impacts may not be quantified or monetised, the same principles apply relating to establishing a clear causal link from the interventions (inputs and actions) to the products and services provided (intermediate outputs) to the changes in community welfare (economic, social and environment outcomes).

Address costs and benefits qualitatively where the best available evidence for valuation or monetisation is not reasonably robust or unavailable. That is, a cost or benefit should be considered qualitatively if one or more of the following is **not** possible[47]:

- a thorough literature review identifies and supports the best valuation, monetisation, or benefit transfer methodology possible given the best available data
- you can use parameters and techniques from the literature review accurately and appropriately in the context of application
- the key risks and uncertainties in the final results stemming from valuation challenges are clearly communicated and defensible.

**Table 10** provides an example of including qualitative factors in a CBA. Importantly, this is a summary of applying qualitative assessment. In some cases, it will be feasible to monetise the impacts included in this table. In other cases, it may not.

**Table 10: Including qualitative factors in the cost-benefit analysis – an example**

| Impact | Summary | Likely materiality |
|---|---|---|
| **Economic costs and benefits** | | |
| **Avoided cost of managing stormwater** | The use of small-scale stormwater reuse and rainwater tanks can reduce the volume of stormwater to be managed downstream of the premises. This can reduce the cost of managing stormwater.<br>However, understanding the materiality of this benefit requires site-specific information on the proposed stormwater solution and changes that would result from the water conservation measure. This can be challenging to access. | Minor benefit |
| **Social costs and benefits** | | |
| **Amenity and recreation opportunities** | Water conservation can create additional amenity and recreation opportunities through the deferral of water restrictions, increasing the likelihood of existing space being irrigated (reducing time spent in restrictions).<br>The recreation benefit relates to reducing the time in which the space is not useable because it "browns off". However, this benefit is likely to be minor because the marginal change in likelihood of restrictions may be minor. | Minor benefit |
| **Urban cooling benefits** | Water conservation can create urban cooling benefits through the deferral of water restrictions, increasing the likelihood of existing open space and tree canopy being irrigated (reducing time spent in restrictions).<br>Irrigation of open space and canopy can contribute to urban cooling, which in turn could reduce energy infrastructure requirements, health infrastructure requirements, and lost heat-related productivity impacts.<br>However, the materiality of this benefit will depend on the scale of the existing irrigation of open space and tree canopy, and extent of change in likelihood of restrictions. Influencing urban heat over a material area requires large-scale irrigation. In most cases this benefit is likely to be minor. | Minor benefit |
| **Mental health outcomes** | Prolonged exposure to the drought-related economic stressors could contribute to declining mental health outcomes in affected individuals, including depression and anxiety. Within close-knit communities, the cost of declining mental health among the local population could be significant. Water conservation can reduce the likelihood of a shortfall on society and the associated impacts on mental health. However, as discussed in more detail below, understanding the exact change in mental health outcomes can be challenging. | Moderate benefit |
| **Environmental costs and benefits** | | |
| **Greenhouse emissions** | Water conservation using the following measures to reduce energy demand.<br>Reducing the volume of water to be supplied through the potable water system. This avoids utility energy use for treating and transporting water.<br>Reducing customer energy use associated with heating water (water-efficient showerheads and washing machines).<br>Reducing energy use associated with manufacture and transport.<br>Assuming "brown energy" from the grid meets this demand, then reduced energy demand will reduce greenhouse emissions. We note: demand met by "green energy" will still involve infrastructure with associated energy use. | Minor benefit |

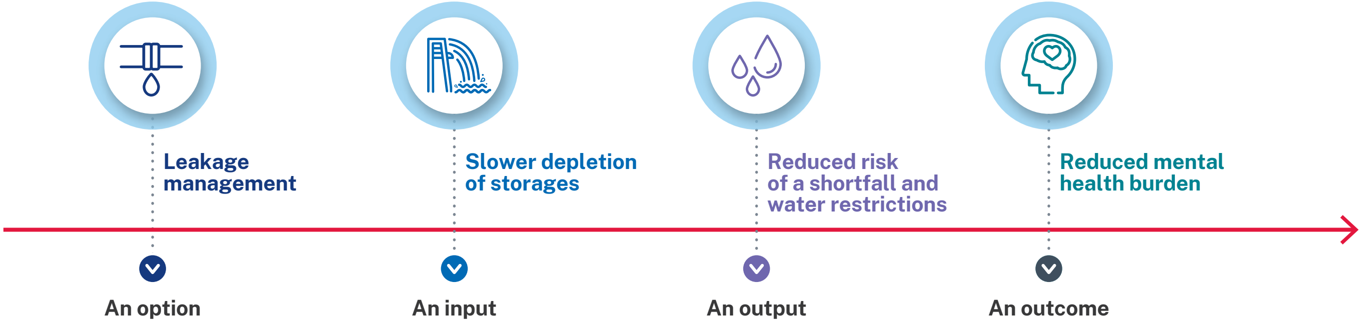
47 New South Wales Treasury, NSW Government Guide to Cost-Benefit Analysis, February 2023.

## 7.4.1 Including impacts qualitatively – an example of mental health outcomes

Mental health outcomes are often included qualitatively in CBA. Information lacks changes in investment in water conservation that link to mental health outcomes.

As discussed in **Box 14**, it is well acknowledged that prolonged water shortages, water restrictions, and drought can have a significant impact on mental health outcomes for communities. However, what is less well understood, is the impact of water conservation on these measures. While water conservation can slow the depletion of storages, it is unlikely to stop the depletion of storages completely, and therefore, is unlikely to completely address the negative mental health outcomes of drought (see **Figure 25**).

**Figure 25: The link between water conservation and mental health outcomes**



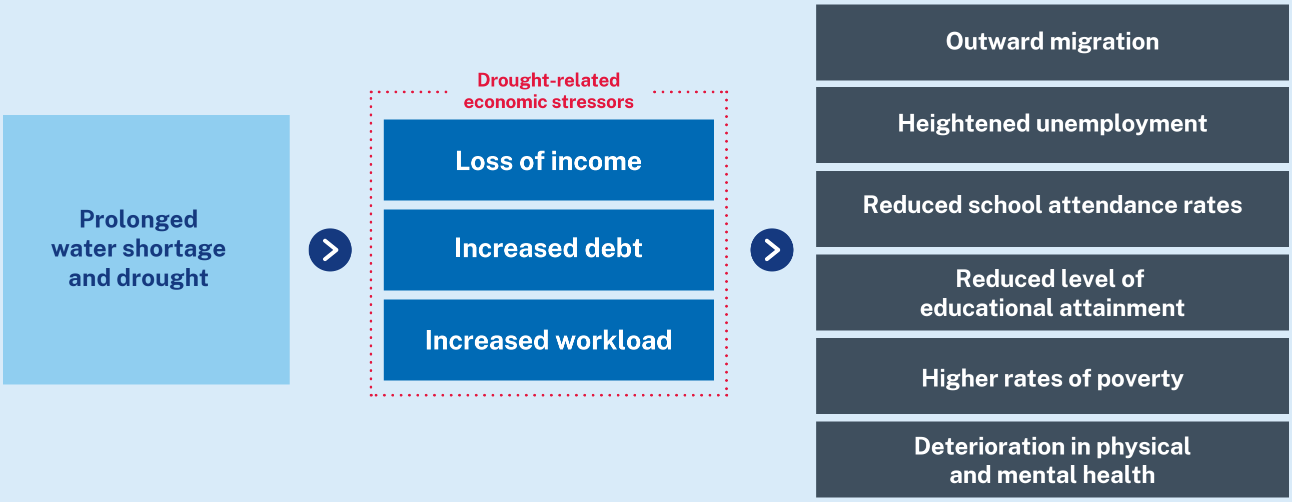

Steps have been taken to improve our understanding of the cost of mental health on the community. WSAA and Frontier Economics' *Health benefits from water centric liveable communities*, for example, sought to develop a framework for quantifying the physical and mental health benefits to the community from investing in water to create liveable cities.[48] These frameworks identified the appropriate value to apply to changes in mental health outcomes (the **P**). However, it requires further work to understand how changes in investment in water conservation, rather than investments in water to support liveability, can impact mental health outcomes for communities (the **ΔQ**).

48 This project developed a framework for quantifying the physical and mental health benefits to the community from investing in water to create liveable cities. For more information see www.wsaa.asn.au/publication/health-benefits-water-centric-liveable-communities.

## Box 14: Included impacts qualitatively – an example of mental health outcomes

It is well acknowledged that prolonged water shortages, water restrictions, and drought can have a significant impact on the social outcomes of rural communities. Loss of income, increased debt, laying off staff, and increased workloads are primary economic stressors associated with prolonged water shortages and drought[49]. Due to the interconnectedness of rural communities, these key economic stressors quickly flow through the local community contributing to a wider "net" of social impacts. These include:

- outward migration
- heightened unemployment
- reduced school attendance rates and levels of educational attainment
- higher rates of poverty
- deteriorations in physical and mental health.[50]




Prolonged exposure to drought-related stressors is a direct contributor to mental health deterioration in areas effected by water shortage. Several studies have noted feelings of fear and helplessness as well as concern for the future of the broader community among individuals living through drought in NSW. In the extreme, some studies warn of increased risk of psychiatric morbidity, in the form of depression or anxiety, as well as higher rates of suicide as a result of prolonged exposure to drought-related stressors[51]. Further exacerbating the effects of drought-related impacts on mental health are the lack of accessible mental health services in rural communities, cultural perceptions, and a reluctance to seek help.

Quantifying the value of drought-related impacts on mental health outcomes can be extremely challenging. While the negative impacts of drought on mental health outcomes are well known, there are limited publicly available studies quantifying the impact of drought-related stressors on the mental health of those impacted, let alone how these outcomes will change as a result of increased investment in water conservation.

Current literature largely focuses on the qualitative assessment of these outcomes.

49 Aslin, H and Russell, J. (2008). Social impacts of drought: review of literature. *Australian Government: Bureau of Rural Sciences*. www.agriculture.gov.au/sites/default/files/abares/documents/socimpctdroughtlitrev2008-1.0.0.pdf

50 Lester, L., Flatau, P and Kyron, M. (2022). Understanding the Social Impacts of Drought. *The University of Western Australia*. www.gsdc.wa.gov.au/app/uploads/2022/07/Understanding-the-Social-Impacts-of-Drought-UWA.pdf

51 Aslin, H and Russell, J. (2008). Social impacts of drought: review of literature. *Australian Government: Bureau of Rural Sciences*. www.agriculture.gov.au/sites/default/files/abares/documents/socimpctdroughtlitrev2008-1.0.0.pdf

# Step 5: Account for key risks and option uncertainty

8

STEP 5

## Accounting for risk and resilience of options – tips and tricks

**DO** include a form of risk analysis that is proportionate to the size of the project. Sensitivity analysis that varies key assumptions, such as cost, timing, or discount rate assumptions, may be appropriate for simple cost-benefit analysis. More complex forms such as real options analysis (ROA), which consider the resilience of the options to these risks, may be more appropriate for detailed analyses.

**DO** consider grouping combinations of risks and uncertainties into a global/bookend *high* and *low*. While it may be unlikely in practice, it can be helpful for decision-makers to understand the best and worst-case outcomes from an option.

**DON'T** try to include every combination of risks and uncertainties. The focus should be to quantitively address uncertainties that are likely to have the most material impact on the value of the options/investments, and qualitatively including others.

# 8.1 The need to consider key risks and the uncertainty in the cost-benefit analysis results

The result of a CBA is often a single estimate of the ratio of benefits to costs. However, a range of uncertainties will drive the size or level of costs and benefits. For example, volume of water saved or cost of an investment might be higher or lower than forecast or be incurred earlier or later in the appraisal period. This means the estimate of the net benefit of certain options may be volatile, and potentially higher or lower than the base case.

Some commonly identified risks and uncertainties of water conservation investments include:

- volume and duration of water savings and estimate of avoidable costs to meet growth in water demand
- change in volume of wastewater to be managed and estimate of avoidable wastewater costs
- impact of water conservation on the probability of triggering drought-response measures, including water restrictions, construction of a drought response and/or a shortfall
- population growth, which can influence the timing of investment requirements
- level of service to be delivered (for example, assumed constraint around likelihood of water restrictions and/or likelihood of a shortfall)
- future community expectations and/or environmental and health regulation, which drive the cost of complying with regulation (managing stormwater and/or wastewater volumes consistent with environmental regulation)
- upfront and ongoing cost estimates
- climate change impacts on rainfall and consequent drought or flooding risk and water supply availability
- discount rates (as discussed above, NSW Treasury guidelines require sensitivity analysis be undertaken on the discount rate)
- customer willingness to pay (WTP) for social and environmental outcomes (for example, WTP to avoid water restrictions or protect waterway health).

It isn't possible to analyse all risks nor whether there are opportunities in the design of the options to manage these risks. **Focus on quantitatively addressing the uncertainties that are likely to have the most material impact on the value of an option (techniques below)**, and qualitatively including other relevant uncertainties.

# 8.2 Overview of approaches to account for risk

To ensure an accurate comparison of costs and benefits across potential options in a world of uncertainty, robust CBA should include tools for assessing and managing risk. (**Figure 26**).

We briefly discuss the techniques below.

**Figure 26: Summary of techniques to account for risk**

| Sensitivity analysis | Scenario analysis | Expected NPV | Adaptive pathways/ real options analysis |
|---|---|---|---|
| Estimates how sensitive the value is to assumptions made about key variables | Estimates how sensitive the NPV is to changes in technical, economic, political factors | Estimates the expected NPV of a project by taking account of the likelihood (or risk) of different impacts occurring | Values the benefit of flexible decisions to respond to risk and uncertainty (for example, the flexibility to defer decision-making until the future is more certain) |

← LOWER — **Complexity of risk assessment** — HIGHER →

## 8.2.1 Sensitivity analysis

Sensitivity analysis can provide information about changes in different variables affecting the overall costs and benefits of the options and their distribution. It can be a useful tool to manage the inherent uncertainty over future costs and benefits of project options, particularly for those parameters that may be material to the project evaluation.

The complexity of sensitivity analysis is likely to vary with the detail of the CBA. An example sensitivity analysis follows.

- A simple CBA could involve between 9 and 27 combinations of sensitivities such as:
  - three discount rates (that is, 7 per cent, 5 per cent, and 3 per cent consistent with NSW Treasury guidelines[52]) combined with
  - three water-saving change scenarios (low, medium, and high) combined with
  - three forecast lifecycle cost estimates (low, medium, and high).
- A complex CBA is likely to involve more than 27 combinations of sensitivities and/or real-options analysis.

## 8.2.2 Scenario analysis

Scenario analysis tests the sensitivity estimates of net present value to key technical, economic, political, or other uncertainties that could affect the success of a project. Scenario analysis seeks to describe “what if” situations that might occur over the medium to long term.

Scenarios usually consist of descriptions of the alternative future environments that differ in crucial respects, usually in terms of significant or “big picture” factors. For example, this could involve grouping together assumptions into a “worst-case” scenario, which represents the lowest value a water conservation option delivers, and a “best-case” scenario, which represents the upper bound of value a water conservation option delivers. **Table 11** shows examples of uncertainties included in a worst-case scenario and best-case scenario.

52 NSW Treasury (2023), *NSW Government Guide to Cost-Benefit Analysis, TPG23-08*, p. 38.

**Table 11: Assumptions underpinning worst-case and best-case scenario analysis – an example**

| Uncertainty | Worst-case | Central estimate | Best case |
|---|---|---|---|
| Costs | High estimate of costs. | Central estimate of costs. | Low estimate of costs. |
| Discount rate | 7 per cent | 5 per cent | 3 per cent |
| Volume of water saved | Lower-bound estimate of volume saved. | Central estimate of volume saved. | Upper-bound estimate of volume saved. |
| Value of avoidable costs of meeting growth in water demand | Low LRMC | Central estimate | High LRMC |
| Value of avoidable wastewater costs | Low LRMC | Central estimate | High LRMC |

It should be noted that this is an example only. In practice, whether specific variables form part of the worst-case scenario or best-case scenario will depend on the characteristics of the investment. Examples follow:

- If the costs of the project are upfront, while the benefits are spread across time, a low discount rate will increase the value of the water conservation option and therefore form part of the "best-case" scenario.
- In contrast, if the costs of the project are spread across time, while the benefits are delivered upfront, a low discount rate will reduce the value of the water conservation option, and therefore form part of the "worst-case" scenario.
- It is best to carry out scenario analysis in conjunction with sensitivity analysis – or take into account the tested assumptions.

## 8.2.3 Expected net present value

The performance of options can depend significantly on the likelihood and consequence of events occurring. Where there is reasonable information to support estimates of the likelihood and consequence of key risks or events, you should incorporate them into the quantification of costs and benefits. To calculate the expected net present value (ENPV), multiply the likelihood (%) with the consequence ($) of an event occurring.

That is, estimating ENPV requires the assignment of a probability of occurrence to a defined set of discrete potential events. The ENPV can then be calculated by multiplying the NPV of a given intervention under each event by the estimated probability of the event occurring (and summing the subsequent results).

"Calculate" or "back-out" probabilities using a range of resources including historical data, expert opinion, or other sources of information. The CBA should clearly document the sources and methodology used for estimating probabilities as well as any associated limitations.

**Use the ENPV** in situations where costs and benefits are highly dependent on the probability of uncertain events in the future, for example, as part of more complex analysis of drought. Drought frequency and severity is an inherently uncertain variable. However, you can use historical data to construct probability distributions to inform estimates with respect to frequency and severity.

Failure to calculate ENPV in situations such as these is likely to inaccurately estimate the value of the options, potentially imposing added economic, social, and environmental costs on the community.

**Expected net present value is most useful where:**

- **the value of the options depends significantly on uncertainty** – for example, the value of resilient infrastructure depends on the likelihood of a drought or flood
- **there is no opportunity to respond to the uncertainty** (as would occur in adaptive pathways or real options analysis).

## 8.2.4 Expected net present value – an example of continued investment in water conservation

Continued investment in water conservation in times of water surplus enables quicker scaling up of measures when needed, for example, in times of water scarcity. This further assists avoiding the cost of drought. Water conservation has future benefits for the community. Scaling up existing programs and initiatives retains water conservation skills and capabilities and achieves the maximum benefit during droughts. It is a form of insurance to ensure decision makers can respond if necessary. This achieves the benefit if a drought occurs.

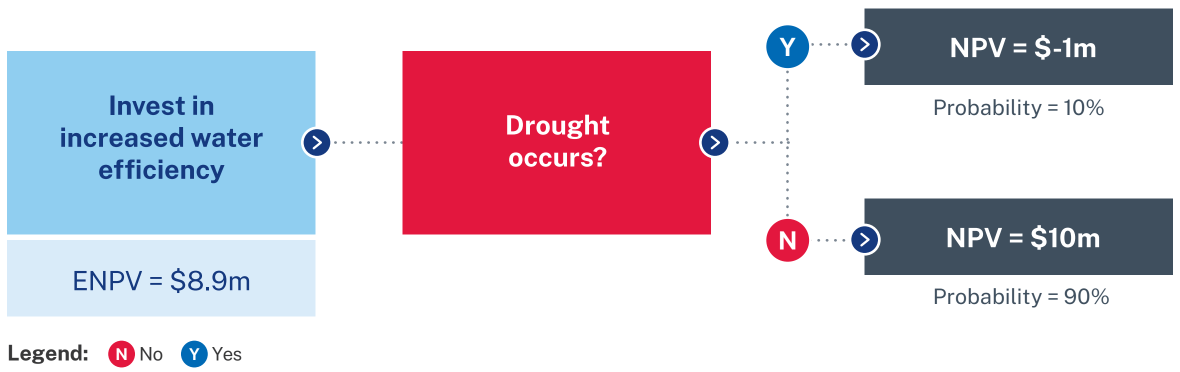
This upfront or baseline investment ensures water conservation is available during drought. Further reducing the rate at which storages deplete, in addition to the benefits discussed above, enhances the resilience of the water system.

Use expected net present value to estimate this "availability value". For example, assume a local water utility invests in a minimum level of water conservation in times of water surplus to ensure it can scale up investment in times of drought. In this area the likelihood of drought is 10 per cent. As shown in **Figure 27**, the value of this solution will be equal to:

- the likelihood of drought (10 per cent) multiplied by the NPV of the option under the drought scenario (-$1m) and
- the likelihood of no drought (90 per cent) multiplied by the NPV of the option under the no drought scenario ($10m).

In other words, the increased investment in water efficiency delivers about $9m in benefit to the community. Providing the flexibility to scale up when necessary avoids the costs of drought that would incur under the base case.

**Figure 27. Expected net present value – an example of drought**




## 8.2.5 Real options analysis (ROA) or adaptive pathways analysis

It is possible to manage some projects and their inherent uncertainties in a dynamic way in response to new information. This can reduce the likelihood of investment "regret".

Where there may be material benefit from deferring the investment decision or pursuing smaller or shorter-lived investments until new information becomes available, use ROA as a quantitative tool to value this flexibility. It models the prospective cashflows that result from responding to new information in the future, when uncertainty is likely to be resolved. It also identifies the pathway that maximises the expected payoff.

ROA or adaptive pathways analysis is most useful for more complex CBA and decision-making where there are credible opportunities to alter the inputs or actions as new information becomes available.

Standard CBA won't identify the approach that generates the highest benefit-cost ratio relating to significant risk. It assumes a fixed investment strategy that remains unchanged as circumstances change. That is, it ignores the flexibility to respond to new information and does not account for the fact that achieving the outcomes in practice may be uncertain. If the impact of risks and value of flexibility in decision-making is large, standard CBA will understate the value of the project.

In contrast, ROA or adaptive pathways analysis recognises the following upfront:

- There is uncertainty about future outcomes. Examples include: the potential for large shock in demand from an uncertain source such as a significant customer; opportunities for new technologies such as purified recycled water if there is community acceptance to implement; or significant regulatory change such as restrictions on wastewater discharge to waterways.
- New information may resolve this uncertainty as it emerges over time.
- The investment is adaptable in certain circumstances in response to the new information. For example, you can break down investments into multiple stages, or where some stages are irreversible.
- This flexibility to adjust the investment can be valuable. It can exploit beneficial outcomes, while avoiding negative outcomes.

The steps in undertaking ROA analysis involve:

- **identifying key sources of uncertainty** – uncertainties may be future drought or the likelihood of a water quality event
- **identifying options to respond to that uncertainty** – in the case of future drought, there are likely a range of infrastructure and governance measures you can implement to address uncertainty
- **building a decision tree that maps the key uncertainties and options** – given the range of outcomes, incorporating every possible response is likely to be difficult to map, let alone model. Focus on the most material.
- **calculating the expected present value of each branch** – this will depend on the NPV of each scenario and the probability of outcomes occurring.

# 8.3 Identifying the appropriate approach to manage risk and uncertainty

In general, **the approach taken to identifying risk and resilience of the options should be proportionate to the size of the project, key risks, and impacts on the community.**

For example, simple sensitivity analysis that varies key assumptions (such as discount rate) may be appropriate for simple CBA. It is undertaken relatively easily and can provide an indication of whether there are key risks that decision-makers need to consider in interpreting the CBA results.

In contrast, ROA may be more appropriate for detailed CBA where options are subject to a range of key risks and/or there are opportunities to build "real options" into the interventions. While you should consider the value of flexibility in decision-making early in the options development stage, real-options analysis can be complex and time-consuming to implement and may require specific supporting expertise.

# Step 6: Identify the high-level distribution of costs and benefits across the community

9

The final step is to assess the distribution of gains and losses across different groups of the community. Distributional analysis disaggregates the overall impacts of the options in a cost-benefit analysis by key groups of interest (such as beneficiaries) or other categories that are relevant.

## STEP 6 Identify the high-level distribution of costs and benefits – tips and tricks

- **DO** consider the distribution of costs and benefits across the broad NSW community, rather than just focusing on those who live in a given development or who are the direct recipients of the water conservation initiative.
- **DO** consider funding from impactors first, then beneficiaries, then government pays.

The distribution of gains and losses is an important aspect of any decision. The success of some decisions can hinge on having a robust understanding of the distributional impacts as well as appropriate strategies to manage the distribution of gains and losses.

As discussed in **Box 15**, distributional analysis disaggregates the overall impacts of the options in a CBA by groups of beneficiaries and losers – for example, by institutional sector (households, private business and government), geographic areas (LGA, region) or other relevant categories. This can be qualitatively or quantitatively and may draw on stakeholder feedback.

We outline the steps involved in undertaking a distributional analysis in **Box 15** and discuss them in more detail in this section.

Importantly, understanding the final distribution of costs and benefits for detailed CBAs may require understanding the approach to funding the investment and any financial impacts. This requires complementing this initial analysis around identification of relevant parties with a separate, but related, financial and funding analysis.

### Box 15: Steps in distributional analysis

1. Identify the key groups of interest in the relevant community, for example, the local community, developers, local water utility and the broader NSW community.
2. Allocate all costs and benefits identified in the CBA to one or more of these groups and consider any unquantified effects and whether these are likely to impact significantly on any of the identified groups.
3. Understand the distribution of costs and benefits across the community. Importantly, the level of detail in the third step is likely to vary depending on the detail of the CBA.
4. For simple CBAs, a qualitative distributional analysis that lists the parties and how they benefit may be sufficient.
5. More detailed CBAs may require a quantitative distribution, which identifies the size of the costs and benefits borne by each party.

# 9.1 Identifying the key groups of interest

The first step in distributional analysis is to find the key groups of interest arising from the costs and benefits identified in the CBA. There are 2 broad categories of relevant parties:

1. **Impactors** – the party creating the need to incur the cost. An example is water customers who create the need for investment in water supply, or residents of a development who create the need for water services within that development.
2. **Beneficiaries** – the party that benefits from an action, but don't necessarily drive the cost of the service.[53] This may include:
   - **direct beneficiaries** – those who derive a private benefit from the activity, such as local residents receiving a customer side of the meter leakage management service, or water customers who benefit from reduced risk of water restrictions
   - **indirect beneficiaries** – those who derive an indirect benefit, such as the broader community, which benefits from improved environmental outcomes from reduced stormwater runoff or wastewater discharge associated with small-scale reuse.

Within these 2 broad categories, relevant parties can also vary across institutions and geographic area. The exact relevant groups of interest will vary on a project-by-project basis depending on the relevant impacts and affected parties identified. We outline examples of relevant parties in **Figure 28.**

**Figure 28: Example of key groups of interest**


There is no fixed number of parties of interest. In general, more complex investments and those with a larger geographic scope would be expected to have more relevant groups of interest.

## 9.1.1 Identifying key groups of interest to guide funding decisions and/or transfer payments

There is a well-established funding hierarchy you can use to inform the potential funding of investments in water conservation. These guidelines are consistent with the National Water Initiative Pricing Principles.[54] A range of economic regulators use them, such as IPART, and the Productivity Commission recommends them. As shown in **Figure 29**, under this hierarchy:

- preferably, the party (or parties) who created the need to incur the cost (the impactor or cost bearers) should pay in the first instance
- if that is not possible, the party who benefits (the beneficiary) should pay
- in cases where it is not feasible to charge either impactors or beneficiaries (for example, because of an administrative or legislative impracticality of charging), the government (taxpayers) should pay on behalf of the broader community.

53 Impactors are usually beneficiaries, but beneficiaries are not exclusively impactors.
54 Department of Agriculture, Fisheries and Forestry (N/A). National Water Initiative Pricing Principles. www.agriculture.gov.au/sites/default/files/sitecollectiondocuments/water/national-water-initiative-pricing-principles.pdf

**Figure 29: Overview of the funding hierarchy – the role of beneficiaries and impactors**

| Overview of the funding hierarchy | | |
|---|---|---|
| **Impactor pays**<br>The party that creates the need to incur the cost (the impactor) | **EXAMPLE**<br>Those living and working in an area create the need for investment in water conservation. Rainwater tanks are a measure that can reduce potable water demand and potentially defer/avoid water system augmentation. | **EXAMPLE**<br>User pays charges to fund the rainwater tanks. |
| **Beneficiary pays**<br>The party that derives value from provision of a service (but not necessarily use of that service) | **EXAMPLE**<br>Utilities and other water users benefit from avoided stormwater and water system augmentations if rainwater tanks sufficiently reduce potable water demand. | **EXAMPLE**<br>Utility (or local council) and/or other customers contribute to these costs (through funding discounts on charges or rebates for tanks). |
| **Government(s) pay**<br>Government(s) pay on basis of efficiency or equity on behalf of community | **EXAMPLE**<br>Costs are shared between users and governments to ensure outcomes and/or minimise financial hardship. | **EXAMPLE**<br>Using government consolidated revenue to buy rainwater tanks. |

Under this hierarchy, costs are recovered from individuals or groups in proportion to their contribution to the need to incur the expenditure or the benefits they receive from the expenditure. In principle, an impactor-pays approach is preferred in the first instance, as it promotes efficient decisions from those who create the need to incur the cost.

Practical limitations or equity concerns often mean that a range of sectors adopt a blend of impactor-pays, beneficiary-pays, and government-pays funding. For example, government may opt to contribute on behalf of impactors if there is a view that, given equity concerns, impactors are unable to contribute in line with the costs they impose.

Another example is contribution from the broader water and wastewater customer base to small-scale reuse measures in a given development. This enables uptake of economically efficient reuse that would otherwise not be pursued because funding from the customers in the development alone is not sufficient.

# 9.2 Allocating impacts to groups

After identifying the relevant groups of interest, allocate their costs and benefits. Some costs and benefits can be easily allocated to an individual group while others need some thinking to split between multiple groups:

- Direct costs and benefits, including the costs of dedicated assets and activities/operations and the benefits that flow from these, are relatively easily allocated to specific groups. The key principle is to ensure there is a clear identification of the characteristics of the cost/benefit item that associate it uniquely with a particular group. For example, visitors to a local park benefit from provision of irrigation to the park.
- Common costs and benefits are incurred in the supply of more than one service or to more than one group but may not easily be attributed to any single service or customer. For example, changes in urban heat impacted by irrigation of open space and tree canopy can be more challenging to attribute to a specific development or customer.
- In some cases, understanding the allotting of costs and benefits for detailed CBAs requires understanding the ultimate approach to funding the investment. This complements the initial distributional analysis with a separate, but related financial and funding analysis (which is not the subject of these guidelines).

# 9.3 Understanding the high-level distribution of costs and benefits across the community

The final step in the distributional analysis is to identify and report on the distribution of costs and benefits across the community. As discussed above, the detail of the distributional analysis is likely to vary depending on the detail of the CBA:

- **Simple CBA** – is likely to involve a qualitative distributional analysis, which lists the groups and discusses their benefit. For example, the beneficiaries of an investment in leakage management that reduces potable water supplied are the water customers of the local water utility.
- **Detailed CBA** – is likely to involve a quantitative distributional analysis, which estimates the size of the costs and benefits borne by each group of interest. It calculates the ultimate distribution across the community, as shown in the indicative example in **Figure 30**. For example:
  - water users benefit from the avoided costs to meet growth in water demand arising from the use of water-efficient showerheads
  - the local community benefits from the improved health of waterways arising from small-scale reuse reducing the volume of wastewater discharged into receiving waters
  - the NSW community derives health benefits from reduced urban heat arising from the presence of water in the landscape and passively irrigated tree canopy.

**Figure 30: Quantitative distribution of costs and benefits across the community – an example**