Green Infrastructure Economic Framework

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Table of contents

Executive summary

'In Australia, our pressing issues of water, energy, environment, healthcare, productivity, mobility, safety and security all stem from four global megatrends – climate change, demographic change, urbanisation and globalisation.... We look into the future to see what kind of world we want to live in. Then, we work backwards to see how we can bring these big ideas to life.'

— *Picture the Future*, Siemens Australia and New Zealand

The world is changing and so are the cities we live in. Changes in population, demographics, technology and the environment are shaping our communities in a way that is beyond our historical context and require new ways of seeing and thinking. For local government there are a number of emerging challenges such as reduced available revenue, increasing risks as a result of changing internal and external environments and an increasing demand for council services. Decision makers in local government are faced with the daunting task of trying to understand how to make the best decision today within these constraints, in a way that supports the future sustainability of their communities.

Resilient infrastructure (both hard infrastructure such as bridges, roads and buildings, and soft infrastructure such as social systems, connectivity and communication) is recognised as being central to helping communities respond effectively to these changes. Understanding the true worth of all infrastructure and assets is crucial to understanding the choices available and what the best one may be.

What is green infrastructure?

Green infrastructure describes the green spaces and water systems which intersperse, connect and provide vital life support for humans and other species within our urban environments. Green infrastructure exists across a range of scales – from residential gardens to local parks and housing estates, streetscapes and highway verges, services and communications corridors, waterways and regional recreation areas. Green infrastructure includes features that are multifunctional, networked and natural, and they have multiple benefits for society and the environment.

Why is green infrastructure important?

Green infrastructure is a key aspect of our towns and cities. It underpins our economy in areas such as health, liveability and industry. It protects and rejuvenates communities by providing essential services such as clean air and water and healthy ecosystems. It can also help reduce the impacts of climate events such as flooding and heat waves. Communities who successfully maintain these assets are more likely to be resilient and able to adapt more effectively to future shocks and changes.

Historically, this type of infrastructure has often been developed in response to emerging needs of communities. In some cases, this has been a reactive process that aims to address a specific issue. In other cases, it may fulfil a particular need at the expense of others. For example, a choice may be made to develop an area of high environmental value to meet the needs of a growing population.

To date, the role and value of green infrastructure has not been well understood in Australia and it is seen in many councils as peripheral to other forms of more established forms of infrastructure. These types of infrastructure and assets also differ from grey infrastructure in that they can offer multiple benefits and services – for example, strategically positioned green areas can reduce heat in surrounding areas, increase property value and improve community health.

Some of the associated benefits are intangible (non-monetary) which are often overlooked as they are difficult to quantify, particularly in relation to future savings. This is, in part, because it is a relatively new area of practice so evaluation tools and methods have not been developed fully. As a result, business cases for this area do not include all the relevant information and can result in decision makers being unable to make fully informed decisions. This has meant that opportunities to improve these assets or maximise their benefits have not been taken up.

Working toward an economic understanding for green infrastructure

Although there are an increasing number of tool kits and methods for valuing green infrastructure, there has not been a clear process outlined for achieving this that aligns with current operational practices in local government in Australia.

This document has three key aspects:

- It provides an economic process-based framework that outlines the key steps needed to value green infrastructure.
- It provides a full life cycle management process that is already established in practice and aligns aspects of the economic process to support integration of the framework into day-to-day operational decision making.
- It provides an explanation of some of the economic methods and approaches that are available to assist practitioners in the area of valuing and evaluating green infrastructure.

The full life cycle management of assets and infrastructure is best practice and aligns with the current federal initiative to improve this area of management in local government bodies. This provides a unique window of opportunity for local government to embed the new knowledge emerging as part of this initiative in a way that can enhance current activities.

It is recognised that councils will have different capacity and resources available. As a result this framework has been developed to be a starting point for councils upon which they can build in their own way, in their own time, with the resources they have.

Photo Shannon Reddaway

Making better decisions for the future

'Growth is inevitable and desirable, but destruction of community character is not. The question is not whether your part of the world is going to change. The question is how.'

— Edward T McMahon

Planning for and providing services that facilitate the development of communities that are resilient to future economic, social and environmental shocks is a key function of local government. Because the risks facing cities and the communities that live in them are systemic and some are increasing, there is a need to think beyond current conditions if this expectation is to be fulfilled. It also requires decision makers to understand the full spectrum of economic values so they can evaluate both monetary and non-monetary values across both short- and long-term time frames. In this way, they can maximise investment opportunities in this area through a more comprehensive understanding of what the benefits and costs are. They can also more clearly assess the possible impact and legacy of their decision.

Integrated infrastructure that incorporates and values green infrastructure is at the heart of the places we make and inhabit, and provides the fabric that supports our economies and our communities. It is an investment that, once established will, in most cases, increase in value. Well maintained, healthy green infrastructure can continue to provide services and benefits that improve the liveability of our communities in a cost-effective manner. This is why integrating green infrastructure into the established investment processes for general infrastructure is key to being able to develop smart cities that maintain our communities' liveability, resilience and wellbeing.

This framework aims to provide a foundation which will support greater understanding of the value of green infrastructure, in a way that is practical and works with current operational processes. Green infrastructure offers many opportunities because it is an area of innovation that has yet to reach its full potential. Understanding more fully how to develop and manage this effectively will help increase these opportunities. It will also help ensure that communities now and in the future, have the infrastructure they need to continue to grow and prosper in a sustainable way through supporting better decision making and smarter investment.

The purpose of the framework

The purpose of this framework is to help local government value the benefits of green infrastructure (GI), especially for the purpose of adapting to climate change. This document outlines a framework that enables local council asset managers and officers to address the multiple benefits of GI projects. It does this by building guidance for developing business cases and asset management into existing decision-making processes for developing GI.

By understanding more fully the costs and benefits of GI, decision-makers can make better informed decisions that are both fiscally and environmentally responsible without sacrificing long-term goals for short-term financial contingencies. In the long run, the entire community will benefit by investing in GI which, by reducing risk and increasing resilience, can provide sustained social returns. It does so by providing better places for people and the rest of nature to live. By addressing a wide portfolio of climate change impacts, local government can make strategic choices about where, when and how to invest in adaptation responses designed to minimise risk and maximise benefits and liveability.

This framework has two main tasks:

1. To value the benefits of GI on a project and program basis to support the development of business cases for GI investment, and
2. To identify opportunities to incorporate GI into current operational systems, using a life cycle asset management process. This can be used to establish and maintain GI asset quality and service delivery on an ongoing basis.

The purpose of this document

The framework is designed to fit into the standard project development and asset management systems used by local government with a minimum of extra modification. We have also tried to keep technical terms to a minimum, although speaking the language of economics is a useful skill when putting GI on a similar footing to conventional infrastructure. Its purpose is to provide a foundation which can be developed and added to by local government bodies as their practice matures.

The two approaches being followed are business case development following the full life-cycle from scoping through to the planned life-cycle of the assets developed by the project and the asset management process that aims to maintain asset quality and service delivery.

The document consists of a general introduction, an introduction to the economic framework for GI development along with key policy settings that help classify the diverse values GI provides. The major part of the document outlines a broad, generic process used by councils for developing GI projects and managing assets. Mapped onto this is a procedure for developing business cases at the project or program scale and for assessing asset value, taking into account the full asset life cycle.

The following reports provide the evidence base used to develop the process-based economic framework:

- *Investing in Growth: Understanding the Value of Green Infrastructure Context Paper* (2014)
- *Investing in Growth: Understanding the Value of Green Infrastructure Workshop Report* (2014)
- *Assessing the Economic Value of Green Infrastructure Literature Review* (2015)
- *Assessing the Economic Value of Green Infrastructure*. Green Paper (2015).

The economic basis for this framework

The greatest difference between green and conventional infrastructure are the multiple benefits that GI provides. Conventional infrastructure is generally single purpose. For example, roads are built mainly for motor transport and pipes for liquid transport. The economic benefits are assessed by analysing the direct monetary benefits of increased economic activity. The additional flow-on benefits to the community of that added economic activity are then assessed by multiplying the direct benefit by a factor.

The most important difference with GI is that many of the direct benefits are not market benefits, but values that flow directly to people and the environment in the form of things such as liveability, resilience and nature conservation. These are so-called intangibles because they don't have a direct market value. Intangible values are costed using indirect methods, what people are willing to pay for a service, or by so called shadow pricing, what people might pay commercially for a 'free service' provided by GI. For example, the value of a beach might be calculated by what people are willing to spend to drive there, pay for parking, accommodation, and beach wear and equipment. Indirectly many of these benefits do flow through to the economy in the form of social returns. These are difficult to quantify but there is a great deal of evidence for their importance to the economy. The potential to use dividends from social returns to re-invest in more GI to encourage further social returns has been called a 'virtuous cycle'.

Key aspects of GI that need to be accounted for include intangible benefits, biological growth patterns and life cycles, the unique nature of species and ecosystems that cannot easily be substituted for, all benefits delivered on a range of time scales that produce long-term social returns. This places greater demands on the economics needed to assess these benefits, compared to conventional economic assessments. Many of the policy aims of local government are also non-commercial. However, economic tools will be needed to assets the cost-effectiveness of measures used to fulfil these policy aims.

The uncertainty around quantifying benefits produced by GI projects means they are at a disadvantage when compared to conventional projects that have strong commercial elements. However, they may be no less valuable.

The economic approach being used here uses different types of value rather than trying to convert all values into dollars. These values range from market through to ethical values, not all of which can, or should, be converted into dollars.

The benefits of GI can be grouped under monetary, social and environmental headings.

1. **Monetary benefits** come from the direct supply of goods and services. Indirect monetary benefits are many but difficult to quantify. For example, by improving amenity, GI can increase adjacent property values and improve consumer activity in some precincts. Ecosystem services also provide a 'free service' that can support other economic activities such as recreation, sport and tourism.
2. **Social benefits** are diverse and often hard to measure because many, such as community identity, amenity and equity, are indirect. Health benefits include mental, physical and spiritual health. The provision of clean air and water, and places to walk and exercise provide the basis for improved community health. Green infrastructure can also play a role in connecting communities through social activities in the spaces provided.
3. **Environmental benefits** can contribute directly to environmental protection or improvements in environmental health that may also have social and or/economic aspects. Direct benefits include healthy ecosystems, healthy populations of flora and fauna, connectivity of different spaces and structure that promotes and protects species diversity. The provision of these benefits can also flow through to the conventional economy.

Table 1, overleaf, shows examples of these different types of benefit and the scale at which those benefits take effect.

The three levels of benefit are:

1. **Individual benefits** contribute to personal welfare. These make up the market economy as personal utility (e.g., market price, willingness to pay) and individual wellbeing.
2. **Community benefits** contribute to the welfare of the community and are things like connectedness, shared values and goals, and access to cultural and natural heritage
3. **Institutional benefits** are those that fulfil institutional goals and values. For local government, they include supporting key policies such as sustainability and healthy communities, in addition to efficient and cost-effective delivery of services.

Photo Shannon Reddaway

Table 1 Examples of individual, community and institutional values as they relate to monetary, social and environmental values provided by GI.

	Individual	Community	Institutional
Monetary	Higher property values, health savings from exercise, reduced climate impact event damages, energy savings	Greater local commerce, attractive to businesses, reduced climate impact event damages	Efficiency, cost-effectiveness, social returns into the economy, avoided costs for changing risks
Social	Personal wellbeing, opportunities to meet friends, opportunities for recreation, places to play	Venues for events, increased social contact in public spaces, knowing one's neighbours, rapid recovery after climate impact events	Community resilience and community health, strong neighbourhood identity, strong post-climate impact event recovery
Environmental	Enjoyment of flora and fauna, personal environmental values being met	Friends groups and volunteerism, environmental education	Conservation values met, high biodiversity

Policy groupings related to green infrastructure

Institutional values are those values that an institution such as local government, invests in and uses to measure its success. With respect to GI, these relate particularly to environmental and social policies.

Local government has three main policy groupings relating to GI. Sustainability is a common over-arching policy, but does not always result in the integration of economic, social and environmental values at the project and program scale. Integrating these values within business cases for GI is one practical way of achieving this aim (Young, et al., 2014b).

The other two main policy areas are safety and liveability. One aspect of safe communities is risk reduction, aiming to prevent or avoid loss from damaging events and processes. Liveability aims to improve the quality of urban spaces for individuals, communities and nature. The key economic difference between risk reduction and liveability is that the first is measured as avoided loss, whereas the second addresses overall gain.

1. **Sustainability**
   - Achieving social, environmental and economic sustainability for future communities.
   - Ensuring the sustainability and continuity of council finance and service provision.
   - Maintaining the ecological resilience of GI in urban settings is challenging because of other pressures, but it is reasonable to assume that many of the qualities for doing so are consistent with other forms of resilience.
   - Strategic resource use to maximise return on investment through development of integrated infrastructure that serves multiple purposes compared to single purpose infrastructure.
2. **Safe communities**
   - Climate impact risk reduction is central to adaptation. Key risks identified in the urban environment are flash flooding, drought, extreme heat, storms including hail storms, and windy and exposed environments.
   - Conventional infrastructure can withstand external disturbances and shocks to known tolerance levels, but when the system fails, the impacts are costly. In some cases, GI can provide added resilience with the same or additional level of service. GI can also reduce the physical, emotional and monetary cost of damaging events.
   - Green infrastructure can be added to conventional infrastructure to soften it and lessen its impacts.
3. **Liveability**
   - GI contributes to healthier and happier communities.
   - GI that improves liveability will expand the services available within urban areas.
   - Urban environments are not always comfortable places. The exterior environment needs the same of level of consideration to people's use of space as is given to building interiors.
   - Key design elements include the provision of shelter, urban cooling in summer and reduced exposure in winter (if well designed).
   - GI can support greater connectivity through the provision of spaces for gatherings, meetings and outings.

Considerations for using the GI economic framework

Green infrastructure development is a relatively new area of practice so needs to be highly innovative. Accordingly, the following aspects need to be considered at the beginning of each project:

- How is GI different to other forms of infrastructure?
- What current tools/systems in use can be used to make GI operational?
- What new and different tools may need to be used?
- How should they be applied?

The use of economic methods and tools in developing business cases for GI and building that knowledge into operational systems and asset management will help develop and deliver innovative practice.

Policy environment

Policy can be both a constraint and enabler of GI development. At the start of a project, it is important to identify the policies supporting GI at all levels of government. It is also important to understand where GI can support other policy agendas. For example, with respect to health policy, GI can provide health benefits, such as improved air quality and urban cooling, and be used to reduce the impacts of extreme weather events, improving personal safety.

It is also essential to identify barriers resulting from current policy or strategic priorities and develop strategies for addressing them. By identifying a wider range of benefits and identifying long-term social, economic and environmental returns to society, the use of an economic framework can help to build stronger business cases that are consistent with council policies and goals.

How a project is framed is a key part of obtaining buy-in and engagement. Potential stakeholders include council executive, councillors, the community, business and state government agencies. For example, an organisation may place a low value on environmental activities, but may place a high value on community health and wellbeing. Directly linking these benefits to GI in a business case can potentially gain the support needed within council and the community. For example, if you are proposing a green business precinct, you may wish to promote aspects such as increased economic activity or employee health and productivity to local business. If you are developing parkland areas in a residential area you may wish to frame it through improved amenity, increased property values and increased health benefits.

Level of understanding

Green infrastructure and its benefits are not well understood by many people. It is also an area of innovation, which means that new technologies and ways of doing things are needed. At the beginning of each project, it is important to assess how well key individuals and groups understand the needs and benefits of GI. Education may be needed to develop a shared understanding of the project and gain the support needed to ensure the acceptance of GI during and after the project. Lack of knowledge and lack of familiarity can both pose risks to innovative projects where outcomes and potential benefits seem uncertain. This often requires extra time to work through and is an ongoing process that requires feedback, adjustment and negotiation with the different parties involved. However, a deeper level of engagement also helps to ensure that decisions are well informed and that the best decision in relation to expenditure for infrastructure can be made.

Resources and needs

As many GI projects involve new technology and ways of thinking, they may have different requirements to standard grey infrastructure projects. The operational infrastructure and learned practice is often being developed and ‘built’ through these projects. Appropriate resources, time and strategic planning are central where learning is an important component. Ongoing actions such as monitoring and evaluation to measure asset performance is also needed to inform asset management. Modifying existing processes is an efficient way to do this. For example, adding in extra checks during tree health and infrastructure assessments can help reduce long-term costs, making the project more financially sustainable in the long term. Managing and negotiating the different expectations in relation to resources and needs is crucial.

Planning projects and programs

Green infrastructure projects and programs have two levels of benefit:

1. **Core or direct benefits:** a project should generally identify up to three core benefits, only identifying more if the planners are expert and well-practised. The type of core benefit will largely dictate the major economic tools needed. The resulting economic assessment will form the central part of the project business case. Examples are shown in Table 2, and a larger number of benefits are listed in Appendix A (see pages 33–34).
2. **Co-benefits:** a much larger set of co-benefits will include potential negatives (e.g., some tree species produce some pollutants while absorbing more). Co-benefits often can be assessed by easy-to-use tools such as look-up tables and simple models, as long as they don’t need to be highly context specific. For example, having stock valuations for a range of benefits such as water substitution, the value of park visits, pollution removal, carbon sequestration and so on can make the collation of many co-benefits a routine task.

Investment in GI at the local government level can serve a wide range of purposes. Examples include:

- Locating and prioritising natural interventions where they are most needed.
- Where the need for GI has been identified (e.g., a park, a wetland, tree planting), and council wants to maximise its potential benefits (e.g., as climate change adaptation, community health) with targeted investment.
- Where a site or neighbourhood with the potential for additional GI has been identified and council would like to select the most suitable kind using an economic assessment.
- Where council has identified the most suitable type of GI for a site and needs an evidence base to support the proposal.
- Where GI is being targeted to maximise specific socio-economic benefits (e.g., health and wellbeing, active exercise, public access).
- Where council would like to weigh up the social, economic and environmental benefits of both GI and non-GI investments for a particular site in order to choose a preferred option.
- Where council has an organisational strategy or target that requires the selection and evaluation of a range of individual actions (e.g., an urban forest strategy).
- Where there is a need to provide an estimate of monetary returns for a planning decision to fulfil regulatory obligations (e.g., for a planning tribunal, mandatory open space in a development).

Examples of potential core benefits and some of the tasks and tools needed to evaluate these are provided in Table 2.

Embedding it in the process

A key part of enabling the economic framework is ensuring that it becomes part of day-to-day practice by embedding it in the current operational systems through the most relevant process area. Operational systems within participating councils were assessed and the most appropriate process identified for the economic framework was asset management. This was divided into four key areas as shown in Figure 1.

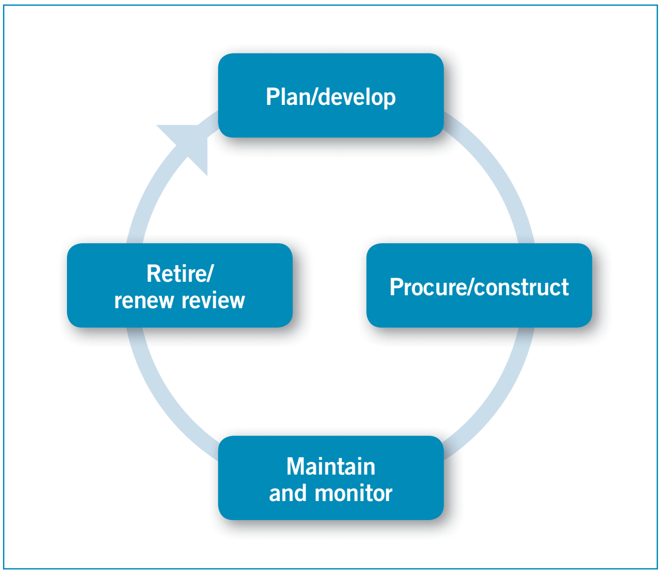

Figure 1 Four key areas of local government operational processes.

Table 2 Examples of projects, core benefits valuations tasks and tools, and co-benefits for GI at the local government level. (WTP – willingness to pay; IUWM – integrated urban water management)

Project	Core benefits	Valuation tasks and tools	Co-benefits
Parks: passive recreation	Amenity, social wellbeing, connectivity	Visitor rates and WTP methods, community valuation	Climate modification, wildlife, property prices
Parks: active recreation	Fitness and health, social connectivity	Health and welfare benefits, revealed preference and substitution methods (public-private exchange)	Climate modification, property prices, retail opportunity
Parks: stormwater recycling	Flood control, water substitution/ drought protection, water quality	Modified IUWM tools, avoided loss, value of nutrients removed	Climate modification, tree health, aquatic biodiversity
Street trees	Amenity, shelter, stormwater interception	Multiple benefit tree models (e.g., I-Tree), individual benefits (e.g., pollution control, microclimate models and benefits)	Climate modification, public safety (slight negative), increased commercial activity, wildlife (birds), property prices
Waterway/ water body	Wildlife and biodiversity, flood management, recreation	Flood and drought management, community use (revealed preference, WTP)	Water quality, climate modification, adjacent commercial activity, property prices
Parks: nature reserves	Wildlife and biodiversity, flood management, water quality	Ecological health, conservation status, community inputs (e.g., friends groups)	Property prices, air quality costs if ecological burns needed, fire danger
Green walls	Amenity	Reputation, visual amenity, market property value	Energy savings, pollution interception, microclimate modification
Urban forest	Climate modification, wildlife, stormwater interception	Energy savings, physical amenity savings, wildlife values, property values, local climate benefits, public health	Heritage values, ecological connectivity, community wellbeing, reputation, pollution interception

process

Photo Shannon Reddaway

The GI economic framework process


Photo Shannon Reddaway

Scoping and initial development

Key task

Ascertain whether GI assets and services are relevant to the current project.

Key considerations

- Is GI applicable to this project?
- How is it applicable?
- What services does it provide?
- What policy/strategic objectives does it fulfil?
- Who are the key stakeholders and how can this project address their needs?
- What sort of education may be needed to gain buy-in and support for the project?
- Can GI enhance the performance of other infrastructure or assets? If so how?
- Why is GI a better alternative to other possible infrastructure options?
- What is the best GI option?

Where you start

Where you start will often depend upon the following factors:

- Your organisation's operational maturity.
- The resources available.
- The policy and strategic environment.
- The conditions attached to project funding.

It is important to work with an understanding of the challenges and opportunities you face and to think strategically about what actions are needed to progress this activity to the next phase. It is also important to generate a shared understanding of the project and obtain the necessary buy-in from key stakeholders internally and externally. It can help to develop a brief summary of what you propose that includes the areas outlined below:

- **Relevance** – what is the value of the action in relation to other primary stakeholders' needs and other regulatory and policy needs?
- **Efficiency** – how will the project use the resources in the most cost-effective manner to achieve its objectives?
- **Effectiveness** – how will the project achieve its objectives?
- **Impact** – what are the projected outputs and outcomes of this project?
- **Sustainability** – what are the factors needed to ensure that the asset and their impact will to continue when the activity is completed?

This involves working within identified constraints, such as resources, but also to think beyond them. This project may also support other long-term visions for your community including your overall plan for GI. You then need to ascertain how GI fits in and adds values to these plans. It is also good to look at how your project value-add to other areas of policy and strategy within and external to your organisation. In terms of the scope of the project, it is always better to work within the constraints of the budget and do a part of the project well and then seek further funding rather than do a whole project badly.

Where you need to build to

An organisational culture where GI understanding is embedded, understood and has equal consideration in planning as other more established forms of infrastructure.

Economic considerations

Key task

Determine what kind of business case is required to support the proposed GI and the resources required to develop it.

Key considerations

- What are the core benefits that GI is planned to deliver?
- Is there existing GI upon which a business case can be based?
- What resources are available to assess potential projects and build a business case (skills, personnel and budget)?
- What partnerships and external resources may be needed?
- What time frame does the economic analysis need to be completed within?
- What kind of economic analysis is required? Simple to complex?

Where you start

Ideally, valuation will consider a project from the R&D stage through its entire life cycle. A barrier is that different potential options may address different benefits, so are hard to compare. The relative size of a benefit may also be uncertain because of the wide range of possible futures that may be encountered. An example is where a town vulnerable to sea level rise, storm surge and groundwater contamination may weigh up the different benefits of protection and relocation.

The scoping of projects can range from investigating alternatives within a single set of design guidelines to assessing a range of different alternatives to see which provides the best return on investment (that may include both green and conventional infrastructure). At this stage, it is worth considering the question: **what type of business case is needed to support the proposal?**

Every economic assessment will have some form of business case, whether as a brief memo describing the physical benefits that accompanies a project design, to a fully comprehensive cost-benefit analysis that captures the long-term returns on investment, including intangibles. The above questions, those to the left and the next few steps help identify the information from which a business case can be constructed.

Two types of business case can be considered here:

1. **Physical economy** – this is a physical description of the project that does not monetise the benefits because it either does not need to, or the information is not available. A business case of this type will describe the proposed assets to be built, and the services and major benefits it will provide and what the project will cost.
2. **Monetary economy** – this type of case estimates benefits in dollar terms, and can be developed on three levels:
    a. Basic: a basic business case will estimate total benefits over the life of the project or representative annual benefits, preferably net of operating costs.
    b. Intermediate: an intermediate business case will estimate the stream of benefits and costs over the life of the project, where numbers are generally available and a discount rate can be applied to estimate return on investment. This application is fairly static, but will want to show a positive return on investment.
    c. Fully applied: a full business case will cover the full life cycle of the GI where asset condition and growth phases are modelled, to accurately represent ongoing costs and benefits; for example, covering tree growth and the relevant streams of benefits.

Even at this early stage, it may be worthwhile creating a rough idea of costs and benefits to scope the viability of the proposal. This may assist in internal approvals to go ahead with planning the project.

Business cases usually provide a mixture of economic outcomes. The case study examples presented here (two from the UK and one local) show both qualitative and quantitative outcomes. The Brooklyn case study emphasises the scoping stage, where previous work and stakeholder visions have a significant impact on business case development (see pages 28–30).

Where you need to build to

An economically aware organisation where the benefits of GI can readily be incorporated into business cases that take in the whole lifecycle of GI and its assets.

Planning and development

Key task

To plan and develop the proposed GI project or program, outlining the key functions and services provided, providing costings and benefits for the full life cycle of the assets produced.

A successful business case will result in a set of GI assets with the potential for delivering a wide range of services. It will also need to show why the option proposed offers a better value proposition than alternatives.

Key considerations

- What services will this asset provide?
- What will it cost to plan, develop, build, monitor and maintain over the full asset life cycle?
- What are the tangible (monetary) and intangible benefits?
- What are the most appropriate tools, methods, systems for assessing the value of GI?
- What is the value proposition for this project?

Where you start

The project scoping and planning stage will have provided the major design elements for the project. The planning stage will need to provide the next level of detail for services and the benefits of those services to be properly assessed. Detailed plans are also required to provide accurate assessment of costs over the life of the project.

All these factors will contribute to developing a sound evidence base to support your business case. Because some areas may be new to potential co-investors or to the assessors who sign off the business case, it is very important not to embellish the benefits or understate cost of projects as this can impact on the viability of current and future projects. It is also important to cost in ongoing maintenance and monitoring and evaluation and show how they can be effectively managed. Creative solutions to reducing costs through adapting current systems or cost sharing with other organisations can be used to strengthen the business case. Policy and community agendas are also an important part of the business case as they provide context for the intangible costs and institutional values associated with the project.

Where you need to build to

Comprehensive business case and project management templates that step practitioners through the process. Governance and systems that support this.

Economic considerations

Key task

Build the business case by identifying core and co-benefits of the proposed GI, developing an economic baseline, assessing life cycle costs and benefits and if feasible, carrying out a cost-benefit analysis to assess the potential return on investment.

Many current cases for GI are advocacy cases assessing the major benefits but lack a sound economic basis. This is for a range of reasons including lack of data, lack of know-how in economics and an imbalance between the economic 'credibility' of GI versus conventional infrastructure.

Key considerations

- What major services will the proposed GI provide (including adaptation)?
- What are the major climate risks that the adaptation component is expected to manage?
- What are the core benefits and co-benefits of those services?
- Who will benefit from the project?
- What is the planned life cycle of the GI?

Where you start

The previous section has scoped many of the questions needed to set up a business case. After scoping, there are three main stages to setting up a business case:

a. Setting up and establishing the baseline.
b. Selecting methods and collating costs and benefits.
c. Analyse and assess costs and benefits.

These are described in the following three sections. The Brooklyn case study (see pages 28–30) also outlines how this was carried out for an area of industrial renewal.

Where you need to build to

An economically aware organisation where the benefits of GI can readily be incorporated into business cases that take in the whole life cycle of GI and its assets.

Setting up and establishing the baseline

Key task

An economic baseline serves as the platform from which future costs and benefits can be calculated. It can also be used to assess the business-as-usual case – the future stream of costs that would occur if the project was not developed.

Key considerations

- What major services will the proposed GI provide (including adaptation)?
- What are the major climate risks that the adaptation component is expected to provide?
- What are the core benefits and co-benefits of those services?
- Who will benefit from the project?
- What is the planned life cycle of the GI?

Where you start

The major services provided by a GI project will form the core of the business case and are the priority for providing benefits in dollar values.

There are two major groups of services:

1. **Avoided costs:** measure the benefits of avoided risks through adaptation. Climate risks include extreme heat, flash, river and coastal flooding, storms and peak winds, hail and fire. Additional avoided costs may include avoided health costs from a fitter, healthier community, energy savings and so on.
2. **Net benefits:** additional benefits that the project may provide include community benefits, higher worker productivity, increased visitors, and commercial opportunities.

Other considerations include providing greater benefits from a higher standard of GI than the minimum required (e.g., accompanying another project). GI may also be used to provide required levels of service, substituting for other infrastructure (e.g., flood mitigation services).

One purpose of this framework is to assist councils in developing the business case to adapt now to climate change. If a council has carried out an adaptation strategy, then the information on existing and potential future exposure to climate risk may be readily available. If it has been identified as an important area for investment, then further specific costing of current and future risk may be needed (e.g., flooding, heat waves).

What are the core benefits of the services provided by the project?

The core benefits are provided by the main services delivered by the project. Core benefits can be measured in dollars to straightforward physical measures depending on what type of information is needed and/or available.

At this stage, it is useful to identify core benefits along with a full list of the co-benefits that will also be provided.

Figure 2, on page 18, shows the major breakdowns for use and non-use values, which help to distinguish market (tangible) from non-market (intangible) values.

Appendices A and B (pages 33–42) present a guide to some evaluation tools. Appendix A gives a brief description of some tools and these are linked to particular types of green infrastructure in Appendix B, with each tool being allocated a particular number. As can be seen in Appendix B, there are many gaps as this field is still developing. For types of green infrastructure where there are no identified evaluation tools for a particular benefit, it is recommended the user search the EVRI database to identify a suitable evaluation tool.

What is the timescale of the full GI lifecycle?

Green infrastructure produces a combination of long-lived natural and built assets that will be expected to deliver services over their lifetime. The planning stage will need to account for not only the planning, development and implementation stages, but also the benefits delivery, maintenance and monitoring stages, ideally extending for the useful life of the assets in question.

A business-as-usual baseline will extend over this period, and may also include projected socio-economic and risk data. This is commonly carried out for climate adaptation, where changes in climate risks and exposure are extended into the future, with and without adaptation measures.

Who will benefit from the project?

Identifying who benefits from the project can help identify potential co-funders and collaborators. It will also identify what demographic and socio-economic data may be required to support the business case. Knowing who benefits will also inform how those benefits can best be communicated in the business plan (e.g., as dollars, health, community benefits).

The major groupings of beneficiary are individuals and businesses, communities and institutions.

- **Individuals and businesses** – individuals can receive direct and indirect benefits that can be market or welfare (non-market) related. Beneficiaries can be residents, regular visitors (e.g., workers) or tourists (internal and external). Each will need to be identified and depending on the type of information needed to construct a baseline, may require some detail (e.g., demographics, income).
- **Communities** – have a set of democratic rights and functions around people and place that relate to social connectivity, community resilience and neighbourhood pride. These are hard to monetise but will feed into the economy through long-term social returns and will also contribute to resilience. Sometimes putting a dollar value on this is double-counting if social returns are addressed separately, but identifying the specific benefit(s) value chain is useful.
- **Institutions** – local and state government especially may have policy targets that can be contributed to by GI-related benefits. Identifying these can be very important in the approval process and in identifying potential co-funding.

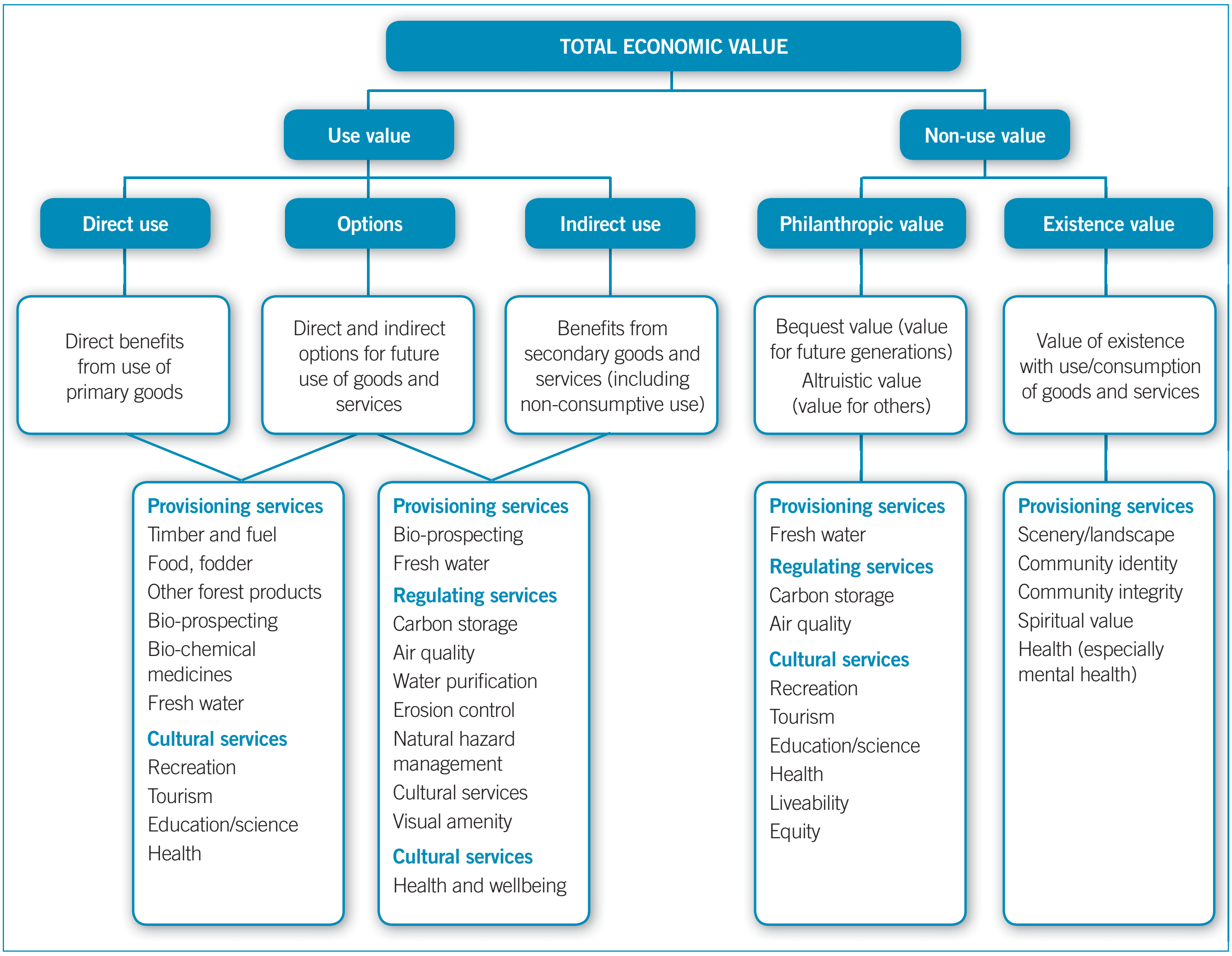

Figure 2 Total economic value system with health and wellbeing additions. Adapted from ten Brink et al. (2011) and Young et al. (2014a).

Distinguishing public and private benefits is important, because the relationship between 'Who pays?' and 'Who benefits?', may become important in determining what local government is expected to support financially. This can also identify co-funding opportunities. In particular, public-private and public-community collaborations are under-utilised.

It is important to identify the stream of benefits from the GI and the services it provides through to its eventual end point. It can help to map the services and benefits provided by the project through a small set of value chains. A visual representation of these chains will link the services that GI provides with the various benefits and beneficiaries. This can help simplify the various benefits and will also help to avoid double-counting when valuing the benefits.

Establish economic baseline

The previous topics can be brought together to create an economic baseline. This serves as the platform from which future costs and benefits can be calculated. It can also be used to assess the business as usual case, where the future stream of values without the proposed GI projects can be assessed.

Included in the baseline are:

- The existing level of services
- Current exposure to risk
- Social, environmental and economic goals
- The values that will be affected
- People and existing assets affected
- The geographic scope
- Time frame of the project
- Projections of key socio-economic and risk data relevant to the assessment.

Information included or omitted from the baseline can heavily influence the conclusions of the economic analysis. The rigour and scope of the baseline description determines the type of analysis that can be conducted on proposed projects, with more complex and expensive projects requiring more data and rigour.

Where you need to build to

Systems that have the tools and integrated data needed to be able to comprehensively ascertain the cost and value of GI and its benefits. Established stakeholder networks that support ongoing work and development in this area.

Principles of baseline specification

Given the context of the project (e.g., resources, time constraints), the following principles should guide the requirements of the baseline:

- Specify the current and future state of relevant economic variables, and the social and environmental issues impacted by the project
- Identify all assumptions made in calculating the baseline
- Specify the start point (in space and time) of the baseline and project
- Specify the end point of the baseline and project
- Specify the uncertain parameters of the baseline, and
- Use the baseline assumptions for the assessment of costs and benefits.

Photo Shannon Reddaway

Collating costs and benefits and select valuation methods

Key task

Collate costs and benefits (both tangible and intangible) for the whole life cycle of the project and assets produced, and select valuation methods and tools.

Key considerations

- What are the costs?
- What are the benefits?
- What valuation methods are most appropriate to asses project value?

Where you start

Collate project costs

Project costs that need to be collated cover the planning, implementation and full life cycle costs of ongoing maintenance and monitoring. This will create a stream of costs that ideally, can be allocated on an annual basis over the life of the project (e.g., 50 years).

The following questions are relevant to addressing ongoing costs:

- What resources (e.g., water) does this asset require, and are there any concerns over possible resource restrictions over its lifetime?
- What are the projected upkeep and maintenance costs?
- What are the costs of the monitoring and evaluation needed to effectively manage the service delivery, asset condition and reporting requirements? (Taking account of building that into current activities and the benefits it provides.)
- Are there risks to either the asset or its ability to deliver services that need to be costed (e.g., contingencies, insurance)?

Collate project benefits

The collation of benefits for further analysis can build on the information collection during the project scoping stage. Four major value types that benefits can be grouped under, are:

- Direct market values.
- Indirect market values that can be costed.
- Indirect markets values that can be identified but not costed.
- Institutional values (e.g., levels of community health or connectivity, resilience, sustainability).

The Brooklyn case study includes examples, and all three case studies include a wide range of benefits. Additional considerations include:

- **What is the division between public and private benefits?**

  Public benefits such as health and liveability often have aspects that can be allocated to individuals, the community and institutions without necessarily being allocated directly to direct market benefits. These are often collated under the heading of social returns.
- **Can these assets and/or services be easily substituted for by other means or are they highly exclusive to this particular project?**

  Assets or essential services that are not easily substitutable have a higher value, potentially reaching the 'priceless' level of ethical, non-monetisable values (e.g., rare species). Assets that are unique because of their age or situation will also have a high value.
- **Is this project likely to acquire further value over time?**

  High quality GI will very quickly acquire community value and over decades can acquire heritage value if high profile species are used or natural values are enhanced.
- **What is the likely stream of benefits over the life of the project?**

  The full stream of costs and benefits need to be projected for several decades or up to a century or more. Some of the considerations that may be needed here are:
  - > Factoring in growing GI where benefits increase over time.
  - > Accounting for socio-economic changes over time; population, demographics and property value.
  - > Accounting for climate change risks and adaptation needs. For example, running two plausible scenarios where the first is the minimum level of risk that needs to be avoided and the second is close to the highest plausible, will generally be sufficient.

Select valuation methods

Valuation methods range from market-based tools, such as cost benefit analysis, through to simple ranking methods (see Appendix C). As markets do not exist for many of the types of benefits produced by GI, a variety of tools may be needed. Different methods can be used to address different subsets of total benefits or to compare alternative measures of value for the same categories of benefit (if resources permit).

It is important to avoid double counting, i.e., calculating the same benefit twice, in dollars. Any potential overlap in benefits should be noted when presenting the results. This can be managed by carefully assessing the stream of benefits and describing intermediate and/or uncertain benefits in qualitative terms.

Valuation methods are listed in Appendix C and can be found using the EVRI database search engine (also in Appendix C).

Where you need to build to

Systems that have the tools and integrated data needed to be able to comprehensively ascertain the cost and value of GI and its benefits. Established stakeholder networks that support ongoing work and development in this area.

Assess project value and prepare business case

Key task

To assess project value by analysing costs and benefits and prepare the business case for project approval.

Key considerations

- What costs are likely to be incurred if this project is not developed?
- Have the costs of innovation been factored in? (see page 23)
- What is the balance between monetary and non-monetary benefits, and how will they be presented?
- What is the value proposition from a policy perspective?
- What level of economic detail is needed for project approval?
- Does this project open up future options for achieving greater value down the track (e.g., improving water quality, linking urban forest canopy, broad scale flood protection, transport links)?

Where you start

A business case will be helped by additional current and future savings that can be made. For example, savings made through reducing damage sustained as a result of flooding or the capture and reuse of water through the development of wetlands and water harvesting projects. As the benefits and outcomes often continue over long time frames, it is important to include projected cost increases of any services currently provided through other means that can be replaced by GI.

Look to other areas of your organisation for data that may help support your business case in related areas such as community wellness and satisfaction and productive economic areas with GI. Current tools such as online tools such as iTree Eco (https://www.itreetools.org/eco/international.php) and research reports (Appendix C) are also useful resources. In terms of intangible values associated with GI, where there is not sufficient data available it is important to still note these in the business case.

Value costs and benefits

An economic analysis should, as much as possible, estimate a project's benefits in monetary terms. Using a consistent measure allows different types of benefits to be compared in the same units. It also allows the total costs over the project life cycle to be subtracted from the sum of benefits in order to assess net benefits from alternative proposals, which can be evaluated against each other and with the baseline scenario. Methods for valuing costs and benefits are described in more detail in Appendix D.

However, some benefits cannot be monetised due to lack of data or too great uncertainty, and other benefits because they should not be monetised for ethical reasons (e.g., the cost of species extinction, human mortality). Non-substitutable values should not be traded off by making them made invisible through conversion into a single metric. The Brooklyn business case prioritises a number of GI projects within a broader framework using both monetary and non-monetary criteria (see pages 28–30).

Establish the present value

The stream of costs and benefits over the life of the project need to be communicated in today's dollars to outline (Appendix D):

- The project costs in today's dollars
- Expected future benefits in today's dollars
- The anticipated return on investment over the life of the asset

The economic baseline, calculated earlier, serves as the baseline for calculating this.

Future dollar values are less than those of today's values for a wide range of reasons, the simplest being that inflation will reduce its value over time. This process is called discounting. Discounting rates for GI will be much lower than those for many other purposes, because of its long-lived nature, high social and environmental values and high intrinsic values.

The most common methods of discounting involves estimating net present values, annualised values or alternatively net future value.

Net present value (NPV)

The NPV of a projected stream of current and future benefits and costs relative to the initial baseline is calculated by applying a discount rate to the benefits and costs in each year, and summing all of the values.

The NPV of health and welfare benefits of reducing dust pollution over 30 years are assessed in the Brooklyn business case on pages 28–30.

Annualised values (AV)

An annualised value is the amount one would have to pay at the end of each time period (usually each year) so that the sum of all payments in present value terms equals the original stream of values. This is how insurance risk is calculated, where a stream of estimated costs over time (e.g., 50 years) is converted into an annualised value. A premium paid that avoids those costs effectively therefore yields a benefit. The annual cost of GI that reduces risk in that way can be seen as a form of insurance.

Net future value (NFV)

Instead of discounting all future values to the present, it is possible to estimate value in some future time period, for example, at the end of the last year of the project's effective life. One example is to estimate the community benefits of a part in 2050, compared to today.

Selecting a discount rate and comparing methods

If GI is substituting for conventional infrastructure (CI), then it makes sense that equivalent discount rates be used to ensure an equal comparison. Current rates for CI are 3–5% per annum.

A stormwater harvesting facility under construction in Fitzroy Gardens, Melbourne in 2014. This tank now supplies up to 119 megalitres of water per year to local parks.

For more traditional parks, nature parks are areas with high ecological values and those areas that are anticipated to exist over very long timescales, very low discount rates of 1.5% or even less may be justified (e.g., Gollier, 2010). Street trees that have a finite life and that will need replacement after a few decades will sit somewhere in the midst of this range. Undertaking an uncertainty analysis and presenting the results with a preferred and justified option is widely recommended.

For most GI projects, we recommend undertaking a sensitivity analysis at 1% and 3.5%, only going higher if the project is competing with a conventional infrastructure project that attracts a higher rate, say 5%.

Depending on the circumstances, one method might have certain advantages over the others. NPV of future benefits can be compared to the NPV of costs to calculate the ration of benefits to cost (e.g., for every dollar spend, the project expects x dollars in return). Annualised returns as a percent of the initial investment may also be of interest to finance professionals. Discounting to the present to get the total yield may be the most informative procedure when assessing a project that offers a stream of highly variable future benefits. Methods that use total benefits are preferred. For example, two projects with different benefit streams may reveal that the project that has a higher capital cost actually has a lower annual cost and offers greater benefits because of its longer lifetime.

The Brooklyn business case shows a roughly one-to-one return on water savings and direct pollution benefits, but multiple returns of community health and welfare is included in the business case. Business cases that combine social, environmental and economic returns are much more likely to be successful than those that concentrate on single aspects (see pages 28–30).

Where you need to build to

Systems that have the tools and integrated data needed to be able to comprehensively ascertain the cost and value of GI and its benefits. Established stakeholder networks that support ongoing work and development in this area.

Procure and construct (implementation)

Key task

To manage costs associated with the project implementation, particularly those associated with innovation.

Key considerations

Does your plan involve any of the following areas that result in additional costs:

- The use of new technologies?
- The application of a technology in a new context?
- The adaptation of current technology?
- Behaviour change or change management?
- The generation of new knowledge?
- Transformation or adaptation of current operational systems?
- New operational processes or practices?
- Uncertainty regarding the outcome of the project?

If any of the above factors are present, the project plan, budget and business case will need to ensure that potentially unexpected outcomes during implementation can be addressed effectively.

Where you start

Project plans are a key part of managing innovative projects. Pre-existing templates may need to be adjusted to reflect this. In some cases, it will simply mean adding in a new section or questions that ensure that this is appropriately managed.

Project risk management may also need to account for potential new risks due to uncertain outcomes that may not be catered for in current systems. The presence of increased risk also requires that interactions with internal and external stakeholders by carefully managed by factoring in the appropriate communication systems and processes needed to support this. Flexible governance that supports collaborative decision making will allow some level of autonomy, whilst still maintaining oversight.

Mechanisms for ongoing feedback and adjustment will need to be factored in to ensure that adjustments can be made throughout the process. Ongoing learning, communication and knowledge exchange may all be needed to support project evaluation and delivery.

Where you need to build to

An operational culture of continuous improvement that is flexible and has the knowledge, systems, processes and networks to support ongoing work for GI.

Project evaluation

Key task

To evaluate the cost-effectiveness of the implementation stage.

Key considerations

- How cost effective was the project implementation?
- Were there any unexpected costs and what were they?
- Has there been any unexpected benefits associated with the implementation and did they add value to the project?

Where you start

Evaluation of these projects has two key areas of assessment:

1. Project implementation performance, and
2. Outputs and outcomes from the project to date.

Evaluation provides an opportunity to look at what has worked and what hasn't worked and why. It is important to document and share learnings out of these evaluations. That way knowledge can be built to support better decision making and management of assets in this area. This can also potentially reduce future costs by identifying new ways of undertaking projects to improve outcomes.

It is also important to look at outputs and check for quality of service delivery. Appropriate mechanisms are needed to ensure that there is appropriate data to assess whether medium and long-term outcomes are meeting the aims of the initial project.

Where you need to build to

Well-defined criteria for evaluating GI projects that are established and accepted across the organisation. This evaluation system should not only ensure continuous improvement but should also integrate knowledge within councils and with the broader stakeholder group.

Asset valuation

Key task

To value assets and incorporate them on an asset register that monitors condition, service delivery, expected life, value and provides a record of upkeep.

Key considerations

- Is there a current asset register in operation at council level?
- How much modification would this register require to incorporate GI assets not currently included?
- Is there scope to incorporate biological assets into a register?
- Do tools that map growth phases of biological assets need to be developed?
- Are there important ecological functions and/or conservation aspects that are essentially irreplaceable on human timescales?

Where you start

Classes, subclasses and types of GI can be based on those developed for local government for conventional infrastructure, which can be adapted to better suit the different types of GI (Appendix E). Assets can also be linked to the delivery of goods and services by using an asset valuation and maintenance program that addresses infrastructure development, maintenance, upkeep and replacement. Asset condition can be linked to specific service levels. By adopting life cycle investment, an asset management program can focus on sustainable service delivery throughout an asset's life.

Green infrastructure assets have a number of similarities and differences with conventional infrastructure that need to be accounted for when valuing assets. For example:

- Methods of conventional asset valuation include market fair price, value of land with restricted uses, replacement cost and reproduction cost, and income approach all with various applications of depreciation or expected service.
- Many elements of GI grow after establishment; some are very long-lived and others may have finite lives (e.g., street trees). Fair asset value in these cases, will be a combination of establishment cost, upkeep, benefit flow and expected life. A fair value for natural assets needs to be developed taking into account the difficulty of replacing ecological services and biodiversity.
- Market valuations make a number of assumptions about substitutability and highest realisable value that misses out 'hidden' values or intangibles, challenging the placement of markets as the arbiter of fair value.
- Asset value ideally should allow for maintenance and upkeep, which preserve asset value and maintain a level of service delivery. This may also accommodate a data gathering role (see next section).

The simplest way to value infrastructure assets is through the cost of replacement, but this may not capture lost services if an asset is lost prematurely. GI can depreciate through lack of maintenance, but can also be extended long beyond its design life by ongoing upkeep and renewal. An asset may also be linked to specific levels of service, which cannot be met if infrastructure is allowed to degrade.

The preferred method of infrastructure reporting as expressed by public and private infrastructure asset managers is to assess the physical condition of assets, combined with current estimates of costs to bring to a satisfactory condition, taking account of written-down replacement costs for degraded assets (e.g., drought-stricken street trees).

This methodology links infrastructure condition to service delivery, vitally important for GI, which is more dynamic than most conventional infrastructure. Its condition at any time is important for understanding levels of service delivery, stage of biological development, potential stress factors and senescence (old age and loss of function). Valuing replacement of biological assets should ideally account for growth stage (juvenile to mature), because of the time it would take to regain a given level of service. For example, street trees have finite lifetimes because of the safety aspect whereas nature parks have planned lifetimes greater than a century and may have levels of ecosystem function that would take decades to centuries to recreate, if at all.

Where you need to build to

Well-defined criteria for assessing GI assets that is established and accepted across the organisation, consistent with the National Asset Management Framework, but taking into account biological and ecological factors.

Maintain and monitor

Key task

Ensure maintenance programs include monitoring of condition, service level and asset value. To ascertain the ongoing costs to maintain asset condition and ensure that the appropriate resources are allocated to support this part of the process.

Key considerations

- What monitoring and evaluation will be needed to effectively manage the service delivery, asset condition and reporting requirements?
- Can this be integrated into current monitoring and evaluation methods and if so how?
- What needs to be measured?
- What tools, systems, processes are needed?
- What resources (e.g., water) does this asset need that require monitoring over the lifetime of the asset?

Where you start

As all councils have different levels of maturity and resources, it is important to start with current knowledge about ongoing maintenance costs for assets such as trees and wetlands. The task of developing a business plan for a given project will help identify key gaps in data linking ecosystem services to economic values. Council may have to capacity to collect some of this data, but other data may be collected by other agencies (e.g., the EPA) or may require research to properly link physical measurements to dollar values.

As GI assets are dynamic in nature, maintenance, monitoring and evaluation needs will vary resulting in uneven ongoing costs. For example, environmental stress will require greater attention. It is important to factor contingency for these events into operational budgets.

The best place to start is with the current monitoring and evaluation tools used across your council. The next step is to look for opportunities to embed new questions and processes into the current systems. For example, tree safety checks could also incorporate other measurements that can help track the increasing benefits and level of services being offered by the tree. If you are a poorly resourced council then strategic partnerships can also be considered, such as engaging in citizen science. For example, local scout groups could potentially measure tree growth on an annual basis as part of their badge attainment.

Local businesses can potentially provide feedback on changes in commercial activity, and property prices can be monitored in areas adjacent to where projects have been undertaken. Once collected, this information can also be shared with key stakeholders and communities to show how their investment is performing and to increase awareness of the benefits of GI. These extra activities can sometimes be absorbed into pre-existing operational budgets, but some will need extra resources allocated to a project to facilitate this. However, such partnerships should be designed in such a way that adds net benefits and is not gathering data for its own sake.

The more sophisticated GI management and the development of business cases becomes, the more data is needed to produce an evidence base at the project proposal and operational stages. It can help to map a wish list of future data needs so you can capitalise on opportunities that arise. Systems for data management also need to have the flexibility to grow and change as knowledge and understanding develop.

It is also important to ensure that such data gathering and management is part of regular reporting frameworks and is not overlooked. Operationally, ongoing monitoring can also ensure appropriate adjustments are undertaken if an asset starts to perform differently during its life cycle to maximise the benefits and minimise non-functioning assets.

Assessing the impacts of external events such as extreme weather events are useful for informing the relevant areas of policy and management, particularly in relation to resilience and adaptation to climate change.

Where you need to build to

A system where you have integrated monitoring and reporting of data relating to GI assets that is accessed and understood across council and shared with the community and wider stakeholder group.

Review, retire, renew

Key task

To ensure strategic management to maintain level of services provided by GI assets.

Key considerations

- Is this asset part of a larger GI asset (e.g., an urban forest)?
- At what point will the benefits/services provided by this asset reach their maximum and potentially begin to decline?
- What is the strategy for renewal to maintain benefit service level of the asset/aggregated assets?
- How is this asset performing in the context of strategic aims and goals?

Where you start

Green infrastructure asset renewal relies heavily on timing and skills in urban ecology, because small, well-timed interventions can often yield sustained benefits, whereas missing such opportunities can lead to the premature loss of assets. This is one of the most overlooked aspects of GI management. It is well worth ensuring that a council's internal systems are flexible and responsive enough to recognise and address such needs.

Review at a more strategic planning level is also important. This depends upon how mature your council is in terms of policy, process and systems. Strategic reviews that review GI assets as a system (as well as individual assets) can be used to inform and shape policy at all levels of government. It can also ensure that appropriate provision to invest in the resources needed to sustain these assets in the long-term is available, and are renewed when appropriate.

Such reviews could be integrated into broader asset management systems so that they can be tracked and recorded. There may also be potential to share tasks, such as quality assurance, risk management and asset management, across areas of council to spread costs.

Where you need to build to

A program that enables of regular strategic reviews for GI as a programmed aspect of reporting, policy making and audit. A dedicated budget for the maintenance and improvement of GI.

Photo Shannon Reddaway

Brooklyn Industrial Precinct – Integrated Urban Water Management

The Brooklyn Industrial Precinct comprises approximately 330 ha of industrially-zoned land in Melbourne's west, 10 km from the CBD. It hosts over 60 industries including quarrying, former landfills, abattoirs, composting, materials recycling, tallow production and logistics. Many of the lots are unsealed, yielding about three times natural runoff, which flows into Kororoit and Stony Creeks. This runoff carries over 110 tonnes of pollutants each year. The air quality from the site is also the poorest in Melbourne. Dust and fine particles emitted by industry and transport on the site result in regulated limits of PM10 fine particles being exceeded on 28 days each year in the residential area south of the precinct. The safe limit is five days exceedance each year.

A project funded by the Office of Living Victoria and led by Brimbank City Council was tasked with developing a business case and vision for integrated urban water management for the precinct. The vision aims to manage the pollution problems and catalyse a transformation in industrial activity. Technical assistance was provided by E2 Design (water management and costings) and Victoria University (air quality assessment and economics).

Scoping and initial development

The project took two approaches: developing a vision to assess what potential benefits were valued most and assessing a physical baseline that assessed the current costs to community and the environment. In the scoping stage, workshops and meetings were held with the main stakeholders to determine the main areas of concern and establish a vision for the future. This helped set the core values for the business case.

The second approach was to gather baseline data for the project that looked at the water cycle and air pollution using data from the EPA, City West Water, council and the ABS. From this data, water use, pollution to local waterways, and health and welfare impacts of air pollution on the local population were assessed.

Setting up and establishing the baseline

Investigation of runoff and site water use identified the following statistics:

- Water use on the site averages 1,250 Ml per year, producing 1,198 Ml of trade waste.
- 587 Ml runoff from the site annually is estimated to carry 95 tonnes of sediments (76,000 80%), 225 kg phosphorus (101 45%), 1,645 kg nitrogen (740 45%), 12 tonnes litter, 5.1 tonnes of hydrocarbons, 80 kg lead, 190 kg zinc, and 35 kg copper.
- Air pollution consists of an estimated 308 tonnes PM10 and 40 tonnes PM2.5 emitted from the site each year. PM10 is emitted from crushing machinery and transport within the site and from traffic on roads within the site. PM2.5 is emitted from combustion engines (trucks, cars, incinerators and furnaces) and open fires.

Base case costs totally or partially estimated include:

- the market value of water use and waste water,
- removal cost for nitrogen pollution from waterways,
- the cost of monitoring, compliance and managing air pollution (see Table 3), and
- direct and indirect health and welfare costs of air pollution on affected residents.

Table 3

Maintenance and compliance	2012–2013	2013–2014
Ongoing ($000)	584	665
One-off actions ($000)	40	185

Noted, but not costed, include:

- pollution effects on approximately 1,700 workers,
- reputation damage as being known as the most polluted site in Melbourne to councils and business,
- costs of heavy metals being washed into waterways,
- effort expended by community groups in trying to manage the problem, and
- welfare costs of odour from the site.

Health costs were calculated for asthma hospitalisation and early death by health modelling of the affected population of 17,000 people, using Australian health data for asthma costs and the statistical value of life for mortality. The welfare costs of air pollution were estimated by transferring the results from two US studies to the Brooklyn site (Benefit transfer method). These studies estimate (1) willingness to pay to have clean air and (2) levels of happiness related to air pollution produced through the difference in household income between clean and polluted locations.

Direct health costs total $7.1 million per year, the rest being taken up by the estimated costs of added mortality. The median welfare costs to the broader community are an estimated $15.5 million per year. Over the past twenty years, allowing for changes in the consumer price index, this amounts to $431 million with estimates ranging from $364 million to $736 million, mostly based as welfare losses (see Table 4).

Collate project benefits

Monetary benefits were calculated from the following actions:

- substitution of potable water by recycled water and rainwater
- increases in human welfare by reducing air pollution levels
- decreased health care and mortality losses
- benefits (increased welfare, decreased health and mortality costs) of tree planting

Table 4

	Low	Median	High
Total health cost PM10 ($m)	2.5	2.7	4.3
Total health cost PM25 ($m)	2.2	4.4	7.1
Total health cost ($m)	4.8	7.1	11.4
Welfare losses PM10 ($m)	13.0	15.5	28.7
Total losses ($m)	17.8	22.5	40.1
Health losses 1994–2013 ($m)	97	135	209
Welfare losses 1994–2013 ($m)	267	296	527
Total losses 1994–2013 ($m)	364	431	736

- limited benefits of dust suppression through street sweeping/watering
- benefits of nutrient removal costed according to costs of direct removal methods.

Qualitative benefits identified were:

- improved neighbourhood image
- improved business image
- improved visual amenity
- increased residential and commercial property values
- options on future improvements in water quality within catchment (by removing large pollution source), and
- pollutant removal not costed (e.g., ozone, nitrous oxide, lead, copper).

While a general level of benefit could be estimated by addressing various best practice relationships, specific benefits could not be estimated without having an overview of specific projects. Instead various scenarios for integrated urban water management were proposed.

Examples of benefits and methods used to calculate them include:

- Street sweeping removes sediment from roads. If the two dirtiest roads are cleaned or watered at a nominal cost of $225 (three hours of truck time), the benefit is estimated to be $1,845 reduction in health costs and $25,080 in welfare costs for reducing one day's pollution. This was calculated by taking the difference between dust emitted from the dirtiest and cleanest roads through dust modelling carried out for the EPA.
- Tree benefits for health and welfare per year were estimated as being $13,800 per hectare. PM10 and PM2.5 removal rates were taken from US studies of urban pollution removal and benefit transfer as described above. Other pollutants (ozone, nitrous oxide, sulphates and carbon monoxide) were not included, so would add further value. The polluted nature of the site means also that capture rates will be underestimated.
- Removing 55% of the pollution by keeping all roads as sediment free as the cleanest road would return $184 million in health and welfare benefits over 30 years at 3.5% discount rate.

Evaluation options for integrated urban water management

- A number of project components aiming to manage the sediment and water cycle on the site assessed for their relative costs and benefits in terms of water use. These included site transport, sediment and erosion management plans, strategic planning for redevelopment, on-site stormwater detention and reuse, perimeter greening, rain gardens, rainwater tanks, green roofs, roadway management and streetscape greening.
- Options were rated high, medium and low based on a multi-criteria analysis that included a limited benefit cost ratio but also assessed physical effectiveness in managing pollution and water conservation and support amongst stakeholders (Table 5).

Kororoit Creek, Brooklyn Industrial Precinct

Table 5

Project	Priority
Perimeter greening – swales and tree-lined	High
On-site stormwater detention and reuse	High
Perimeter greening – swales only	Medium
Rain gardens	Medium
Rainwater tanks	Medium
Green roofs	Low

Poor water quality, Kororoit Creek

Business plan

A master plan was constructed for the site that treated 216 hectares of catchment, reducing potable water use by 29 Ml per year, stormwater runoff by 162 Ml per year, reducing total suspended solids by 50 tonnes, nitrogen by 700 kg, litter by ten tonnes and increasing green space by 47 hectares. It was not possible to estimate the total health and welfare benefits of these actions, but they are considered to be a large proportion of current pollution (Table 6).

Clearly, the social returns from implementing this project would be overwhelmingly positive. Ongoing barriers are provided by who pays and who benefits? Ideally, a project such as this would involve private industry, local government, state government and the community, all who stand to benefit in different ways.

Acknowledgements: City of Brimbank, Victorian Government (funding), E2Designlab, EPA Victoria, The Brooklyn Residents Action Group, and private industries within the Brooklyn Industrial Precinct.

Table 6 Estimated costs and benefits of the projects proposed in the medium scenario over a 30-year period in $million using a 3.5% discount rate. Note that dust control is for PM10 unless stated otherwise.

		Total
Costs	Upfront – construction and establishment	$9.3
	Ongoing – annual operation/maintenance	$5.7
	Total costs	$14.9
Benefits	Nitrogen treatment offset	$5.0
	Potable water savings	$1.3
	Air quality improvement (trees)	$0.2
	Total benefits	$6.5
Benefits of dust control	Two worst roads sealed and clean	$81.2
	All roads onsite best practice (55%)	$184.7
	All sediment under control	$333.4
	Ten percent reduction in PM2.5	$8.1

Case Study 2

Erith Marshes and Belvedere Links, Belvedere, London Thames Gateway

The project will rehabilitate 156ha of existing marshland, including 15km of drainage dykes, and redevelop 12.5ha of derelict land. A new link road is being built to open up 70ha of vacant land in a flood prone area of low employment. The marshland rehabilitation will offer recreation services, water treatment, flood protection, conservation and outdoor exercise. The number of residents living within 300m and 1200m of the project were estimated to be over 5,000 and around 47,500, respectively.

Climate change adaptation and mitigation

Urban cooling impacting on 2,000 to 2,500 households within 300–450m of the marshes. Uncosted.

Water management and flood alleviation

Savings on energy and carbon emissions through the use of natural drainage to reduce water treatment costs. Value £0.6 million and £0.3 million, respectively, at present value (PV).

Health and wellbeing

Reduction in mortality rates from increased take-up of moderate exercise (walking and cycling) of £7.4million (PV) for walking and £1.5 million (PV) for cycling.

Land and property values

Estimated residential land and property uplift within a 450m radius of the site of £9.5 million (PV).

Investment

Green links employment increase estimated as 650, but combined road link and green link addition of 6,500 the estimation of site employment benefit was £31 million (PV).

Labour productivity

Reduced absenteeism was calculated to be worth between £0.1 million and £0.5 million (PV).

Recreation and leisure

Based on a ‘willingness to pay’ measure, the recreational benefits were estimated to be £1.64 million (PV).

Biodiversity

Erith Marshes are key remnants of grazing marshes in south London with high conservation status. Uncosted.

Land management

Direct employment in land management for three people, benefit of £0.6 million (PV).

Wetlands

Summary

The total value of benefits generated, most over ten years, was estimated to be £53.1 million–£55.8 million (PV). Just over half (56%) was increased employment potential considered attributable to the GI.

Total capital investment by regeneration and economic development agencies is £10.54 million, including road construction and £1.84 million for landscape improvements. The return on total investment is approximately 5:1, but the GI implies a net additional benefit of up to 25:1. (Note that a great deal of private investment would be needed to actually create the employment, so that the most direct benefit there is attraction of private investment.)

Source: Natural Economy Northwest, CABE, Natural England, Yorkshire Forward, The Northern Way, Design for London, Defra, Tees Valley Unlimited, Pleasington Consulting Ltd, and Genecon LLP (2010). *Building natural value for sustainable economic development: Green Infrastructure Valuation Toolkit*. Version 1.3 (updated in 2014). http://bit.ly/givaluationtoolkit

Case Study 3

Knowledge Quarter, Liverpool

Liverpool's Knowledge Quarter (LKQ) is a diverse inner city neighbourhood which includes three universities, the two cathedrals, a large teaching hospital, a concert hall, theatres, restaurants and bars. A residential district includes attractive Georgian streets and squares.

A program of street improvements (projects estimated at £15 million) and place improvements (projects estimated at £7.25 million) was proposed. As a follow-up, a GI Enhancement Plan was commissioned. The plan proposes a net gain in green cover of 7.7ha, increasing it from 37.7ha (22% of the area) to 45.4ha (27% of the area). This increase is planned to be primarily in the form of street trees (3,300) and green roofs, with some additional green spaces.

Direct beneficiaries are residents (7,500) and visitors to the LKQ, including employees (26,250), students (45,200) and patients at the hospital (uncounted). Some benefits were valued over 10 years, others 25 years.

Climate change adaptation and mitigation

Savings in energy costs from reducing heating and reduced carbon emissions estimated to be £3.4 million–£4.7 million at present value (PV). Stored carbon in trees £6K–£18K (PV).

Water management and flood alleviation

Water saving and water treatment savings (primarily due to green roofs) worth £1.6 million–£2.0 million (PV).

Health and wellbeing

Pollution control benefits £14K–£112K (PV).

Land and property values

Over 2,000 houses within the LKQ and over 4,000 just outside (within 450m) estimated property value uplift of £1.7 million–£6.7 million (PV).

Investment

Assuming 5,600 – 8,000 additional jobs created over the next decade and that 7% is attributable to the GI, this equates to £23 million–£32 million (PV).

Place and communities

Improved quality of place. Uncosted.

Land management

Direct employment in land management for 1.5 people, benefit of £40k (PV).

Liverpool, UK

Summary

The value of the GI benefits were estimated to be between £29.3 million and £45.6 million (PV). 70%–78% is accounted for by increased employment benefits and 10%–12% by climate change adaptation benefits. On a proposed landscape capital investment of £29.7 million, at the lower estimate of value, the benefits almost cover the cost of investment, and at the higher end of the range there is a definite positive return. Benefit value is likely to have been understated, because considerable benefits to both hospital patients and visitors to the area have not been quantified); nor has air pollution reduction.

Source: Natural Economy Northwest, CABE, Natural England, Yorkshire Forward, The Northern Way, Design for London, Defra, Tees Valley Unlimited, Pleasington Consulting Ltd, and Genecon LLP (2010). *Building natural value for sustainable economic development: Green Infrastructure Valuation Toolkit*. Version 1.3 (updated in 2014). http://bit.ly/givaluationtoolkit

Appendix A GI benefits and valuation tools

	GI	Benefit	Tool description
1	Trees providing shelter for buildings, level of green cover	Reduced building energy consumption for heating ($)	Quantification and monetisation available for residential properties.
2		Avoided carbon emissions from building energy saving for heating ($, E)	Quantification and monetisation available for properties. Estimates reduction in carbon emissions associated with energy savings for heating by multiplying energy reduction (in kWh) by 0.203.
3		Avoided damage from wind and storms ($)	Quantification and monetisation require further research.
4	**Level of green cover**	Reduction of peak summer surface temperatures (H&W)	Estimates reduction in peak temperature, a key factor in improving the liveability of urban areas during summer months.
5	**Trees and green roofs**	Reduced energy consumption for cooling ($)	Quantification and monetisation functional only for green roofs. Further work required to also factor in the cooling effect of trees surrounding the buildings. Estimates reductions in air conditioning cost associated with having green roofs on buildings.
6	**Trees, green roofs, adjacent parks**	Avoided carbon emissions from building energy saving for cooling ($, E)	Estimates the reduction in carbon emissions associated with energy savings for cooling by multiplying the reduction in energy consumption (in kWh) by 0.537.
7	**Areas of urban forest**	Carbon stored and sequestered in woodland and forests ($, E)	Quantification and monetisation functional for most tree types.
8	**All vegetation**	Carbon stored and sequestered in non-woodland based landscapes ($, E)	Quantification and monetisation require further research.
9	**WSUD, vegetation**	Energy and carbon emissions savings from reduced stormwater volume entering combined sewers ($, E)	Estimates the energy savings associated with the impact of vegetation on reducing the amount of stormwater entering combined sewers.
10	**On property grey water collection**	Reduced wastewater treatment costs for domestic and commercial water customers ($)	Uses published water industry figures for surface water drainage charges, to estimate the actual cost savings to residential and commercial customers who are not draining rainwater into combined sewers.
11	**Water storage and retention**	Avoided costs of traditional water drainage infrastructure ($)	Estimates cost saving from managing stormwater through SUDS rather than through traditional engineering solutions.
12	**Open space views**	Willingness to pay for a view of urban green space (amenity)	Quantification and monetisation require further research.
13	**Natural areas**	Increase in volunteering	Quantification and monetisation require bespoke appraisal.
14	**Active open space**	Health costs savings from increase in physical activity	Quantification and monetisation require further research.
15	**Active and passive open space**	Reduced mortality from increased walking and cycling	Estimates the reduction in mortality rates from take-up of moderate physical exercise through walking or cycling.
16	**Active and passive open space, parks**	Health cost savings from mental health disorders	Quantification and monetisation require further research.
17	**Open space near health facilities**	Health cost savings from reduced inpatient stays ($, W)	Quantification and monetisation require further research.
18	**Trees reducing air pollution**	Reduced mortality from respiratory illnesses ($, W)	Quantification and monetisation require further research.
19	**Trees, green walls and roofs**	Avoided costs for air pollution control measures ($)	Estimates savings from not having to implement other pollution control measures to prevent emissions or remove from the air sulphur dioxide, carbon monoxide, PM10 captured by trees.
20	**Quality open space**	Residential land and property values uplift ($)	Estimates residential land and property uplift within 450 metres of park/open space.

21		Commercial land and property values uplift ($)	Commercial land and property uplift – requires bespoke willingness to pay surveys with prospective investors/developers, purchasers, tenants or occupiers.
22		Private sector investment levered ($)	Quantification and monetisation require further research. Estimate of the level of private sector investment levered.
23		Employment creation ($, W)	Quantification and monetisation require further research. Estimates site employment capacity and employment based gross value added (GVA) that can be attributed to the presence of high quality GI.
24		Image enhancement ($)	Quantification and monetisation require further research. No generally applicable monetisable tool, but anecdotally, high quality environment has been reported to influence location decision-making.
25	**All GI**	Savings from reduced employee turnover ($)	Quantification and monetisation require further research.
26		Increase in labour productivity ($)	Quantification and monetisation require further research.
27		Savings from reduced absenteeism from work ($, W)	Quantification and monetisation functional only for the amount of work days loss avoided. Estimates the reduction in working days lost and associated employment-based GVA.
28		Tourism expenditure ($)	Estimates the volume and value of tourism-related expenditure.
29		Employment supported by tourism ($)	Quantification and monetisation require good project data. Estimates the number of jobs supported by tourism activity and GVA associated with employment.
30		Recreational use by the local population (H&W)	Estimates the willingness to pay for various types of outdoor recreation.
31		Willingness to pay for protection or enhancement of biodiversity (E)	Application of benefit transfer values from appropriate studies.
32	**Environmental goods**	Market value of products ($)	Quantification and monetisation require bespoke appraisal.
33	**Quality open space**	Employment supported by land management ($)	Employment-based GVA generated by land management.
34		Health Economic Assessment Tools (H&W)	Assess health benefits and are not specific to a certain type of GI feature. The benefit of these recreation activities is measured through reduced mortality.
35		Capital Asset Value for Amenity Trees (CAVAT) (Multivalue)	Estimates the cost of replacing a tree. The cost can be adjusted for location, relative contribution to amenity value, and assessment of functionality and life expectancy.
36		iTree design (Multivalue)	Assessments of individual or multiple trees at the parcel level.
37	**Trees**	iTree eco (Multivalue)	Uses field data from complete inventories or randomly located plots throughout a community along with local hourly air pollution and meteorological data to quantify urban forest structure, environmental effects, and values to communities.
38		iTree streets (Multivalue)	Focuses on the benefits provided by street trees. It makes use of a sample or complete inventory to quantify and put a monetary value on the street trees' annual environmental and aesthetic benefits.
39	**Parks, urban forests**	Integrated Valuation of Environmental Sciences and Tradeoffs (InVEST) (Multivalue)	Family of tools to map and value ecosystem goods and services provided by terrestrial, freshwater, and marine ecosystems.

Additional guidance: the evaluation tools described in Appendix A can be found in the following documents: Center for Neighborhood Technology. (2010). *The Value of Green Infrastructure A Guide to Recognizing Its Economic, Environmental and Social Benefits*; Natural Economy Northwest. (2010). *Building Natural Value for Sustainable Economic Development. The Green Infrastructure Valuation Toolkit User Guide*; Natural England. (2009). *Green Infrastructure Guidance Report NE176*; and Natural England. (2013). *Green Infrastructure – Valuation Tools Assessment Commissioned Report NECR126*.

Appendix B Parks and open space

			Parks	Sporting areas	Formal gardens and zoos	Cemeteries
Social	i) Human health and wellbeing	(a) Physical	14, 15, 17, 18, 30, 34, 35, 37, 38	14, 15, 17, 18, 30, 34, 35, 37, 38,	14, 15, 17, 18, 30, 34, 35, 37, 38	37
		(b) Social and psychological	12, 16, 37, 38	16, 37, 38	12, 16, 37, 38	37
		(c) Community				
	ii) Cultural and spiritual					
	iii) Visual and aesthetic					
Economic	i) Commercial vitality		22, 23, 24, 28, 29	22, 23, 24, 28, 29	22, 23, 24, 28, 29	
	ii) Increased property values		20, 21, 24	20, 21, 24	20, 21, 24	
	iii) Value of ecosystem services					
Environmental	i) Climatic modification	(a) Temperature reduction	4, 5, 6	4, 5, 6	4, 5, 6	4, 5, 6
		(b) Shading				
		(c) Evapotranspiration				
		(d) Wind speed modification	3	3	3	3
	ii) Climate change mitigation	(a) Carbon sequestration and storage	7, 8, 37, 39	7, 8, 37, 39	7, 8, 37, 39	7, 8, 37, 39
		(b) Avoided emissions (reduced energy use)	1, 2, 6, 37, 45	1, 2, 6, 37, 45	1, 2, 6, 37, 45	1, 2, 6, 37, 45
	iii) Air quality improvement	(a) Pollutant removal	1, 2, 6, 18, 19, 37, 39	1, 2, 6, 18, 19, 37, 39	1, 2, 6, 18, 19, 37, 39	1, 2, 6, 18, 19, 37, 39
		(b) Avoided emissions	1, 2, 6, 37	1, 2, 6, 37	1, 2, 6	1, 2, 6
	iv) Water cycle modification	(a) Flow control and flood reduction	10, 37, 43	10, 37, 43	10, 37, 43	10, 37, 43
		(b) Canopy interception	37	37	37	37
		(c) Soil infiltration and storage	37, 39	37, 39	37, 39	37, 39
		(d) Water quality improvement	9, 10, 11, 37, 39	9, 10, 11, 37, 39	9, 10, 11, 37, 39	9, 10, 11, 37, 39
	v) Soil improvements	(a) Soil stabilisation				
		(b) Increased permeability				
		(c) Waste decomposition and nutrient cycling				
	vi) Biodiversity	(a) Species diversity	31, 37, 39	31, 37, 39	31, 37, 39	31, 37, 39
		(b) Habitat and corridors	31, 37	31, 37	31, 37	31, 37
	vii) Food production	(a) Productive agricultural land				
		(b) Urban agriculture				

Additional note: cells without numbers show where further research is needed, or where studies exist but were not located by the research team.

Water infrastructure

			WSUD	Rain gardens	Permeable pavements	Stormwater management
Social	i) Human health and wellbeing	(a) Physical	38			
		(b) Social and psychological	38	12, 16, 38		
		(c) Community				
	ii) Cultural and spiritual					
	iii) Visual and aesthetic					
Economic	i) Commercial vitality		22, 23, 24	22, 23, 24		
	ii) Increased property values			20, 21, 24		
	iii) Value of ecosystem services					
Environmental	i) Climatic modification	(a) Temperature reduction		4, 5, 6		
		(b) Shading				
		(c) Evapotranspiration				
		(d) Wind speed modification				
	ii) Climate change mitigation	(a) Carbon sequestration and storage		8, 37, 39, 51, 52		
		(b) Avoided emissions (reduced energy use)				
	iii) Air quality improvement	(a) Pollutant removal		1, 2, 6, 19, 37, 39, 48, 49		
		(b) Avoided emissions	9			9
	iv) Water cycle modification	(a) Flow control and flood reduction	9, 10, 11	9, 10, 11	9, 10, 11	9, 10, 11
		(b) Canopy interception				
		(c) Soil infiltration and storage		37, 39		
		(d) Water quality improvement		9, 10, 11, 37, 39		
	v) Soil improvements	(a) Soil stabilisation				
		(b) Increased permeability				
		(c) Waste decomposition and nutrient cycling				
	vi) Biodiversity	(a) Species diversity				
		(b) Habitat and corridors				
	vii) Food production	(a) Productive agricultural land				
		(b) Urban agriculture				

Natural areas, waterways and bush

			Rivers and streams	Conservation parks	Coastal margins	Wetlands
Social	i) Human health and wellbeing	(a) Physical	14, 15, 17, 18, 30, 34, 37, 38	14, 15, 17, 18, 30, 34, 35, 37	14, 15, 17, 18, 30, 34, 35, 37	14, 15, 17, 18, 30, 34, 35, 37
		(b) Social and psychological	12, 16, 37	12, 16, 37	12, 16, 37	12, 16, 37
		(c) Community				
	ii) Cultural and spiritual					
	iii) Visual and aesthetic					
Economic	i) Commercial vitality		22, 23, 24, 28, 29	22, 23, 24, 28, 29	22, 23, 24, 28, 29	22, 23, 24, 28, 29
	ii) Increased property values		20, 21, 24	20, 21, 24	20, 21, 24	20, 21, 24
	iii) Value of ecosystem services					
Environmental	i) Climatic modification	(a) Temperature reduction	4, 5, 6	4, 5, 6	4, 5, 6	4, 5, 6
		(b) Shading				
		(c) Evapotranspiration				
		(d) Wind speed modification		3	3	3
	ii) Climate change mitigation	(a) Carbon sequestration and storage		7, 8, 37, 39	7, 8, 37, 39	7, 8, 37, 39
		(b) Avoided emissions (reduced energy use)		1, 2, 5, 6, 37	1, 2, 5, 6, 37	1, 2, 5, 6, 37
	iii) Air quality improvement	(a) Pollutant removal		1, 2, 6, 18, 19, 37, 39	1, 2, 6, 18, 19, 37, 39	1, 2, 6, 18, 19, 37, 39
		(b) Avoided emissions		1, 2, 6, 37	1, 2, 6, 37	1, 2, 6, 37
	iv) Water cycle modification	(a) Flow control and flood reduction		9, 10, 11, 37	9, 10, 11, 37	9, 10, 11, 37
		(b) Canopy interception		37	37	37
		(c) Soil infiltration and storage		37, 39	37, 39	37, 39
		(d) Water quality improvement		9, 10, 11, 37, 39	9, 10, 11, 37, 39	9, 10, 11, 37, 39
	v) Soil improvements	(a) Soil stabilisation				
		(b) Increased permeability				
		(c) Waste decomposition and nutrient cycling				
	vi) Biodiversity	(a) Species diversity	31, 39	31, 37, 39	31, 37, 39	31, 37, 39
		(b) Habitat and corridors	31	31, 37	31, 37	31, 37
	vii) Food production	(a) Productive agricultural land				
		(b) Urban agriculture				

Built environments – Part A

			Houses and apartments		Commercial	
			Building envelope	Garden	Building envelope	Open space
Social	i) Human health and wellbeing	(a) Physical		35		35, 38
		(b) Social and psychological				38
		(c) Community				
	ii) Cultural and spiritual					
	iii) Visual and aesthetic					
Economic	i) Commercial vitality					
	ii) Increased property values					
	iii) Value of ecosystem services					
Environmental	i) Climatic modification	(a) Temperature reduction				
		(b) Shading				
		(c) Evapotranspiration				
		(d) Wind speed modification				
	ii) Climate change mitigation	(a) Carbon sequestration and storage	50	7, 8, 36, 39	7, 8	7, 8, 36, 39
		(b) Avoided emissions (reduced energy use)		5, 36	5	5, 36
	iii) Air quality improvement	(a) Pollutant removal	47	36, 39, 48, 49	47	36, 39, 48, 49
		(b) Avoided emissions		36		36
	iv) Water cycle modification	(a) Flow control and flood reduction		9, 10, 11, 36		9, 10, 11, 36
		(b) Canopy interception		38		38
		(c) Soil infiltration and storage		38, 39		38, 39
		(d) Water quality improvement		9, 10, 11, 38, 39		9, 10, 11, 38, 39
	v) Soil improvements	(a) Soil stabilisation				
		(b) Increased permeability				
		(c) Waste decomposition and nutrient cycling				
	vi) Biodiversity	(a) Species diversity		39		39
		(b) Habitat and corridors				
	vii) Food production	(a) Productive agricultural land				
		(b) Urban agriculture				

Built environments – Part B

			Industrial		Council properties	
			Building envelope	Open space	Building envelope	Open space
Social	i) Human health and wellbeing	(a) Physical		35, 38		35, 38
		(b) Social and psychological		38		38
		(c) Community				
	ii) Cultural and spiritual					
	iii) Visual and aesthetic					
Economic	i) Commercial vitality					
	ii) Increased property values					
	iii) Value of ecosystem services					
Environmental	i) Climatic modification	(a) Temperature reduction				
		(b) Shading				
		(c) Evapotranspiration				
		(d) Wind speed modification				
	ii) Climate change mitigation	(a) Carbon sequestration and storage	50	7, 8, 36, 39	7, 8	7, 8, 36, 39
		(b) Avoided emissions (reduced energy use)	44	5, 36	5	5, 36
	iii) Air quality improvement	(a) Pollutant removal	47	19, 36, 39	19	19, 36, 39
		(b) Avoided emissions		36		36
	iv) Water cycle modification	(a) Flow control and flood reduction		9, 10, 11, 36		9, 10, 11, 36
		(b) Canopy interception		38		38
		(c) Soil infiltration and storage		38, 39		38, 39
		(d) Water quality improvement		9, 10, 11, 38, 39		9, 10, 11, 38, 39
	v) Soil improvements	(a) Soil stabilisation				
		(b) Increased permeability				
		(c) Waste decomposition and nutrient cycling				
	vi) Biodiversity	(a) Species diversity		39		39
		(b) Habitat and corridors				
	vii) Food production	(a) Productive agricultural land				
		(b) Urban agriculture				

Transport – Part A

			Roads		Rail	
			Sealed surfaces	Verges	Tracks	Verges
Social	i) Human health and wellbeing	(a) Physical		38		38
		(b) Social and psychological		38		38
		(c) Community				
	ii) Cultural and spiritual					
	iii) Visual and aesthetic					
Economic	i) Commercial vitality					
	ii) Increased property values					
	iii) Value of ecosystem services					
Environmental	i) Climatic modification	(a) Temperature reduction				
		(b) Shading				
		(c) Evapotranspiration				
		(d) Wind speed modification				
	ii) Climate change mitigation	(a) Carbon sequestration and storage		7, 8, 36, 39	7, 8	7, 8, 36, 39
		(b) Avoided emissions (reduced energy use)		45		45
	iii) Air quality improvement	(a) Pollutant removal		19, 36, 39		19, 36, 39
		(b) Avoided emissions				
	iv) Water cycle modification	(a) Flow control and flood reduction		9, 10, 11		9, 10, 11
		(b) Canopy interception				
		(c) Soil infiltration and storage		39		39
		(d) Water quality improvement		9, 10, 11, 39		9, 10, 11, 39
	v) Soil improvements	(a) Soil stabilisation				
		(b) Increased permeability				
		(c) Waste decomposition and nutrient cycling				
	vi) Biodiversity	(a) Species diversity		39		39
		(b) Habitat and corridors				
	vii) Food production	(a) Productive agricultural land				
		(b) Urban agriculture				

Transport – Part B

			Tram		Pavements and bike/pedestrian pathways	
			Tracks	Verges	Sealed	Unsealed/verges
Social	i) Human health and wellbeing	(a) Physical		38		38
		(b) Social and psychological		38		38
		(c) Community				
	ii) Cultural and spiritual					
	iii) Visual and aesthetic					
Economic	i) Commercial vitality					
	ii) Increased property values					
	iii) Value of ecosystem services					
Environmental	i) Climatic modification	(a) Temperature reduction				
		(b) Shading				
		(c) Evapotranspiration				
		(d) Wind speed modification				
	ii) Climate change mitigation	(a) Carbon sequestration and storage		7, 8, 36, 39	7, 8	7, 8, 36, 39
		(b) Avoided emissions (reduced energy use)		45		45
	iii) Air quality improvement	(a) Pollutant removal		19, 36, 39		19, 36, 39
		(b) Avoided emissions				
	iv) Water cycle modification	(a) Flow control and flood reduction		43		43
		(b) Canopy interception				
		(c) Soil infiltration and storage		39		39
		(d) Water quality improvement		9, 10, 11, 39		9, 10, 11, 39
	v) Soil improvements	(a) Soil stabilisation				
		(b) Increased permeability				
		(c) Waste decomposition and nutrient cycling				
	vi) Biodiversity	(a) Species diversity		39		39
		(b) Habitat and corridors				
	vii) Food production	(a) Productive agricultural land				
		(b) Urban agriculture				

Food and fibre

			Market gardens	Urban horticulture and agriculture	Community gardens
Social	i) Human health and wellbeing	(a) Physical	38	38	38
		(b) Social and psychological	38	38	38
		(c) Community			
	ii) Cultural and spiritual				
	iii) Visual and aesthetic				
Economic	i) Commercial vitality				22, 23, 24
	ii) Increased property values				20, 21, 24
	iii) Value of ecosystem services				
Environmental	i) Climatic modification	(a) Temperature reduction	4, 5, 6	4, 5, 6	4, 5, 6
		(b) Shading			
		(c) Evapotranspiration			
		(d) Wind speed modification	3	3	3
	ii) Climate change mitigation	(a) Carbon sequestration and storage	8, 39	8, 39	8, 39
		(b) Avoided emissions (reduced energy use)	1, 2, 5, 6	1, 2, 5, 6	1, 2, 5, 6
	iii) Air quality improvement	(a) Pollutant removal	1, 2, 6, 19, 39	1, 2, 6, 19, 39	1, 2, 6, 19, 39
		(b) Avoided emissions	1, 2, 6	1, 2, 6	1, 2, 6
	iv) Water cycle modification	(a) Flow control and flood reduction	43	43	43
		(b) Canopy interception	38	38	38
		(c) Soil infiltration and storage	38, 39	38, 39	38, 39
		(d) Water quality improvement	9, 10, 11, 38, 39	9, 10, 11, 38, 39	9, 10, 11, 38, 39
	v) Soil improvements	(a) Soil stabilisation			
		(b) Increased permeability			
		(c) Waste decomposition and nutrient cycling			
	vi) Biodiversity	(a) Species diversity	39	39	39
		(b) Habitat and corridors			
	vii) Food production	(a) Productive agricultural land			
		(b) Urban agriculture			

Appendix C GI valuation methods

Ideally, valuation will consider a project from the R&D stage through its entire life cycle. A barrier is that different potential options may be address different benefits, so are hard to compare. The relative size of a benefit may also be uncertain because of the wide range of possible futures that may be encountered. An example is where a town vulnerable to sea level rise, storm surge and groundwater contamination may weigh up the different benefits of protection and relocation.

Benefits

Benefits can be valued according to the following hierarchy:

- Direct economic benefits with market values.
- Indirect benefits that can be allocated a shadow or proxy price that sustain social and environmental values through areas such as social welfare and environmental health.
- Acquired values with benefits ranging from direct to indirect, but often convertible into dollar values.
- Existence and other ethically-framed values.

Valuation draws upon many tools, the broad categories of which are described below.

Market valuation

Benefits sold or exchanged within markets can be given a direct monetary value – a price.

Shadow pricing

Shadow pricing methods estimate the value of an asset or commodity by the benefits associated with closely linked economic variables. For example, property prices are higher near open space providing shadow prices for the benefits of open space amenity in urban settings. It is a method for assessing mean conditions and not suitable for assessing rapid change. However, it has great potential for assessing the co-benefits of adaptations where social and environmental outcomes are important.

The use of substitution is also an important tool, where a market value is substituted for a like activity. For example, the use of open space for exercise can be valued according to paying for the same service in a gymnasium. This principle has led to local government charging rents for private use of public space where public good is contributing to private gain.

Preference methods

Three formal methods for eliciting value preferences are willingness to pay (WTP), willingness to avoid damages (WTA), which are both stated preference methods (what people say) and assessments of how people behave in given circumstances, or revealed preference. These methods are subject to framing effects where the first two are asymmetric, but measure the same thing, and the second only deals with past but not future values. An example of revealed preference is when travel costs are used to value visits to a location such as a park or beach – the average cost paid then becomes the value a person obtains from each visit.

WTP and WTA are often used to measure intrinsic value but are not recommended for that purpose as open-ended questions about what a person may pay to preserve nor not lose a benefit are considered unreliable. Such methods are more reliable if linked to a bounded and clear transaction or payoff.

Benefits transfer

One such web-based resource is the Canadian-run Environmental Valuation Reference Inventory (EVRI). EVRI is a software toolkit that uses the benefits transfer approach to estimate economic values for changes in environmental services. Existing studies can be used (transferred) to estimate the economic value of changes stemming from other programmes or policies. In conducting an economic valuation with a benefits transfer, it is important to find the most appropriate studies to use in the benefits transfer exercise. The toolkit helps the user define the service to be valued and identifies studies with potential for transfer. EVRI includes a database of more than 2000 environmental valuation studies. A similar searchable database has been compiled by the New South Wales Government Department of Environment and Climate Change.

The main challenge faced in conducting an economic valuation with a benefits transfer is in finding the most appropriate studies to use in the transfer exercise. Choosing an appropriate set of studies involves matching the context of the previous economic study(ies), termed study sites, with the context of the current program or policy, termed the policy site. The EVRI has been designed specifically to help economists evaluate the quality of the information about the study site(s) and to match the studies with current policy sites. The EVRI's search tool assists the user to define the good or service to be valued and identifies studies with potential for transfer. The Screening Module helps the user assess the suitability of the studies identified in the search according to criteria outlined in the benefits transfer literature.

The EVRI's abstracts of valuation studies outline the relevant valuation issues and results necessary for a researcher to identify the most appropriate studies for a potential benefits transfer. The five main categories of information include:

1. **Study reference** – basic bibliographic information.
2. **Study area and population characteristics** – information about the location of the study along with population and site data.
3. **Environmental focus of the study** – fields that describe the environmental asset being valued, the stressors on the environment, and the specific purpose of the study.
4. **Study methods** – technical information on the actual study, along with the specific techniques that were used to arrive at the results.
5. **Estimated values** – the monetary values that are presented in the study as well as the specific units of measure.

The range of studies within the EVRI varies broadly according to geographic location, assets and benefits valued and valuation techniques. This is shown in Figures C1–C4 on page 45. As can be seen in the Figures, most studies listed on the EVRI are in the area of water valuation in the Americas, however the range of valuation studies is constantly being broadened to other fields and other parts of the globe.

EVRI workflow process

Using the EVRI to locate suitable studies for benefits transfer involves a specific four step workflow process:

1. Define the particular characteristics to match study summaries sites to the project site.
2. Search for potential study matches using the Searching Study Summaries.
3. Refine the search using the Searching Study Summaries.
4. Evaluate the applicability of the study summaries using the Screening Study Summaries.

The search function defines three major categories of information:

- geographic location,
- environmental focus asset, and
- valuation technique.

Study summaries may also be searched using keywords or advanced search. The initial results may then be refined to narrow or broaden the search.

Suitability is determined based on similarities between the policy site and the study sites in the following areas:

- geographic location,
- type of study,
- environment asset,
- type and timeliness of data,
- valuation technique, and
- economic measure.

Cost-effectiveness analysis

Cost-effectiveness is used whenever benefits cannot be quantified in monetary terms, or does not need to be. Cost effectiveness may be required for the following reasons:

1. A decision has been made on the basis of expediency, as policy, or is required by regulation and the cheapest or most effective option is being sought.
2. The benefits are self-evident and cost-effectiveness is common sense.
3. The benefits and costs are incommensurate, but that costs are perceived as being less than the potential benefits over the long term. This consideration is most relevant to environment and social assets.
4. The benefits of different options are considered roughly equivalent.

Avoided loss and other risk-based methods

The assessment of avoided loss requires information about a hazard, its frequency and magnitude, and the cost of the impacts with respect to the magnitude. This is often difficult information to obtain, especially at local government scale.

Furthermore, future events are essentially unpredictable, although not necessarily unforeseeable. This accentuates the need to run scenarios and assess for robust solutions. Greater knowledge can give greater precision, but a risk premium may be required to allow for future uncertainty, particularly if severe consequences are possible and the value of GI in avoiding these consequences may increase.

Other valuation methods

Other valuation methods include:

- Deliberative democracy and citizen jury methods where options are explored by a community or representative panel members.
- Ranking methods such as the use of INFFER, developed by David Pannell and colleagues.

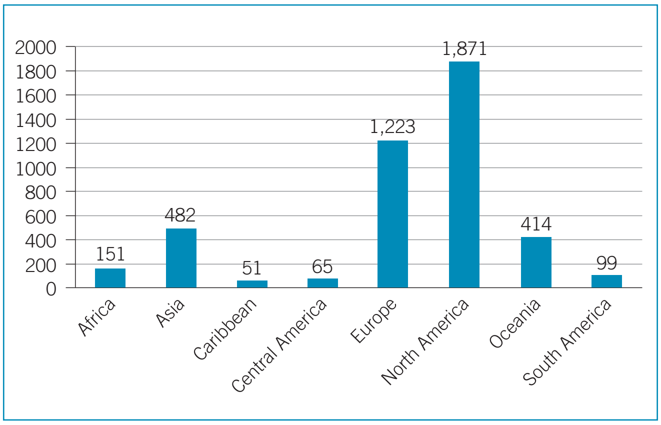

Figure C1 Number of studies in the EVRI by region

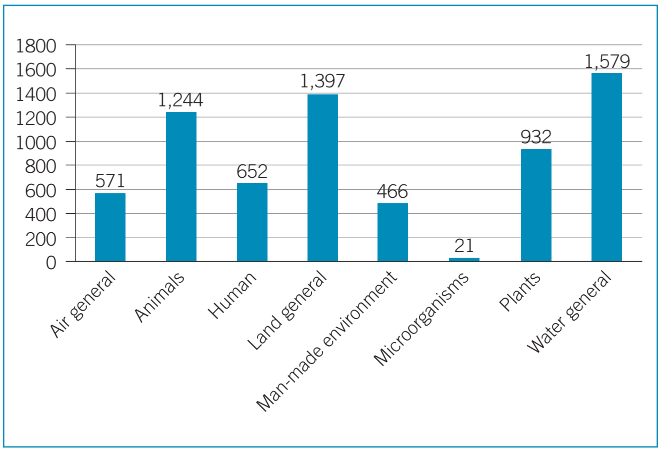

Figure C2 Number of studies in the EVRI by asset type

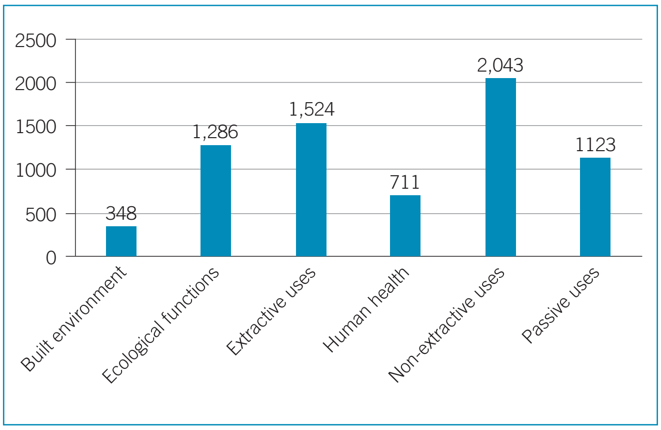

Figure C3 Number of studies in the EVRI by ecosystem service

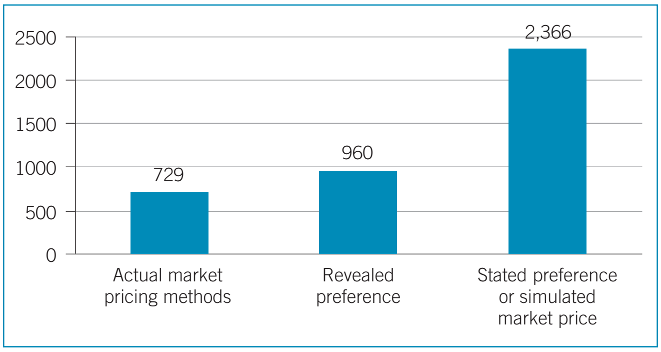

Figure C4 Number of studies in the EVRI by valuation type

Appendix D Valuation of costs and benefits

Reaching a decision as to which project is favoured if more than one is being examined, or whether a project should proceed, involves valuing the costs and benefits. This is known in finance as capital budgeting.

Within capital budgeting there are several methods used to compare cost and benefits. The most common methods include the following:

- Net present value (NPV)
- Cost-benefit ratio (CBR)
- Internal rate of return (IRR)
- Payback period
- Discounted payback period.

Net present value

Net present value (NPV) is the sum of the present values (PVs) of incoming and outgoing cash flows over a period of time. Incoming and outgoing cash flows can also be described as benefit and cost cash flows, respectively. Costs and benefits in the future are reduced using a discount rate. NPV is the most commonly used tool in discounted cash flow analysis and the conventional method for using the time value of money to appraise long-term projects. Theoretically, any project with a positive NPV should be implemented,, but given financial constraints, usually projects are prioritised according to the size of the NPV. However, this is complicated by the size of the project, for example one large project may produce a higher NPV than many smaller projects, but the NPV sum of the smaller projects may be larger than the one large project. Consequently a detailed analysis is required to ensure the most favourable outcome.

Cost-benefit ratio

A cost-benefit ratio (CBR) is the ratio of the net present value (NPV) of benefits associated with a project relative to the NPV of the costs of the project or proposal. The ratio indicates the benefits expected for each dollar of costs. It is important to consider that this ratio is not an indicator of the magnitude of net benefits, but rather the relative proportion. Two projects with the same benefit-cost ratio can have vastly different estimates of benefits and costs. CBRs can be useful when choosing one or more projects subject to a budget constraint. In most cases, choosing options in descending order of cost-benefit ratios will generate the largest net benefits within a fixed budget.

Internal rate of return

The internal rate of return (IRR) on a project is the 'annualised effective compounded return rate' or rate of return that makes the net present value of all cash flows (costs and benefits) from a particular investment equal to zero. It can also be defined as the discount rate at which the present value of all future cash flow is equal to the initial investment, or in other words, the rate at which an investment breaks even.

Specifically, the IRR of an investment is the discount rate at which the NPV of costs of the project equals the NPV of the benefits of the project. Consequently, the higher the IRR the more the project is worth. As opposed to NPV, this does not take into account the size of the project, rather the relative sizes of costs and benefits. Consequently, a large project may have a small IRR but a large NPV.

Payback period

Payback period refers to the period of time required to recoup the funds expended in an investment, or to reach the break-even point. For example, a $1000 investment which returned $500 per year would have a two-year payback period. The time value of money, or discount rate, is not taken into account. Payback period intuitively measures how long something takes to 'pay for itself'. Ceteris paribus, shorter payback periods are preferable to longer payback periods.

Although primarily a financial term, the concept of a payback period is occasionally used in other fields such as energy payback period (the period of time over which the energy savings of a project equal the amount of energy expended since project inception, or embodied energy).

Discounted payback period

Discounted payback period is calculated in the same way as payback period in that it is the time required to recoup costs. However, the discounted payback period incorporates a discount rate into future costs and benefits of the project. Consequently, discounted payback period takes into account time value of money.

There is not definitive answer as to which method is the best, and some methods are better suited to some projects than others. One project may produce different answers depending upon the type of method used. This is complicated by the incorporation of non-quantified costs and benefits as the above methods are only suitable for monetised values.

Hybrid decision-making methods

In order to reach a decision, it may be necessary to include a hybrid decision-making process which includes a monetary decision obtained from one of the above methods together with a qualitative decision from non-quantified costs and benefits. Such methods include, but are not limited to, multiple criteria decision analysis and analytic hierarchy process.

Multi-criteria analysis

Multiple-criteria decision analysis (MCDA) is a sub-discipline of operations research that explicitly considers multiple criteria in decision-making environments. Operations research is a discipline that deals with the application of advanced analytical methods to help make better decisions. Operations research is considered to be a sub-field of mathematics and is also known as management science. MCDA uses mathematical modelling, statistical analysis, and mathematical optimisation (e.g., linear programming), to arrive at optimal or near-optimal solutions to complex decision-making problems.

Cost is usually a main criteria in MCDA. Other measures, such as quality, are often in conflict with the cost. A simple example is commonly used in the bicycle industry to illustrate conflicting constraints: 'light, cheap, strong. Choose two'. Intangible measures, such as amenity, may also be included. To reach a decision, optimisation tools within spreadsheet software are used to reach non-dominated solutions.

'Solving' can be interpreted in different ways. This may correspond to choosing the 'best' alternative from a set of available alternatives (where 'best' can be interpreted as 'the most preferred alternative' of a decision maker). Or 'solving' could involve selecting a small set of good alternatives, or grouping alternatives into different preferences. One interpretation could be to find all 'efficient' or 'non-dominated' alternatives. A non-dominated solution is when it is not possible to move away from it to any other solution without sacrificing in at least one criterion. Therefore, a decision maker should choose a solution that is non-dominated. If not, then the decision maker could do better in terms of some or all of the criteria, and not do worse in any of them. Often the set of non-dominated solutions is too large to be presented to the decision maker for a final choice. Normally it is necessary to 'trade-off' certain criteria for others.

Analytic hierarchy process

The analytic hierarchy process (AHP) is a structured technique for organising and analysing complex decisions, based on mathematics and psychology, and has been used successfully in different fields, as well as group decision making. AHP does not attempt to reach a 'correct' decision, but rather AHP helps decision makers find a decision that best suits their goal and constraints of the problem.

Decision problems are initially broken down into a hierarchy of more easily understood sub-problems, each of which may be analysed separately. The hierarchy of sub problems can incorporate any aspect such as tangible or intangible factors, or anything that is relevant to the decision.

Once the hierarchy is established, decision makers systematically evaluate its various elements by comparing them to one another two at a time, with respect to their impact on an element above them in the hierarchy. In order to make the comparisons, decision makers can use concrete data about the factors, such as NPV; however, they usually use judgments about the factors' relative importance.

AHP converts these evaluations to numerical values that can be processed and compared over the entire range of the problem. A numerical weight or priority is derived for each factor of the hierarchy, which allows diverse and often incommensurable factors (a key factor with GI) to be compared to one another in a consistent way. Finally, numerical priorities are calculated for each of the decision alternatives. These numbers represent the alternatives' relative ability to achieve the decision goal, so they allow a straightforward consideration of the various courses of action. There are several software alternatives that can be used to implement AHP, one such being the INFFER method mentioned in Appendix C.

Which method?

Depending upon the project, time and resources available, one method will be preferred over another and can support a decision as to whether the particular GI project should proceed. This leads to the implementation phase of the project. Given the incommensurable nature of many costs and benefits, consideration should be given to including qualitative estimates, or considering hybrid methods. Of course, methods that calculate monetary value can be very powerful and these should be used if data, time and resources permit.

Appendix E Asset planning and valuation

Infrastructure forms assets and GI is no different. However, these assets are not very well accounted for in any area of government planning and operations.

One major reason for this is the strong emphasis on the use of market prices in asset valuation, largely because the market is considered the fairest and most objective means of assessing value. However, as we discussed in our accompanying Green Paper (Jones, et al., 2015), there is a range of short-comings to this assumption. So here we base the classes and methods for valuing GI on those developed for local government for conventional infrastructure but this is also being expanded to account for the broader range of values being addressed.

A framework of asset classes developed for local governments is outlined in Table E1. GI relates to all these classes except the Information Technology class. There are significant areas of overlap between the different classes which is consistent with the application and benefits of GI.

We have developed a draft list of green asset sub-classes and types for further consideration (see Table E2 on page 49).

Asset valuation

Most GI assets currently do not need to be formally valued, but doing so can yield benefits such as an improved ability to explain and defend budgets, a better focus on priorities, a better understanding of risks and alternative decisions, benefits beyond balance sheet considerations, improved ability to balance capital and operating expenses and reduced cost without sacrificing service. Some guiding principles for asset valuation can be gleaned from the Australian Accounting Standards Board, especially property, Plant and Equipment (AASB 116), Agriculture (AASB 141) for biological assets and Intangible Assets (AASB 138).

A major condition for asset valuation in these standards is that a current or future economic value sets the benchmark for whether a value can be established. For GI, we are moving beyond that into an area where a range of non-monetary benefits are also being valued. However, this is consistent with the Office of Best Practice Regulation who only require environmental assets and their benefits to be described. They also distinguish between value and price, consistent with the findings of our Green Paper. From the standards, an asset is a resource controlled by an entity as a result of past events; and from which future economic benefits are expected to flow to the entity. Here this is expanded to future economic, social and environmental benefits.

Rules for an intangible asset include that it must be identifiable in that it is separable and can be sold, licenced, rented or exchanged, or arises from contractual or legal rights.

Table E1 Local government asset classes

Local government asset classes	Sub-class examples
Land	Reserves, botanical garden, parks, sportsgrounds and playing fields, landfill sites, cemeteries and other land assets.
Buildings	Administration buildings, animal shelters, libraries, public toilets, halls, heritage listed sites and other building assets.
Infrastructure	Road networks (sealed, gravel, reseals, formed) including car parks, pavement, seal, kerb and channel, drainage, traffic management, furniture and signs, lighting and paths. Drainage networks (including open channel storm water drains), flood mitigation networks, water supply network, sewerage networks (including waste treatment facilities). Bridges, airports, wharves, piers, jetties and pontoons. Infrastructure on parks, gardens and reserves, tunnels, retaining walls, sea and river walls and canals, and other infrastructure assets.
Information technology	Hardware (including computers, monitors, servers, network hubs). Software (including all operating software, excluding internally developed software, specialist software – e.g., finance/GIS, customer service systems). Communications (telephone systems, radio systems, fibre optics conduits/pipe). Application specific technology (CCTV cameras/systems, CCTV monitoring room equipment, GIS recording units).
Plant and equipment	Vehicles (including corporate fleet, service vehicles; e.g., rubbish collection vehicles/ranger vehicles, works vehicles, heritage plant). Equipment (including fixtures and fittings, furniture, street cleaning equipment, roads/paving equipment, parks equipment, heritage equipment, library books).
Other assets	Off-road paths, beaches, urban open space, streetscapes.

Table E2 Draft list of asset classes, subclasses and types.

Class	Subclass	Type
Land	Park	Active
		Passive
		Nature
		Sports
		Formal
	Gardens	Botanical
		Community
	Sporting ground	Extensive
		Developed
	Cemetery	Where the dead reside
	Landfill	Capped landfill
		Capped toxics
Buildings	Vegetated	Green roofs
		Green walls
	Structures	Nature integrated tech
Infrastructure	Transport	Roadsides*
		Paths*
		Islands*
		Rail reservations
	Water	Hybrid systems
Other assets	Plants	Trees
		Shrubs
		Grasses and herbs
	Waterways and drainage	Rivers and streams
		Billabongs
		Lakes and ponds
		Flood retention basins
		Rain gardens
		Swales
		Drains
		Aquifers
	Coastal systems	Beaches
		Dunes
		Cliffs
		Estuaries
		Tidal zones and nearshore

* Currently allocated as land under roads

Asset valuation methods

- **Fair value** is defined as 'the amount for which an asset could be exchanged between knowledgeable, willing parties in an arm's length transaction' (AASB 116). If there is no evidence of market price due to rarity or limited utility to another buyer, then depreciated replacement cost or future value of benefits can be used.
- **Value of land with restricted uses.** Land under restricted use can be valued according to that use rather than at market price. These include parks and gardens, national parks and reserves that are held for public benefit, vacant Crown land and council reserves and parks.
- **Replacement/reproduction costs.** Replacement cost for GI is a challenging concept for GI with complex ecological functions because of the time required to re-establish function, if at all possible. For that reason, highly complex ecosystems are considered irreplaceable on human generational timescales. However, simpler systems and the engineering structures that may accompany GI can be valued using conventional methods.
- **Fair value for biological assets.** Most biological assets are equivalent to bearer biological assets in the Agricultural guidelines (AASB 141), but mainly offer services rather than produce. The valuation of biological assets needs to take in their condition, stage in the lifecycle and exposure to risk. Depreciation (appreciation) rates need to take in stage of growth, condition, expected life and future value of benefits.

Green infrastructure glossary

Annualised value
An annualised value is a constant stream of benefits or costs. The annualised cost is the amount that a party would have to pay at the end of each period to add up to the same cost in present value terms as the stream of costs being annualised. Similarly, the annualised benefit is the amount that a party would accrue at the end of each period to add up to the same benefit in present value terms as the stream of benefits being annualised.

Average costs
The total costs divided by the total output.

Baseline
A baseline describes an initial, status quo scenario that is used for comparison with one or more alternative scenarios. In typical economic analyses, the baseline is defined as the best assessment of the world prior to the proposed project.

Cost-benefit analysis (CBA)
A CBA evaluates the favourable effects of policy actions and the associated opportunity costs of those actions. It answers the question of whether the benefits are sufficient for the gainers to potentially compensate the losers, leaving everyone at least as well off as before the policy. The calculation of net benefits helps ascertain the economic efficiency of a regulation.

Benefits
Benefits are the favourable effects society gains due to a policy or action. Economists define benefits by focusing on changes in individual wellbeing, referred to as welfare or utility. Willingness to pay (WTP) is the preferred measure of these changes as it theoretically provides a full accounting of individual preferences across trade-offs between income and the favourable effects.

Bequest values
Willingness to pay to preserve the environment for the benefit of our children and grandchildren.

Contingent valuation method
Directly asks people what they are willing to pay for a benefit an/or willing to receive in compensation for tolerating a cost through a survey or questionnaire. Personal valuations for increases or decreases in the quantity of some good are obtained contingent upon a hypothetical market. The aim is to elicit valuations or bids which are close to what would be revealed if an actual market existed. Several biases, including strategic, design, (starting point, vehicle, and informational), hypothetical, and operational are discussed above and below.

Discount rate
Degree to which future dollars are discounted relative to present dollars. Economic analysis generally assumes that a given unit of benefit or cost matters more if it is experienced now than if it occurs in the future. The degree to which the importance that is attached to gains and losses in the future is known as discounted. The present is more important due to impatience, uncertainty, and the productivity of capital.

Existence value
Value from knowing environmental goods exist independent of use or option value. If we lose a species in the wild, such as the Bengal tiger, very few of us will have our welfare directly affected by not being able to see it, photograph it or hear it. That ‘use value’ is very small. But many people will lose the option to do that in the future, should they care to. Economists call that ‘option value’. Further, many people around the world derive some benefit just from knowing that Bengal tigers exist in the wild. That is ‘existence value’.

Externalities
A situation in which an individual or firm takes an action but does not bear all the costs (negative externality) or receive all the benefits (positive externality).

Hedonic pricing approach
Derives values by decomposing market prices into components encompassing environmental and other characteristics through studying property values, wages and other phenomena. The premise of the approach is that the value of an asset depends on the stream of benefits derived, including environmental amenities.

Incommensurable
Kinds of value that are not considered to be interchangeable according to moral or philosophical reasoning.

Integrated urban water management (IUWM)
The practice of managing freshwater, wastewater, and storm water as components of a basin-wide management plan. It builds on existing water supply and sanitation considerations within an urban settlement by incorporating urban water management within the scope of the entire river basin.

Intrinsic values
Value that resides ‘in’ something and that is unrelated to human beings altogether.

Monetary economy
The part of the economy where goods and services are traded for money and assets are sold in the marketplace. The market/non-market economy is delineated according to barter and trade.

Net benefits
Net benefits are calculated by subtracting total costs from total benefits.

Net future value (NFV)
Net future value is similar to NPV, however, instead of discounting all future values back to the present, values are accumulated forward to some future time period – for example, to the end of the last year of a policy’s effects.

Net present value (NPV)

The NPV is calculated as the present value of a stream of current and future benefits minus the present value of a stream of current and future costs.

Non-monetary economy

The part of the economy where goods and services are provided without monetary exchange (e.g., household labour, volunteerism, ecosystem services). Assets are generally (though not always) publicly owned.

Option value

Potential benefits of the environment not derived from actual use. This expresses the preference or willingness to pay for the preservation of an environment against some probability that the individual will make use of it at some later date. Economists call that 'option value'.

Physical economy

Stocks and flows in the material world, often simulated using input/output tables of material flows.

Present value

Value today of a sum to be paid or collected in the future to buy a good or service.

Provisioning services

Ecosystem services that describe the material or energy outputs from ecosystems.

Public goods

Goods that cannot be withheld from people even if they don't pay for them. A good which, if made available to one person, automatically becomes available to all others in the same amount.

Social return

Flow on benefit to the economy and society of a direct action that may result in a change in tangible or intangible values – social returns are indirect.

Sustainability (strong)

Assumes that many aspects of natural capital and the services it provides cannot be substituted or compensated by money and that natural and manufactured capital are complementary but not interchangeable.

Sustainability (weak)

Assumes substitutability between natural and manufactured capital and that environmental degradation can be compensated by payments from the monetary economy.

Travel cost method

Derives values by evaluating expenditures of recreators. Travel costs are used as a proxy for price in deriving demand curves for the recreation site.

User benefits

Benefits deriving from the actual use of the environment. Anglers, hunters, boaters, nature walkers, bird watchers, etc. use the environment and derive benefits.

User values

Benefits deriving from the actual use of the environment. Anglers, hunters, boaters, nature walkers, bird watchers, etc. use the environment and derive benefits. If we lose a species in the wild, such as the Bengal tiger, very few of us will have our welfare directly affected by not being able to see it, photograph it or hear it. That 'use value' is very small. But many people will lose the option to do that in the future, should they care to. Economists call that 'option value'. Further, many people around the world derive some benefit just from knowing that Bengal tigers exist in the wild. That is 'existence value'.

Value

The worth of a thing:

- Anthropocentric value: confers intrinsic value on humans alone and instrumental values on everything else.
- Bequest/vicarious values: a willingness to pay to preserve the environment for the benefit of other people, intra- and inter-generationally.
- Community value: a value shared by or benefiting a group of people who constitute a community through place, activity, or shared aspirations and goals.
- Economic value: the worth of a good or service, or the measure of benefit provided by that good or service. Economic value is not just monetary, and there are many definitions across different economic traditions, from financial to philosophical.
- Existence value: the value attached to the knowledge that species, natural environments and other ecosystem services exist, even if the individual does not contemplate ever making active use of them.
- Institutional value: value held by an institution as a guiding principle and/or goal.
- Intangible value: non-monetary goods, services, assets and intrinsic values.
- Intrinsic value: the value attached to the environment and life forms for their own sake irrespective of any reference to humans.
- Market value: the exchange value or price of a commodity or service in the open market. Sometimes also synonymous with economic value in neoclassical economics.
- Option value: a willingness to pay a certain sum today for the future use of an asset.
- Non-anthropocentric value: intrinsic value is attributed to human and non-human beings, and perhaps natural systems.
- Non-use value: passive or non-active use of an ecosystem good or service
- Quasi-option value: the value of preserving options for future use assuming an expectation of increasing knowledge about the functioning of the natural environment.
- Tangible value: the monetary or market values of a good, service or asset.
- Use value: active use of an ecosystem good or service, sometimes also translation of unpaid or partially paid use to market-equivalent value.

Willingness to accept (WTA)

Minimum amount of money one would accept to forgo some good or to bear some harm.

Willingness to pay (WTP)

Maximum amount of money one would give up to buy some good.

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