Hort Innovation

Final Report

Integrating Plant Life into Building Infrastructure Ratings Tools

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Delivery partner:

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Project code:

NY16007

Project:

Integrating Plant Life into Building Infrastructure Ratings Tools – NY16007

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Content

Summary

This project was commissioned to help communicate to a range of stakeholders - spanning the property, infrastructure and nursery sectors - about the benefits of green infrastructure and the role it can play in delivering a more sustainable built environment.

Green infrastructure contributes to a range of other environmental and social benefits in urban areas, from making cities cooler in warm conditions, to supporting biodiversity, to making communities healthier and happier. A significant amount of research has been undertaken to identify and quantify these benefits both nationally and internationally. The project included an extensive literature review to consolidate this research, and make it more accessible to decision-makers. It also aimed to validate the feasibility of achieving these benefits through consultation with stakeholders involved with the on-the-ground, development, regulation and operation of green infrastructure. The consultation presented an opportunity to understand the drivers and barriers that green infrastructure currently faces.

To achieve a more sustainable built environment, the property and infrastructure sectors have, amongst other things, self-regulated through the use of rating tools. Yet, again, the owners of these tools have not had easy access to the evidence on the benefits offered through investment in green infrastructure. The proponents of this project saw an opportunity to further boost its take up through close engagement and collaboration with organisations such as GBCA and ISCA. In turn, it is hoped that the industry will be incentivised to incorporate more plants into the built environment.

As such, this project is highly applied in nature. Through a series of carefully designed activities, it has collected the evidence of green infrastructure's value, developed case studies, and engaged with key stakeholders. In doing so, it supported rating tool developers in strengthening the role of green infrastructure in their schemes, in turn encouraging the wider built environment sector to plan, design and deliver more green assets into our built environment.

The contact undertaken with those in the field, designing, planning and building Australia's property and infrastructure, generated a set of recommendations for the horticulture industry to better support them in making urban Australia greener.

Keywords

Green infrastructure; urban green; environmental impacts; social impacts; ecosystem services; sustainability; Green Star; GBCA; ISCA

Introduction

Green infrastructure is a relatively new term with a still evolving definition. In essence, green infrastructure broadly refers to a range of different 'green' elements and structures which can perform ecosystem service functions, such as local climate regulation, water purification and air purification, supporting cultural and spiritual value, and preventing erosion. This translates into direct, physical benefits such as building energy efficiency, healthier individuals and reduced urban-heat island effect.

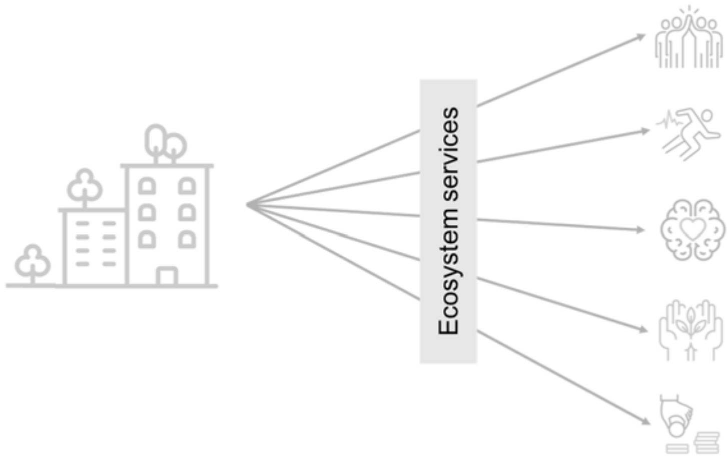

Figure 1 – The ecosystem services provided by green infrastructure result in a suite of sustainability benefits to the built environment investigated by this project.

A notable feature of green Infrastructure is that there are typically co-benefits from the same element. For example, a green wall can help to improve air quality while also contributing to the mental health of building occupants. These co-benefits should strengthen the argument for replacing traditional grey infrastructure with a greener alternative, but have often been overlooked or excluded from business cases.

The Australian Construction Sector has a revenue of $356.4bn and is projected to grow 2.5% each year between 2019–2023. The significant majority of this spending (55%) is on the materials and products that end up constituting our built environment. The farm-gate value of nursery plants sold to landscapers, developers and builders in 2015-16 was $558.4 million (equal to 24% of nursery plant sales), with turf sales accounting for another $92 million per annum (34% of all turf sales). Yet, together, nursery plants and turf only account for 0.33% of the total construction sectors spend on materials and products. Addressing information gaps and increasing the demand for green infrastructure could therefore have enormous benefits for the nursery industry.

At the same time, the construction and operation of the built environment accounts for a huge proportion of humanity's environmental impacts. The Organisation for Economic Co-operation and Development (OECD) found that, globally, buildings are responsible for about 30 per cent of raw materials use, 42 per cent of energy use, 25 per cent of water use, 12 per cent of land use and 40 per cent of atmospheric emissions (Centre for Design RMIT, 2003).

It is generally agreed that self-regulation is helping to improve the sustainability of the built environment in Australia and mitigate its negative impacts. This is being achieved, most notably, via voluntary rating schemes such as the Green Building Council of Australia (GBCA) 's Green Star and the Infrastructure Sustainability Council of Australia (ISCA) Infrastructure Sustainability (IS) standard. Such tools can, and do, provide incentives for the uptake of green infrastructure, but there are gaps to be filled and improvements to be made in those mechanisms. Regular reviews to these schemes provide an opportunity to further integrate the sustainability benefits of vegetation and green spaces into their future development.

Inspired by the 202020 Vision, this project aimed to engage GBCA and ISCA with a suite of organised scientific evidence and empirical feedback from green infrastructure practitioners across Australia, to promote effective reward mechanisms for the property and infrastructure industries to incorporate more plants into their projects.

Methodology

This section describes the project's activities. Figure 2 details the project methodology in relation to expected project outputs.

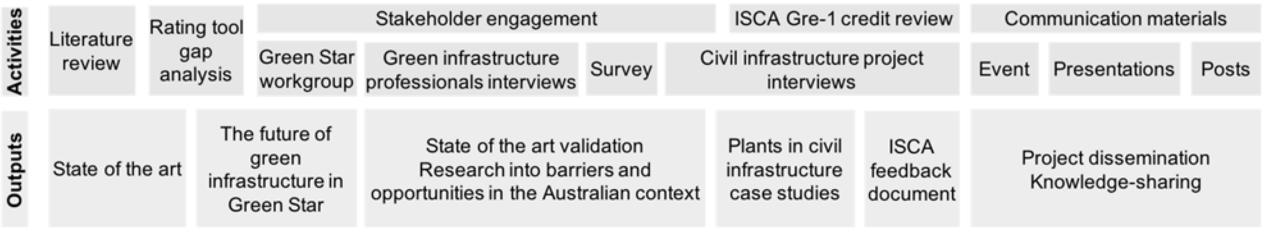

Figure 2 – Project activities and intended outcomes.

Formation of project advisory group

The project advisory group consisted of Jorge Chapa (GBCA), Nicole Boyd (ISCA), Brenda Kranz - succeeded by Byron de Kock (Horticulture Innovation Australia) – and Tom Davies and Joana Almeida (both Edge Environment).

Literature review

AIM: COMPILING AND ORGANISING AVAILABLE KNOWLEDGE ON THE SUSTAINABILITY BENEFITS THAT CAN BE HARNESSED FROM THE USE OF PLANTS IN THE BUILT ENVIRONMENT.

This involved a literature review of studies documenting:

- Evidence, mechanisms and quantification of the provision of ecosystem services by green infrastructure.
- Discussion on the definition of green infrastructure and classification of green infrastructure typologies.
- Discussion on the ecological function and biodiversity value of green infrastructure.

As much as possible the review aimed to separately categorise information related to different green typologies (e.g. green roofs, green walls, urban parks) and for specific sustainability benefits. Priority was given to Australia-based or Australia-published studies, in order to maximise geographic consistency, with data gaps filled by studies from overseas. The studies were largely sourced from searches on indexing websites, such as Google Scholar, Scopus and Google's main search engine.

The review covered 144 studies, of which 105 provided direct inputs to the deliverable. The majority of sources (>80%) were scientific and technical literature, including peer-reviewed academic outputs and technical reports.

Green infrastructure in sustainability rating tools

AIM: TO FURTHER STRENGTHEN THE MECHANISMS BY WHICH SUSTAINABILITY RATING TOOLS REWARD THE USE OF PLANTS IN PROPERTY AND INFRASTRUCTURE.

Gap analysis

This task involved a credit-by-credit review of Green Star and the IS Tool rating schemes to assess how these rating tools reward the use of plants in projects. Building on the information gathered in the literature review, the gap analysis identified:

- The credits that directly or indirectly reward the use of plants.
- The ecosystem services being rewarded in each credit and he types of green infrastructure that may be considered.
- Key ecosystem services provided by green infrastructure not being considered in current versions of these tools.

Liaison with the GBCA working group on green infrastructure in Green Star

Innovation challenges are new, exploratory Green Star credits that are trialled and, if successful, may be incorporated into the scheme as a credit. This project proposed six draft innovation challenges to reward green infrastructure in Green Star. The suggested challenges were designed to fill the gaps identified in the current versions of the tools, supported by evidence from the literature review. The drafts were presented to the GBCA in a workshop.

Undertaking an ISCA Green infrastructure credit review

This task assessed the relevance and applicability of the new *Green Infrastructure-1* (Gre-1) credit, to be launched this year in the new version of the IS Tool (v2). Gre-1 is the first green infrastructure-focused credit to be included in the IS Tool and has been included based on the notion that civil infrastructure projects with a green infrastructure strategy are likely to be more sustainable.

This project trialled the Gre-1 credit with civil infrastructure projects across Australia, to understand how the credit requirements align to current industry practice and to identify any issues or opportunities for improvement. This occurred through a series of interviews with representatives from a number of high-profile projects, structured to align with each of the proposed requirements of the Gre-1 credit.

Each interviewee's responses were collated into individual project case studies. These provide summaries of interviewees' perspectives, experiences and key messages, as well as "Project Snapshot" tables that summarise project context and the *take-home messages* of each interview. The outcomes were subsequently shared with ISCA to inform the further development of the credit.

Stakeholder engagement

The objective of the stakeholder engagement was broadly to:

- Validate research findings from tasks 1 and 2.
- Gauge a level of practice of green infrastructure in Australia.
- Communicate and discuss the ongoing project and project findings with key stakeholders and broader audiences.

This project stage was subdivided in a stakeholder consultation task and communications and knowledge-sharing tasks, which were delivered centrally via an event. These two subtasks are the detailed in the ensuing sections.

Stakeholder consultation

AIM: INVESTIGATING THE EXPERIENCE OF PRACTITIONERS, AND DOCUMENTING BARRIERS AND OPPORTUNITIES IN THE IMPLEMENTATION, MONITORING AND MANAGEMENT OF GREEN INFRASTRUCTURE.

This project interviewed 10 professionals from across the general field green infrastructure field and six professionals working in civil infrastructure. The latter group consisted of the same people who participated in the peer-review of the IS Tool Green Infrastructure Credit.

The full list of interviewees in provided in

Table 1.

The interviewees were selected to meet the following criteria, in order of relevance:

- The set of interviews covered different geographies within Australia and different types of green infrastructure.
- All interviewees have a high level of experience in their discipline.
- The interviews covered several disciplines, such as architecture, engineering, landscape architecture, academia, government, management and horticulture.
- The interviews in the civil infrastructure component have direct experience of implementing green infrastructure in relevant projects.

Table 1 – Scope summary of stakeholder engagement.

Name	Role	Organisation	Project	Type/Function	Benefit	Geography
Ian Shears	Manager, Urban Sustainability	City of Melbourne	Various projects in Green Public Spaces/Environmentally Sustainable Development	Infrastructure/Green Walls	Positive social impact	Melbourne
Euan Williamson	ESD advisor, within the statutory planning department	Yarra City Council	Various projects in Green Public Spaces/Environmentally Sustainable Development	Building/Green Roof	Positive social impact	Victoria
Jock Gammon	Founder and Managing Director	Junglefy	Hassel Head Office Building	Building/Internal Green Wall	Air quality	Sydney
Noel Corkery	Managing Director	Corkery Consulting	The Great Western Highway Upgrade - Woodford to Hazelbrook Section	Infrastructure/Bioswale	Hydrological regulation	NSW
Sara Wilkinson	Associate Professor, School of the Built Environment	UTS	Policy Guidelines for Royal Institute of Chartered Surveyors	Buildings/Green Walls and Roofs	Multiple	Australia
Emil Montibeler	National Business Development Manager	OZBREED Pty Ltd	Gold Coast Council Car Park	Infrastructure/Bioswale	Hydrological regulation	Gold Coast
Nadia Ford	Strategic Planning	City of Stonnington	Community facility upgrade	Buildings/Green Walls and Roofs	Local climate regulation, air quality	Victoria
Robyn	Green Infra	City of	Various projects	Infrastructure/Ur	Local climate	Melbourne

Mitchelll	Coordinator	Melbourne		ban Forest	regulation	
Matt Williams	Sustainability Manager NSW/ACT	Lendlease	Darling Park	Building/Green Roof	Mental Welfare	Sydney
Justin Foley	Program Director	ACT Government	ACT Healthy Waterways	Water sensitive urban design	Hydrological regulation	ACT
Yanos Fill-Dryden	Senior Urban Designer	Transport for New South Wales	Parramatta Light Rail[1]	Green tracks	Aesthetics, local climate regulation	Sydney
Adam van der Beeke	Environmental Advisor	Fremantle Ports	Rous Head Industrial Park	Water sensitive urban design and ecological restoration	Hydrological regulation, ecological value	WA
Sophie Wallis & Rob Arnott	Sustainability manager / Project Director	Upthink / Mainroads WA	NorthLink WA	Green corridors, wildlife corridors, water sensitive urban design	Local climate regulation, positive social impact, physical activity, habitat connectivity and biodiversity, hydrological regulation	WA
Mark Sawatzki	Sustainability Coordinator	LendLease	Gateway Upgrade North	Water sensitive urban design initiatives	Hydrological regulation	Brisbane
Maggie Baron	Environmental Manager - Rail Systems Alliance and Urban Ecology Manager	Melbourne Metro	Melbourne Metro	Green walls, water sensitive urban design, Street trees, wildlife corridors	Local climate regulation, aesthetics, hydrological regulation, shading, cooling, community satisfaction, wellbeing, physical activity, habitat connectivity and biodiversity	Melbourne

Further to the interviews, a survey was made available online during the months of February and March 2018 and propagated via various channels, such as social media, mailing lists and peer-to-peer sharing. The exact reach of the survey is unknown. There were 25 responses, of which 23 constituted useful responses (i.e. coherent and complete).

The table below (

[1] Disclaimer: the outputs of this interview are for informative purposes only and are not reflective of a commitment of the project.

Table 2) lists the questions for all three stakeholder consultation tasks.

Table 2 – List of questions included in the face-to-face interviews and in the survey.

Question scope	Overall built environment questions		Civil infrastructure
	One-on-one interview question	Survey question	One-on-one interview question
Project description **Identification of green infrastructure type**	How have you included green infrastructure in your project?	Please tell us about your project. When have you incorporated plants into a building or infrastructure project. What type of green infrastructure project was it?	Did this green infrastructure asset replace or supplement a planned "grey infrastructure" solution? If so, how?
Identification of potential benefits	Did you design the project so to capture the benefits of green infrastructure? If so what where the benefits? If the project is built/complete, are you seeing the benefits that you expected? Have there been any co benefits?	If you have incorporated plants into a project to achieve particular benefits or mitigate a particular impact, please indicate which benefits.	What were the main drivers of incorporating green infrastructure into this asset? Were there any internal or external demands for incorporating green infrastructure into the project? Can you describe the benefits obtained from including this green infrastructure asset?
Monitoring	Are you measuring or monitoring the benefits?	Are you measuring or monitoring the benefits? If so how?	*Specific questions relevant to the Gre-1 IS credit.*
Identification of barriers	Have there been challenges?	What have been the challenges implementing your green infrastructure project?	What were the key challenges for incorporating green infrastructure into your project?
Identification of opportunities		What opportunities have arisen during your green infrastructure project?	What are your key lessons learnt from this project? What would you do differently next time?
Next steps	Is there anyone we should speak to next?		Do you have any additional comments for Hort Innovation?

Development of communication materials

AIM: BROADCASTING PRELIMINARY PROJECT FINDINGS IN A LIVE-DISCUSSION CONTEXT AND PROMOTING THE PROJECT.

This task involved communicating project outcomes by:

- Organising and facilitating an industry event.
- Presenting on the project at various seminars and conferences.

- Facilitating media content.
- Producing industry-targeted info sheets.

Outputs

The outputs of this project are detailed in Table 3 below.

Table 3 – Project outputs.

Output	Deliverable
State of the art **The future of green infrastructure in Green Star** **State of the art validation** **Research into barriers and opportunities in the Australian context**	This project has produced the following documentation: • Literature review of science-based evidence of the benefits of green infrastructure. • Gap analysis of the consideration of vegetation in Green Star and IS Tool. • Stakeholder consultation methodology, results and full transcripts. These documents are summarised in the outcomes section and compiled in detail in the report in annex.
ISCA green infrastructure credit feedback document	This document was submitted to ISCA (not for public disclosure). It includes summaries of the civil infrastructure case studies and the stakeholder-based trial of the Gre-1 credit. This document, along with the literature review and the stakeholder interview findings, have been discussed in a meeting with ISCA held in Sydney on 16th April 2018.
Project dissemination and knowledge sharing	**Green infrastructure event** This project organised and moderated an event held in Sydney on the 8th March 2018. The event hosted an audience of 50 hailing from different backgrounds, quickly and informally surveyed on site. The event was designed in forum format. There was a panel presentation by 5 professionals who represented several stages of the green infrastructure supply chain: Emile Montibeller (Ozbreed - horticulture and agronomy), Suzie Barnett and Andrew Wand (Junglefy - design, manufacture and maintenance), Matt Williams (Lendlease - adoption and monitoring), Nicole Boyd (ISCA, sustainability ratings). In addition, the 202020 Vision was presented by Ben Peacock (Republic of Everyone) and the project outcomes were presented by Joana Almeida (Edge Environment). Following the presentation, there was a discussion with the audience.
	Info sheets Three info sheets were produced for the nursery, property and infrastructure sectors summarising the relevant findings of this project and the opportunities identified of relevance to each industry.
	This project was presented at the following events: • 2017 WA Infrastructure Sustainability Conference, held on 16th May 2017 in Fremantle. Tom Davies presented the project objectives and program to infrastructure stakeholders. • Green Star Ecology Category review workshop, held on 1st September 2017 in Melbourne. Tom Davies attended the discussion and made connections with stakeholders in the property and green infrastructure sectors. • Urban Green Research Forum, held on 3rd November 2017 in Sydney. Joana Almeida presented the project objectives and preliminary results to a diverse audience. • Climate Adaptation 2018 Conference, which was held 7th – 10th May 2018 in Geelong. Tom Davies presented the findings of this project on applications of green infrastructure

	in climate change adaptation and resilience. • 2018 Green Building Da Conference, held on 24th May 2018 in Sydney. Tom Davies presented the project outcomes.

Outcomes

This project purported that one way to increase the use of plants in the built environment is by harnessing the potential of industry self-regulation through sustainability rating schemes in the property and infrastructure sectors. To achieve that aspirational outcome, three interim outcomes were defined, and are reported against here.

Science-based evidence of the benefits of green infrastructure for use in rating tools

The literature review and gap analysis compiled and organised information on:

- What sustainability benefits and ecosystem services can be harnessed from different green infrastructure types and, therefore, building and civil infrastructure aspects.
- The known underlying mechanisms and magnitude of those benefits.
- The constraints to implementing and managing effective green infrastructure, from an ecosystem service provision point of view.
- How these ecosystem services can be translated into economic gains.
- How these ecosystem services map onto sustainability benefits that Green Star and the IS Tool could seek to reward.

The literature review identified that green infrastructure provides a series of ecosystem services that reflect on broader sustainability benefits to the built environment. These sustainability benefits can be broadly divided into five categories: environmental benefits, physical health improvement, mental health improvement, communal cohesion and perceived liveability, which are expected to have economic benefits (Figure 3).

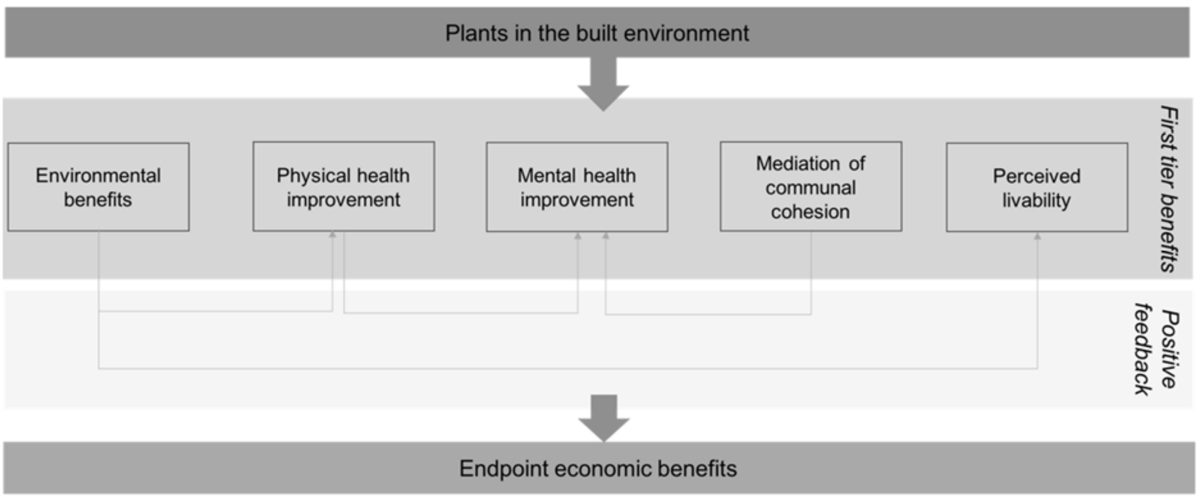

Figure 3 –Social, environmental and economic benefits of plants in the built environment.

A detailed description summarising the findings of the literature review is provided in

Table 4.

Table 4 – Summary of the literature review findings on the ecosystem services and benefits of green infrastructure.

Ecosystem service type	Ecosystem services identified	Sustainability benefits	Evidence related to green infrastructure
Provisioning	Food	Reducing the environmental impact of food production (food miles, wastage, etc.) Community experiences	Urban agriculture is a benefit of green infrastructure in the shape of agricultural productive land which is preserved on the urban fringe, as well as urban gardens (Mok, et al. 2014). Food production occurs in different assets, from private and public gardens to road verges and rooftop installations. These decentralized food sources have multiple benefits, reviewed in (Government of SA; Botanic Gardens of SA; Natural Resources, Adelaide and Mount Lofty Ranges; Renewal SA 2014, Deen and Tempany 2011, Mok, et al. 2014, Sanjuan-Delmás, et al. 2018).
Supporting	Primary production	Carbon sequestration	The potential for green infrastructure to sequester carbon depends on the asset, local climate and vegetation type (Weissert 2016, Yoon, et al. 2016, Livesley, et al. 2015). These elements code for the amount and type of biomass that is generated in the asset and therefore the amount of carbon accumulated. They also determine the potential for soil organic carbon sequestration.
	Habitat	Support of biodiversity Mitigation of negative impacts of urban development	Urban development is associated with negative impact on biodiversity due to habitat fragmentation, encroachment and loss, and to the promotion of invasive and predatory species. Green infrastructure has the potential to lessen this impact by increasing levels of biota and habitats to otherwise grey infrastructure and by bridging fragmentation (Goddard, Dougill and Benton 2009, Savard, Clergeau and Mennechez 2000). Biodiversity can also be manipulated to design green infrastructure to meet specific typology goals (e.g. reed species in bioswales). There is widespread evidence on the habitat value of green infrastructure, such as in its support of pollinator and bird biodiversity and in the high level of functional diversity (Threlfall, et al. 2016, Savard, Clergeau and Mennechez 2000, Van Mechelen, et al. 2015, Verboven, et al. 2014, Verboven, Brys and Hermy 2012).
	Water cycling	Replacement of grey infrastructure in the treatment and management of wastewater and stormwater Reduction of the effect of impervious surfaces on	Impervious surfaces in urban developments affect waterway health by preventing water infiltration and evapotranspiration. Stormwater diversion to evacuation systems modifies natural discharge rates onto receiving waterways, causing waterway erosion and disturbing its ecology (Water By Design 2010). Green infrastructure reduces and delays stormwater runoff and reduces pollutant discharge to waterways. Reductions can be as high as 100% in green roofs (Pataki, et al. 2011, Getter

		stormwater management	and Rowe 2006) and 99% annually in rain gardens (Orbendorfer, et al. 2007). Street trees capture water and retain nitrogen and phosphorous leachates, benefiting from the nutrients to their own development (Denman, May and Moore 2016, Green Blue Urban 2015). Water Sensitive Urban Design (WSUD) is an approach to urban planning aiming to minimize disturbance of natural water flows induced by urban development (Water By Design 2010). Green infrastructure can be used in WSUD as: • Stormwater management systems with bioswales, raingardens and constructed wetlands. • Building features such as green roofs. • Inclusion of tree-covered landscapes in developments.
Cultural	Recreational	Social capital created in social spaces Community satisfaction Improved physical health Improved mental health Childhood development	One of the better documented benefits of green infrastructure is the promotion of physical activity. Granting communities access to green spaces has been shown to have produce changes in physical activity levels with positive health effects (Willis, et al. 2016, Rolls, Fordham and Sunderland 2016, Giles-Corti, Bull, et al. 2013, Giles-Corti, Broomhall, et al. 2005). Populations with easy access to green spaces have been observed to have lower body-mass indexes, an indicator of good physical fitness. Green spaces and vegetation have a restorative effect and increase perception of wellbeing. Studies have observed a positive link between proximity to green space and good mental health. The link has been extensively investigated and is documented in reviews such as Townsend et al (2015), Kuo (2015) and the Green Infrastructure Evidence Base project (2014). Some well investigated benefits are: combating mental illness, reducing stress levels and attentional fatigue, perceived wellbeing and connectedness. By providing spaces of gathering, interaction and relationship development, green spaces promote social cohesion and sense of community. Members of communities with access to green space feel less isolated and more connected (Townsend, et al. 2015). In addition, wellbeing and experiences provided by green infrastructure is beneficial to the integration and protection of vulnerable social groups (Townsend, et al. 2015).
	Spiritual, religious and inspirational value		Some green infrastructure assets embody cultural values (heritage, trees as symbol of intergenerational legacies). Nature connected is also thought to underpin spiritual health.

	Education		Green spaces facilitate playing outdoors, which promotes pro-social behaviour in children.
	Aesthetics	Amenity value Neighbourhood satisfaction	Amenities provided by green infrastructure are favoured by homebuyers all across Australian cities and is liked to neighbourhood preference , as well as to property premiums (Plant, Rambaldi and Sipe 2016).
Regulating	Pollination	Support of pollinators	Green infrastructure can attract pollinators to levels observed in rural spaces (Verboven, et al. 2014, Verboven, Brys and Hermy 2012).
	Local climate regulation	Local cooling and reduction of urban heat island effect Energy savings	Urban dwellers are vulnerable to urban heat islands (UHI), an effect by which urban areas become hotter than surrounding areas due to heat accumulation. The UHI effect occurs due to grey surfaces (e.g. concrete or asphalt), which are often heat-absorbing, due to their dark coloration and/or high thermal mass. In contrast, natural, vegetated surfaces promote shading and cooling by evapotranspiration (Rizwan, Dennis and Liu 2008, US EPA 2016, Government of SA; Botanic Gardens of SA; Natural Resources, Adelaide and Mount Lofty Ranges; Renewal SA 2014, AILA 2015). Besides discomfort and direct health problems caused by excessive sensible heat, the UHI effect is linked to poor air quality, reduced liveability of cities and increased peak energy loads, due to demand of cooling devices (which in turn aggravate local heat). It is expected that these issues will be magnified for Australians by more frequent heat waves due to climate change coupled with high urbanization and population growth (AILA 2015, Government of SA; Botanic Gardens of SA; Natural Resources, Adelaide and Mount Lofty Ranges; Renewal SA 2014, Palin 2017, Wouters, et al. 2017). Green infrastructure can promote cooling at different scales, from city-wide areas to the building level (AILA 2015, Gago, et al. 2013). The key mechanisms underlying cooling are shading and dissipation of heat. The direct benefits of local climate regulation are: improved comfort, reduced heat-related morbidity, energy savings from building cooling and extended service life of building and paving materials.
	Natural hazard protection	Mitigation of extreme heat events through cooling Mitigation of extreme rainfall events through stormwater regulation	See: *Local climate regulation, Water cycling, Erosion regulation*

		Mitigation of tidal surges	
	Erosion regulation	Reduction of soil and coastal erosion.	Green infrastructure can be deployed as defence against erosion of soils and coastal barriers. Increasing vegetative cover in infrastructure and community property projects reduces run-off of minerals, nutrients and soil matter and preserves soil quality. Vegetation can also be used to stabilize dune systems, which function as a buffer against wave erosion (NSW Department of Land and Water Conservation 2001). In addition, there are dedicated green infrastructure types that protect coastal environments, such as engineered wetlands and grassland (Liquete, et al. 2013).
	Air quality	Reduction of indoor and outdoor air pollutant levels	Vegetation reduces air pollution levels through: the indirect effect of cooling; direct air filtration through the capture of particulates by stomata; and deposition of pollutants on leaves (Amati, et al. 2013). The effectiveness of green infrastructure in improving air quality depends on the asset, species employed and environmental factors such as pollutant load, pollutant type, wind, etc. (Irga, et al. 2017, Jayasooriya, et al. 2017).

Figure 4 below shows the services that can be expected from each asset type and the building/infrastructure element where it is commonly implemented. This matrix provides guidance on the green infrastructure strategy to implement to attain functions or achieve sustainability targets within projects. The success of harnessing these services and benefits depends on the asset to be implemented; the building and infrastructure element where it is implemented; its design; and its location and its wider urban planning context.

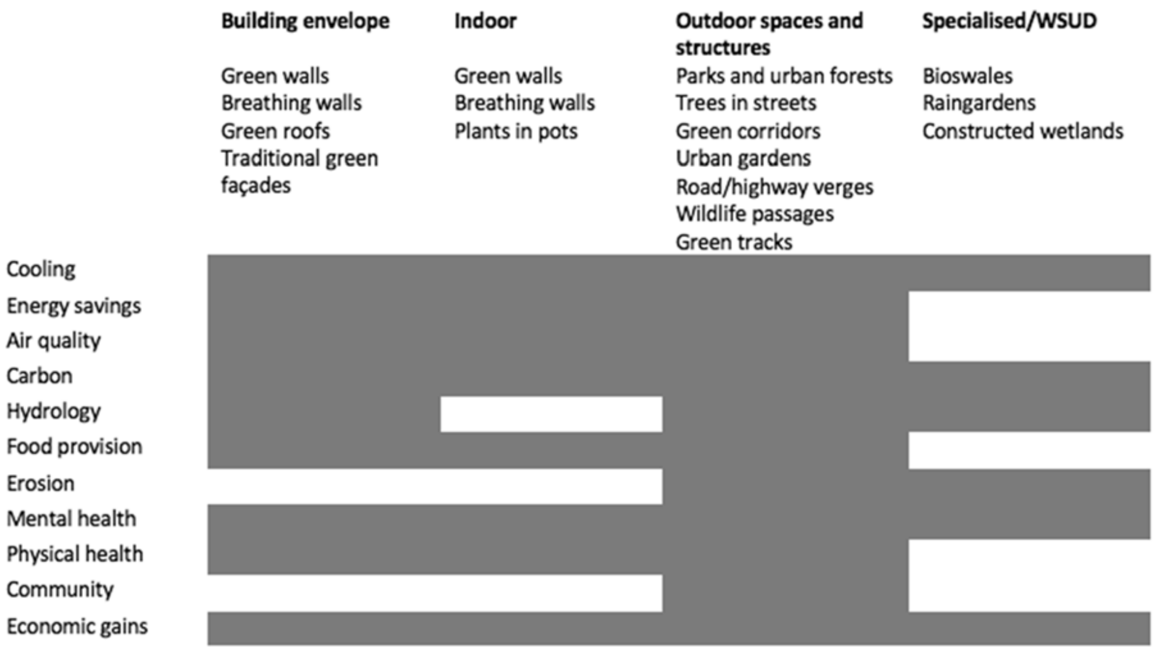

Figure 4 - Map of evidence found for significant benefits and services provided by asset classes in their context in the building or infrastructure.

This mapping exercise shows that a project aiming at specific sustainability targets or economic benefits through green infrastructure must select and design assets accordingly. It also summarizes the potential of green infrastructure to affect the environmental, societal and economic performance of the project in which it is included. This is the scope of building and infrastructure rating tools, as they reward projects on a credit system based on how certain performance criteria are achieved.

An individual green infrastructure asset can deliver a series of benefits, that can be monitored with different metrics. Measuring the services provided by green infrastructure has been a bottleneck in the monitoring of applied green infrastructure, its appraisal in the built environment and consideration in building and infrastructure tools. Agreement on metrics is necessary to adequately monitor and implement ratings of green infrastructure and to promote uptake (Figure 5).

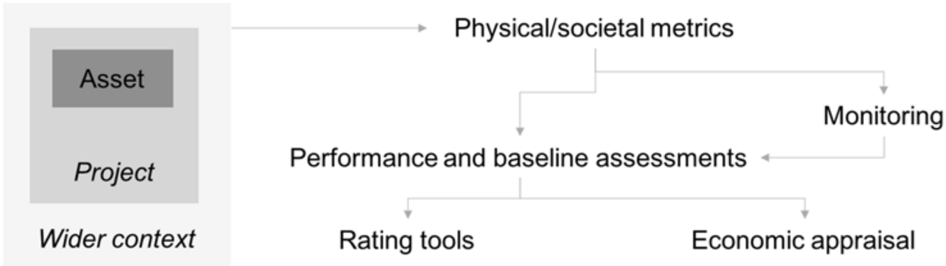

Figure 5 – Measuring green infrastructure performance.

The stakeholder consultation suggests that economic metrics would be desirable, to enhance buy-in and to facilitate cost benefit analysis (see following section). This suggestion is consistent with evidence of endpoint gains and cost savings suggested by several sources (Rossetti 2013, Plant, Rambaldi and Sipe 2016, Planet Ark 2014, AECOM 2017, Wolf 2004).

Drivers, barriers and opportunities

The stakeholders consulted in this project identified a series of drivers to implement green infrastructure (Figure 6).

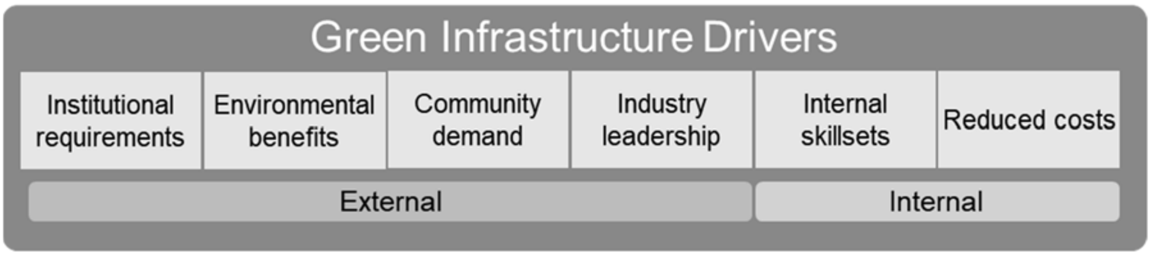

Figure 6 – Green infrastructure drivers identified by the stakeholder consultation tasks.

The interviews of stakeholders broadly linked to green infrastructure in planning, architecture and buildings identified leadership and branding as strong drivers for the implementation of green infrastructure. Examples of success are Central Park One and Lendlease's headquarters breathing wall, both in Sydney. In the specific context of civil infrastructure, green infrastructure is increasingly perceived as best practice and an important differentiator.

Green infrastructure is often resorted to in order to mitigate potential negative impacts of a project by better managing sensitive receivers or addressing stressors already identified in the project site. Example of the former are applying WSUD to decrease impact on water bodies; implementing wildlife passages or fauna bridges to reduce impact on habitat connectivity; or using green roofs and walls to improve visual amenity. The latter is better demonstrated by a project that increases vegetated area in a region prone to urban heat island effect.

Managing risks and pressures from regulatory bodies and from the community is a common driver, particularly for large developments and infrastructure assets. Large projects often involve diverse stakeholders, including communities, all levels of government and related authorities. Green infrastructure is perceived as a strategy to promote local community engagement and partnerships. Civil infrastructure interviewees highlighted that green infrastructure elements facilitated the integration of the asset into the broader institutional context. Several projects included green infrastructure elements to meet the environmental requirements of local planning and development frameworks.

Green infrastructure is driven internally within project teams and institutions by two main factors: (i) internal skillsets in green infrastructure and capability to generate internal buy-in; (ii) economic benefits achievable by replacing traditional grey structures and by improving local economic impacts (e.g. house prices).

At the same time, lack of internal buy-in in design and contracting companies and perceived costs and economic risks were identified key barriers to the adoption of green infrastructure in Australia (Figure 7). These issues seem to be underpinned by lack of accessible and comprehensive information on the benefits of green infrastructure, namely:

- Challenges associated with accurately costing both the construction and ongoing operational maintenance of green infrastructure. Operational costs are often perceived and high due to uncertainty surrounding maintenance requirements and plant success rates.
- Lack of information regarding the magnitude of the benefits that green infrastructure delivers to a project and its broader context. This is linked to the lack of performance modelling tools for many green infrastructure types, WSUD being a notable exception. Even for popular green infrastructures such as green roofs and walls, performance factors and tools for Australia are not readily available. This significantly hinders efforts to appropriately monetise the environmental and social benefits of green infrastructure.
- Climate change and how it conditions plant performance and species selection and the resilience of assets where green infrastructure is applied.
- Institutional issues such as existing regulation, strict management of contracts and competing priorities pose significant challenges for more streamlined green infrastructure implementation.

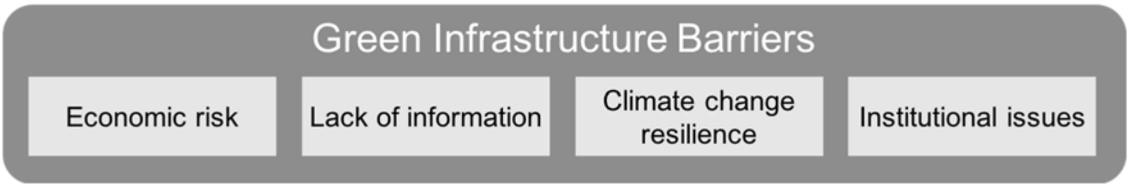

Figure 7 – Barriers to the adoption of green infrastructure, identified in the stakeholder consultation.

Sustainability rating tools, such as Green Star and the IS Tool, operate on a target-reward logic. That is, for a specific topic, a design feature such as green infrastructure delivers credits to the project if the design feature meets sustainability objectives prescribed in the credit. Those objectives are often set out in targets, or involve target-setting, that assess a level of performance. Operational performance factors of green infrastructure, when calibrated for Australian conditions, could play into optimizing rewards for green infrastructure in rating tools.

Increased industry awareness of the benefits of plants in the built environment

One of the key outcomes of this project was to promote awareness and discussion in the property and infrastructure sectors on the benefits of green infrastructure. This was delivered by engaging the industry continually during the project, working particularly closely with ISCA and GBCA to further strengthen the consideration of green infrastructure in their rating tools.

Collaboration with GBCA

Green Star provides mechanisms to recognise most of the value that plants can bring to a building. However, due to the low weighting of the credits compared to others, they suffer from low take up. As Green Star rating tools are only concerned with an individual building or communities project, introducing considerations for the wider urban landscape would expand the benefits of plants within a site's boundary.

This project has provided the GBCA with knowledge and advice as to how green infrastructure is rewarded and communicated with Green Star. Alongside this project, the GBCA has been working on a discussion paper outlining how the built environment can improve the ecology and biodiversity of the urban landscape at the building scale. The paper, to be released in 2018, also details how Green Star is expected to address these issues in the future.

The paper is due to set out five guiding principles that GBCA believes the built environment should follow when considering developing a new building:

- **Protect ecological value,** by encouraging development on land of limited value.
- **Minimise ecological impact,** by minimising the impact on on-site ecology and biodiversity during and after construction.
- **Enhance ecological value and biodiversity,** by improving the site as a first priority, and only then consider off-site ecology. This is the key principle that will achieve gains in ecological value.
- **Connect ecological networks,** by linking or maintaining connections, between native or built landscape corridors.
- **Create and manage on-site and off-site natural spaces,** by constructing new natural environments within the built environment and encouraging the maintenance of enhancements on-site and off-site.

These five principles will guide how Green Star will be amended in the future when it comes to improving ecology and biodiversity services in the built environment.

More generally, the GBCA is set to overhaul the Green Star suite of tools in 2019 and has committed to using the outputs from this project to inform the redesign of green infrastructure-related credits.

Collaboration with ISCA

The second version of the IS Tool, to be released later this year, will have a new credit focused on green infrastructure (Gre-1 credit). This will be one of two pathways (the other being the Ecology credit) through which civil infrastructure projects may use green infrastructure as an element of their strategy for an IS rating.

ISCA recognise the importance of credit trials and industry feedback in the development of new credits under the Infrastructure Sustainability (IS) Rating Tool. The tool must push the boundaries and encourage innovation and dedication in sustainability, but their requirements must also be responsive and relevant to the industry. Most other credits in the IS rating scheme focus on improved environmental decision-making and procurement rather than the incorporation of additional project elements to improve sustainability. The Green Infrastructure credit is thus unique due to its additionality – it requires that *additional* elements be built into the project to gain points.

The results of the interview-based credit trial undertaken under this project are reported in a document which includes:

- Key outcomes of draft credit trial.
- Challenges in terms of specific issues related to credit requirements.
- Opportunities for credit improvement.
- Recommendations for ISCA.

ISCA has given verbal confirmation that it will consider the project outputs in the next versions of the Gre-1 credit, namely in the requirements regarding target setting and monitoring.

Outreach

Several activities of this project involved external stakeholders, through consultation, collaboration and dissemination.

The success of the outreach can most clearly be measured in people reached. Even though a definite number cannot be calculated, it is estimated that circa 300 had extensive contact with the project and its outcomes. This number includes those who were interviewed and consulted; those who attended presentations on the project and the project event; survey respondents; and clicks on media articles. More indirect content – i.e. those who received newsletters or who saw social media – was estimated to be around 7000 individuals.

Industry roadmap for the increased uptake of green infrastructure

There are physical and societal parameters, subject to multiple variables of influence, to measure and to shape baselines against which performance and relative success of green infrastructure projects can be tracked. These metrics are fundamental to developing a wider understanding of, and appraisal models for, green infrastructure. Current knowledge is scattered, non-comprehensive and highly affected by site-specific factors, such as climate. Systematized predictive factors for how specific asset designs will perform across the significant services they provide in different contexts of the Australian climate and urban planning setups are required.

Furthermore, there is the need for a set of universal metrics that translate into industry values and supports the adoption of green infrastructure. This project’s literature review concludes that the environmental and social benefits can be traced to endpoint economic benefits. While it is not the scope of this study to develop a business case or cost-benefit analysis for green infrastructure, the industry consultation shows that a set of universal economic metrics could be a meaningful uptake factor.

This project has succeeded in connecting and coalescing multi-disciplined stakeholders to promote green infrastructure. Described as the “green infrastructure industry”, they have shown interest and enthusiasm to connect, learn, experiment and deliver more green infrastructure. The project has demonstrated a clear and timely opportunity to exploit the opportunity for more plants into the built environment, with the recommendations below (see Recommendations section) providing the basis for a roadmap that could be followed over the short and medium term.

Monitoring and evaluation

Project impact

The methodology and intended outputs and outcomes of this project were mapped against a monitoring and evaluation plan. This plan was designed as part of the project kick-off and iterated throughout the project for relevance and consistency with the project progress. The plan included key performance indicators (KPIs) for each activity. All proposed KPIs have been achieved and translate into the outcomes table (Table 3). The only the exception is the post-event survey of the impact of the communication activities on stakeholder perception. This has not been executed due to the diversity of communication channels adopted of which the event is only a part . Instead, the success of the outreach has been measured in terms of people reached through all points of contact created during the project.

This project interacted with external stakeholders through the interviews and surveys, ongoing communication and discussion with broader audiences, and direct collaboration with the GBCA and ISCA. This participatory approach embedded the project methodology with mechanisms to receive continuous feedback on activities and outputs. It also created immediate opportunity to assess the impact of the project outputs.

The project's main targets were the industry bodies that manage sustainability ratings for the built environment, namely the GBCA and ISCA. Table 5 outlines the scope of the feedback obtained from those institutions throughout the project and the impact of the relationship with those institutions. The impacts are considered to align with the performance criteria set out in the project's inception.

Table 5 – Scope of outcomes of the collaboration with the GBCA and ISCA and broader industry stakeholders.

Stakeholder	Scope of feedback	Associated project impact
GBCA	Usefulness of project approach and findings to the development of the next version of Green Star.	The GBCA will consider the results of the literature review, Green Star gap analysis and proposed innovation challenges in the next version of Green Star.
ISCA	Peer-review of the IS Gre-1 credit: format and selection of cases-studies. Usefulness of overall project findings to the development of the IS Tool.	ISCA will consider the project findings and the peer-review of the Gre-1 credit in further development of the credit.
Other industry stakeholders	Validation of findings of peer-review, in terms of feasibility of harnessing benefits identified.	Direct discussions and broadcasting of Hort Innovation's mission, project objective and findings.

Discussion of methodology and results

The literature review was based on a comprehensive set of publications that identified and described 13 sustainability benefits provided by green infrastructure, how they relate to ecosystem services and different green infrastructure typologies.

The set of ecosystem services that were identified by stakeholders to be relevant or motivational for projects in Australia was predicted by the literature review. Stakeholders distinguish between dedicated ecosystem services, which are those the green infrastructure is implemented to provide, and co-benefits. An example is building an asset of green infrastructure for shading and visual amenity and earning community satisfaction as well. There seems, therefore, different priority scales for the functions and applications of green infrastructure. This links to the findings on drivers of the industry's current practice of green infrastructure. Interviewees flagged compliance with stakeholder and regulatory expectations and/or extracting specific functions from green infrastructure to improve their project or mitigate its negative impact as being particularly important. Most industry stakeholders consulted within this project did not identify sustainability ratings as a driver for green infrastructure. Efforts in simplifying the adoption and reward of green infrastructure should consider these different priorities and how the value from green infrastructure is perceived.

One of the objectives of the review was to compile evidence on predictive factors for these benefits, i.e. numerical relations between measurable properties of the green infrastructure asset and a sustainability outcome. An example would be kg of carbon sequestered by m^2 of green space or kWh of energy saved in a building per m^2 of green wall installed. The goal of compiling such data was to: (i) provide stakeholders with known magnitudes of the benefits of different green infrastructure assets; (ii) provide GBCA and ISCA with data to refine the criteria and guidance of credits relating to green infrastructure. While some data was gathered (e.g. property premium increases in relation to canopy cover), it was not possible to propose predictive factors specific for different green infrastructure. This is because not all ecosystem services are specifically characterised in literature and because the performance of green infrastructure is highly dependent on typology, application and location/climate. Adequate predictive factors would also need to be specific for different climatic regions of Australia, which did not always correspond to available information.

The literature review highlighted that there are also disservices associated with green infrastructure. The format of the interview questions did not allow for validation of how extensively these correspond to operational reality. However, one of the key challenges highlighted by interviewees relates to the uncertain costs of operating and maintaining green infrastructure. In addition, most interviewees agree with the literature review in that there is insufficient means and knowledge to effectively monitor green infrastructure, which is both a barrier to its adoption and an impediment to ground-truthing its purported benefits.

The conclusions from this project, including the recommendations made to Hort Innovation, must be seen in the light of the representativeness of the research sample:

- The sampled literature includes 140 studies, mostly peer-reviewed works. Several review studies of specific ecosystem services were included to make the capture of information more effective. The findings align with other, large scale review studies such as the Green Infrastructure Evidence Base project, carried out by the Government of South Australia and associated institutions. The main limitation of the findings is in its geographic representativeness due to the limited amount of evidence based off Australian studies (discussed above).
- This study interviewed and surveyed stakeholders involved in implementing green infrastructure. A total of 39 stakeholders was consulted and provided useful answers. This can be considered an acceptable sample size, considering the green infrastructure professional field was found to be largely fragmented. The sample provides inputs from different professional areas, geographies and on different types of green infrastructure.

Recommendations

This project has created momentum for green infrastructure by connecting and coalescing a multi-disciplinary industry. Key stakeholders at the centre of the green infrastructure movement include the GBCA and ISCA. It is recommended that Hort Innovation continue to invest in developing knowledge and practice to support the growth of this relatively new asset class by engaging with GBCA and ISCA on progressing some of the recommendations below.

The following recommendations are made based on the outcomes from the project and are organised in order of priority. The recommendations are made based on the assumption that delivering green infrastructure-related products and services is an opportunity that the nursery industry wishes to pursue. The recommendations are based on the experiences throughout the project and they would be complemented with discussion.

A proposed investment is attached to each recommendation as an exemplary project to each recommendation. The proposed investment plan follows the logic outlined in the following page (Figure 8).

Recommendation 1 - Set an Australian Industry Definition for green infrastructure.

There is an opportunity for the horticulture industry to set the definition of green infrastructure. Stakeholder engagement demonstrated that there was a general understanding of what green infrastructure is, but multiple stakeholders referred to multiple definitions indicating that the broader construction industry is not clear on what constitutes green infrastructure and what benefits can be achieved using it.

A clear definition would provide a useful foundation around which the horticulture industry could build a range of activities, from communications to professional development programmes for architects, engineers and specifiers.

EXAMPLE PROJECT

Title	Defining Green Infrastructure
Objective	Building on the finding of the report run a small project to engage with the emerging Green Infrastructure profession and facilitate a working definition. The primary objective would be to set a working definition that Australian stakeholders agree on, and can build initiatives (CPD, standards, guidelines) around.
Method	1. Publish Report and send to stakeholders that have been engaged throughout the project 2. Work with GBCA and ISCA to organise an event, “Defining Green Infrastructure” 3. Design an event with a panel of four speakers representing the Green Infrastructure profession asked to make short presentation on their definitions of Green Infrastructure. Have a facilitator use the collective knowledge and intelligence of the invited audience to define Green Infrastructure. Write up the definition and promote in collaboration with GBCA and ISCA.
Cost	Estimated cost - $10,000K
Timing	August – September 2018

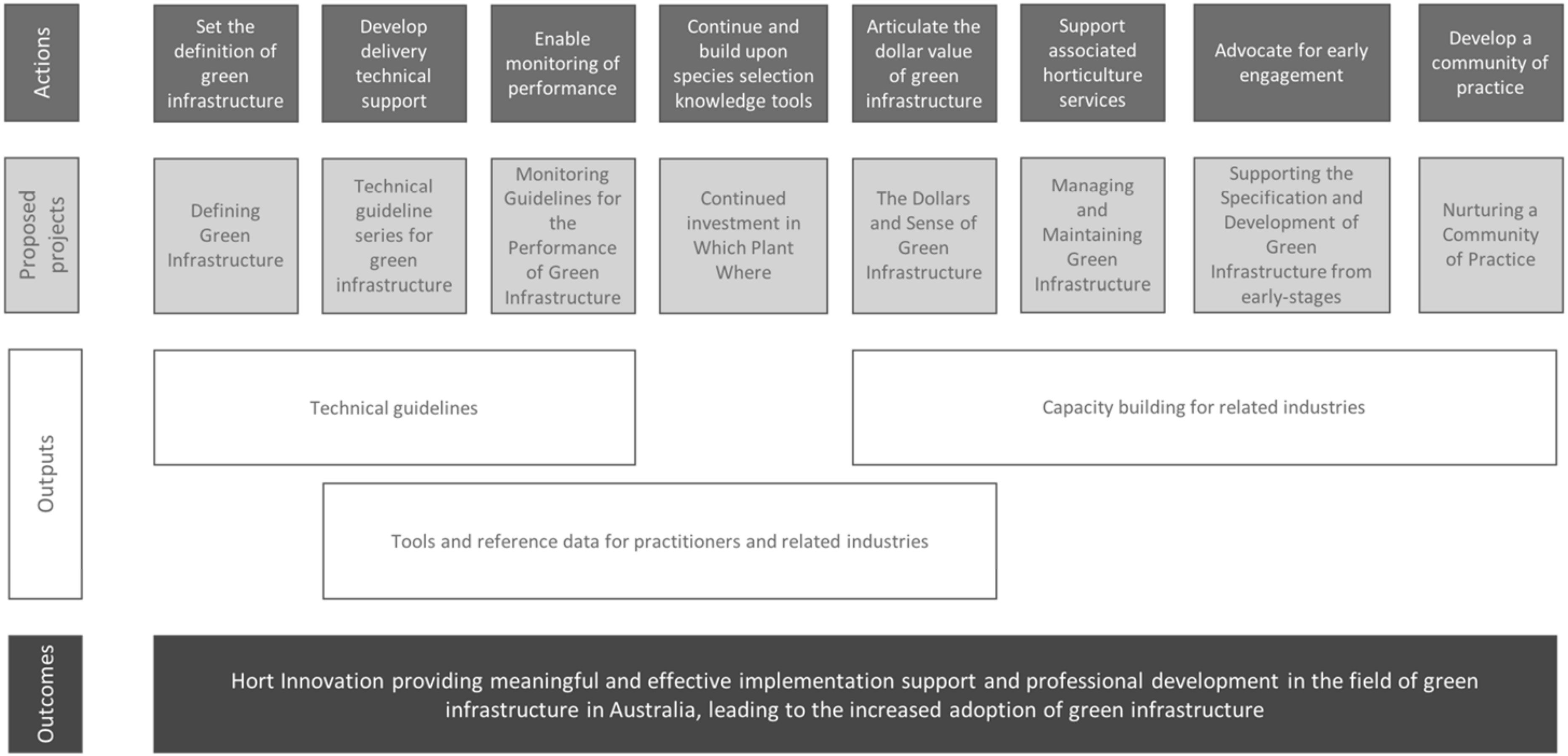

Figure 8 – Proposed investment plan logic.

Recommendation 2 – Articulate the dollar value of green infrastructure

The project has demonstrated that articulating the economic benefits of green infrastructure (allocating a dollar value to each benefit) and demonstrating positive value compared to grey infrastructure is likely to be the most effective way of achieving traction with project proponents. It is recommended that the horticulture industry does a cost-benefit analysis of green infrastructure assets and develops financial metrics that can be used in project costing in order to better articulate the business case for green infrastructure to the construction community.

A key aspect of green infrastructure assets is that they are typically multifunctional. An asset may be designed to serve a particular function (benefit), and it will also deliver additional co-benefits. An example is a bioswale constructed to provide WSUD and water management that also provides visual amenity and mental health benefits. It is recommended that co-benefits be emphasised and the financial benefit articulated to complement cost benefit analysis.

EXAMPLE PROJECT

Title	The Dollars and Sense of Green Infrastructure
Objective	To create the business case for green infrastructure versus Grey in order that green infrastructure can be properly accounted for in investment decisions. To deliver the guidelines for individual projects to undertake CBA in a streamlined manner.
Method	1. Research and Develop dollar value for each benefit and co-benefit delivered by Green Infrastructure 2. Research installation and maintenance costs for green infrastructure assets 3. Create a guideline document on the cost-benefit analysis of green infrastructure projects 4. Conduct a cost benefit for a select set of case studies 5. Expert review 6. Communicate
Cost	$120 – 180K
Timing	August 2018 – December 2018

Recommendation 3 – Enable effective monitoring of the performance

In many projects green infrastructure is being implemented to meet specific targets that demonstrate the utility and benefits created by using plants. However, monitoring a green asset's performance towards a target is still a challenge across the industry. The nursery industry could create guidelines on what metrics should be used in cost-effective monitoring plans for different types of green infrastructure.

EXAMPLE PROJECT

Title	Establishment of monitoring guidelines for the performance of green infrastructure
Objective	The guidelines will be directed at non-specialists of green infrastructure, that have a necessity create and implement monitoring plans for assets. The monitoring guidelines will start with the existing knowledge on functions of green infrastructure and set the criteria for what makes valid and meaningful monitoring method for each performing function. A performing green infrastructure asset will consist of different things depending on the asset and what it was been created for. The range of

	performance parameters and variables is therefore too extensive to identify and quantify in a single project. On the other hand, trying to reduce the concept of performance might either make monitoring cost-prohibitive to many projects or be alienated from the purpose of the asset.
Method	1. Research existing performance assessment protocols and methods and identify gaps and hotspots in criteria and variables 2. For each green infrastructure asset type, establish: a. Possible functions b. Performance criteria for those functions 3. Specify sets of variables along which to measure the performance criteria for each function 4. Specify requirements for effective performance monitoring for each asset type and function 5. Report and validate guidelines with stakeholders 6. Publish validated guidelines in Collaboration/partnership with professional bodies 7. Communicate
Cost	$5-10K per asset.
Timing	ongoing

Recommendation 4 – Develop technical support for the delivery of green infrastructure.

This project has evidenced that there are a series of measurable benefits that are already being recognised by building and infrastructure proponents as they replace “grey infrastructure” with “green infrastructure”. The green infrastructure industry is young and requires support to overcome technical delivery issues that can be barriers to adoption. This could include, for example, specifications for water tightness of a green roofs, or engineered loads for additional material on roofs. Hort Innovation could support adoption by commissioning this kind of technical advice.

EXAMPLE PROJECT

Title	Technical Guideline Series for Green Infrastructure
Objective	To develop a series of technical guidelines that enable professionals to design and specify green infrastructure with confidence. The guidelines will collate all existing information and be complimented by contemporary industry knowledge, expertise and practice. They will include typical specifications for green infrastructure and provide examples and case studies of successful implementation. They will also include links to additional resources to support the design and implementation of green infrastructure.
Method	1. Classify Green Infrastructure elements (this report includes an initial classification) 2. Create a framework for the technical guidelines 3. Conduct a literature review to collate all existing information/guidelines on each element 4. Identify a set of up to four experts for each element 5. Write each guideline 6. Technical Review 7. Publish in Collaboration/partnership with professional bodies 8. Communicate

Cost	$75 – 100K
Timing	August – December 2018

Recommendation 5 – Support the associated horticulture services industry; enabling success

As more green infrastructure is incorporated into the built environment, replacing grey infrastructure, the monitoring and maintenance business and delivery of these services will also change. For example, an air-conditioning engineer may be replaced by a horticulturist to service the plants in a building or piece of infrastructure. Just as machines need servicing, plants will require tending and nurturing to maintain their ability to provide the desired service. It is recommended that the Hort Innovation invest in the development of this industry with suitable skills and competencies as more green infrastructure is incorporated into our built environments, so it stands a greater chance of success.

EXAMPLE PROJECT

Title	Managing and Maintaining Green Infrastructure for optimal results – A professional development series supported with factsheets.
Objective	To support the development of the property and infrastructure facility managers and maintenance managers knowledge and practice in managing and maintaining Green Infrastructure assets in order that the asset succeeds.
Method	1. Use the Classification of green infrastructure to segment fact sheets 2. Interview existing green infrastructure asset managers and identify any issues that they are having and how they resolved 3. Draft Fact sheets 4. Fact sheet review by expert panel 5. Publish 6. Communicate
Cost	$5-10K per fact sheet
Timing	January 2019 – December 2020

Recommendation 6 – Advocate for early engagement with horticulture industry in the planning and design phase

The horticulture industry needs to be engaged early in the delivery cycle, ideally in the earliest stages of planning in order that species selection and propagation can be started in good time. It is therefore recommended that Hort Innovation educate and advocate for early engagement in green infrastructure projects in order to optimise the chance of successful delivery of green infrastructure projects.

EXAMPLE PROJECT

Title	Supporting the specification and development of green infrastructure from initial concept to final implementation
Objective	To support the development of green infrastructure through the design and build of property and infrastructure in order that it is not despecified. Green infrastructure is often despecified from projects due to perceived risk, perceived additional cost and limited knowledge/awareness of benefits and co-benefits
Method	1. Continuing advocacy for the benefits of green infrastructure. 2. Development of Knowledge and tools to support specification, design and build

	3. Develop case studies to support advocacy.
Cost	$50 – 100K per year
Timing	5 Years

Recommendation 7 – Develop a community of practice

The project interviewed a series of green infrastructure stakeholders to collect evidence of projects and to create case studies. These interviews discovered a series of successful projects that have overcome barriers, are achieving benefits, and are recognizing co-benefits. There is an opportunity to create a community of green infrastructure practitioners by expanding the catalogue of projects and building out the case studies to achieve a reference source for professionals wanting to evidence their case for their own green infrastructure project and to seek professional advice from others. It is recommended that the horticulture industry create a repository of case studies that can be used to promote, support uptake and provide technical reference material as the Green Infrastructure community evolves.

Example project

Title	Nurturing a community of practice
Objective	To nurture and grow a community of practice around green infrastructure in order to develop the skills and competencies to deliver the green infrastructure of the future.
Method	1. Engage GBCA and ISCA and potentially other professional bodies and discuss CPD programmes and support. 2. Identify collaborative opportunities with professional bodies to promote leading practice for green infrastructure 3. Promote green infrastructure outputs, such as guidelines, tools, reports.
Cost	Dependent on engagement - $100 - $500K
Timing	5 year program

Recommendation 8 – Continue and build upon species selection knowledge and tools

Species selection is proving to be a crucial factor for the performance of green infrastructure assets, determining, among others, maintenance requirements, resilience to climate change and fitness to local conditions. Knowledge of species selection for different assets needs to be developed and spread. Continued investment into "Which Plant Where" and greater outreach to the built environment professions is recommended.

Example project

Title	Species Selection Tool
Objective	To support the selection of the right plant for the job in order that green infrastructure performs optimally. Integrate more horticulture knowledge into the built environment. It is vital that the correct plants are specified for purpose. Just as building products are specified fit-for-purpose so should plants be.
Method	1. Identify audience 2. Continual investment in tools like Which Plant Where
Cost	Not estimated

Timing	Multi-year program

Refereed scientific publications

None to report

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Intellectual property, commercialisation and confidentiality

No project IP, project outputs, commercialisation or confidentiality issues to report'

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We would like to thank green infrastructure and 202020 Vision researchers at UTS, Western Sydney University and Macquarie University for the knowledge sharing.

Appendices

The following documents are attached to this report:

- Info sheet for the nursery industry
- Info sheet for the infrastructure sector
- Info sheet for the property sector.
- Full report with detailed project findings: literature review, rating tool gap analysis and stakeholder engagement.

Horticulture Innovation Australia

EDGE

Green Infrastructure & the Nursery Industry

The nursery industry's opportunity to harness the value proposition of building and infrastructure ratings

There is a significant opportunity for the nursery industry to increase market share in the construction industry in Australia. This opportunity is driven by the recognition of green infrastructure within sustainable built environment tools such as the Green Building Council of Australia (GBCA) Green Star rating system and the Infrastructure Sustainability Council of Australia (ISCA) Infrastructure Sustainability (IS) Tool. The Green Star Tool provides formal environmental ratings for buildings, interiors and precincts for design, as-built and in-operation performance. The IS rating tool rates infrastructure projects across the transport, water, energy, and communications industries. Both tools reward the substitution of grey with green infrastructure and the promotion of services that can be mediated by plants, such as climate change adaptation, improved health of the community and aesthetic value.

greenstar ISCA

Green infrastructure is a relatively new classification of engineering infrastructure that replaces conventional infrastructure with "green" elements that provide ecosystem service functions, such as energy efficiency, water management, air purification or mental health

What should you do?

- **Know the opportunity presented by built environment rating tools**
- **Understand the benefits of green infrastructures**
- **Share this information with clients and in marketing material**
- **Support the opportunities listed in this info sheet**
- **Read more at [LINK]**

benefits. Green infrastructure can be designed into different assets ranging from indoor plants in pots through to city parks and thus can be found at different scales of the built environment, depending on their intended function and typology. Features can include Green Walls (internal and external), green roofs, green spaces, bioswales and shading amongst others.

This info sheet is designed to raise awareness for Nursery Growers of the emerging opportunity that the green building and infrastructure market brings. The info sheet gives growers some facts that will help start the conversation with built environment stakeholders and recommendations on how growers can capitalise on the green infrastructure wave.

Quick Facts:

Market Opportunity

- The Construction Sector has a revenue of $356.4bn and is projected to grow 2.5% each year between 2019 – 2023.
- The significant majority of this spend (55%) is on the materials and products that constitute our built environments.
- Farmgate value of nursery plants sold to *landscapers, developers and builders* in 2015-16 was $558.4 million, equal to 24% of nursery plant sales.
- Farmgate value of turf sales to *trade (landscapers and turf installers)* in 2016-17 was $92 million, equal to 34% of turf sales.
- Current sales to the built environment sector accounts for 0.33% of their total spend on products and materials; there is a significant opportunity to increase this market share through inclusion of Green Infrastructure.
- 5% of Australia's workforce and 30% of its office space is currently rated under Green Star by the GBCA
- The capital value of infrastructure projects registered with ISCA is worth $80.2 billion.

The multiple benefits of plants in the built environment

Plants can be used in a variety of ways in the built environment and offer a wide range of economic, environmental and social benefits. The matrix below outlines the multiple services and benefits that are available from each type of green infrastructure asset. It demonstrates that different projects can be designed to achieve specific targets.

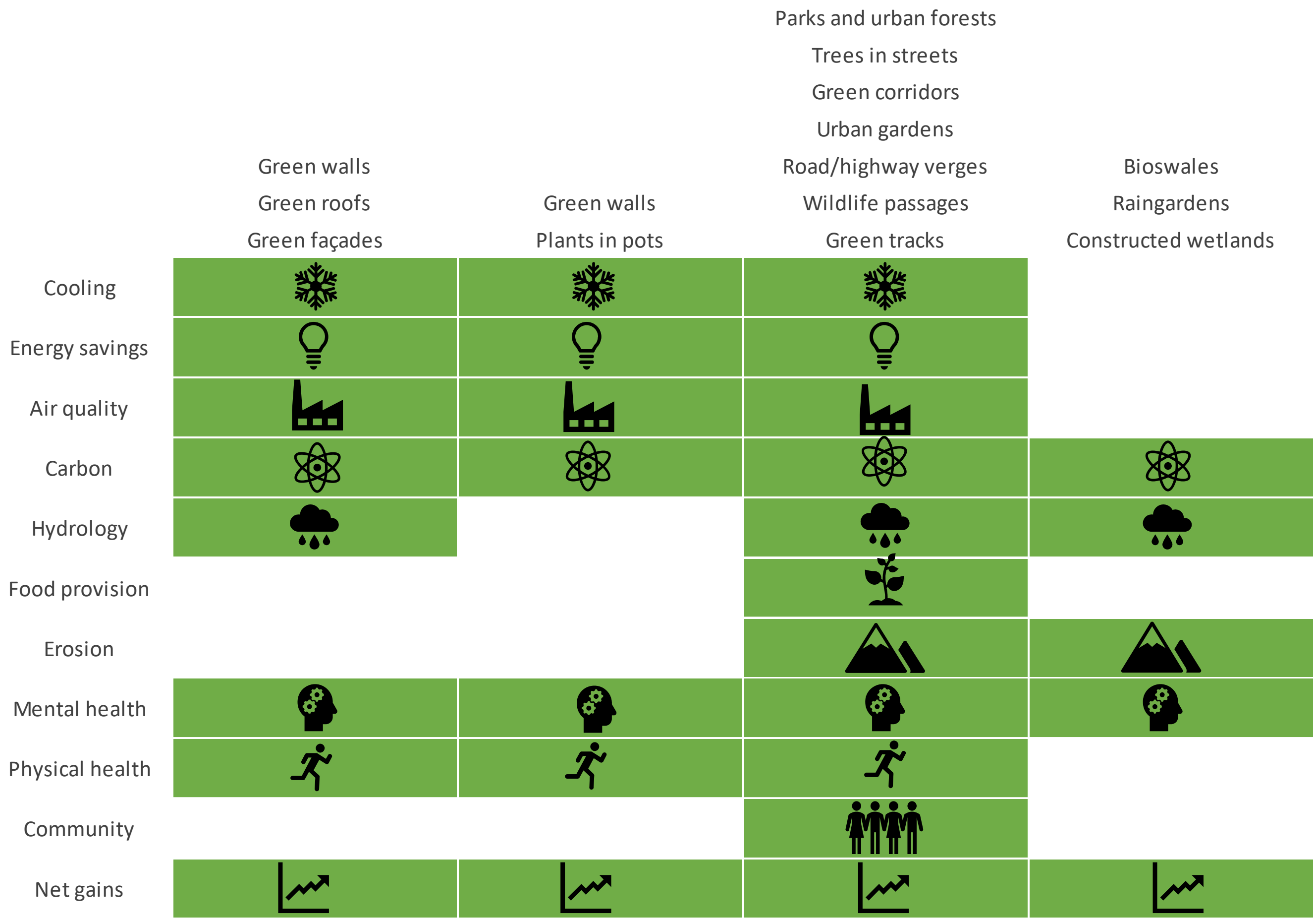

Figure 1 - Map of evidence found for significant benefits and services provided by each building or infrastructure asset

Opportunities for the Horticulture Industry

Growers can contribute to the momentum of green infrastructure by supporting HIA as they pursue the following opportunities:

1. **Set an Australian Industry Definition for green infrastructure.** Multiple definitions for green infrastructure exist. Defining and promoting GI would create a proactive stance for the industry which could be used in professional development programmes for architects, engineers and specifiers to build capacity and capability to deliver green infrastructure.
2. **Develop technical support for the delivery of green infrastructure.** Improvement of technical specifications and standards could improve the adoption of green infrastructure within the construction industry.
3. **Enable effective monitoring of performance.** Guidelines on what metrics should be used in cost-effective monitoring plans for different types of green infrastructure.
4. **Support the associated horticulture services industry.** As take up of green infrastructure increases more industry professionals will be require required to service

the green infrastructure and ensure it maintains its function within the built environment.

5. **Advocate for early engagement with horticulture industry in planning and design phase.** The Horticulture industry needs to be engaged early in the delivery cycle, to ensure species selection and propagation can be started early and that stock is available at the right maturity for inception of the project.
6. **Articulate the dollar value of GI benefits.** Development of a cost benefit analysis for green infrastructure assets including financial metrics that can be used in project costing to better articulate the business case for to the construction community.
7. **Describe the co-benefits and allocate financial values (associated with point 6)** A key aspect of green infrastructure assets is that they are typically multifunctional. It is recommended that co benefits be emphasised and the financial benefit articulated to complement cost benefit analysis.
8. **Develop a community of practice.** A repository of case studies and a community of practice can be developed to promote, support uptake and provide technical reference material as the green infrastructure community evolves.
9. **Continue to build upon species selection knowledge and tools.** Species selection is proving to be very important for green infrastructure and continued investment into "Which Plant Where" and greater outreach to the built environment professions is recommended.
10. **Maintain the momentum.** Continued investment in the development of knowledge and practice to support the growth of this relatively new asset class including continued engagement with GBCA and ISCA.

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3. **Government of SA; Botanic Gardens of SA; Natural Resources, Adelaide and Mount Lofty Ranges; Renewal SA.** Green Infrastructure Evidence Base. *The Green Infrastructure Project.* [Online] 2014. http://gievidencebase.botanicgardens.sa.gov.au/contents/green-infrastructure-concepts-and-definitions.
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9. **Rossetti, J.** *Valuation of Australia's green infrastructure: hedonic pricing model using the enhanced vegeation index.* Melbourne : Monash University, 2013.

Horticulture Innovation Australia

EDGE

Capturing the benefits of plants

A growing opportunity for the Infrastructure sector to benefit from "green infrastructure".

This info sheet highlights the benefits that plants can deliver when incorporated into buildings and infrastructure. The term green infrastructure is a relatively new classification of engineering infrastructure that replaces conventional infrastructure with "green" elements which provide ecosystem service functions, such as energy efficiency, water management, air purification or mental health benefits.

Green Infrastructure can be designed into different assets ranging from indoor plants in pots through to city parks and thus can be found at different scales of the built environment, depending on their intended function and typology. Features can include green walls (internal and external), green roofs, green spaces, bioswales and shading.

There is a growing trend of civil infrastructure capturing the benefits of plants such as reducing stormwater flows, preventing erosion, improving physical and mental health of communities and energy savings. This is done through rating tools that are used to measure and communicate performance. These tools provide credits for incorporating green infrastructure into ciil infrastructure, helping to achieve sustainable design.

The benefits of plants in the built environment have been researched and evidenced and are presented below. This info sheet is designed to make Infrastructure professionals aware of the benefits and opportunity that green infrastructure can deliver, and provide some facts that will help start the conversation with key stakeholders.

Quick Facts

- Plants are considered in 13 of the credits in the IS Rating Tool such as; air quality, receiving water quaility, ecological value, community health & wellbeing, energy & carbon reduction.
- ISCA is currently developing a new credit on green infrastructure. The credit is based on the definition of green infrastructure, as a solution replacing conventional “grey” engineering solutions.
- The capital value of infrastructure projects registered with the Infrastructure Sustainability Council of Australia is worth $80.2 billion.
- A green roof can reduce the cooling load of the building up to 60% **(1)**.
- People in contact with vegetation are healthier, happier and more productive **(2)**.
- A survey among Australian’s concluded they would give up 5% of their salary to have regular interaction with nature during their workday and pay 7% for a home if a green space is nearby **(2)**.

The multiple benefits of plants in the built environment

Plants in the built environment have the potential to relieve urban populations from issues affecting Australian cities, such as low air quality caused by pollution and the urban heat island effect. Well planned and designed green offers environmental mitigation services, by curbing greenhouse gas emissions, replenishing biodiversity and ecological value that is lost through urban development and by contributing to more efficient stormwater management **(3; 4)**.

Civil infrastructure projects my use green infrastructure instead or in addition of “grey” infrastructure, to harness specific functions. For instance, using tree shading to improve the thermal comfort of users, using water sensitive urban design instead of conventional stormwater management solutions, and using green walls to reduce pollutant loads around transport infrastructure.

ISCA and the IS Tool

There are several rating systems that assess the sustainability performance of buildings and infrastructure. These include green building rating systems like Green Star, WELL and the Living Building Challenge, and infrastructure rating systems such as the Infrastructure Sustainability Council of Australia's (ISCA) Infrastructure Sustainability (IS) Tool.

Environmental rating schemes provide a way for buildings and infrastructure to have their environmental benefits rewarded and to have innovative and forward-thinking designs acknowledged as best in class. Rating systems often reward the use of plants by capturing the benefits that plants can provide.

The ISCA IS Tool rates infrastructure projects across the transport, water, energy, and communications industries. The IS Tool provides credits for infrastructure projects that have a minimal impact on the environment, namely the maintenance of ecological value and hydrological cycles, minimal levels of air pollution, or minimal impact on habitats. Through the green infrastructure credit, the IS Tool directly rewards the adoption of ecological solutions in civil infrastructure.
The IS Tool also directly rewards the substitution of grey with green infrastructure and the promotion of services that can be mediated by plants, such as climate change adaptation, improved health of the community and aesthetic value.

Integrating green infrastructure in projects

Green infrastructure is now part of the industry leadership, community engagement, and impact mitigation strategies of civil infrastructure projects across Australia. These are their lessons learned on the successful implementation and use of green infrastructure:

Start early	• Plan for green infrastructure early • Manage stakeholder expectations
Understand costs and benefits	• Capital costs • Operational costs • Value benefits
Gain buy-in	• Internal stakeholders (project team, management) • External stakeholders (client, local community, interest groups)
Develop partnerships	• Local governments • Research partnerships with universities

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4. **Water By Design.** *A Business Case for Best Practice Urban Stormwater Management (version 1.1).* Brisbane : South East Queensland Healthy Waterways Partnership, 2010.

Capturing the benefits of plants

A growing opportunity for the Property sector to harness the value proposition of building ratings

This info sheet highlights the benefits that plants can deliver when incorporated into buildings and infrastructure. The term green infrastructure is a relatively new classification of engineering infrastructure that replaces conventional infrastructure with "Green" elements that provide ecosystem service functions, such as energy efficiency, water management, air purification or mental health benefits.

Green infrastructure can be designed into different assets ranging from indoor plants in pots through to city parks and thus can be found at different scales of the built environment, depending on their intended function and typology. Features can include green walls (internal and external), green roofs, green spaces, bioswales and shading.

There is a growing trend of buildings to capture the benefits of plants such as hydrology, erosion, physical and mental health and energy savings. This is done through rating tools that are used to measure and communicate performance. These tools provide credits for incorporating green infrastructure into building projects, helping to achieve sustainable design.

The benefits of plants in the built environment have been researched and evidenced and are presented below. This info sheet is designed to make Property professionals aware of the opportunity and some green infrastructure facts that will help start the conversation with built environment stakeholders.

Quick Facts

- Plants are considered in 11 different credits of the Green Star Rating Tools including Ecological Value, Heat Island Effect, Stomwater, Healthy & Active Living & Indoor Pollutants.
- 5% of Australia's workforce and 30% of its office space is currently rated under GreenStar by the Green Building Council of Australia.
- Property values in Sydney are expected to increase on average $164/m2 in result of a 10% canopy increase in street trees (8).
- A green roof can reduce the cooling load of the building up to 60% (1).
- People in contact with vegetation are healthier, happier and more productive.
- A survey among Australian's concluded they would give up 5% of their salary to have regular interaction with nature during their workday and pay 7% for a home if a green space is nearby (2).

The multiple benefits of plants in the built environment

Plants in the built environment have the potential to relieve urban populations from issues affecting Australian cities, such as low air quality caused by pollution and the urban heat island effect. Plants also offer environmental mitigation services, by curbing greenhouse gas emissions, replenishing biodiversity and ecological value that is lost through urban development and by contributing to more efficient stormwater management (3; 4).

Plants can be used on the building envelope to contribute to energy savings and aesthetics, can be situated in outdoor spaces such as food gardens that reduce-food miles and bring community members together, or used in parks and green corridors that promote walkability, exercise and outdoor activities (5).

Well planned and designed green infrastructure is correlated with healthier individuals enjoying lower stress levels and high emotional resilience, as well as with higher workplace and neighbourhood satisfaction (6; 7). Australians' preference for working and living in places where they can enjoy contact with plants and nature is reflected in economic gains, such as higher workplace productivity, property premiums and more affluence to local commerce (8; 5; 9).

The matrix below outlines the multiple services and benefits that are available from each type of green infrastructure asset. It demonstrates that different projects can be designed to achieve specific economic, social or environmental targets.

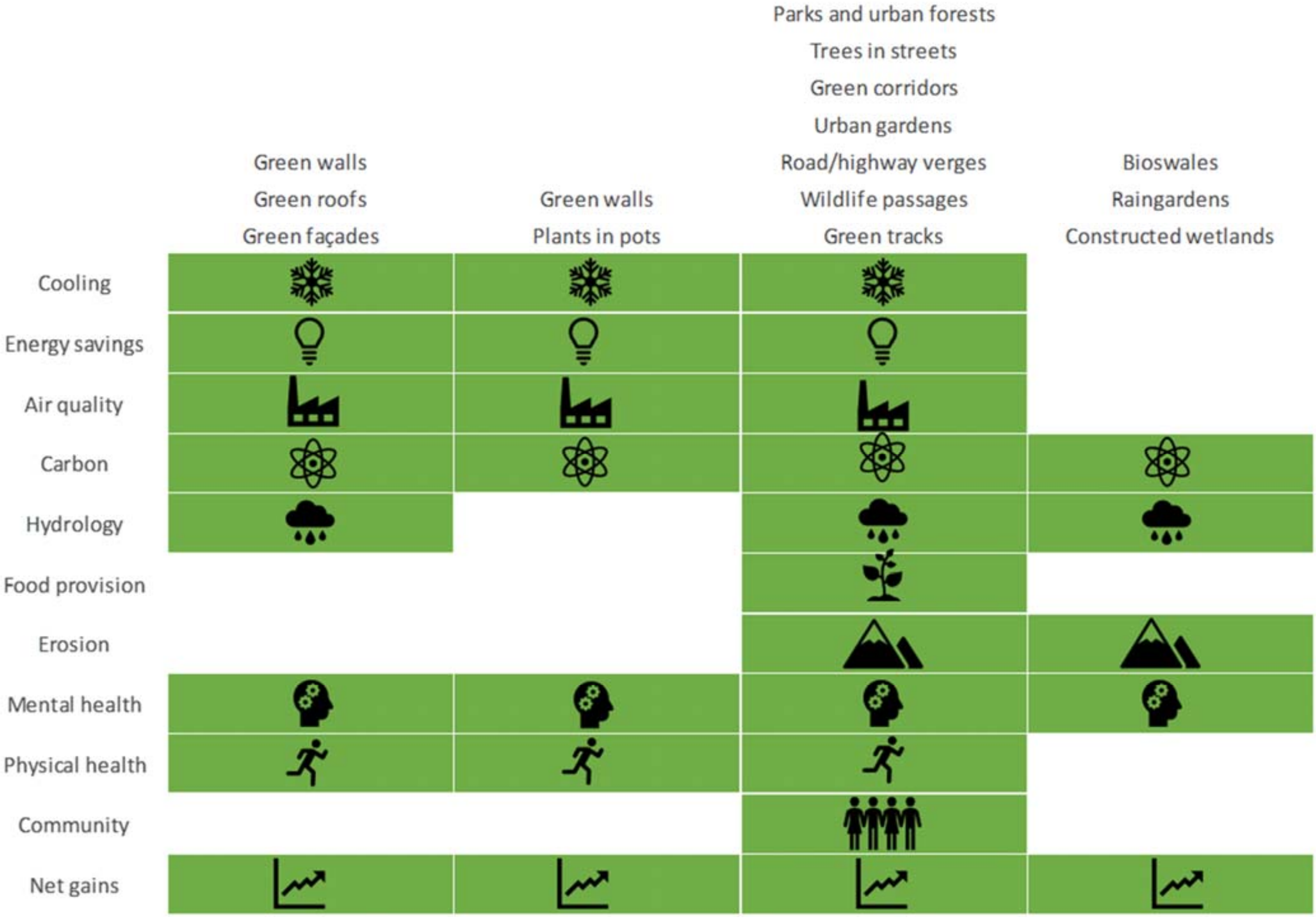

Figure 1 - Map of evidence found for significant benefits and services provided by each building or infrastructure asset

Built environment rating tools

There are several rating systems that assess the sustainability performance of buildings and construction. These include green building rating systems like Green Star, WELL and the Living Building Challenge, and infrastructure rating systems such as the Infrastructure Sustainability Council of Australia's (ISCA) Infrastructure Sustainability (IS) Tool.

Environmental rating schemes provide a way for buildings and infrastructure to have their environmental benefits rewarded and to have innovative and forward-thinking designs acknowledged as best in class. Rating systems often reward the use of plants by capturing the benefits that plants can provide.

Green Star – Commercial buildings and interiors, and precincts

The Green Star rating system is administered by the Green Building Council of Australia and provides formal environmental ratings for buildings, interiors and precincts for design, as-built and in-operation performance. Green Star has an ecology credit that rewards the use of plants and is being significantly updated to include more credits related to the benefits of plants in the 2019 version of the tool.

IS Tool – Infrastructure

The ISCA IS Tool rates infrastructure projects across the transport, water, energy, and communications industries. The IS Tool provides credits for infrastructure projects that have a minimal impact on the environment, namely the maintenance of ecological value and hydrological cycles, minimal levels of air pollution, or minimal impact on habitats. The IS Tool also directly rewards the substitution of grey with green infrastructure and the promotion of services that can be mediated by plants, such as climate change adaptation, improved health of the community and aesthetic value. ISCA and Greenstar intend to align more into the future recognising that buildings are often part of large infrastructure projects and vice versa. It may be that Green Infrastructure is where ISCA and Green Star connect.

The Living Building Challenge

The Living Building Challenge is a rigorous performance standard which calls for the creation of building projects at all scales that operate as cleanly, beautifully and efficiently as nature's architecture. To be certified under the Challenge, projects must meet a series of ambitious performance requirements, including net zero energy, waste and water, over a minimum of 12 months of continuous occupancy.

International WELL Building Standard

WELL is a performance-based system for measuring, certifying, and monitoring features of buildings that impact the health and well-being of the people who live, work, and learn in them.

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Report for Hort Innovation:

NY16007 – Integrating plant life into building and infrastructure rating tools
Annex to MS104 Milestone report

April 2018

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Revision	Revision Details	Author(s)	Approved by	Date Approved
1	Draft	Joana Almeida, Tim Watson, Joel Clayton, Nicole Thompson and Tom Davies	Richard Griffiths	17 April 2018

This report is an **annex to the Final Project Report** submitted to Horticulture Innovation Australia documenting the following project deliverables:

- Literature review on the benefits and service metrics of green infrastructure
- Gap analysis of Green Star and the IS Tool on the treatment of green infrastructure
- Progress of engagement with the GBCA
- Results of the stakeholder engagement

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1 Project context

The key objective of this project is to provide the scientific basis, in the form required by both the Green Building Council of Australia (GBCA) and the Infrastructure Sustainability Council of Australia (ISCA), to underpin the development and improvement of Green Star and Infrastructure Sustainability (IS) rating tool (IS) credits which capture the benefits of vegetation in the built environment. The desired outcome is that the tools could subsequently become catalysts for greater investment in green infrastructure across the built environment.

This report documents in detail the full project outcomes, including:

- The definition of green infrastructure (section 2).
- The research findings on the services and benefits provided by green infrastructure (section 3).
- How these services and benefits are currently captured in Green Star and the IS Tool (section 4).
- The likely future of green infrastructure in Green Star and how this project contributes to it (section 4.2.3).
- How green infrastructure is being adopted in Australia and recommendations to accelerate investment (section 5).
- Strategic recommendations for Horticulture Innovation Australia (section 5.5).

2 Definition of green infrastructure

2.1 What is green infrastructure?

“Green infrastructure” is a relatively new classification with various definitions proposed in literature:

- “*A strategically planned network of high quality natural and semi-natural areas with other environmental features, which is designed and managed to deliver a wide range of ecosystem services and protect biodiversity in both rural and urban settings.*” (European Commission, 2013).
- “*A specialized form of engineering infrastructure, replacing conventional engineering structures with ‘green’ elements which can perform ecosystem service functions, such as waste management or building energy efficiency*” (Margolis & Robinson, 2007).
- “*[an] Ecological solution underpinned by the concept of ecosystem services to improve the sustainability level of the urban and built environment*” (Pakzad, et al., 2017).

Each of these definitions can be traced to an approach on green infrastructure practice. A literature review carried out in South Australia by The green infrastructure Project (Government of SA; Botanic Gardens of SA; Natural Resources, Adelaide and Mount Lofty Ranges; Renewal SA, 2014) identified three approaches:

- **The ecosystem services approach** - which considers green infrastructure to be a means to regulate natural cycles and therefore ensure ecosystem services in urban environments, and is best translated by urban ecology concepts.
- **The linked urban spaces approach** - which focuses on the connectivity between green infrastructure elements to ensure ecosystem services are maintained.
- **The green engineering approach** - which considers that green infrastructure can be a replacement for grey engineering[1] to deliver specific functions (e.g. building energy efficiency, stormwater management).

The literature review below is aligned to the first and last approaches. These were selected on the basis that, by systematising knowledge of the ecosystem services provided by green infrastructure, it also identifies how it replaces grey infrastructure. These two aspects are also key in mapping green infrastructure solutions to the different credits in sustainability rating tools for buildings and infrastructure – and therefore better contribute to the overall objective for the project.

2.1.1 Types of green infrastructure

Green infrastructure is manifested across a wide range assets, as set out in Table 1. Examples range from indoor plants in pots to city parks, and can be found at a variety of scales within the built environment depending on their intended function and typology.

Table 1 – Examples of green infrastructure assets.

Building fabric/envelope	Indoor	Outdoor spaces and structures	Specialized/Water Sensitive Urban Design
Green walls	Green walls	Parks and urban forests	Bioswales
Breathing walls	Breathing walls	Trees in streets	Rain gardens
Green roofs	Plants in pots	Green corridors	Constructed wetlands
Traditional green façades		Urban gardens	Screens

[1] Grey can be defined as Conventional Infrastructure typically constructed from steel and concrete.

	Road/highway verges Wildlife passages Green tracks	

3 Literature review on the benefits of green infrastructure

This section reports on the sustainability benefits that may be achievable from implementing green infrastructure, how they relate to an ecosystem service network and the evidence on their magnitude and mechanisms.

3.1 Ecosystem services and green infrastructure: the role of biodiversity

Novel ecosystems are those which reorganize themselves after human intervention into a new form. Some green infrastructure assets can be classified as novel ecosystems because, even though the assets are constructed, they may come to function as ecosystems – albeit often very different to their natural counterparts. As such, green infrastructure is expected to provide ecosystem services, and to see that provision regulated by its functional traits and wider environmental scope.

Indeed, the common thread to all three green infrastructure definitions outlined above in section 2.1 is that each asset will deliver specific ecosystem services and/or collectively allow for ecosystem services and biodiversity conservation to be attained in the urban environment.

Rather than an ecosystem service, biodiversity is dependent on ecosystems' function and their ability provide and sustain services (Isbell, et al., 2011; Department of the Environment, Water, Heritage and the Arts, 2010). Figure 1 below explores the link between biodiversity and ecosystem services.

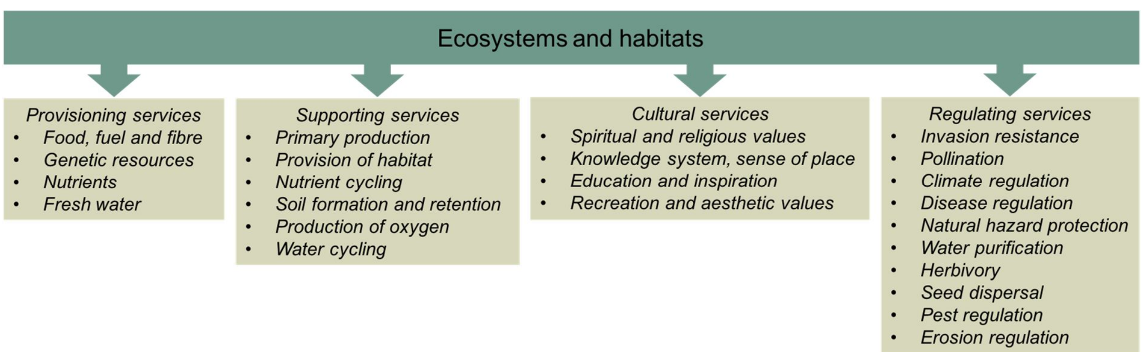

Figure 1 – Biodiversity and ecosystem services.

Urban development is usually associated with negative impact on biodiversity due to habitat fragmentation, encroachment and loss, and to the promotion of invasive and predatory species. Green infrastructure has the potential to lessen this impact by introducing new habitats into otherwise grey infrastructure, and by bridging fragmentation (Savard, et al., 2000; Goddard, et al., 2009). Biodiversity can also be manipulated in green infrastructure designs to meet specific typology goals (e.g. reed species in bioswales).

There is widespread evidence of successfully implemented green infrastructure in terms of biodiversity conservation:

- Wildlife crossing structures (such as eco-ducts, underpasses) are purposefully designed to minimize the risks to animals posed by crossing transportation corridors. Studies from North America, Europe and Australia show that such structures successfully minimize collision with vehicles and connect wildlife habitats (Donaldson, 2011; van Bohemen, 1998; Taylor & Goldingay, 2010).
- Flowers in urban green space, from parks to green tracks, attract pollinators to levels otherwise only typically observed in rural spaces (Verboven, et al., 2014; Verboven, et al., 2012);

- Green roofs can achieve high levels of functional diversity and emulate native species stocks (Van Mechelen, et al., 2015).
- Bird diversity in urban regions responds positively to the volume and abundance of vegetation, such as trees and shrubs (Savard, et al., 2000), and natural structures (Threlfall, et al., 2016).

Whether or not green infrastructure mitigates biodiversity loss depends on the extent to which it can ensure functional diversity and is constrained by green infrastructure typology and design. It also depends on the extent of the functional shift between native ecosystems and novel ecosystems: a larger functional shift, the farthest green infrastructure is from a pristine environment.

There are noticeable challenges in ensuring biodiversity value in green infrastructure, which ought to be considered when evaluating its ecological value:

- Urban green spaces require sufficient space, connectivity, and habitat heterogeneity if they are to support species (Beninde, et al., 2015).
- Area management is more important than design (Beninde, et al., 2015; Kowarik, 2011).
- Green spaces can easily become sinks in which species do not flourish, and reproduction is negative, due to fragmentation within densely urbanized areas (Lepczyk, et al., 2017).
- Green roofs have limited support capability of non-generalist species (e.g. rare taxa) (Williams, et al., 2014).
- Different species have different habitat requirements, and the effectiveness of similar green spaces in different locations varies widely (Lepczyk, et al., 2017).
- Engineering green infrastructure for optimal functional diversity requires careful species selection and the consideration of the space allocated to and connectivity of habitats (Van Mechelen, et al., 2015; Lepczyk, et al., 2017; Orbendorfer, et al., 2007).
- Native plant species are not necessarily optimal promoters of diversity attributes in urban green, despite their central role in conservation efforts (Kowarik, 2011).
- Green spaces can be planned in resemblance of native ecosystems in order to minimize functional shifts (Dearborn & Kark, 2010).
- Green infrastructure design and management must consider people-wildlife interactions and people-plant interactions and maximize positive responses (Savard, et al., 2000).

3.2 Environmental benefits

Plants in the built environment are also considered to have the potential to relieve urban populations from direct environmental stressors, such high concentrations of pollutants and urban heat, and to provide a multitude of environmental mitigation services, such as curbing greenhouse gas emissions and loss of ecological value and managing stormwater.

Green infrastructure highlight 1

Greening Laneways Project

Location: Melbourne

The City of Melbourne funded four green lanes in the city. Some of the expected benefits of this project include, amongst others, the provision of attractive walkways that offer shadow in hot days and encourage people to walk; and reducing flooding, filtering dust from the air (City of Melbourne, 2017).

3.2.1 Cooling and local climate regulation

Urban dwellers are vulnerable to the creation of urban heat islands (UHI), an effect by which urban areas become hotter than surrounding areas due to heat accumulation. The UHI effect occurs due to materials such as concrete and asphalt's dark coloration and/or high thermal mass, and therefore their ability to absorb and retain heat. In contrast, natural, vegetated surfaces promote shading and cooling by evapotranspiration (Rizwan, et al., 2008; US EPA, 2016; Government of SA; Botanic Gardens of SA; Natural Resources, Adelaide and Mount Lofty Ranges; Renewal SA, 2014; AILA, 2015).

Besides discomfort and direct health problems caused by excessive heat, the UHI effect is linked to poor air quality, reduced liveability of cities and increased peak energy loads due to demands of cooling devices (which in turn aggravate local heat). It is expected that these issues will be magnified for Australians by more frequent heat waves due to climate change, coupled with high urbanization and population growth (AILA, 2015; Government of SA; Botanic Gardens of SA; Natural Resources, Adelaide and Mount Lofty Ranges; Renewal SA, 2014; Palin, 2017; Wouters, et al., 2017).

Green infrastructure can promote cooling at different scales, from city-wide areas to the building level (AILA, 2015; Gago, et al., 2013). For example:

- Studies in North America have identified lack of vegetation as direct cause of UHI effect and estimate that urban vegetation has the potential to lower air temperatures by 1-3°C in wide areas (Bounoua, et al., 2015; Kurn, et al., 1994).
- Green roofs have been observed to lower indoor temperatures 3 to 4°C in >25°C days (Getter & Rowe, 2006).
- Parks with trees have been found to be 0.9-4°C cooler than surrounding grey landscapes in summer. The cool air from green spaces disperses to adjacent areas and greater cooling effect can be obtained from multiple interconnected greenspaces (Sugawara, et al., 2016; Kendal, et al., 2016; Green Blue Urban, 2015; Eliasson, 1996).
- Traditional green walls can reduce indoor temperature in summer months by 4-5°C (Franz, 2017) and wall temperature by 5.5°C (Pérez, et al., 2001).
- A study in Toronto found green roofs to lower ambient temperature between 0.5 and 2°C (Banting, et al., 2005).
- Temperature measurements at a Sydney suburb found 14°C difference on concrete and asphalt surface temperatures between streets with 20% and 28% canopy coverage (AECOM, 2017). The shading effect of trees has also been shown to extend the service life of street pavements by 30% (Moore, 2016; McPherson & Muchnick, 2005).

Different approaches to vegetation-mediated cooling can be used (Getter & Rowe, 2006; Government of SA; Botanic Gardens of SA; Natural Resources, Adelaide and Mount Lofty Ranges; Renewal SA, 2014; Franz, 2017; Orbendorfer, et al., 2007):

- Shading by trees and façades, preventing solar radiation to reach man-made surfaces and reduce temperature changes produced by building materials.
- Replacement of grey surfaces in buildings with green surfaces, such as green roofs, green walls or climbing plants on façades of small dwellings, which dissipate heat with evapotranspiration.

Integrating green spaces in urban and infrastructure planning to reduce the urban heat island effect should consider the following factors:

- Green infrastructure asset types, with preference towards multiple interconnected spaces.
- Climate, which influences water availability and species selection and may call for increased reflectivity rather than shading (Bounoua, et al., 2015).
- Species performance, which calls for selection criteria in function of cooling (e.g. high leaf-area index) (Ballinas & V.L., 2016; Franz, 2017).
- Available space, which can dictate typology selection and distribution in relation to buildings (Gago, et al., 2013).

- Potential integration with climate change mitigation policies (Creutzig, 2015; Government of SA; Botanic Gardens of SA; Natural Resources, Adelaide and Mount Lofty Ranges; Renewal SA, 2014).

The cooling potential of green infrastructure is better measured by the resulting energy savings. This benefit is described and quantified in the following section (3.2.2).

> ***Green infrastructure highlight 2***
>
> **Urban Forest Strategy**
>
> Location: Melbourne
>
> This strategy aims to manage the regeneration of its existing tree population, and thus mitigate the urban heat island effect and cool down inner-city temperatures by increasing the canopy cover from 22% to 40% by 2040 (The City of Melbourne, 2017).

3.2.2 Energy conservation

Vegetation cools constructed surfaces and urban space (section 0), which has the consequence of saving energy that would otherwise be invested in cooling buildings. Moreover, certain assets may have insulating properties and reduce the energy required to heat spaces.

The table below summarizes research on energy savings within the building envelope across outdoor spaces and elements. It can be seen that the most well-researched asset in terms of energy savings are green roofs. The main challenge in harnessing this benefit has been in assessing the thermal performance of different green roof installations across Australia's climatic range (Pianella, et al., 2016). In fact, because energy conservation depends on heat exchanges, which in turn are related to climate, it is difficult to precisely assess energy savings across different assets and different locations.

Table 2 - Cooling and heating energy savings as a result of green infrastructure use.

	Building envelope	Outdoor spaces
Assets	Green walls and green façades, green roofs	Green spaces in general, green surfaces in general, trees in streets
Effect	Insulation Intercept incoming radiation	Intercept incoming radiation Cooling by evapotranspiration
Factors	Asset type and characteristics (extensive vs intensive green roof, thickness, media, cover), environmental factors (climate, building context, incoming radiation)	Asset type, asset characteristics (leaf area index, cover), environmental factors (climate, building context, incoming radiation)
Quantified benefits	• Green walls lead to cooling energy savings of 8% (aircon) and to a decrease of 3.4% in annual energy consumption (Oosterlee, 2013). • Heat transfer through green roofs is 10-50% less than a typical roof (Orbendorfer, et al., 2007). • Green roofs reduce cooling energy loads 6-60% (Orbendorfer, et al., 2007). • Green roofs in temperate climates have been seen to reduce gas consumption	• Shade provided by trees lead to cooling energy savings of 30% in houses (Akbari, et al., 1997). • City parks have been found to reduce cooling loads of buildings by 10% (Yu & Hien, 2006). • Trees can be used as wind barriers, reducing the chilling effect of wind tunnels created by buildings and convection heat losses in building surfaces (Government of SA; Botanic Gardens of SA; Natural Resources,

	Building envelope	Outdoor spaces
	for heating by 42% (Kosareo & Ries, 2007). • Traditional green façades reduce cooling energy by 28% and reduce heat loss in cool months by 25% (Di & Wang, 1999; Köhler, 2008).	Adelaide and Mount Lofty Ranges; Renewal SA, 2014).

Green infrastructure can also reduce the energy required by heating, ventilation, and air conditioning (HVAC) systems due to the ability of indoor plants to eliminate indoor pollutants such as VOCs and CO_2 (section 3.2.3). The removal of indoor pollutants by plants has been found to reduce ventilation energy in urban Australian buildings by 10-20% (Burchett, 2011).

Green infrastructure highlight 3

Surry Hills Library

Location: Sydney

The building incorporates demanding sustainability standards, which include a green roof with plants that act as air filters and that insulates the building, minimising energy consumption and keeping the roof's solar panels at an optimal temperature (City of Sydney, 2017).

3.2.3 Air purification

Air quality deterioration in urban environments is a well-documented environmental burden (Nowak, et al., 2013; Begg, et al., 2007; Simpson, et al., 2005). Air pollution is estimated to cause around 3,000 deaths annually in Australia, mainly due to the effects of prolonged exposure (Begg, et al., 2007). The population of all major Australian cities are exposed to noxious levels of particulate matter (PM10) and ozone (O_3) (Simpson, et al., 2005), two indicators of low air quality standards.

Indoor air quality is currently an increasing point of focus for commercial buildings, due to its influence on employee satisfaction and health and, ultimately, productivity (Wyon, 2004; Zhang & Smith, 2003). The main culprits of poor indoor air quality are volatile organic compounds (VOCs), often emitted by building materials (Zhang & Smith, 2003).

Vegetation reduces air pollution levels through:

- The indirect effect of cooling.
- Direct air filtration through the capture of particulates by stomata.
- Deposition of pollutants on leaves.

The effectiveness of green infrastructure in improving air quality depends on the asset, species employed and environmental factors such as pollutant load, pollutant type, wind, etc. Evidence for this includes:

- Trees along 19 km of the Pacific Highway in Sydney were found to remove 11 tonnes of pollutants annually (Amati, et al., 2013).
- Patches of urban forest in different parts of Australia have been found to remove between 2.2 kg pollutants/yr.ha and 46.52 kg pollutants/yr.ha (Jayasooriya, et al., 2017).
- Particulate levels on tree-lined streets can be up to 60% lower than those without trees (Green Blue Urban, 2015).
- Traditional façades with climbing plants can filter approximately 95 grams of fine dust from the air every year, as much as a 25-year old tree. Particulate uptake is directly proportional to leaf-area index (Franz, 2017).

- Laboratory testing of green walls engineered to actively filtrate air have shown their efficacy is close to that of HVAC systems (Irga, et al., 2017).
- Indoor pot plants in Australian offices have been found to reduce indoor levels of VOCs by 75% and of CO_2 by 25% (Wood, et al., 2006).

Green infrastructure highlight 4

Green Building Council of Australia interior design

Location: Sydney

In the design of its new offices in Barangaroo, the GBCA incorporated indoor plants that help remove volatile organic compounds (VOCs), decrease complaints of symptoms associated with respiratory illness and improve poor indoor air quality, and added to lower workplace stress and increased productivity (Ambius, 2017).

3.2.4 Carbon sequestration and emission mitigation

Ultimately, climate change is a result of a shift of carbon stocks from its sinks in terrestrial and marine environments, and from fossil fuel reserves onto the atmosphere. Urban greening has the potential to mitigate climate change through climate regulation and primary production services. The underlying mechanisms are:

- The sequestration of carbon in plant biomass.
- The preservation of carbon stocks in vegetated soils.
- Avoided greenhouse gas emissions from energy savings (discussed in section 3.2.2).

In 2009, it was estimated that a 15% increase in the terrestrial carbon stock alone would offset all the greenhouse gas emissions from fossil fuel use since the industrial revolution (Wentworth Group of Concerned Scientists, 2009). A part of that significant terrestrial stock is held in biomass and soils and is determined by the extent and type of land occupied by vegetation, as well as how the land is managed. Even though urban landscapes have a lower potential for carbon sequestration than natural ecosystems, adequate urban planning can both maximize sequestration in urban land and decouple urban development from carbon stock losses (Wentworth Group of Concerned Scientists, 2009; Francis, 2013). A single mature tree absorbs carbon at a rate of 21.6 kg per year (Green Blue Urban, 2015) and it has been estimated that the public trees in Melbourne hold 1 million tonnes of carbon (Ely & Pitman, 2014).

The potential for green infrastructure to sequester carbon depends on the asset, local climate and vegetation type (Weissert, 2016; Yoon, et al., 2016; Livesley, et al., 2015). These elements determine the amount and type of biomass that is generated in the asset and therefore the amount of carbon accumulated. They also determine the potential for soil organic carbon sequestration.

3.2.5 Hydrological regulation

Impervious surfaces in urban developments affect waterway health by preventing water infiltration and evapotranspiration. Stormwater diversion to evacuation systems modifies natural discharge rates onto receiving waterways, causing waterway erosion and disturbing its ecology (Water By Design, 2010). Urban landscapes with 50–90% impervious cover can lose 40–83% of rainfall to surface runoff, in contrast to 13% losses in forested landscapes (Pataki, et al., 2011).

Water Sensitive Urban Design (WSUD) is an approach to urban planning aiming to minimize disturbance of natural water flows induced by urban development (Water By Design, 2010). Green infrastructure can be used in WSUD as:

- Stormwater management systems with bioswales, raingardens and constructed wetlands.

- Building features such as green roofs.
- Inclusion of tree-covered landscapes in developments.

Green infrastructure reduces and delays stormwater runoff and reduces pollutant discharge to waterways. Reductions can be as high as 100% in green roofs (Pataki, et al., 2011; Getter & Rowe, 2006) and 99% annually in rain gardens (Orbendorfer, et al., 2007). Street trees capture water and retain nitrogen and phosphorous leachates, benefiting from the nutrients in their own development (Denman, et al., 2016; Green Blue Urban, 2015).

The effectiveness of green infrastructure in regulating surface stormwater flows depends on several factors, including:

- The type of infrastructure, which will determine its specific function and potential contribution to hydrological regulation.
- Its scale, in order of increasingly limited impact: green infrastructure can be part of integrated water management systems capable of regulation at the watershed scale; implemented at the level or a single development project; or used in isolation, such as a green roof on a building (Carter & Jackson, 2007; Water By Design, 2010).
- Species used. For example, findings from midwestern United States suggest that species with high stomatal conductance and large forms contribute best to bioswales' performance, due to increased evapotranspiration (Scharenbroch, et al., 2016).
- Geography: climatic region influences rainfall patterns, which in turn determines the design and functioning of stormwater management systems (Water By Design, 2010).

Green infrastructure highlight 5

Implementing urban stormwater management practices

Location: Six different sites in Queensland

This project investigated the benefits of applying water-sensitive urban-design (WSUD) practices, which include: reduced stormwater pollutant loads; avoided costs of waterway rectification and maintenance; increased property values; and reduced infrastructure costs. The conclusion was that the benefits of the project are likely to exceed the costs (Water By Design, 2010).

3.2.6 Food provision

Urban agriculture can be a benefit of green infrastructure, for example in the preservation of productive agricultural land on the urban fringe and the creation of food-producing urban gardens (Mok, et al., 2014). Indeed, food production can occur in a range of different assets, from private and public gardens to road verges and rooftop installations.

These decentralized food sources have multiple benefits (Government of SA; Botanic Gardens of SA; Natural Resources, Adelaide and Mount Lofty Ranges; Renewal SA, 2014; Deen & Tempany, 2011; Mok, et al., 2014; Sanjuan-Delmás, et al., 2018), for example:

- Reducing food miles, with impacts on climate change.
- Reducing pollution and waste associated with large-scale food production and with analogue food-production systems.
- Increasing independence from food networks, which increases food security.
- Building community cohesion (section 3.3.3).
- Coupling access to affordable nutrition with physical exercise, which benefits physical health (section 3.3.2).

The main barriers to the mainstreaming of urban food gardening fall in the realm of planning: competition of space with other land uses and against urban expansion, adequate access, adequate land quality and ownership and management issues. There are also matters of divided perception towards the local benefits of food production grounds (Deen & Tempany, 2011; Government of SA; Botanic Gardens of SA; Natural Resources, Adelaide and Mount Lofty Ranges; Renewal SA, 2014).

Green infrastructure highlight 6

Australian City Farms & Community Gardens Network

Location: National

The ACFCGN connects city farms and community gardens around Australia with the aim to facilitate the benefits of urban food. The network links and aids over 550 gardens (ACFCGN, 2016).

3.2.7 Erosion and coastal defence

Green infrastructure can be deployed as defence against erosion of soils and coastal barriers.

- **Soil erosion:** Bare soils have no protection from eroding elements such as wind, rain and waves. Increasing vegetative cover in infrastructure and community property projects reduces run-off of minerals, nutrients and soil matter and preserves soil quality.
- **Coastal erosion:** Coastal areas are vulnerable to the advance of sea driven by storms and sea-level rise. Managing coastal barriers is an important planning measure in climate change adaptation and climate change risk planning. Vegetation can be used to stabilize dune systems, which function as a buffer against wave erosion (NSW Department of Land and Water Conservation, 2001). In addition, there are dedicated green infrastructure that protect coastal environments, such as engineered wetlands and grassland (Liquete, et al., 2013).

3.3 Wider societal benefits

Urban green provides cultural ecosystem services that affect community and individual wellbeing, which can either relate directly to exposure to nature or be achieved from improved environmental outcomes. Even though the sections below distinguish between mental, physical and societal fitness, the three aspects are intertwined by cause-effect and feedback links. Ultimately, vegetation is considered to lower stress levels and disease rates in populations due to soothing effect of direct connectedness to nature and increased rates of physical exercise, and because it helps to create a more connected and resilient community.

Green infrastructure highlights 7 and 8

Perth Children's Hospital – Therapy Garden

Location: Perth

Besides implementing various forms of green infrastructure, the hospital built a "therapy garden" which provides a range of physical, psychological and social therapy benefits (Huxtable, 2017).

Woody Meadow Project

Location: Melbourne

A research project by the Universities of Melbourne and Sheffield aims to use colourful and attractive urban meadows to enhance people's wellbeing. By transforming unattractive areas, the project wants to contribute to the creation of more liveable cities (Bolge, 2017).

3.3.1 Mental health and wellbeing

Green spaces and vegetation are widely considered to have a restorative effect and increase perceptions of wellbeing. Various studies have observed a positive link between proximity to green space and good mental health. The link has been extensively investigated and is documented in reviews such as Townsend et al (2015), Kuo (2015) and the green infrastructure Evidence Base project (2014).

A connection to nature is both protective against and remedial of mental illness, suggesting that green infrastructure can provide restorative and preventative services in terms of mental health in urban populations. Some of the observed and suggested cause-effects are:

- Plants release molecules that are linked to the amelioration of mental illness and promoting the release of physiological mediators that mitigate mental illness.
- Contact with nature is thought to induce thought processes that induce low-stress conditions, recorded as improved emotional states and low nervous arousal levels.
- Useable parks facilitate coping mechanisms in children and adolescents.
- Usable green spaces and the sight of vegetation reduce work-related stress by mitigating attentional fatigue and providing a place of escape.
- Nature connectedness underpins spiritual health, which in turn health underpins positive behaviour towards the environment in a positive feedback mechanism.
- Nature-based experiences foster transcendent experiences, which are associated with hope and recovery from negative circumstances.
- Nature-based experiences have been observed to enable individuals to express positive feelings.
- Exercise in green spaces, comparing with urban spaces, has been observed to significantly improve emotional wellbeing even in regularly active populations.
- Usable green spaces facilitate social interactions, increasing individuals' level of satisfaction with their community.

Research into the abovementioned mechanisms are reported in different urban settings, relating to different types of green infrastructure:

- Inside buildings (viewing indoor plants and green walls, viewing nature from the window).
- When in green spaces, such as parks.
- When in residential areas with gardens or leafy outlooks.

The different underlying mechanisms explored in literature that may explain the mental and spiritual benefits of green infrastructure are:

- Physiological interactions (e.g. reaction to particles release by plants or to noises).
- Anthropology (natural habitats as part of human nature).
- Green spaces as a vehicle of mental health inducing practices (playing, exercising).

3.3.2 Physical health

Vegetation in urban spaces is linked to a variety of mechanisms leading to good physical health outcomes (Towsend, et al., 2015; Willis & Osman, 2005; Kuo, 2015).

One of the better documented benefits of green infrastructure is the promotion of physical activity. Granting communities access to green spaces has been shown to have produce changes in physical activity levels with positive health effects (Willis, et al., 2016; Rolls, et al., 2016; Giles-Corti, et al., 2013; Giles-Corti, et al., 2005). For example, populations with easy access to green spaces have been observed to have lower body-mass indexes, an indicator of good physical fitness. Similarly, an experiment in Perth showed that improving access to walkable green space in a community lead to an increase in recreational walking of 23% (Giles-Corti, et al., 2013). The health benefits of this change can be further illustrated by an example from the UK in which data showed that the impact of decreasing the incentive to recreational walking by reducing access to green space would amount to 23.6 million sterling pounds per year in healthcare costs (Rolls, et al., 2016).

Other reported, direct benefits are reviewed by Towsend et al (2015) and Kuo (2015) and include:

- Green spaces aid cognitive and physical development in children.
- Exposure to green spaces promotes development of immunity mechanisms.
- Exposure to nature triggers physiological wellbeing mechanisms.

In addition, less severe urban heat (section 0) and better air quality (section 3.2.3) reduce morbidity and illness related to extreme heat and pollution.

Types of green infrastructure that promote physical health are:

- Parks and walkable green spaces – providing areas for physical activity, triggering positive physiological responses, and creating stimulant environments and minimizing environmental stressors on health (Towsend, et al., 2015; Giles-Corti, et al., 2005).
- Green corridors, for reducing perceived lack of safety due to traffic that often hinders park accessibility and neighbourhood walkability (Towsend, et al., 2015).
- Non-walkable green infrastructure, for triggering positive physiological responses and minimizing environmental stressors on health (section 0).
- Indoor plants for reducing stress levels and purifying indoor air (Lee, et al., 2015; Dijkstra, et al., 2008).

3.3.3 Community function

Green infrastructure promotes community function through two main mechanisms, based on perception and social capital generation. Perception-mediated roles are based on individual and collective understanding of liveability. The social capital effects pertain mainly to social cohesion and social contact, which are strong mediators between greenery and positive mental health (see section 0). The outcomes of these mechanisms are outlined in Table 3, below, and are reviewed in Townsend et al (2015) and the green infrastructure Evidence Base project (2014).

Table 3 – Effects of green infrastructure on community function.

Perceived liveability	Social capital
• Presence of vegetation improves neighbourhood and community satisfaction values (comfort, safety, enjoyment). • Some green infrastructure assets embody cultural values (heritage, trees as symbol of intergenerational legacies).	• By providing spaces of gathering, interaction and relationship development, green spaces promote social cohesion and sense of community. • Green spaces facilitate playing outdoors, which encourages pro-social behaviour in children.

Perceived liveability	Social capital
• Green infrastructure holds visual and aesthetic values.	• Wellbeing and experiences provided by green infrastructure are beneficial to the integration and protection of vulnerable social groups. • Members of communities with access to green space feel less isolated and more connected.

In addition, green infrastructure is correlated with lower incidence of noxious behaviours, such as littering, vandalism and crime (Government of SA; Botanic Gardens of SA; Natural Resources, Adelaide and Mount Lofty Ranges; Renewal SA, 2014). The cause of this link is believed to be:

- Mediated by better wellbeing in individuals, which decreases their stress and aggression levels and improves cognitive functions (section 0).
- Due to greater use of public spaces which leaves less opportunity for unsupervised wrong-doing.
- A direct result of improved social cohesion and community satisfaction.

3.4 Economic benefits

The benefits outlined above can also be monetised, and a wide range of studies have sought to quantify the economic benefits of green infrastructure through cost-benefit analyses (CBA). For clarity, the terms “benefit” and “gain” used are not net gains or benefits.

The benefits of green infrastructure can be translated into wider economic benefits to the society and economic benefits from added value. The flow between the environmental and social benefits described in sections 3.2 and 3.3 and economic benefits is shown in Figure 2.

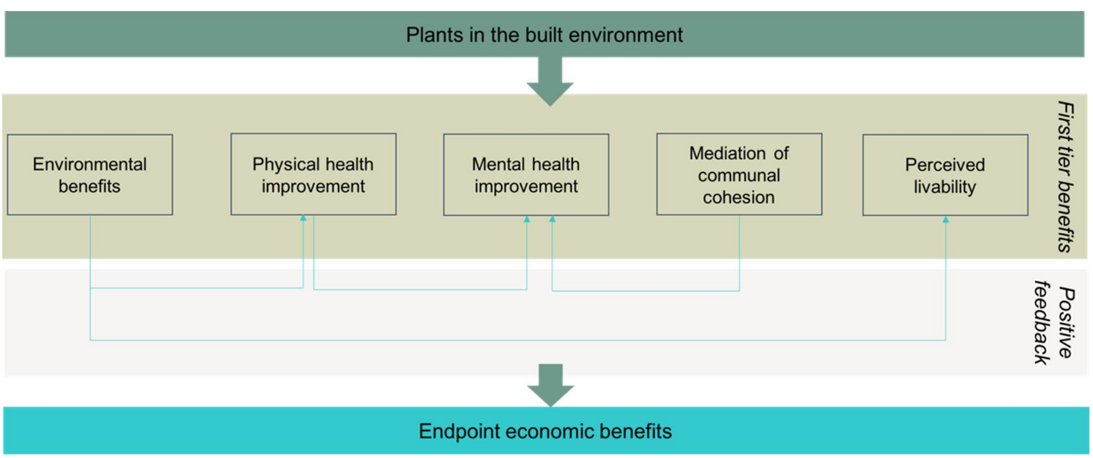

Figure 2 – The link between social and environmental benefits and economic benefits of plants in the built environment.

Two kinds of economic benefits can be attributed to green infrastructure, described in Figure 3: those arising from avoided loss and those arising from net benefits.

Avoided loss

- Benefits from cost savings (e.g. in energy)
- Benefits from avoided or reduced environmental and social impacts (e.g. economic benefit of reducing disease from air pollution)

Gains

- Benefits from increased amenity value (e.g. property premiums)
- Benefits from provision (e.g. food, carbon stock)

Figure 3 – Types of benefits from green infrastructure.

3.4.1 Avoided loss

Green infrastructure facilitates different services that lead to cost savings and avoided impacts. Studies seeking to quantify these include:

- Canberra's publicly managed trees are worth $US 1.57 million in energy and avoided emissions savings due to their cooling effect (Plant, et al., 2016). Melbourne's street trees are estimated to be worth $14 million due to the benefits of their shade at $200/tree (Gadd, 2009).
- Brisbane's street trees are estimated to be returning $1.67 million annually each in air purification, reduced run-off of storm water (Brisbane City Council, 2017).
- Trees along high-traffic roads in Sydney are estimated to result in up to $740/km annual savings avoided carbon emission and pollution removal. Their annual benefits from their cooling effect is $2,900/km (Amati, et al., 2013).
- The several pathways whereby green infrastructure addresses climate change risks (climate regulation, erosion and coastal defences, flood risk reduction, etc.), suggests that it is linked to avoided economic loss. No specific values have been found.

Impact cost factors

The costs of environmental and health impacts can be calculated through the use of externality cost values. Externality costing translates the comprehensive economic burdens of climate change, pollution, resource depletion, disease burdens, and other consequences of human activities. Such values can also be used to quantify the benefit of interventions that avoid impacts, by converting avoided impact units into dollars.

Below is an outline of valuations of externalities relevant to green infrastructure that can be used in CBA of green infrastructure.

- **Carbon** emissions and removals are measured in kg CO_2. The impact of each unit of CO_2 emitted is often assessed from the broad impacts of climate change, through the Social Cost of Carbon (SCC). Presently, the SCC is set at $60/t CO_2 (Interagency Working Group on Social Cost of Greenhouse Gases, 2016). This SCC is used, for instance, in the economic valuation of transport infrastructure projects in New South Wales (TfNSW, 2016). The SCC can be used to estimate the economic benefit of avoided emissions due to energy savings as well as of carbon sequestration in biomass.
- The economic benefits of interventions that aim to increase **health** quality and/or decrease disease burden may be assessed with value of statistical life year (VSLY). In Australia, the latest VSLY value is $180,000 (Australian Government, 2014). It is also possible to use cost factors for burden of specific diseases if the pathway to the avoidance of specific ailments is known. Disease burdens are measured in Disability Adjusted Life-Years (DALYs).

- **Air quality** is often measured in mass of particulate matter, particularly PM10. This unit is also used to assess pollutant removal rates by green infrastructure (section 3.2.3). The cost of respiratory disease caused by air pollution in Australia has been estimated to be up to \$762/t PM2.5 and \$383/t PM10 (Victoria Transport Policy Institute, 2016; TfNSW, 2016).
- In terms of **resources**, green infrastructure influences mainly **water** and **oil** (energy). Cost factors for resource use can be derived from impacts on depletion of reserves, of industry subsidies and of extractive activities. For instance, the cost to society of non-renewable fuels may be estimated from the subsidies paid to the oil industry, which stand at \$0.88/kg oil eq (Coady, et al., 2015). Water use maybe be valued by the value of water entitlements, sits at \$1.42/m^3, the average across Australia's water markets (Australian Government, 2017).

Note that in valuing the benefits of green infrastructure, compounding these externalities leads to double or triple counting. This is because they are linked by cause-effect (e.g. the SCC includes disease burden).

3.4.2 Economic gains

Amenity is the characteristics of a place or property that contribute to it being more desirable (e.g. being more enjoyable or more aesthetically pleasing). Improved or more desirable amenities are linked to higher property prices and favourable locations to live, recreate and work (Investopedia, 2017). Amenities provided by green infrastructure are favoured by homebuyers all across Australian cities and is linked to neighbourhood preference and property premiums (Plant, et al., 2016). For example:

- 73% of Australians favour homes with gardens, 57% consider it important to have a park within walking distance of their home and 56% to have a leafy outlook from their home (Planet Ark, 2014).
- Market studies show that green infrastructure use for WSUD is positively perceived by homebuyers in Melbourne. Low water quality due to deficient stormwater management has led to recorded drops in property premiums of 20-25% in Victoria (Water By Design, 2010).
- Constructed wetlands in the of development green spaces led to increases premium on land and property. Data has shown 7% price increase for property adjacent to wetlands in WA and 100% land premium increase for land in sight of water bodies (Water By Design, 2010).
- Tree-lined streets in Perth can increase house prices by 4.27% (Pandit, et al., 2013).
- Brisbane street trees deliver \$29.7 million in residential property value benefits (Brisbane City Council, 2017).
- Property values in Sydney are expected to increase on average \$164/m^2 in result of a 10% canopy increase in street trees (AECOM, 2017).

Green infrastructure is also linked with other economic variables:

- Exposure to plants and contact with nature in the work environment leads to higher employee satisfaction and higher productivity (Planet Ark, 2014; Husti, et al., 2015).
- Green infrastructure is considered to favour local economic activity, for example by attracting people to areas of local commerce (Victoria Institute of Strategic Economic Studies, 2016; Wolf, 2004).

Valuing green infrastructure amenities

A common approach to amenity valuation is the contingent valuation method: a non-market method that measures the value that a person places on an asset or its benefits. "Willingness to pay" can be used to value environmental assets, by indicating people's valuation of the asset or the minimum compensation for loss of access to the benefit brought by the asset (Tyrväinen, 2001).

A study conducted by Planet Ark in 2014 surveyed Australians for their willingness to pay for proximity to nature in the workplace and at home. Australians responded that:

- They would be willing to sacrifice 5% of their salary to connect regularly with nature during their working day, either by enjoying work-breaks outdoors, having a window with views of nature or indoor plants.
- They would pay 7% more for the same home in a green neighbourhood in detriment of an area with no proximate green space.

Net benefits on property prices, for instance, can be modelled by another method: hedonic regression metrics. Hedonic regression analyses price variations in property prices in relation to changes in characteristics which are perceived as being part of the price package.

A study performed in Australia between 2000 and 2010 linked increased and decreased vegetation abundance across the Australian housing market. Vegetation abundance was measured with the Environmental Vegetation Index (EVI), which can be derived from analysing the intensity of photosynthesis read from satellite imagery. The average EVI across all sampled sites was 0.295 out of 1. An increase in 25% of that value was correlated with increases in housing prices by between 8.6% and 15.6% (Rossetti, 2013).

This study considered the amount of primary production as a proxy for vegetation abundance, which was considered an indicator of the abundance of green infrastructure. As such, it excluded differences between assets and the determinant factors to harness their services (e.g. accessibility, planning context). A study by Kong and colleagues (2007) in China, established that for each 1% of additional green space area and of improved accessibility the m^2 price increased by 2.1% and 1.6% respectively (Kong, et al., 2007). This suggests the importance of putting green infrastructure in a wider planning context to maximize economic gains.

These findings are summarized in Table 4 below.

Table 4 - Factors predicting increases property premiums resulting from green infrastructure.

Predictive factor	Property price increase	Reference
Existence of proximate green space	7%	(Planet Ark, 2014)
1% increase in proximate green space area	2.1%/m^2	(Kong, et al., 2007)
1% improvement in access to proximate green space area	1.6%/m^2	(Kong, et al., 2007)
25% increase from average vegetation cover	8.6% to 15.6%	(Rossetti, 2013)
Tree-lined streets	4.27%	(Pandit, et al., 2013)
10% increase in canopy cover	$164/$m^2$	(AECOM, 2017)
Proximate water bodies (inc. green infrastructure)	7%	(Water By Design, 2010)

3.5 Disservices and barriers

When considering how to increase the uptake of plants in the built environment it is important to recognise that there are also negative aspects or disservices. In recognising and being aware of disservices we can then take measures to mitigate or avoid them. The literature sources consulted in this part of the review point out ecosystem disservices linked to green infrastructure, which hinder uptake:

- **Safety,** with concerns on liability for, for example, damage cause by fallen trees.

- **Water use** of irrigated assets, such as green walls and turf.
- **Damage to utilities**, such as root damage to street plumbing, street pavements and electricity cables.
- **Attraction of invasive species**, when alien species brought in for landscaping purposes and override the growth of native flora and fauna.
- **Allergies** caused by pollen, which are a higher risk in greener areas.
- **Nutrient leaching** from fertilizer application.
- **Negative perception,** for example building tenants who associate vegetation with the presence of vermin.

Another barrier to the uptake of green infrastructure are added costs. These costs often compound with the perception that green infrastructure is a low value and low return asset in competition with profitable land uses.

- **Installation costs**, often adding to the costs of property and infrastructural development.
- **Maintenance costs**, such as trimming of trees, landscaping, renewing green wall substrates.

Most disservices could be managed on a case-by-case basis and at the city/precinct level by addressing core issues in urban planning that the previous sections touched upon: appropriate design, appropriate species selection, matching assets to the key issues to be addressed and to their location. Moreover, a cost-benefit analysis of green infrastructure assets could provide guidance on the economic return to installation and maintenance costs of different assets.

3.6 Conclusion

3.6.1 Green infrastructure assets and construction elements

Figure 4 below shows the services that can be expected from each asset type and the building/infrastructure element where it is commonly implemented.

This matrix provides guidance on the green infrastructure strategy to implement to attain specific functions or achieve sustainability targets within projects. The success of harnessing these services and benefits depends on the asset to be implemented; the building and infrastructure element where it is implemented; its design, location and wider urban planning context.

This mapping exercise shows that a project aiming at specific sustainability targets or economic benefits through green infrastructure must select and design assets accordingly. It also summarizes the potential of green infrastructure to affect the environmental, societal and economic performance of the project into which it is inserted. Addressing this is within the scope of building and infrastructure rating tools, as they reward projects on a credit system based on how certain performance criteria are achieved. How the findings of this literature review align with what is currently being implemented in such rating tools in Australia is reported in section 4.

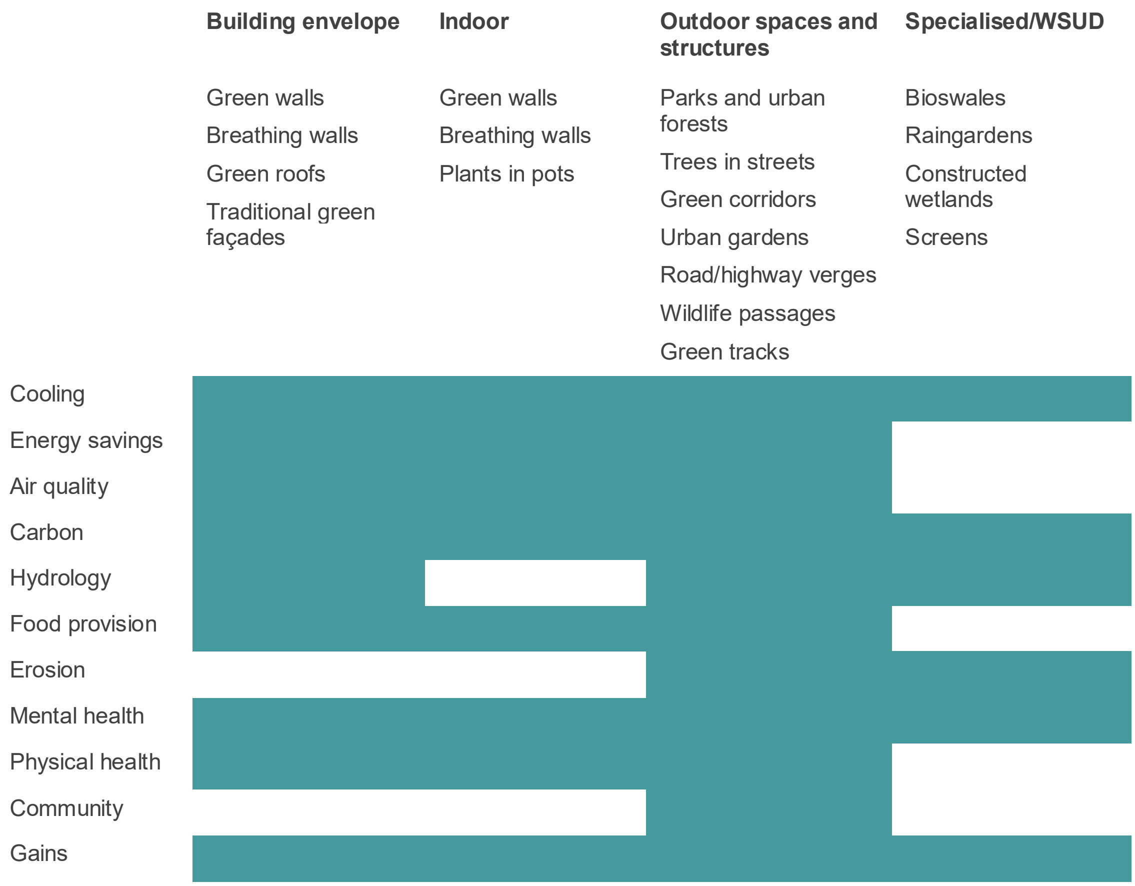

Figure 4 - Map of evidence found for significant benefits and services provided by asset classes in their context in the building or infrastructure.

3.6.2 Translating benefits into metrics

The mapping exercise in section 3.6.1 above shows that one asset can attain different benefits, which consequently can be monitored with different metrics. Measuring the services provided by green infrastructure has been a bottleneck in the monitoring of applied green infrastructure, its appraisal in the built environment and consideration in building and infrastructure tools. Agreement on metrics is necessary to adequately monitor and implement ratings of green infrastructure and to promote uptake (Figure 5).

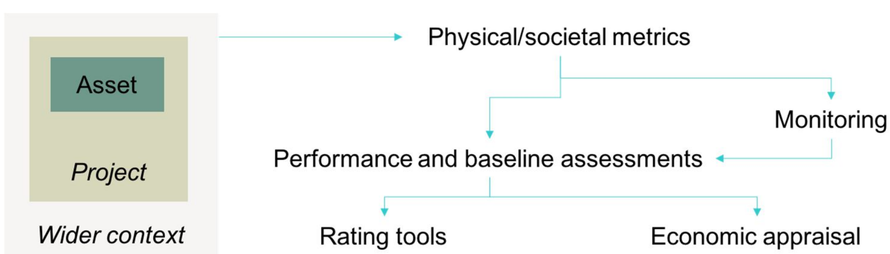

Figure 5 – Measuring green infrastructure performance.

There are physical and societal parameters, subject to multiple variables of influence, to measure and to shape baselines against which performance and relative success can be tracked. These metrics are fundamental to the monitoring of performance and to feed into wider understanding and appraisal models of green infrastructure. Current knowledge is scattered, non-comprehensive and highly affected by site-specific factors, such as climate. Systematized predictive factors for how specific asset designs will perform across the significant services they provide in different contexts of the Australian climate and urban planning setups are required.

Furthermore, there is the need for universal metrics that translate into industry values and underpin the adoption of green infrastructure. This literature review concludes that the environmental and social benefits can be traced to endpoint economic benefits. While it is not the scope of this study to develop a business case or cost-benefit analysis for green infrastructure, the literature review and preliminary industry consultation shows that a universal economic metrics could be a meaningful uptake factor.

4 The state of the art and opportunities: plants in building and infrastructure rating tools

4.1 Introduction

Rating tools are used in the infrastructure and property industries to rate and pre-select projects according to sustainability principles. Their ultimate goal is to improve sustainability of the built environment and the industries that serve it, by promoting best practice and involving the whole supply chain. Two main built environment rating tools in Australia are:

- **Green Star**, which applies to all buildings and community developments, and is managed by the Green Building Council of Australia (GBCA)
- **IS Tool**, which is applied to infrastructural developments, and is managed by the Infrastructure Sustainability Council of Australia (ISCA).

Both tools work with a credit system, whereby a project proponent can adopt different strategies and measures to reach credit compliance and see its project rewarded with points. The final rating of the projects considers the points earned across a range of selected credits, which the proponent defines in its Green Star or IS strategy. Credits can be earned at the planning, design, construction and/or operational stages of the project.

The requirements and design of each credit will make it more or less attractive to project proponents. Credits focus on different things, from energy efficiency to material selection, thereby influencing the supply chain upstream of the project development to satisfy the demand of Green Star and IS strategies.

Amongst other things, this project seeks to demonstrate that the adoption of more plants into the built environment can be promoted by delivering ISCA and the GBCA with recommendations on how to design credits, and to communicate the benefits of doing so in a manner that is both appealing to development proponents.

Sections 4.2 and 4.3:

- Provide an overview of Green Star and the IS Tool functioning.
- Explore how green infrastructure is currently captured in Green Star and the IS Tool.
- Identify opportunities to incorporate the evidence found in the literature review provided in section 1.

4.2 Green Star

4.2.1 Green Star aims and structure

Green Star is an internationally recognized rating system which aims to encourage sustainable design and operation of property assets by providing a framework for identifying, prioritising and rewarding sustainable practices. Even though obtaining a Green Star rating is not mandatory, it is widely adopted by designers, planners and developers to establish and showcase sustainability targets and attract tenancy premiums. Presently, 30% of Australia's office space, covering 5% of the nation's workforce, is Green Star-rated.

There are four distinct Green Star rating tools, each one capturing a successive aspect of property projects. The four types and their scope and categories are listed below in Table 5.

Table 5 – Applicability of Green Star tools.

<table>
<tr><th>Tool</th><th>Scope</th><th>Assessment categories</th></tr>
<tr><td>Communities</td><td>Large scale development projects, at a precinct, neighbourhood, and/or community scale</td><td>Governance
Liveability
Economic prosperity
Environment
Innovation</td></tr>
<tr><td>Design & As Built</td><td>Design and construction of new buildings and major refurbishments</td><td rowspan="3">Management
Indoor environment quality
Energy
Transport
Water
Materials
Land Use and Ecology
Emissions
Innovation</td></tr>
<tr><td>Interiors</td><td>Design and construction of new fitouts</td></tr>
<tr><td>Performance</td><td>Applicable in the operational stage</td></tr>
</table>

4.2.2 Gap analysis

Table 6 below identifies all Green Star credits in the three Green Star rating tools that focus on green infrastructure (plants of any kind) and the services it provides, and which aspect of the asset is considered.

The assets considered by Green Star – Design & As Built and Green Star – Performance are those that can be implemented on the building envelope or inside the building (e.g. green roofs, indoor plants) and small green spaces which are part of the development (e.g. a garden next to a building). Assets that are excluded normally from a building development, such as city parks or trees on streets are only included in Green Star – Communities.

The key findings on how green infrastructure is captured in Green Star – Design & As Built are:

- The 'Ecological Value' and 'Heat Island Effect' credits in Green Star are prescriptive when detailing requirements for vegetation in buildings (e.g. "at least x% of an area covered by vegetation").
- Both horizontal and vertical surfaces are measured in the 'Ecological Value' credit. However, vertical surfaces are discounted compared to horizontal surfaces. The area taken into account is the soil/substrate area, not the total area covered by plants.
- Ecological value considers the amount of plants, and the type of plants with heavier weighting given to native vegetation.
- There are several credits where the benefits of green infrastructure can be captured. For example, a green roof will be taken into account by the energy modeller with the thermal benefit captured in 'Greenhouse Gas Emissions'. However, as is mostly the case in Green Star, specific technologies and solutions are generally not specified.
- Indoor benefits of plants are not generally considered in Green Star – Design & As Built due to the contractual limitations of tenanted spaces. That is, in most cases, the fit out of a building is subject to another party's design, management, and control (as such they are rewarded in Green Star – Interiors).
- However, in recognition that there are mental health benefits and air quality benefits to having indoor plants in tenanted spaces, an Innovation Challenge point is currently awarded for buildings that do have vegetation throughout the tenanted space.
- The Innovation Category also rewards the introduction of food gardens through the Community Benefits Innovation Challenge.

The key findings on how green infrastructure is captured in Green Star – Performance are:

- The ecological value credit recognises the difficulties in greening an existing building. It covers both biodiversity and the natural diversity of a site. However, it acknowledges that the purpose of the credit is to manage and maintain the ecological value of the site where present. It is not aimed at improving a site's ecological value at this stage.

Both rating tools provide mechanisms to recognise most of the value that plants can bring to a building. However, due to the low weighting of the credits compared to other issues, these are not taken up to the same extent as other credits. As these two rating tools are only concerned with an individual building, introducing considerations for the urban landscape would expand the benefits of plants within a site's boundary.

4.2.3 The future of green infrastructure in Green Star

From the Green Star gap analysis, the main identified opportunities to improve the consideration of green infrastructure in Green Star are:

- Increasing the value of ecology and biodiversity in the rating system.
- Improve the Ecology Calculator to go beyond rewarding native species, and into rewarding ecosystem function. Review the vertical garden discount as well.
- Introduce points for improving the urban landscape and ecological considerations of the city's network via green infrastructure.
- Introduce points for providing green spaces for social interaction & physical activity in the built environment.
- Working with GBCA to improve communication on the benefits of plants in the workplace and home.

Based on the findings of the gap analysis and the literature review, this project developed a set of 6 concepts for Green Star Innovation Challenges focusing on green infrastructure. Innovation Challenges are new, exploratory Green Star credits that are trialled and, if successful, may be incorporated into Green Star as a full, permanent credit.

In a meeting in Sydney in February 2018, this project presented[2] the GBCA with the proposed innovation challenges. The report documenting the literature review (section 3) and the Green Star gap analysis (section 4.2) were provided to the GBCA prior to the meeting for discussion and review.

The outputs of the discussion with the GBCA are documented in sections **Error! Reference source not found.** and 0 below.

The following dot-points summarise the outcome of the discussions with GBCA:

- GBCA currently has no resources to use for new Innovation Challenges, as all the effort is being put into updating the Green Star tool for 2019.
- Any recommendations from this report will influence the new Green Star tool. These recommendations are provided in section 0.
- The model proposed in the shading pathways and outdoor air quality criteria could be pathways or additional criteria for the Urban Heat Island credit already in Green Star.
- Residential guidance for number/type of plants in homes and apartments would be useful for Green Star Living[3]. This opportunity may be re-visited next year after the new Green Star tool is finished.

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[2] The content of that presentation is provided in the project annexes not for public disclosure.

[3] Green Star's consumer-facing knowledge portal on sustainable homes, recently launched online at https://www.livinggreenstar.org.au/.

Proposed improvements to Green Star

GBCA has been working on a discussion paper outlining how the built environment can improve the ecology and biodiversity of the urban landscape at the building scale. The paper also details how Green Star is expected to address these issues in the future.

The paper sets out five guiding principles that GBCA believes the built environment should follow when considering developing a new building:

- **Protect ecological value**, by encouraging development on land of limited value.
- **Minimise ecological impact**, by minimising the impact on on-site ecology and biodiversity during and after construction.
- **Enhance ecological value and biodiversity**, by improving the site as a first priority, and only then consider off-site ecology. This is the key principle that will achieve gains in overall ecological value.
- **Connect ecological networks**, by linking or maintaining connections, between native or built landscape corridors.
- **Create and manage on-site and off-site natural spaces**, by constructing new natural environments within the built environment and encouraging the maintenance of enhancements on-site and off-site.

These five principles will guide how Green Star will be amended in the future when it comes to improving ecology and biodiversity services in the built environment.

The paper is expected to be released in May 2018.

Table 6 – Gap analysis: green infrastructure in Green Star.

Credit	Name	green infrastructure asset captured	Criteria	Gaps
Green Star – Design & As Built				
Credit 03	Adaptation and Resilience	Capturing landscaped and green space.	Planted native vegetation (including gardens, green roof & vertical gardens, forests) considered Land Types with High Weightings (>0.5) in the Ecological Value Calculator.	
Credit 12	Visual Comfort	Captures the mental health value of internal or external vegetation in buildings	60% of the nominated area has a clear line of sight to a high quality internal or external view. Views include landscaped areas, vegetated areas, and vertical gardens.	
Credit 13	Indoor Pollutants	Captures the air quality improvements from internal vegetation in the space	Innovation Challenge, meet the requirements of 'Indoor Plants' in Green Star – Interiors.	
Credit 15	Greenhouse Gas Emissions	Captures the energy saving benefits of green roofs and walls	Energy modelling takes into consideration the benefits of additional insulation values and shading provided by green roofs and walls.	
Credit 23	Ecological Value	Capturing landscaped and green space.	Planted native vegetation (including gardens, green roof & vertical gardens, forests) considered Land Types with High Weightings (>0.5) in the Ecological Value Calculator.	
Credit 25	Heat Island Effect	Capturing green roofs and green space / landscaping.	At least 75% of the plan area is covered by vegetation, including: green roofs, hard-scaping elements shaded by overhanging vegetation?	Surface covered by green walls (going beyond plan view - height and spacing of buildings- was suggested in credit 31 of the Communities tool).
Credit 26	Stormwater	Capturing landscaped and green space.	Ensuring reduced peak discharge (pre-vs post development modelling)	
Green Star – Interiors **In addition to criteria (Visual Comfort, Indoor Pollutants, Greenhouse Gas Emissions, the rating tool also includes other cre dits)**				
Credit 12	Indoor Pollutants (12. 3 Indoor Plants)	Capturing individual indoor plants.	Plants every $10m^2$ and ongoing plants maintenance.	

Credit	Name	green infrastructure asset captured	Criteria	Gaps
Credit 14	Quality of Amenities	Captures the mental health and air quality benefits of vegetated areas	A space must be provided for staff to relax. Landscaping of the space is a consideration.	
Green Star – Performance				
Credit 24	Ecological value	Capturing landscaped and green space.	Having a policy with operational requirements for biodiversity and ecological diversity (vegetated areas including green walls).	
Credit 25	Grounds keeping	Capturing landscaped and green space.	Sustainable site and landscape maintenance plan and reporting.	
Credit 26	Stormwater	Capturing landscaped and green space.	Stormwater management plan and identification of risks for pollutants removal.	
Communities Tool				
Credit 9	Healthy & Active Living (9.2 recreational facilities & 9.3 healthy places)	Capturing landscaped and green space.	Ensuring access to paths, parks, open spaces. Increase walkability and access to healthy spaces and social interaction spaces (compliance method with checklist)	Health benefits associated with types of green infrastructure, other than walkable spaces.
Credit 14	Access to fresh food	Plants and vegetable garden (productive landscape) space.	Proximity, availability (size) and maintenance plan of productive landscape (e.g community food garden)	
Credit 29	Ecological value	Capturing landscaped and green space.	Planted native vegetation (including gardens, green roof & vertical gardens, forests) considered Land Types with High Weightings (>0.5) in the Ecological Value Calculator.	
Credit 31	Heat island effect	Capturing green roofs and green space / landscaping.	At least 50% of the plan area is covered by vegetation, including: green roofs, hard-scaping elements shaded by overhanging vegetation?	Surface covered by green walls (going beyond plan view - considering height and spacing of buildings- was suggested in the credit)

4.3 IS Tool

4.3.1 ISCA and the IS rating scheme

Infrastructure sustainability, as defined by the Infrastructure Sustainability Council of Australia (ISCA), is infrastructure that is designed, constructed and operated to optimise environmental, social and economic outcomes over the long term.

The Infrastructure Sustainability (IS) rating scheme has been developed by ISCA. The IS rating scheme evaluates sustainability initiatives and potential environmental, social and economic impacts of infrastructure projects and assets. It is an industry-compiled, voluntary rating but is now compulsory for some government projects. As an illustration, Transport for NSW (TfNSW) requires an IS rating for all capital projects over $50m in value. The present value of assets holding an IS rating is $80.2 billion.

IS rating scheme rates infrastructure based on performance at the project's milestones detailed in Table 7: Design, As Built and Operation.

Table 7 – IS rating types

Rating Type	Scope	Details
Design	End of Planning and Design	May be awarded based on the inclusion of design elements and construction requirements for sustainability in the project documentation. The rating may be awarded after completion of design. This is an 'interim' rating and must be replaced by an As Built rating after construction.
As Built	End of Construction	May be awarded for the inclusion of design elements, and construction requirements for sustainability in the project documentation along with the measured sustainability performance during construction and built into the infrastructure asset. The rating may be awarded after practical completion of the project. This rating supersedes the Design rating.
Operation	During Operation	May be given any time during operation. The Operation rating is based on the measured sustainability performance of the operating infrastructure asset. There is no requirement for the infrastructure asset to have achieved either a Design rating or an As Built rating to achieve an Operation rating. Existing infrastructure assets in operation are eligible to apply for an Operation rating. The Operation rating must be revalidated every five years.

Each category is divided into a number of credits each of which addresses a specific aspect of sustainability performance within the category (Table 8). Each credit:

- Has a series of benchmark performance levels which define increasing levels of performance for that credit from Level 1 to Level 3.
- The three levels approximately correspond to 'Commended, 'Excellent' and 'Leading' performance. Note that all benchmark levels are intended to reflect 'beyond business as usual' performance.
- In some cases, not all of the three levels are used.

Future themes covering 'Economic Performance', 'Workforce' and 'Green infrastructure' are planned to be developed and released in Version 2.0 of the scheme.

Table 8 – Rating scheme framework

Themes	Categories	Abbreviation
Management & Governance	Management Systems	Man
	Procurement & Purchasing	Pro
	Climate Change Adaptation	Cli
Using Resources	Energy & Carbon	Ene
	Water	Wat
	Materials	Mat
Emissions, Pollution & Waste	Discharges to Air, Land & Water	Dis
	Land	Lan
	Waste	Was
Ecology	Ecology	Eco
People & Place	Community Health, Wellbeing & Safety	Hea
	Heritage	Her
	Stakeholder Participation	Sta
	Urban & Landscape Design	Urb
Innovation	Innovation	Inn

4.3.2 Gap analysis

Plants are considered in several credits of the IS rating. Table 9 summarizes all credits where plants can impact the rating of a project, as well as the specific aspect of green infrastructure to consider.

The achievement criteria for IS credits are less prescriptive than Green Star's, in the sense that several credits do not specify targets as metrics or prescribe best practice. Instead, each credit has a goal and suggests methods to assess and monitor measures. Often, the goal is to mitigate nefarious impacts of the project onto its immediate environment (e.g. minimize habitat disruption or destruction, reduce negative discharges to the environment).

The key findings of this analysis are:

- ISCA ratings offer wide and flexible opportunities to integrate diverse and functional green infrastructure.
- Most achievement criteria pertain to minimizing expected impacts of the project, while others call for the adoption of solutions that could be provided by green infrastructure.
- The aspects and assets to be used towards achievement are also not specified by the tool. There are also credits where green infrastructure is not mentioned, but the goal can be achieved with green infrastructure assets (e.g. climate adaptation measures may use resilience benefits of increased vegetation).

Due to the open-ended criteria, gaps are not readily identifiable. The achievement criteria summarized in Table 9 show the contexts where green infrastructure can be applied, and which ecosystem services can be harnessed.

4.3.3 The new green infrastructure credit

At the time of writing, ISCA is preparing the launch of a new green infrastructure credit (Gre-1). Horticulture Innovation Australia (henceforth Hort Innovation) commission he review of the GR-1 credit through a stakeholder consultation and the development of case studies where the credit was trialled. The Gre-1 review is documented a separate report, which has been submitted to ISCA and not for public disclosure.

Table 9 - Gap analysis: Green infrastructure in the IS rating.

Credit	Name	green infrastructure asset	Criteria
Design and As-Built Tool			
Cli-2	Adaptation measures	Could capture climate regulation by vegetation	Demonstrated adaptation measures addressing risks identified in a climate change risk analysis.
Ene-1	Energy and carbon monitoring and reduction	Vegetated land	Calculate land clearing GHG emissions impact and reduce emissions from land clearing.
Dis-1	Receiving Water Quality	Vegetation to reduce discharge of pollutants and to reduce stormwater flows	Measure, monitor and minimize pollutants in water discharges to the environment. No increase of stormwater flows for rainfall events as result of the project.
Dis-4	Air Quality	Vegetation to reduce air quality adverse impacts	Measures to minimize adverse impacts to local air quality during construction and operation can include: Areas of exposed earth would be minimised by staging construction activities and progressively landscaping and vegetating completed areas as the construction activities proceed, where feasible and reasonable.
Lan-2	Conservation of on-site resources	Vegetation to preserve soil quality	Conservation of soil resources: subsoil and topsoil impacted by the project is separated and protected from degradation, erosion or mixing with fill or waste.
Lan-4	Flooding design	Could capture green infrastructure minimising bank and bed erosion	Designing for flood events and flood resilience measures with demonstrated no increase or decrease in flood risk as result of the project.
Eco-1	Ecological value	Landscaped and green space	Maintenance or enhancement by 20% of ecological value. Methods to assess ecological value: Ecological Value Calculator or Ecological Impact Assessment. If the project occupies sensitive habitat areas, an ecological management plan must be implemented.
Eco-2	Habitat connectivity	Landscape and green space, wildlife corridors	Maintenance or enhancement of habitat connectivity (greater than 20%).
Hea-1	Community health and wellbeing	Could capture green space, green corridors, urban agricultural land	Positively contribute to community health and wellbeing in previously identified key issues.
Hea-2	Crime prevention	Parks	Design assets and plan construction works for reduced likelihood of crime.

Credit	Name	green infrastructure asset	Criteria
Urb-1	Urban design	All	Adoption of best practice urban design principles and design review. Objectives for landscape, green infrastructure, environment, heritage, accessibility, liveability, etc.
Urb-2	Implementation	All	Effective implementation of urban and landscape design, evaluated by the production of a compliant plan
Operations – additional credit			
Ene-2	Energy and carbon reduction opportunities4	Vegetated land	Calculate land clearing GHG emissions impact, reduce emissions from land clearing

[4] Differs from Ene-1 in that Ene-1 covers opportunities to reduce GHG emissions, while Ene-2 in the Operations rating considers the payback period of reduction opportunities and incentivizes the implementation of feasible ones.

5 Stakeholder engagement

5.1 Introduction and objective

The aim of the stakeholder engagement around this project was to collect first-hand information from the industry and gauge a level of green infrastructure practice in Australia. The engagement provided an opportunity to understand the on-the-ground experiences of practitioners, including barrier and opportunities and the day-to-day process of implementing, monitoring and managing green infrastructure.

The objectives of the stakeholder engagement were broadly to:

- Validate research findings from section 3.
- Gauge a level of practice of green infrastructure in Australia.
- Communicate and discuss the ongoing project and project findings with key stakeholders and broader audiences.

This project stage was subdivided in a stakeholder consultation task and communications and knowledge-sharing tasks. The latter included a centrally delivered event and the production of infosheets.

5.2 Approach

5.2.1 Interviews

Two parallel interview campaigns were carried out:

- Interviews of professionals of several disciplines operating in the green infrastructure field (outputs in section 5.3).
- Interviews focused of civil infrastructure professionals, focused on the use of green infrastructure in civil infrastructure projects (outputs in section 5.3).

Ten professionals in general green infrastructure field and six professionals in the field of civil infrastructure were interviewed. The latter were the same people who participated in the peer-review of the IS Tool green infrastructure Credit. The full list of interviewees in provided in Table 10.

The interviewees were selected to meet the following criteria, in order of relevance:

- The collective of interviews covers different geographies within Australia and different types of green infrastructure.
- All interviewees have a high level of experience in their discipline.
- The collective of interviews covered several disciplines, such as architecture, engineering, landscape architecture, academia, government, management and horticulture.
- The interviews in the civil infrastructure scope either have experience in implementing green infrastructure in relevant projects or are exploring the possibility of implementing green infrastructure.

The questions provided the structure for a semi-structured interview. A relatively flexible interview approach was chosen given the need to allow time to cover topics and information of which the interviewee might otherwise have been unaware (for example, the full range of co-benefits). This allowed for a completeness check of the literature review, in terms of issues and benefits identified.

Table 10 - Scope summary of the stakeholders interviewed under the stakeholder consultation.

Name	Role	Organisation	Project	Type/Function	Benefit	Lcation
Ian Shears	Manager, Urban Sustainability	City of Melbourne	Various projects in Green Public Spaces/Environmentally Sustainable Development	Infrastructure/Green Walls	Positive social impact	Melbourne
Euan Williamson	ESD advisor, within statutory planning department	Yarra City Council	Various projects in Green Public Spaces/Environmentally Sustainable Development	Building/Green Roof	Positive social impact	Victoria
Jock Gammon	Founder and Managing Director	Junglefy	Hassel Head Office Building	Building/Internal Green Wall	Air quality	Sydney
Noel Corkery	Managing Director	Corkery Consulting	The Great Western Highway Upgrade - Woodford to Hazelbrook Section	Infrastructure/Bioswale	Hydrological regulation	NSW
Sara Wilkinson	Associate Professor, School of the Built Environment	UTS	Policy Guidelines for Royal Institute of Chartered Surveyors	Buildings/Green Walls and Roofs	Multiple	Australia
Emil Montibeler	National Business Development Manager	OZBREED Pty Ltd	Gold Coast Council Car Park	Infrastructure/Bioswale	Hydrological regulation	Gold Coast
Nadia Ford	Strategic Planning	City of Stonnington	Community facility upgrade	Buildings/Green Walls and Roofs	Local climate regulation, air quality	Victoria
Robyn Mitchelll	Green Infra Coordinator	City of Melbourne	Various projects	Infrastructure/Urban Forest	Local climate regulation	Melbourne
Matt Williams	Sustainability Manager NSW/ACT	Lendlease	Darling Park	Building/Green Roof	Mental Welfare	Sydney
Justin Foley	Program Director	ACT Government	ACT Healthy Waterways	Water sensitive urban design	Hydrological regulation	ACT
Yanos Fill-Dryden[5]	Senior Urban Designer	Transport for New South Wales	Parramatta Light Rail	Green tracks	Aesthetics, local climate regulation	Sydney

[5] The outputs of this interview are for informative purposes only and are not reflective of a project commitment.

Name	Role	Organisation	Project	Type/Function	Benefit	Lcation
Adam van der Beeke	Environmental Advisor	Fremantle Ports	Rous Head Industrial Park	Water sensitive urban design and ecological restoration	Hydrological regulation, ecological value	WA
Sophie Wallis & Rob Arnott	Sustainability manager / Project Director	Upthink / Mainroads WA	Northlink WA	Green corridors, wildlife corridors, water sensitive urban design	Local climate regulation, positive social impact, physical activity, habitat connectivity and biodiversity, hydrological regulation	WA
Mark Sawatzki	Sustainability Coordinator	LendLease	Gateway Upgrade North	Water sensitive urban design initiatives	Hydrological regulation	Brisbane
Maggie Baron	Environmental Manager - Rail Systems Alliance and Urban Ecology Manager	Melbourne Metro	Melbourne Metro Tunnel	Green walls, water sensitive urban design, Street trees, wildlife corridors	Local climate regulation, aesthetics, hydrological regulation, shading, cooling, community satisfaction, wellbeing, physical activity, habitat connectivity and biodiversity	Melbourne

5.2.2 Surveys

Further to the interviews, a survey was made available online during the months of February and March 2018 and distributed through various channels, such as social media, mailing lists and peer-to-peer sharing. The exact reach of the survey is unknown. There were 25 responses, of which 23 constituted useful responses (i.e. were coherent and complete).

The table below (Table 11) lists the questions for all three stakeholder consultation tasks.

Table 11 – List of questions included in the stakeholder consultation.

Question scope	General green infrastructure		Focus on civil infrastructure
	One-on-one interview	Survey question	One-on-one interview
Project description **Identification of green infrastructure type**	How have you included green infrastructure in your project?	Please tell us about your project. When have you incorporated plants into a building or infrastructure project. What type of green infrastructure project was it?	Did this green infrastructure asset replace or supplement a planned "grey infrastructure" solution? If so, how?
Identification of potential benefits	Did you design the project so to capture the benefits of green infrastructure? If so what where the benefits? If the project is built/complete, are you seeing the benefits that you expected? Have there been any co benefits?	If you have incorporated plants into a project to achieve particular benefits or mitigate a particular impact, please indicate which benefits.	What were the main drivers of incorporating green infrastructure into this asset? Were there any internal or external demands for incorporating green infrastructure into the project? Can you describe the benefits obtained from including this green infrastructure asset?
Monitoring	Are you measuring or monitoring the benefits?	Are you measuring or monitoring the benefits? If so how?	*Specific questions relevant to the Gre-1 IS credit.*
Identification of barriers	Have there been challenges?	What have been the challenges implementing your green infrastructure project?	What were the key challenges for incorporating green infrastructure into your project?
Identification of opportunities		What opportunities have arisen during your green infrastructure project?	What are your key lessons learnt from this project? What would you do differently next time?
Next steps	Is there anyone we should speak to next?		Do you have any additional comments for HIA?

The full transcripts of interview responses and survey responses are record in the project annexes not meant for public disclosure.

5.2.3 Project event

Alongside the interviews, a stakeholder event held in Sydney on the 8th March 2018 ("Green is the new grey"). The event hosted an audience of 50 hailing from different backgrounds, many of whom were informally surveyed on site.

The event was designed in forum format. There was a panel presentation by five professionals who represented several stages of the green infrastructure supply chain:

- Emile Montibeller, Ozbreed - horticulture and agronomy
- Suzie Barnett and Andrew Wand, Junglefy - design, manufacture and maintenance
- Matt Williams, Lendlease - adoption and monitoring
- Nicole Boyd, ISCA - sustainability ratings (infrastructure)

In addition, the 202020 Vision was presented by Ben Peacock (Republic of Everyone) and the project outcomes were presented by Joana Almeida (Edge Environment). Following the presentation, there was a discussion with the audience.

Figure 6 – Tom Davies (Edge) moderating “Green is the new Grey”.

5.3 Results

5.3.1 Overall findings

Edge interviewed ten professionals who have had direct involvement in green infrastructure projects and six professionals of the civil infrastructure industry (Table 10).

At the project design stage, it was assumed that building and development related professional bodies such as Engineers Australia, The Planning Institute, and Architects Australia would have sub-groups relating to green infrastructure practice. This is not the case. There are networks relating to green infrastructure such as Green Roofs Australia, but they are relatively unknown across the mainstream built environment professions. As such, individuals were identified through intelligent networking to achieve broad representation of professions, green infrastructure types, elements, benefits and geography. Moreover, the individuals interviewed in the scope of the ISCA GR-1 credit review were also surveyed in relation to general green infrastructure.

The pre-interview research identified multiple different green infrastructure types. The set of interviews was subsequently designed to capture as many different types as possible (Table 12). These different types are a subset of a larger set that could be defined in a classification of green infrastructure (see section 5.5).

Table 12 – Green infrastructure asset types identified as implemented or under consideration by interview and survey respondents.

General interviews and surveys		Civil infrastructure interviews
• Green Walls • Green Roofs • Urban Green Space – Roof Garden • Internal Green Walls (Breathing Walls) • Bioswales • Urban Forests	• Community gardens • Green walls • Urban Green Space • Green Roofs • Urban Shading • Bioswales	• WSUD • Green tracks • Green corridors/tree lined streets • Fauna corridors • Screening

It should be noted there was a noticeable variability in nomenclature of green infrastructure types proposed by the interview and survey respondents. In some cases, this did not match the classification adopted in the early sections of this report (e.g. section 2.1.1).

5.3.2 Capturing the benefits of green infrastructure

All the interviewees were confident that their project had achieved the benefits that were intended in the original brief. In the civil infrastructure projects there was a greater requirement to achieve a specific and measurable outcome/benefit for some specific applications. For example, in bioswale projects, development controls require particular volumes of water to be retained and treated. The design is therefore required to meet a particular hydraulic regime as a threshold of performance. As such, in this area, there was a more clarity around which plants to use in order to achieve a given outcome. For other applications – such as energy efficiency in a green roof or wall – choices and outcomes can be less objective. Table 13 below summarises the benefits of different green infrastructure elements as described by civil infrastructure interviewees.

In some cases, the integration of green infrastructure aspects was a function of a desire to achieve an iconic or a 'hero' project; for example, Central Park Green Wall and Lend Lease Head Office. These projects represent an important phase of the green infrastructure movement as they are pioneering, and the owners of the projects are willing to invest in solving problems and addressing perceived risks to achieve the desired hero status.

Even though most interviewees were confident that green infrastructure achieves its expected ecosystem services and as co-benefits, there was little to no ability to justify that with metrics, particularly outside civil infrastructure projects. For example, if a specified benefit was to provide energy efficiency benefits, no project in this study could directly attribute a specific value to the impact of the green infrastructure aspect of the project.

Outside of civil infrastructure projects, there was no reported measurement or monitoring of the benefits of green infrastructure. General green infrastructure interviewees recognised that actual performance metrics about the benefits of green infrastructure were missing. I should be noted, however, that mostly those interviewees played a role in the delivery of the green infrastructure but were not responsible for the ongoing maintenance or management of the asset.

Table 13 - Key benefits identified by interviewees attributed to green infrastructure types in consideration or already implemented in civil infrastructure projects.

Green infrastructure element	Benefits identified		
	Environmental	**Societal**	**Economic**
WSUD elements (bio-filtration systems, constructed wetlands, vegetated swales etc.)	• Pollutant reduction • Runoff quantity reduction • Local biodiversity benefits • Biodiversity values including the introduction of threatened species, increased faunal and vegetation diversity • Improved landscape connectivity. • Groundwater quality improvements • UHI effect mitigation	• Visual and cultural amenity benefits.	• Housing price uplift • Cost savings through avoided construction and maintenance of gross pollutant traps
Green tracks	• Rainwater retention • UHI effect mitigation	• Improved visual aesthetic	
Trees and vegetation shading	• Biodiversity • Habitat connectivity • UHI effect mitigation	• Landscape amenity • Aesthetic value • Community connectivity	
Fauna reserves/overpass	• Habitat connectivity • Biodiversity	• Aesthetic value • Community support and ownership	
Visual/auditory screening	• Biodiversity • UHI effect mitigation	• Landscape amenity	

The point was made in two interviews that, in particular projects, building managers would face an ongoing expenditure for the upkeep of elements such as green walls and roofs, and that this is likely to be accounted for by the owner in terms of delivery of a particular service. A general measure was discussed at a city scale – that of liveability, which may be measured through the value of amenity or even with tools such as liveability rankings.

While the majority of survey respondents reported that no measurement of specific metrics had taken place, there were eight which described measurement of their projects using methods including:

- Group satisfaction surveys.
- Partnering with a research organisation to assess reduction in heat island effect.
- Monitoring of ecological health, water quality, erosion reduction and indoor air quality.
- Using the WELL rating scheme to rate success of benefits.
- Financial savings from changing from concrete drains to bioswales.

5.3.3 Industry drivers

According to civil infrastructure interviewees, current demand for green infrastructure originates from both internal (within the project team or organisation) and external sources (communities, interest groups, local and regional governments, etc.). Key drivers are summarised in Figure 7 below.

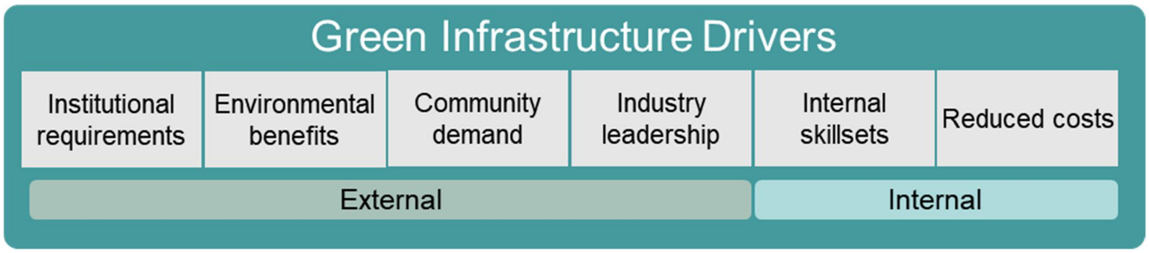

Figure 7 – Key drivers for green infrastructure in civil infrastructure projects identified by interviewees.

The rationale for including green infrastructure in many projects was linked to:

- Its ability to deliver specific benefits, such as UHI effect mitigation or runoff quality improvement.
- The asset types, for example, road projects often included WSUD elements.
- The local environmental and social context, such as downstream sensitive receivers or strong community interest in the project.

Key drivers are discussed in more detail below.

Institutional requirements

Civil infrastructure projects frequently involve diverse institutional stakeholders, including local, state and federal governments and transport authorities. Interviewees highlighted that green infrastructure elements facilitated the integration of the asset into the broader institutional context. For example, several projects included green infrastructure elements to meet the environmental requirements of local planning and development frameworks. This included the Melbourne Metro Tunnel project which, through its ambitious tree canopy plans and construction impact mitigation targets, aims to pro-actively respond to strict local government planting and vegetation requirements.

Managing sensitive environmental receivers

The sensitivity of the local environment was an important driver to employing green infrastructure strategies to mitigate downstream impacts. In several case studies, green infrastructure elements offered solutions for managing and reducing impacts to sensitive nearby receivers.

Examples included:

- The Gateway Upgrade North project team in Brisbane, who identified the ecological importance of the downstream Ramsar-listed wetland and incorporated WSUD elements to reduce runoff quantity and improve water quality.
- The Rous Head Industrial Park project team, who included WSUD to reduce negative impacts on nearby receiving waters (Figure 8).
- In response to the project's footprint bisecting an important arid ecosystem, the Northlink WA team included a fauna bridge to maintain ecological connectivity between otherwise disconnected habitats.

Figure 8 - WSUD at the Rous Head Industrial Park.

Climate regulation

Urbanisation increases local temperatures via the UHI effect. Interviewees representing projects located in already highly urbanised areas cited UHI mitigation strategies as important drivers for the inclusion of green infrastructure elements, particularly in increasing the resilience of urban communities to a changing climate. Both the Melbourne Metro Tunnel and Parramatta Light Rail projects are exploring the use of green infrastructure to address this issue.

Community demand

Large-scale infrastructure projects are subject to diverse community expectations. All interviewees discussed the implementation of green infrastructure elements as a means of meeting social and environmental expectations of communities.

Several examples are illustrated below:

- For the Melbourne Metro Tunnel, the significant tree removal requirements were considered an important reputational risk to the project, leading to the development of a broad green infrastructure strategy through the Living Infrastructure Plan (Melbourne Metro Rail Authority, 2017).
- The ACT Healthy Waterways project in Canberra was also developed in response to community demand for improved local water quality. The project team employed WSUD elements to achieve this, which has been widely supported by local communities.
- For Northlink WA, there was a need to incorporate and develop upon verge planting themes from neighbouring road projects to match stakeholder expectations.

Industry leadership

Increasingly considered best practice in the civil infrastructure sector, green infrastructure was identified as an important differentiator for several project teams in this study. Examples include:

- The exploration of green infrastructure Parramatta Light Rail project was observed by the interviewee as “*responsive to current best practice in rail infrastructure and local planning guidelines*”.
- Melbourne Metro Regional Authority aimed for the Metro Tunnel project to become an “*example for how green infrastructure can be incorporated into large projects*” through the comprehensive Living Infrastructure Plan (Melbourne Metro Rail Authority, 2017).
- For the Rous Head project, Fremantle Ports identified the unique opportunity to include the fairy tern reserve to show industry leadership through added ecological value, driving increased community interest and educational benefit through interpretive signage (Figure 9).

The interviewees highlighted the trend of recognising the responsibility in this sector to deliver the best possible outcomes, and how this has been achieved through green infrastructure. Demonstration of industry leadership was also identified in a strong driver outside of civil infrastructure, as demonstrated by stakeholders perceiving brand and iconic value of green infrastructure projects (see below).

Figure 9 - Fairy tern reserve at the Rous Head Industrial Park.

Co-benefits

All interviewees reported co-benefits, which were noted as a strong theme of green infrastructure. For example, a green wall specified to provide shading to a building envelope is a primary benefit, with co-benefits across a range of the areas described in previous sections (e.g. visual amenity, external air purification, biodiversity, urban food, mitigation of Urban Heat Island effect). Typically, there are multiple co-benefits that were unintended, but provide value to stakeholders invested in the project and to passive stakeholders, particularly the wider community.

Investment in green infrastructure might therefore benefit from articulating the co-benefits associated with investment and advocating to planning authorities to require green infrastructure in projects to achieve wider social, environmental and economic benefits to the community. In essence this is what this project aims to do in the self-regulatory sphere, which is often a pre-cursor to regulation and/or legislation.

The surveys reflected all the co-benefits as were described in the interviews. Some of the strongest themes that appeared were fostering collaboration/partnerships, increasing engagement and enhancing visual amenity. Research and development in support of the green infrastructure sector, such as testing different plant applications and assessing the opportunity for photovoltaics to compliment green infrastructure installations, were also described to be unintended opportunities/consequences.

Benefits that were described in addition to those identified in the research included: urban design, aesthetic enhancement, educational outcomes, brand/marketing (hero/iconic projects)

Internal skillsets

Internal drivers were identified as important to the success of incorporating green infrastructure into the various projects discussed. In particular, having in place a knowledgeable and committed project team was highlighted an essential element of success. Interviewees highlighted the importance of internal environmental and urban design teams that had prior knowledge of green infrastructure elements and who could champion these throughout the project’s development. Green infrastructure champions were considered important in illustrating and selling the benefits of green infrastructure to the wider project teams.

Reduced costs

Cost reductions were demonstrated by WSUD elements in both the Rous Head Industrial Park and ACT Healthy Waterways projects. The cost savings were identified as a primary driver for green infrastructure when comparing traditional stormwater systems with WSUD elements. In addition, house price uplift has been modelled for the ACT Healthy Waterways project, where a positive effect of WSUD on local housing has been demonstrated.

5.3.4 Key challenges for green infrastructure

There were many challenges mentioned throughout the interviews including perceived cost; perceived risks; lack of technical information and experience; ability to obtain buy-in or support for green infrastructure elements from wider project teams (typically due to a “business as usual” mentality); and the lack of available data on benefits (Figure 10).

A further key challenge is the change in behaviour required to successfully achieve the benefits of green infrastructure from a management perspective. In most cases, due to green infrastructure being “living infrastructure” it needs nurturing and maintaining to stay healthy and continue to perform its function. This requires a change in management regimes, and in many cases requires a horticulturist to regularly attend. This represents a change for the property and infrastructure industry, and needs to be better understood, planned and costed.

Each survey respondent listed barriers to their project. These were in-line to those identified in the interviews ranging from high costs (including perceived cost of maintenance and proto-type development); gaining support and commitment: lack of consistent government policy; and the need for planning and planning approval. A reoccurring theme was the gap in being able to prove or quantify the benefits and a need to be able to easily communicate value for money.

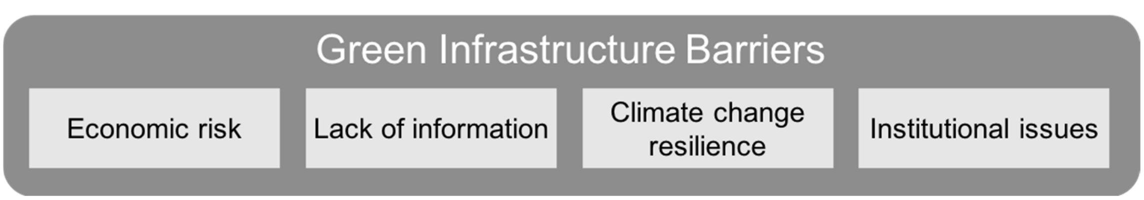

Figure 10- Barriers to the uptake of green infrastructure identified in the stakeholder engagement.

Lifecycle costs and valuing green infrastructure benefits

Challenges associated with accurately costing both the construction and ongoing operational maintenance of green infrastructure elements were common across the projects. Given the significant capital costs surrounding green infrastructure initiatives, proponents from both Northlink WA and Gateway Upgrade North in Brisbane identified conflicting priorities for an improved user experience and environmental performance for local communities with the desire from government clients to reduce upfront and operational costs. Managing the justification of these costs was identified as an important challenge in the implementation of green infrastructure.

Operational costs were also identified as an important barrier to including green infrastructure. Novel green infrastructure types such as green tracks were considered more difficult to cost given uncertainty surrounding maintenance requirements and plant success rates. In both WSUD examples (Rous head Industry Park and Gateway Upgrade North projects), understanding lifecycle costs was identified as a barrier to increased green infrastructure uptake within the project.

Measuring and modelling benefits

Green infrastructure can deliver a diversity of both economic and non-economic benefits to infrastructure projects and neighbouring communities. Understanding the magnitude of these benefits was identified as an issue for project proponents. While modelling tools are available for the field of WSUD, quantifying the benefits of more novel types of green infrastructure was identified as a significant challenge. For the Metro Tunnel team, relaying these benefits to senior project leaders was crucial to gaining buy-in and commitment to the strategies adopted.

An additional challenge identified is appropriately monetising the environmental and social benefits of green infrastructure. This was identified by both the ACT Healthy Waterways and Parramatta Light Rail teams.

Climate change

Increased average temperatures and more frequent and intense heat waves associated with a changing climate are likely to put increased strain on plants in green infrastructure systems, leading to risks associated with higher asset maintenance costs. The effects of climate change were of key concern for the Parramatta Light Rail project team, where the project proponents had concerns about the resilience of green infrastructure to a changing climate, especially given that the current exposure of the Parramatta area to heat waves is high.

Institutional barriers

Institutional issues such as existing regulation, strict management of contracts and competing priorities pose significant challenges for more streamlined green infrastructure implementation. For the Northlink WA team, regulatory and planning requirements that applied to the project (particularly around safety risk management) were at times worked against the inclusion of green infrastructure. Similarly, for Parramatta Light Rail, green infrastructure approaches were highlighted as presenting higher regulatory and institutional risks than a business as usual.

For the Metro Tunnel team, the lack of maturity of the green infrastructure market means writing these elements into procurement contracts required significant resources, highlighting the challenges of bringing a “forward thinking culture” into large scale infrastructure projects.

5.3.5 Identified opportunities

Through the different perspectives brought on by stakeholder responses, several opportunities were identified. Table 14 summarises potential actions relating to capacity-building in the field of green infrastructure, and also implementation support that could be provided on a project or area level.

Table 14 – Cross-sector opportunities identified in the interviews and surveys.

Capacity building	• Create case study projects showcasing where particular benefits have been achieved with measurable benefits. Work with the building owner and manager to measure the benefits relative to a conventional building type; conduct a cost benefit analysis. • Promote partnerships on novel green infrastructure with research institutions to develop localised insights into the design, monitoring and maintenance management plans for this asset. • Provide more information about green infrastructure for stakeholders considering incorporating it into their projects. For example, infrastructure-specific guidance from Hort Innovation such as green infrastructure and vegetation guidelines for specific infrastructure types, based on current research and industry best practice and innovation. • Undertake cost benefit analysis capturing the costed co-benefits as they compare to grey infrastructure counterparts • Conduct a whole of life cost study on a green infrastructure project, or a set of green infrastructure projects, to articulate the benefits and compare against a benchmark. This might suit a building example best with clear measurables such as cost per metre square of Net Lettable Area (NLA). This would serve the business case for Green Star, provide quantity surveyors with a metric to use, and support the case for the provision of points in Green Star. • A study of development/planning controls to see where green infrastructure is specified to meet a particular requirement or benefit to a broad community, above visual amenity. • Supporting green infrastructure specification into procurement guidelines, pushing project suppliers to improve supply chain sustainability and contractors to meet sustainability targets.
Implementation support	• Create a typology of green infrastructure/classify and define green infrastructure as part of a broad knowledge strategy to support the ongoing development and delivery of green infrastructure. • Produce a compendium of green infrastructure benefits/catalogue them; where possible provide metrics with associated case studies. A more standardised approach to assess the merits of green infrastructure elements would facilitate increased uptake of vegetation through many different green infrastructure elements and help to reduce costs. • The description of co-benefits was a key attribute of green infrastructure. Often the biophilic response from the community has been described as strong. This is certainly a benefit and ideally would be costed and weighed at the inception of projects when specifications are being made. • Promotion of the relationship of nursery and civil infrastructure industry to establish mutual needs and capacities. • Overcome the disconnect between plant affordability and local planting guidelines and regulations. The interviewee highlighted the importance of local nurseries being able to cost-effectively supply plant types that are required.

5.4 Recommendations for the uptake of green infrastructure in civil infrastructure projects

Each interview offered important insights into the on-the-ground implementation of green infrastructure elements in the infrastructure sector. Lessons learnt from the diversity of projects provide Hort Innovation with a shortlist of industry-specific guidance (Figure 11).

Start early	• Plan for green infrastructure early • Manage stakeholder expectations
Understand costs and benefits	• Capital costs • Operational costs • Value benefits
Gain buy-in	• Internal stakeholders (project team, management) • External stakeholders (client, local community, interest groups)
Develop partnerships	• Local governments • Research partnerships with universities

Figure 11 - Lessons learnt for implementing green infrastructure in the civil infrastructure sector.

5.4.1 Start early

Given the innovative nature of some green infrastructure types, a sound understanding of maintenance requirements and costs was not always readily available to project teams. The interviewees consistently noted the need to begin associated research early to understand these issues to manage stakeholder expectations and operational costings more effectively. This was particularly the case where, after construction, the asset would be transferred to an operational organisation (e.g. ACT Healthy Waterways).

Northlink WA also benefited significantly from a development schedule that allowed sufficient time for the exploration of green infrastructure elements in the project. Building internal commitment to green infrastructure elements early on was also crucial in the exploration of green infrastructure for the Parramatta Light Rail project.

Engaging early with clients on green infrastructure elements increased the chances of approval and inclusion.

5.4.2 Understand costs and benefits

Given that infrastructure developers do not necessarily become asset operators, the lifecycle costing of specific green infrastructure elements was a key concern among the interviewees. It was noted that ongoing maintenance and other costs associated with green infrastructure elements need to be managed early in the project to ensure operators understand these requirements. The innovative nature of some green infrastructure types (green walls and roofs for example) presents a barrier to costing efforts.

5.4.3 Gain buy-in

Interviewees highlighted the importance of gaining internal buy-in for green infrastructure elements within project teams. This includes engaging design and engineering teams to understand the objectives and benefits of these assets.

External buy-in from both governments and community groups was also identified as important to drive motivation towards implementation. For the Metro Tunnel project, “Engaging with the community was worth every hour…it is challenging but is required and offers great insights and feedback to develop sound living infrastructure plans.”. Similarly, the ACT Healthy Waterways project in Canberra gained strong community support once the public was informed of the plans and understood the benefits associated with the project.

5.5 Strategic recommendation for Hort Innovation and the nursery industry

The following recommendations are made based on the outcomes from the project. The recommendations are made based on the assumption that delivering green infrastructure-related products and services is an opportunity that the nursery industry wishes to pursue. The recommendations are based on the experiences throughout the project and they would be complemented with discussion.

Recommendation 1 - Set an Australian Industry Definition for green infrastructure.

There is an opportunity for the horticulture industry to set the definition of green infrastructure. Stakeholder engagement demonstrated that there was a general understanding of what green infrastructure is, but multiple stakeholders referred to multiple definitions indicating that the broader construction industry is not clear on what constitutes green infrastructure and what benefits can be achieved using it.

A clear definition would provide a useful foundation around which the horticulture industry could build a range of activities, from communications to professional development programmes for architects, engineers and specifiers.

Recommendation 2 – Develop technical support for the delivery of green infrastructure.

This project has evidenced that there are a series of measurable benefits that are already being recognised by building and infrastructure proponents as they replace “grey infrastructure” with “green infrastructure”. The green infrastructure industry is young and requires support to overcome technical delivery issues that can be barriers to adoption. This could include, for example, specifications for water tightness of a green roofs, or engineered loads for additional material on roofs. Hort Innovation could support adoption by commissioning this kind of technical advice.

Recommendation 3 – Enable effective monitoring of the performance

In many projects green infrastructure is being implemented to meet specific targets that demonstrate the utility and benefits created by using plants. However, monitoring a green asset’s performance towards a target is still a challenge across the industry. The nursery industry could create guidelines on what metrics should be used in cost-effective monitoring plans for different types of green infrastructure.

Recommendation 4 – Support the associated horticulture services industry; enabling success

As more green infrastructure is incorporated into the built environment, replacing grey infrastructure, the monitoring and maintenance business and delivery of these services will also change. For example, an air-conditioning engineer may be replaced by a horticulturist to service the plants in a building or piece of infrastructure. Just as machines need servicing, plants will require tending and nurturing to maintain their ability to provide the desired service. It is recommended that the Hort Innovation invest in the development of this industry with suitable skills and competencies as more green infrastructure is incorporated into our built environments, so it stands a greater chance of success.

Recommendation 5 – Advocate for early engagement with horticulture industry in the planning and design phase

The horticulture industry needs to be engaged early in the delivery cycle, ideally in the earliest stages of planning in order that species selection and propagation can be started in good time. It is therefore recommended that Hort Innovation educate and advocate for early engagement in green infrastructure projects in order to optimise the chance of successful delivery of green infrastructure projects.

Recommendation 6 – Articulate the dollar value of green infrastructure benefits

The project has demonstrated that articulating the economic benefits of green infrastructure (allocating a dollar value to each benefit) and demonstrating positive value compared to grey infrastructure is likely to be the most effective way of achieving traction with project proponents. It is recommended that the horticulture industry does a cost-benefit analysis of green infrastructure assets and develops financial metrics that can be used in project costing in order to better articulate the business case for green infrastructure to the construction community.

Recommendation 7 – Describe the co-benefits and allocate financial values (associated with recommendation 6)

A key aspect of green infrastructure assets is that they are typically multifunctional. An asset may be designed to serve a particular function (benefit), and it will also deliver additional co-benefits. An example is a bioswale constructed to provide WSUD and water management that also provides visual amenity and mental health benefits. It is recommended that co-benefits be emphasised and the financial benefit articulated to complement cost benefit analysis.

Recommendation 8 – Develop a community of practice

The project interviewed a series of green infrastructure stakeholders to collect evidence of projects and to create case studies. These interviews discovered a series of successful projects that have overcome barriers, are achieving benefits, and are recognizing co-benefits. There is an opportunity to create a community of green infrastructure practitioners by expanding the catalogue of projects and building out the case studies to achieve a reference source for professionals wanting to evidence their case for their own green infrastructure project and to seek professional advice from others. It is recommended that the horticulture industry create a repository of case studies that can be used to promote, support uptake and provide technical reference material as the community evolves.

Recommendation 9 – Continue and build upon species selection knowledge and tools

Species selection is proving to be a crucial factor for the performance of green infrastructure assets, determining, among others, maintenance requirements, resilience to climate change and fitness to local conditions. Knowledge of species selection for different assets needs to be developed and spread. Continued investment into “Which Plant Where” and greater outreach to the built environment professions is recommended.

Recommendation 10 – Maintain the momentum

This project has created momentum for green infrastructure by connecting and coalescing a multi-disciplinary industry. Key stakeholders at the centre of the green infrastructure movement include the GBCA and ISCA. It is recommended that Hort Innovation continue to invest in developing knowledge and practice to support the growth of this relatively new asset class by engaging with GBCA and ISCA on progressing some of the recommendations above.

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