VICTORIA INSTITUTE OF STRATEGIC ECONOMIC STUDIES

INVESTING IN GROWTH: UNDERSTANDING THE VALUE OF GREEN INFRASTRUCTURE

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Glossary

Bequest Values
Willingness to pay or value placed in the preservation of an item, good or service to be available to future generations.

Contingent Valuation Method
Directly asks people what they are willing to pay for a benefit and/or willing to receive in compensation for tolerating a loss.

Cost-Benefit Analysis
A formal analysis of costs and benefits to undertake an action, with the benefits often converted into net present value by some form of discounting.

Cost-Effectiveness Analysis
Least expensive way of achieving a given outcome or undertake a specific task.

Discount Rate
Degree to which future dollars are discounted relative to current dollars.

Existence Value
Value from knowing environmental goods exist independent of use or option value. Extinguished when a species becomes extinct or other irreversible loss occurs

Externality
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)

Green Infrastructure
A network of ecological systems and supporting technologies and structures within and across human settlements.

Hedonic Pricing Approach
Converts market prices into environmental or social benefits/costs by studying their relationship with property values, wages, prices, rents or household income.

Intangible Values
Non-monetary goods, services and assets/liabilities. These include social, cultural and environmental values that contribute to long-term social welfare.

Opportunity Cost
The highest-valued sacrifice needed to get a good or service.

Option Value
Potential environmental of the environment not derived from actual use. The preference or willingness to pay for the preservation of an environment against some likelihood it will be of use at a later date.

Present Value
Value today of a sum to be paid or collected in the future to buy a good or service. Net present value, the sum of current and future costs with future benefits converted into today's dollars.

Public Goods
Goods that cannot be withheld from people even if they don't pay for them. Air and rainfall are examples.

Substitutability
The degree to which a given good or services can be substituted with another.

Tangible Values
The monetary or market values of a good, service or asset.

Travel Cost Method
Evaluates travel and visiting expenditures of recreators as a proxy for the value they get from going to a recreational venue.

Use Values
Benefits deriving from the actual use of the environment, though the provision of goods or services.

Welfare
Wellbeing.

Introduction

"Green infrastructure is dynamic – it must be strategically planned for, invested in and managed at local and regional levels, if it is to function in underpinning and providing for a prosperous and sustainable economic future."

Dr Will Williams, Program Director, Natural Economy Northwest

Cities are complex, dynamic systems that depend on the resilience of their people, their economies and their natural environments for ongoing sustainability. Green infrastructure is a key aspect of the total infrastructure that supports this. It underpins our economy in areas such as health, liveability and industry. Green infrastructure protects and rejuvenates liveable 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.

To date, planning for green infrastructure has largely been opportunistic, taking advantage of funding opportunities, rather than being a strategically managed portfolio sustained by ongoing funding. This has meant that tools and methods to integrate green infrastructure with other types of infrastructure have not been developed fully. Decision-makers find it difficult to properly evaluate the type of investment needed, why it is needed and how it is needed. As a result, green infrastructure is viewed as a peripheral aspect of infrastructure planning so is often underutilised and undervalued. This has meant that opportunities to improve these assets or maximise their benefits have been not been taken up.

As part of the Victorian Adaptation and Sustainability Partnership Program, Victoria University is developing an economic framework for green infrastructure in collaboration with four local government bodies. This framework aims to provide a foundational step in addressing this lack of progress. It will do this by developing an economic framework that will help local government decision makers step through the decision process. It will also identify how and where aspects of this framework can be integrated into the mainstream decision-making process of organisations.

The framework aims to create better understanding of:

- The value and benefits of green infrastructure.
- The available options and how these options support the future viability and liveability of our communities.
- The development of business cases for preserving existing and investing in future green infrastructure.

The workshop

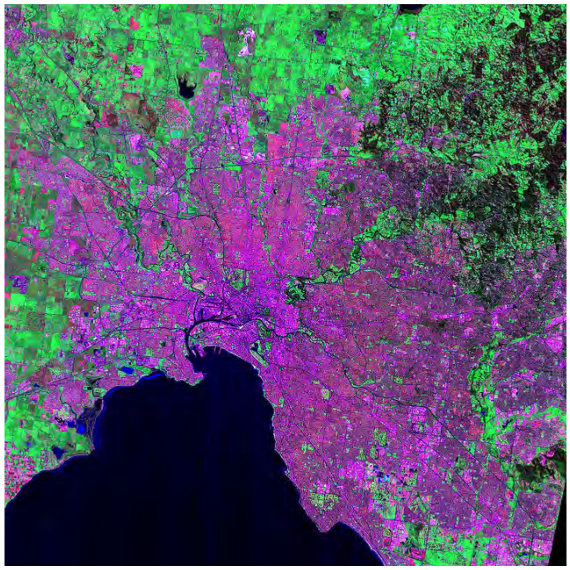
This one-day workshop is the last in a series examining decision making in relation to green infrastructure. It aims to inform the development of the economic framework and a Green Paper outlining important issues through:

- Ascertaining how green infrastructure benefits are perceived within local government organisations.
- Identifying the current barriers to ascertaining the value and benefits of green infrastructure.
- Identifying opportunities to integrate this knowledge and improve asset management and infrastructure planning.

Smart infrastructure for changing futures

"Infrastructure is not exactly the sexiest word in architecture. There are no 'starchitects' proudly boasting about their pipe designs or subsurface drainage systems. By its very definition – the underlying structures that support our systems – infrastructure is inherently hidden from us, and therefore often overlooked. But without it our current cities couldn't possibly exist. Without finding ways to improve it, our future cities will struggle to survive."

Timothy Carter, Smart Cities, The Future of Urban Infrastructure, BBC[1]



Satellite infrared image of greater Melbourne showing warmer built up (purple) and cooler vegetated (green) areas.

Historically, infrastructure has often been developed in response to emerging needs of communities. The drivers for this can be many and include:

- Increasing populations, for example, growing regional cities such as Bendigo and Ballarat need to integrate green and conventional infrastructure in a rural setting.
- The management of essential resources such as water, for example, management of urban water catchments to provide alternative water supplies, improved water quality and stormwater management.
- Reponses to threats or natural disasters, for example, building levees in Wagga Wagga and Roma to protect the homes from floods and inundation.

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, the development of areas on the edge of the metropolitan areas of Melbourne fulfil the need for affordable housing, but can degrade the natural environment as a result.

Current environmental, social and economic landscapes across the globe are changing and creating new conditions, some of which are novel so cannot always be understood through previous experience. These risks and their impacts are systemic and dynamic (see Figure 1, overleaf). This requires rethinking future infrastructure needs, especially specific types of infrastructure and why they are needed.

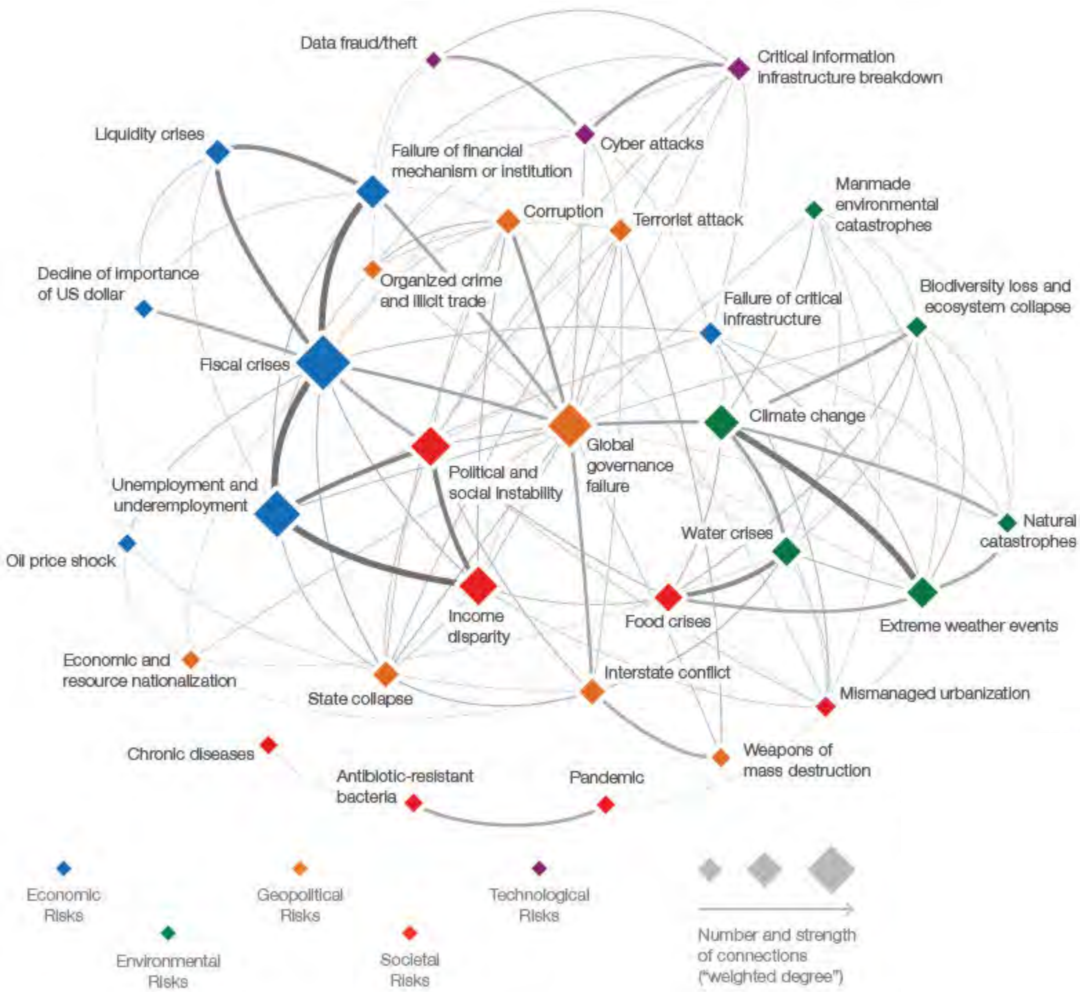


Figure 1: The Global Risks 2014 Interconnections Map. DAVOS 2014[2]

Some of the key areas of change impacting on the communities we live in are:

- Population increase
- Population migration
- Decreasing resources
- Increasing impacts from systemic risks, in particular those associated with climate change (see Appendix 1).
- Increasing dependence on technology systems

Resilient infrastructure (both hard infrastructure such as bridges, roads and buildings and soft infrastructure such as social systems, connectivity and communication) are now recognised as being central to helping future communities respond effectively to these changes. Creating resilient infrastructure requires integrated planning and implementation, where interactions between all systems of infrastructure are considered and combined in order achieve the most resilient outcome (see Figure 2, overleaf).

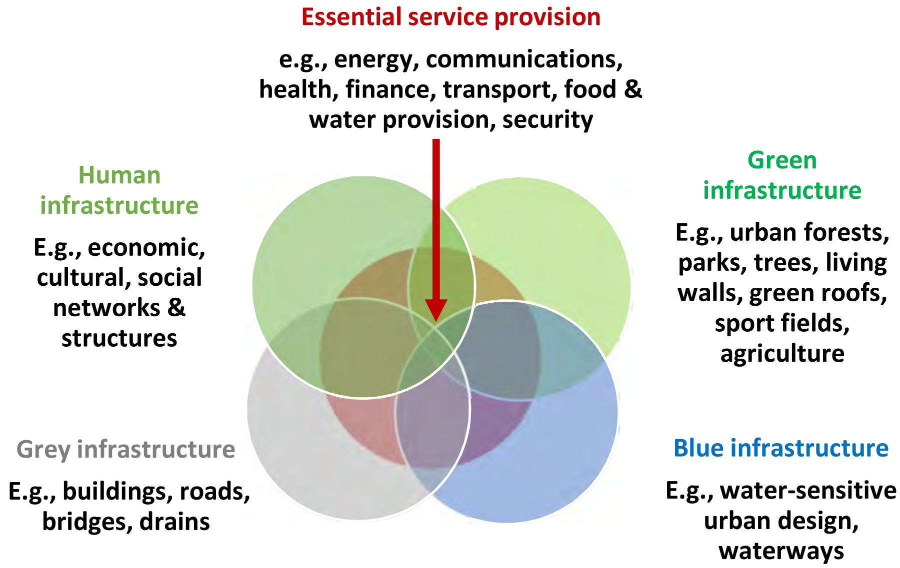


Figure 2: Model for resilient infrastructure (C. Young)

Two examples of integrated approaches to small- and large-scale infrastructure projects are shown below.

Integrated infrastructure, Green Precinct Project Moonee Valley – case study[3]

The Green Precinct received $190,000 from the Victorian Government's Sustainability Fund and is coordinated by Moonee Valley City Council. The project officially ran from September 2008 to May 2010, however its legacy continues for businesses in Moonee Valley. It bought together a variety of local businesses, community organisations and local government in Moonee Ponds to deliver the following environmental improvements:

- Greenhouse gas savings of 24 per cent
- Water savings of 20 per cent
- 100 per cent increase in recycling
- 3.8 per cent of land area with improved habitat
- Increased sustainable transport options available

This was achieved through a combination of technological solutions such as the renewable energy and water technologies, energy efficiency initiatives and behaviour change programs. It also included upgrading current infrastructure and amenities to include more water efficiency and the introduction of more bike racks and extra bins to encourage recycling. Habitat improvements have been achieved over 3.8 per cent of the site, through improved planting at Essendon Historical Society, St Thomas Anglican Church, and Queens Park. Education to enable behaviour change and increase understanding of the changes was a key part of all aspects of this program.

Eastlink integrated infrastructure case study[4]

EastLink is eastern Melbourne's major north-south link. Over one million people live in the corridor east of Warrigal Road and are serviced by EastLink. It features 45km of freeway standard road, including 39km of tolled roadway and 6km of untolled bypasses at Dandenong and Ringwood. This project had a number of unique aspects which included:

- The development of an environmentally sensitive path through the Mullum Mullum Valley. The 2.75 km shared use path winds through the valley between Deep Creek Road in Mitcham and Park Road in Donvale, and crosses the Mullum Mullum Creek five times. It predominantly follows long-established foot and cycle routes, and is part of the wider EastLink Trail which includes 35kms of shared-use bicycle trails and pedestrian overpasses along the motorway.
- A specially designed platypus tunnel constructed in the Corhanwarrabul Creek area. To make it as natural as possible, the realigned creek consisted of an arch culvert with specially selected crushed rock placed on the floor and a skylight.
- Relocation of the Boggy Creek Wetlands near the Mornington Peninsula Freeway, which contained several rare species of pre-historic ferns. The wetland was in the direct path of EastLink. After extensive consultation, it was agreed the ecosystem should be moved one sod at a time to a nearby location. The relocation included the installation of a sediment pond, drainage and an irrigation gate to control water flow in and out of the area. It set new standards in conservation and environmental management.

Some of these developments were not in the original plans and came about after sustained community campaigns. This has resulted in an ongoing legacy where these natural assets have become much more widely valued by the community.

Integration can be challenging as it requires all four areas of infrastructure in Figure 2 to be understood, especially in how they can be combined to deliver multiple benefits. Different departments across organisations will need to collaborate, learn and innovate to achieve shared outcomes. In many cases, they will also need to engage in external collaborations with both the private and public sectors, and in particular, between different levels of government. This often requires adapting governance arrangements and operational frameworks, particularly if they have siloed structures. It may also need educational and behavioural change within organisations and the broader community to facilitate activities.

What is green infrastructure?

Green infrastructure can be defined as a network of ecological systems and supporting technologies and structures within and across human settlements. It is multifunctional; delivering many environmental, economic and social benefits.

Green infrastructure includes parks and reserves, backyards and gardens, waterways and wetlands, streets and transport corridors, pathways and greenways, squares and plazas, roof gardens and living walls, sports fields and cemeteries.

Why is it important?

Green infrastructure plays a key role in our communities by providing assets that can help increase liveability and prosperity by:

- Reducing environmental impacts and increasing resilience
- Protecting other types of infrastructure
- Contributing to human and environmental health
- Providing ecosystem goods and services
- Sustaining natural resources

Green infrastructure can also offer protection to existing infrastructure and extend the life of some built structures, through providing protection from impacts such as weather or pollution. It can also reduce the use of energy needed to heat or cool these structures through initiatives such as green roof technology and living walls.

Ecosystem services

"In New York in 1994 the value of the city's trees in removing pollutants was estimated at US$10 million per annum. Planting 11 million trees in the Los Angeles basin saves US$50 million per annum on air conditioning bills."[5]

Green infrastructure provides a number of ecosystem services which are important for maintaining the wellbeing, health and survival[6] of our cities and the communities within them.

> *They have been defined as "..the benefits provided to humans through the transformations of resources (or environmental assets, including land, water, vegetation and atmosphere) into a flow of essential goods and services, e.g. clean air, water and food."*
>
> *Costanza, d'Arge et al. (1997)*

Some examples are:

- Plants reduce pollution in air and water by acting as filters for contaminants.
- Wetlands and tree cover reduce the impacts of climatic extremes, offering protection to other assets and communities in the event of flooding or heatwaves, (see Namatjira Park case study overleaf).
- Climate regulation – reducing temperature extremes, increasing human comfort and assisting productivity in weather-sensitive businesses.
- Improved amenity leading to increased house prices and increased consumer activity in commercial precincts.

Ecosystem services are commonly categorised using the Total Economic Value (TEV) system into the following four areas:

- **Provisioning Services,** the products obtained from ecosystems. These include crops, freshwater, timber, livestock, aquaculture, fibres, capture fisheries, wild foods, biomass fuel, genetic resources, and biochemical materials.
- **Regulating Services,** the benefits obtained from the regulation of ecosystem processes. These include pollination, water regulation, climate regulation, disease regulation, air quality regulation, erosion regulation, water purification, pest regulation, and natural hazard regulation.
- **Cultural Services,** the non-material benefits obtained from ecosystems. These include recreation and ecotourism, ethical values, and spiritual values.
- **Supporting Services,** the services necessary for the production of all other ecosystem services. These include soil formation, nutrient cycling, primary production and habitat provision.

Namatjira Park wetlands benefits case study[7]

Clayton residents near Namatjira Park in Kingston, benefit from greater flood protection due to wetlands developed as part of a $7.36 million project funded by Melbourne Water, the Australian Government and Kingston Council. The stormwater harvesting system allows more than 5 million litres of stormwater to be collected and used to irrigate local parks, playgrounds and street trees – saving almost 100 million litres of drinking water each year. The project also provides greater flood protection for more than 110 properties downstream by capturing excess water during flash flooding and heavy rain.

The wetlands also benefit the community as storm water is collected to maintain local parks and gardens, and nitrogen and phosphorus are removed from the water as it flows onto Port Philip Bay. More than 10,000 new aquatic and land plants around the wetland greatly improved the amenity of the area and provide a healthy habitat for flora and fauna to thrive in.

Council also constructed more than 3 km of walking, tracks, 12 seats, two viewing platforms and a bridge connecting the park with surrounding streets and sporting equipment to encourage residents in healthy living practices.

Understanding the benefits of green infrastructure

"Portland completed a comprehensive cost-benefit analysis of its current green roof program in 2008, calculating that green roofs provide each private homeowner, on average, a net benefit of $404,000 over 40 years from avoided stormwater fees, reduced heating and cooling costs, and longer roof life. Green roofs on public buildings were estimated to provide a net-benefit of $191,000 from reduced operations and maintenance costs, avoided storm-water management costs, particulate pollution and carbon absorption benefits, and habitat amenities."

Centre for Clean Air Policy (2011)[8]

The benefits that green infrastructure provides fall into three broad areas: economic, environmental and social.

Economic benefits
Green infrastructure can directly or indirectly improve productivity. It can also increase property values and improve consumer activity in some precincts. [9] Ecosystem services also provide a 'free service' that can support other economic activities such as recreation, sport and tourism. In some cases it may provide the basis for such activities.

Environmental benefits
Environmental benefits include reduction of weather-related impacts such as: heat waves and flooding, cleaner environments that have less pollution and better soils which are more productive. Also connectivity of different spaces and structure promotes biodiversity and protects diversity of species.

Social benefits
Social benefits are diverse and sometimes hard to measure as many are indirect, such as community identity, amenity and equity. Many health benefits are provided, encompassing mental, physical and spiritual health (see Figure 3). 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.

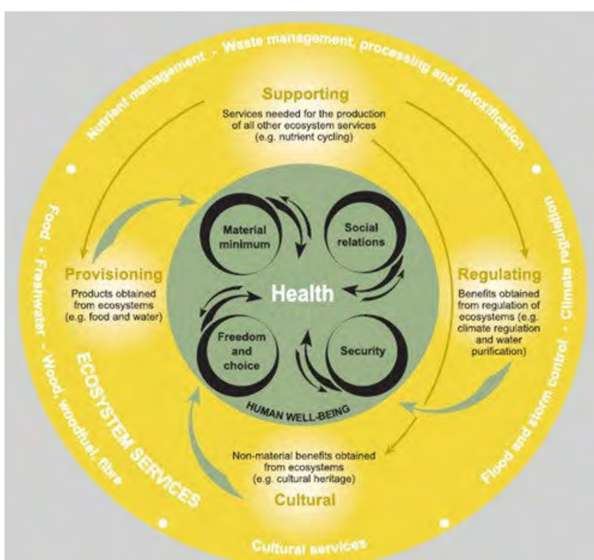


Figure 3: Interrelationship between ecosystem services, aspects of human well-being and human health. Source: Millennium Ecosystem Assessment 2005[10]

These benefits will continue over the life of the asset, often increasing as it develops. For example, as trees mature they store more carbon, provide more habitat, shade and cooling, and remove greater amounts of air pollution. This not only improves functionality of these assets, but can also provide a substantial return as a long-term investment. For further details, see Appendix B.

Banyule stormwater harvesting – the benefits of wetlands case study[11]

The Banyule Council's stormwater harvesting project was established as one of the largest stormwater harvesting networks in Melbourne. It was developed across Kalparrin Gardens in Greensborough, Chelsworth Park and Ivanhoe Golf Course in Ivanhoe and DeWinton Park in Rosanna. The council was awarded the Excellence in Infrastructure Award at the Stormwater Victoria 2014 Awards for Excellence for this project. Kalparrin Gardens innovative double-decker wetland, won the Excellence in Integrated Stormwater Design Award from Stormwater Victoria in 2013.

This project involved installing underground water storages, litter traps, sedimentation basins, wetlands and rain gardens. It will provide up to 138 million litres of stormwater for irrigation and remove over 200 tonnes of litter and other pollution which would otherwise have fouled Banyule's waterways.

These three stormwater harvesting facilities also provide a sustainable water source for irrigating over 30 hectares of local sports fields and open space, as well as contributing to keeping the natural environment healthier for the community. The council will benefit with a major saving of $350,000 a year because of reduced tap water needed for irrigation.

Valuing ecosystem services

The benefits human civilization enjoys from the world's natural ecosystems — such as grasslands, marshes, coral reefs and forests in 2011 has been estimated at US$125 trillion/yr compared to the conventional global GDP of US$75 trillion per year.[12]

Dynamic models of the Earth's natural and human systems suggest that the value of global ecosystem services is about 4.5 times that of gross world product. Based on the annual GDP of $75 trillion/yr given above, this would total US$347 trillion/yr.

In 1997, based on Costanza and colleagues' estimate of the value of the world's ecosystem services, [13]Australia's ecosystem services were valued at $0.9 trillion/yr.[14] Updated to the 2011 figures these services would be worth US$2.4 trillion/yr, comparing favourably with Australia's 2011 GDP of US$1.1 trillion/yr.

To date, complete estimates of global ecosystem assets have not been produced because of the extent of the task, data limitations and shortcomings in the available models and tools. For example, the above estimates of ecosystem services is only partial – more services exist that could not be quantified. When green infrastructure assets and ecosystem services have been quantified, the resulting values are often substantial. Aggregating total values at the local scale and across large areas requires adding social, environmental and economic values, which can be a difficult task. These values are not always monetary, and consist of:

- Tangible values, covering the monetary or market values of a good, service or asset.
- Intangible values, covering non-monetary goods, services and assets/liabilities. These include social, cultural and environmental values that contribute to long-term social welfare.

There are a number of established methods for calculating tangible benefits. These are usually market-based (for further explanation of market valuation, see Appendix A).

Tools for estimating intangible values are less well developed. This includes considering how intangible values should be framed. For example, what is something worth if it isn't paid for directly or is a public asset enjoyed by everyone? Usually there is no single or 'correct' answer, so ascertaining such values can be challenging. For example, market, welfare, survey or revealed preference methods can all be used. Ethical considerations of 'fairness' and 'justice' may also be important.

One way of assessing intangible values is to assess how non-monetary values are represented in decision-making processes and adapt valuation methods to quantify the different types of 'currency' used in such processes. This may require the blending of different economic methods within a single framework. Such methods are generally not included in formal cost-benefit type valuation frameworks. Conventional infrastructure is almost always assessed using some form of cost-benefit analysis.

Tools for valuing green infrastructure

"What we measure affects what we do; and if our measurements are flawed, decisions may be distorted. Choices between promoting GDP and protecting the environment may be false choices once environmental degradation is appropriately included in our measurement of economic performance. So too, we often draw inferences about what are good policies by looking at what policies have promoted economic growth; but if our metrics of performance are flawed, so too may be the inferences that we draw."

***(Stiglitz et al., 2009)*[15]**

Economic methods and tools used to value green infrastructure are still under development. Due to the many different contexts and values involved, no one tool can serve all needs. Instead tools are more likely to combine different economic methods and frameworks, adjusted to suit particular circumstances.

One of the concepts that has been developed to account for the many and diverse ecosystem services is the concept of Total Economic Value (TEV). This adds up all the ecosystem goods and services provided, dividing them into use and non-use values (Figure 4). It is one of the most commonly used methods for valuing the ecosystems services. The TEV system recognises a range of values that are often used as a foundation for the evaluation of ecosystem services. Figure 4 shows an adapted version of this with added health and wellbeing aspects.

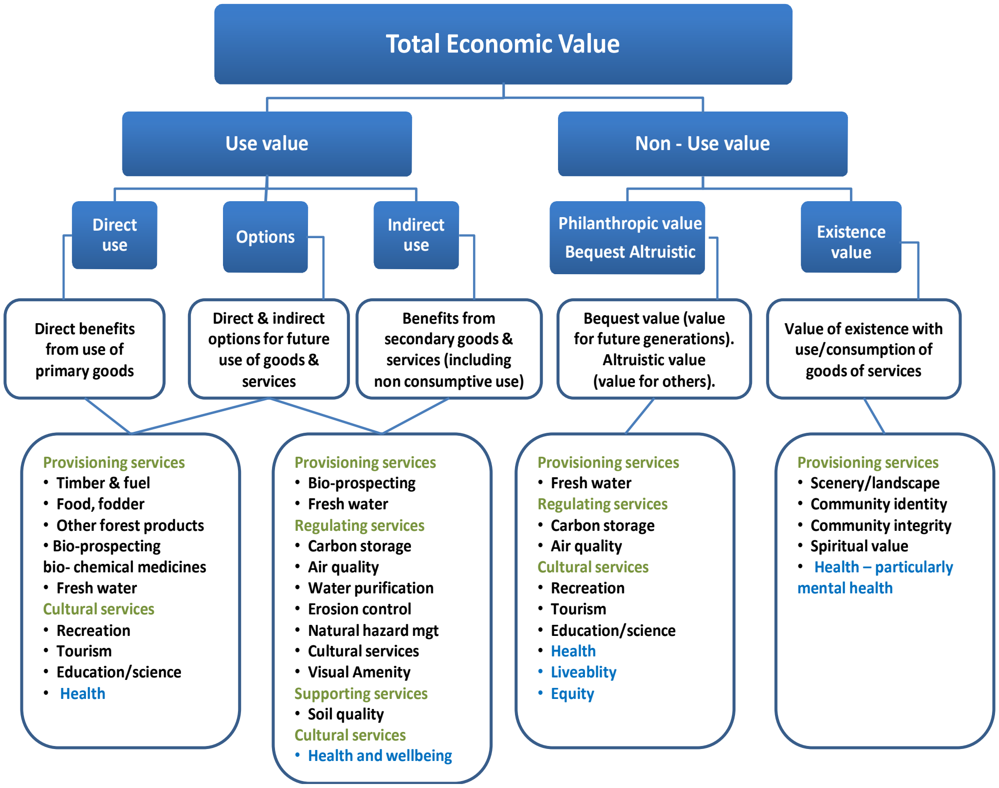


Figure 4: Total Economic Value system with health and wellbeing additions – adapted from Ten Brink et al. (2011)[16]

The different aspects of the TEV system can be measured in a number of ways (see Table 1). The method used will depend upon the context it is applied to and what is to be measured. For example, the measurement of pollution reduction in the air due to trees collecting pollutants provides a range of health and welfare benefits, some tangible and others intangible.

Direct use values	Option values
▪ Productivity changes ▪ Cost-based approaches ▪ hedonic (shadow) pricing ▪ Travel-cost methods (tourism and recreation) ▪ Contingent valuation (stated benefit) ▪ Change in health of communities and Individuals (social welfare changes)	▪ Change in productivity ▪ Cost-based approaches ▪ Contingent valuation (stated benefit) ▪ Replacement/substitution value
Indirect use values	**Existence value**
▪ Productivity changes ▪ Cost-based approaches ▪ Contingent valuation (stated benefit) ▪ Change in health of communities and individuals (social welfare changes)	▪ Contingent valuation (stated benefit) ▪ Social welfare assessment ▪ Cultural value assessment ▪ Loss of asset, function (extinction)

Table 1: Valuation methods for TEV[17]

Economic models will continue to be developed to account for these different types of value. Economics has traditionally assessed all values as they pertain to the firm or individual. The aggregation of these individual preferences and outcomes are assumed to be the total output value. This model excludes community values which are important for green infrastructure. Sometimes flow-on benefits will be calculated of a good or service which creates extra employment through added productivity. For example, the value of a production system can be considered to include all the people who transport, value-add through manufacture, distribute and sell those products. This is also highly relevant to the production of ecosystem goods, including food, fibre and flowers.

Limitations of the TEV model

The TEV model is limited in what it can value. These limitations and some within classical approaches include:

- Community values are demonstrably different to individual values and serve as 'collective' values shared within a society. Communities will collectively invest considerable sums in such values, whereas individuals cannot or will not.
- Systems, including infrastructure systems, operate at collective scales, which are different to aggregated individual interactions. For example, a forest is more than a collection of trees. A stream network is different to a collection of creeks. As a result the benefits they produce are different and will be valued differently under TEV.
- Traditional economics assumes that ecosystem goods and services can be readily substituted by those supplied by the conventional economy. For example, a forest that delivers clean drinking water would need to be replaced by artificial treatment if that forest was removed from the catchment. However, the functions of green infrastructure cannot be easily replaced because of the many benefits it supplies, often making natural systems irreplaceable. If an asset is irreplaceable and its removal is irreversible, its value will be higher. This is important to factor into valuation methods.
- Cost-benefit methods tend to preference current conditions compared to the future, which is quite appropriate in commercial situations, and is mirrored by personal preferences. However, many of the functions associated with green infrastructure such as intergenerational equity and the life of long-lived natural assets are not subject to the same discounting, so should not be treated in the same way.

Discounting prices future benefits at a rate that declines over time compared to the upfront investment. However, it also bundles quite a few different issues together including, peoples' preference for the present compared to the future, their rate of future preference for different goods and services (tangibles usually fast and intangibles usually slow) . These issues will be discussed further in the forthcoming project Green Paper.

New economic models need to be able to represent these aspects more fully. They will also need to combine valuation methods to produce appropriate, or fit-for-purpose frameworks. This is highly relevant to local government, who work with community values and are key managers of green infrastructure. The multiple values provided by green infrastructure need to be represented within the local government context and its accompanying decision processes. The application of the collective values inherent in green infrastructure requires collaborative decision-making within and across councils to achieve effective outcomes.

The challenge

"Protecting our natural capital is a hedge against the risk of collapse. That is, even under the most challenging and threatening global economic conditions, it is even more important to develop the economy with a long term view that protects natural capital. An alternative approach where natural capital is exploited for short term industry gain would lead to total economic disruption with severe consequences to our industries as well as major job losses."

Nous Group (2014)[18]

Because ecosystem services have only been partially valued, or come from common assets owned by everyone and no-one, the value they provide is often overlooked. Natural assets may even be regarded as a drain on finances in terms of their upkeep or 'undeveloped' status. At times, this has led to the degradation or removal of green infrastructure and the loss of its eco-services. In some cases, artificial solutions been financed and developed to replace the services the asset offered for 'free'. For example, if wetlands that reduce urban flooding are removed, the adjacent community may require added infrastructure to manage the increased risk. However, they will not regain the other services provided, such as environmental amenity and local temperature mediation.

"There will be a loss of 52 trees on Arden Street and 406 on Footscray Road, if the design as proposed is implemented. These trees have a combined amenity value of $1.85 million."

Submission to the Assessment Committee for the East West Link, City of Melbourne 2013

Most green infrastructure cannot be easily replaced. If removed, its asset value and services may be permanently lost. Retaining and improving green infrastructure leads to ongoing community resilience and prosperity. This highlights the need to better understand the trade-offs being made when specific actions affecting green infrastructure are undertaken, even if those trade-offs are not in plain view. Understanding what options are available when managing and developing green infrastructure will help us to make choices that ensure future communities have ongoing access to its benefits. Often this requires looking beyond short-term financial gain to the long-term value and cost of actions. A good example of this is the City of Melbourne's Urban Forest Strategy.

Looking into the future – The City of Melbourne Urban Forest Strategy case study[19]

"This is a once-off opportunity to look seriously into the future, not be frightened by it, but actually challenge yourself to think about what will make this a good future for our grandchildren."

Professor Rob Adams, City of Melbourne

The City of Melbourne has approximately 70,000 council-owned trees in the public realm and 20,000 in the private realm which make up its urban forest. This forest has numerous social, economic and environmental benefits that are a central to the liveability and resilience in its community. Due to the age of the trees and environmental impacts of climate change such as the drought and increasing temperatures, 27% of these trees are expected to be lost in 10 years and 44% of trees within the next 20 years.

As a result, the City of Melbourne has decided to develop an Urban Forest Strategy to ensure that its urban forest is not only maintained, but is increased from 22% to 40% canopy cover. The vision is "creating a city within a forest not a forest within a city."[20] Climate change and urban growth are two key challenges that are also addressed in this strategy.

Key actions in the strategy are diversification of plant species that make up the forest, increases in biodiversity and improving the overall health of the plants and soil to make it more resilient to future shocks. It allows communities to participate through precinct plans and to look at the types of the trees that are most appropriate for their area and engage the City of Melbourne to decide the landscape they want for the future.

Local government

"It [green infrastructure] is always seen as an add-on and this means that it is the first thing to be cut if the budget gets reduced, when are people going to realise that this is important?"

Participant, local government research workshop

Local government in Victoria has a pivotal role in the planning, development and maintaining of the infrastructure needed to secure their communities' future. Understanding how to make the most of all the assets and resources available is central to being able to achieve this. This task can be particularly difficult if operations are carried out in a siloed way or if infrastructure and assets are poorly integrated. Our research so far has revealed disconnects between different departments involved in infrastructure planning and within the planning process. This suggests that there are opportunities to increase the robustness of current infrastructure decision making and also to embed green infrastructure into current and new systems.

In particular there are opportunities to:

- Embed consideration of green infrastructure into the general infrastructure decision-making process.
- Embed process steps project management to better integrate the different types of infrastructure projects, ensuring better decision making and project management.
- Integrate ongoing monitoring and evaluation of green projects into the general asset maintenance program to be able to show the benefits that are being accrued.
- Feed lessons learnt from individual projects back into the planning and implementation steps of the process to improve decision making, understanding and management of projects.

Where green infrastructure can differ from other forms of infrastructure, is that as it matures it can increase in value and in the services it provides. Understanding how this develops is important, not only for the asset managers but also the communities who invest in and use them. However, it is also important to embed the ongoing maintenance and improvement costs in the project budget to ensure these gains can be made.

In view of the innovative nature and the long life-times of green infrastructure provision and use, it is important to track these projects and their benefits to provide knowledge for future green infrastructure initiatives. This can be achieved by incorporating the ongoing monitoring and evaluation of these assets within mainstream asset maintenance systems. Regular monitoring of ecosystem service provision and infrastructure condition will improve the understanding of asset performance and management. It will also provide data that can be used to support future business cases.

Factors that have enabled successful projects at a local government level to date have been:

- Initiatives supported by an established strategy.
- Adequate funding and resources available for projects.
- A champion at councillor and community level to drive specific action.
- An ability to collaborate with different departments internally and diverse parties externally.
- Alignment of multiple agendas both internally and externally.
- Persistence and stamina.

The need for education about green infrastructure so it is more fully understood, has been articulated by all councils interviewed to date. They have also nominated the need for improved frameworks and methods that can support more robust business cases to develop and implement future projects.

It is also important for local government to assess the governance and skills needed to achieve effective collaboration both within council and externally with other public and private bodies.

Making the future

"In Australia, our pressing issues of water, energy, environment, healthcare, productivity, mobility, safety and security. Healthcare 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[21]

The world we live in is changing, requiring us to think and consider what our future needs may be and how we can plan to accommodate these. This type of forward thinking seeks not only to address current problems and needs, but also to anticipate those in the future, and consider how they can be addressed through the technology, resources and knowledge that are currently available. The risks we face are systemic and dynamic and the infrastructure we create needs to reflect this. Integrated infrastructure that is resilient and incorporates and values green infrastructure is pivotal to being able to address these risks.

At the heart of the places we make and inhabit is green infrastructure which 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 will 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 day-to-day decision-making of general infrastructure is key to being able to develop smart cities that maintain our communities' liveability, resilience and wellbeing.

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 green infrastructure effectively will help optimise 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.

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Appendix A: Valuation methods for green infrastructure

Direct effects valued on conventional markets

These methods are directly based on changes in market prices or productivity, due to environmental impacts.

Change in Productivity. Projects can affect production. Changes in marketed output can be valued by using standard economic prices.

Loss of Earnings. Environmental quality affects human health. Ideally, the monetary value of health impacts should be determined by the willingness to pay for improved health. In practice, proxy measures like foregone net earnings may be used in case of premature death, sickness, or absenteeism.

Actual Defensive or Preventive Expenditures. Individuals, firms, and governments undertake "defensive expenditures" to avoid or reduce unwanted environmental effects. Defensive expenditures may be easier to obtain than direct valuations of environmental harm. Defensive expenditures can be interpreted as a minimum valuation of benefits, assuming they are cost effective.

Potential expenditure valued on conventional markets

Replacement Cost. Estimated costs to be incurred in order to replace a damaged asset. Damage costs may be higher or lower than the replacement cost. This approach is especially relevant if there is a sustainability constraint that requires certain assets stocks to be maintained intact.

Shadow Project. This approach is based on costing one or more "shadow projects" that provide for substitute environmental services to compensate for environmental assets lost under the ongoing project. For example, the capital and running cost of water purification as a value for clean water derived from closed, forested catchments.

Valuation using implicit (or surrogate) markets

Techniques described in this section use market information indirectly. Each method has advantages and disadvantages, including specific data and resource needs.

Travel Cost. The travel cost method has been used to measure benefits produced by recreation sites. It determines the demand for a site (e.g., number of visits per year), as a function of variables like consumer income, price, and various socio-economic characteristics. More sophisticated versions include comparisons across sites, where environmental quality is also included as a variable that affects demand.

Property Value. A hedonic price technique based on the more general land value approach which decomposes real estate prices into components attributable to different characteristics like proximity to schools, shops, parks, etc. The method seeks to determine the increased WTP for improved local environmental quality, as reflected in housing prices in cleaner surroundings.

Wage Differential. Also a hedonic technique, which assumes a competitive market where the demand for labour equals the value of the marginal product and labour supply varies with working and living conditions. Thus, a higher wage is necessary to attract workers to locate in polluted areas or undertake more risky occupations. This method relies on private valuation of health risks, not necessarily social ones.

Marketed Goods as Proxies for Non Marketed Goods. In situations where environmental goods have close substitutes that are marketed, the value of an environmental good may be approximated by the observed market price of its substitutes.

Benefit Transfer. Values determined at one place and time are used to infer values of similar goods at another place and time (where direct valuation is difficult), with adjustments for differences in incomes, prices, quality, behaviour, etc.

Valuation using constructed markets

Contingent Valuation. This method asks people what they are willing to pay for a benefit, and/or what they are willing to accept by way of compensation to tolerate a cost. It has been applied to common property resources, amenity resources with scenic, ecological or other characteristics, and to other situations where market information is not available.

Artificial Market. Such markets could be constructed for experimental purposes, to determine consumer willingness to pay for a good or service. For example, a home water purification kit might be marketed at various price levels or access to a game reserve might be offered on the basis of different admission fees, thereby providing an estimate of the value placed on water purity or on the use of a recreational facility, respectively.

Adapted from Munasinghe. M. (2007) Valuing environmental costs and benefits, The Encyclopaedia of Earth, http://www.eoearth.org/view/article/156826/ (sighted 7.9.14)

Appendix B: Benefits of green infrastructure

Area of Benefit	Type of Benefit
Social	
i) Human health and well-being	
(a) Physical	• It can increase opportunities and reduce barriers to physical activity.[1] • It can influence travel behaviour, including the levels of walking, cycling, public transport and car travel.[2] • It can increase opportunities for recreational activity, by providing useable open spaces, as well as streets conducive to walking and cycling.[3]
(b) Social and psychological	• Activities in green settings can reduce children's Attention Deficit-Hyperactivity Disorder symptoms.[4] • Children who live in apartments with greener, more natural views scored better on tests of self-discipline than those living in more barren settings.[5] • Women who live in apartment buildings with trees and greenery immediately outside reported greater effectiveness in dealing with their major life issues than those in more barren settings.[6] • Dramatically fewer occurrences of crime have al observed against both people and property in apartment buildings surrounded by trees and greenery than in nearby identical apartments that were surrounded by barren land.[7] • Green Infrastructure can also be incorporated into medical institutions for therapeutic purposes where patients recover faster.[8]
(c) Community	• Residential common areas with trees and other greenery help build strong neighbourhoods.[9] • Urban amenity, including the role of Green Infrastructure in creating more 'walkable' streets and more 'liveable' cities by enhancing human comfort, safety and enjoyment.[10] • The specific liveability benefits of air quality improvement and noise abatement in cities.[11]
ii) Cultural	• Cultural values, including community heritage values and the deeper symbolic and other values of urban nature.[12]
iii) Visual and aesthetic	• The visual and aesthetic role of Green Infrastructure contributes to the attractiveness of urban streets, neighbourhoods and city centres.[13]
Economic	
i) Commercial vitality	Consumers show a preference for shopping areas with trees, which also influenced customer perceptions of businesses and their products. Survey respondents indicated they would travel further, visit more often and spend more.[14]
ii) Increased property values	Many studies have shown the presence of trees has been found to increase the selling price of a residential property.[15]
iii) Value of ecosystem services	Research in the US 'Measuring the Economic Value of a City Park System' identified two factors that parks provide a city with direct income: 1. Increased rates and property tax from the increase in property value due to the proximity to parks. 2. Increased sales tax on spending by tourists who visit an area primarily due to the parks. Three other factors lead to direct savings: 1. Residents' free use of parkland and other free or low-cost recreation opportunities (rather than having to purchase these in the marketplace) is the largest. 2. Health savings in medical costs due to the benefits of increased physical activity in parks comes second. 3. Community cohesion benefit of communities 'coming

	together' to save or improve local parks has been shown to reduce antisocial problems that may otherwise cost the city more in policing and rehabilitation. The last two factors provide environmental savings, including water pollution reduction through stormwater retention via the park system's trees, vegetation and soil, reducing treating stormwater control and treatment costs. Air pollution is also reduced by park's trees and vegetation.[16]
Environmental	
i) Climatic modification	
(a) Temperature reduction	Trees and vegetation can improve local microclimate and help reduce the 'urban heat island effect'. These climatic benefits provided by trees and vegetation include: • Improving human comfort for street users. • Modifying local microclimates. • Reducing the urban heat island effect. • Providing health benefits especially for the aged. • Reducing energy use and carbon emissions.[17] • Assisting in climate change mitigation and adaptation.
(b) Shading	Tree shading decreases local temperature and improves comfort. By applying the effects of tree shade on the eastern and western sides of a Brisbane single story three star energy rating home to the Building Energy Rating System model, energy savings of up to 50% per year could be achieved.[18]
(c) Evapotranspiration	Trees provide additional cooling through evapotranspiration which absorbs heat in the process of evaporating water in the plant.[19]
(d) Wind speed modification	A barrier of approximately 35 percent transparent material can create a long calm zone that can extend up to 30 times the windbreak height.[20]
ii) Climate change mitigation	
(a) Carbon sequestration and storage	As about 50% of wood by dry weight is comprised of carbon, tree stems and roots act to store up carbon for decades or even centuries. Over the lifetime of a tree, several tons of atmospheric carbon dioxide can be absorbed.[21]
(b) Avoided emissions (reduced energy use)	Avoided CO_2 emissions due to reduced energy use and the associated reduction in carbon dioxide emissions from fossil-fuel based power plants[22]
iii) Air quality improvement	
(a) Pollutant removal	Trees absorb gaseous pollutants through the leaf surface (SO_2, NO_2) as well as intercepting particulate matter on leaves (PM10 and PM2.5).[23]
(b) Avoided emissions	Indirectly, by reducing air-conditioning use and related energy consumption in buildings (through shading of buildings, air temperature reduction and wind modification) leading to lower air pollutant emissions from power plants (known as 'avoided emissions).[24]
iv) Water cycle modification	
(a) Flow control and flood reduction	Urban stormwater harvesting raises the possibility of increasing urban water supply and improving water quality in riparian environments and receiving water. In addition, benefits from stormwater harvesting including reduced heat stress, improved balance between high and low flows in water ways, improved amenity of the landscape.[25]
(b) Canopy interception	Canopy interception is the rainfall that is intercepted by the canopy of a tree and successively evaporates from the leaves.
(c) Soil infiltration and storage	Biofiltration systems are an important component in improving the quality of urban stormwater runoff, and protecting aquatic ecosystems. Vegetation is the key factor in biofiltration systems as it increases the pollutant removal function of the soil through a combination of physical, chemical and biological processes.[26]

	(d) Water quality improvement	Biofiltration improves water quality through the removal of pollutants.[27]
v)	**Soil improvements**	
	(a) Soil stabilization	Greater amounts of vegetation increase soil stability and decrease soil erosion and loss.[28]
	(b) Increased permeability **(c) Waste decomposition and nutrient cycling**	Porous and permeable surfaces paving can play a role in water quality through pollutant removal from stormwater runoff, by assisting in biological decomposition of contaminants.[29]
vi)	**Biodiversity**	
	(a) Species diversity	Increased and differing habitats lead to increased species diversity.[30]
	(b) Habitat and corridors	Wider benefit to the local area through biodiversity and habitat provision.[31]
vii)	**Food production**	
	(a) Productive agricultural land	Agricultural and other productive land, including vineyards, market gardens, orchards and farm.[32]
	(b) Urban agriculture	Urban agriculture incorporates productive land on the peri-urban boundary to provide more sustainable food sources for urban areas. It also includes community gardens, kitchen gardens and 'edible landscapes'.[33]

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