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Embedding Green Infrastructure Economic Framework

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CONTENTS

1. Green Infrastructure Economic Framework

1.1 Introduction

A business case should set out why a specific project should proceed based on an assessment of the costs (i.e. capital and on-going), risks and benefits. It must clearly state why action is required, what the proposed Green Infrastructure (GI) solution is and what the alternative or 'do nothing' outcome would be. Additionally, it should identify the financial, structural and human resources required for delivery, as well as the key stakeholders impacted or involved. Before preparing a business case it is important to step back and survey the broader context within which the project sits. Who are the key decision makers? What are the drivers for change? Who needs to be engaged? Who are the project advocates?

The following pages present a process for providing a sound and transparent basis on which to support a GI business plan for internal council budgetary purposes and potentially project funding applications. The criteria adopted in the process are informed by the approaches presented in CRC Water Sensitive City reports (Gunawardena, et al., 2017) and our previous studies.

The following aspects are considered:

Monetised outcomes are the benefits and costs associated with GI projects that can be readily quantified and have a widely accepted monetary value. However, most GI benefits are yet to be monetised. Various government bodies (e.g. DELWP) and academic institutions (e.g. CRC for Water Sensitive Cities) and economists are working towards monetising them.

Measurable outcomes are the benefits and costs associated with GI projects that can be readily quantified but currently do not have a widely accepted monetary value. Many of these benefits are quantified in the conceptual design stage of a GI project and through modelling programs such as eWater MUSIC.

Intangible outcomes are the benefits and costs associated with GI projects that are difficult to quantify and do not have a widely accepted monetary value. These benefits and costs are captured through narrative descriptions of the outcomes.

1.2 Assessment framework

The GI Assessment Framework is a five-step process that captures key data to make an informed decision on when do Green Infrastructure.

The process begins at Stage 1 by defining the project's main characteristics, objectives and role in supporting wider council strategies and targets. The next three stages (Stages 2, 3 and 4) seek to capture an array of potential outcomes of the GI project. Each of these stages has been individually assembled so users can fill them out separately. In each stage, key questions and suggested council staff for consultation are listed. Standard staff titles have been used, however these are expected to vary between councils. Supporting data in the form of figures and tables has been provided to assist users provide high-level answers without the use of modelling software. Example answers for each question are also provided for guidance.

The final stage (Stage 5) pulls together all the gathered outcomes of the GI project and compares them to the business as usual or 'do nothing' approach. This comparison provides a holistic overview for council to make an assessment and project recommendation. Chapter 2 provides templates for each of the five stages and Chapter 3 describes the method for using them.

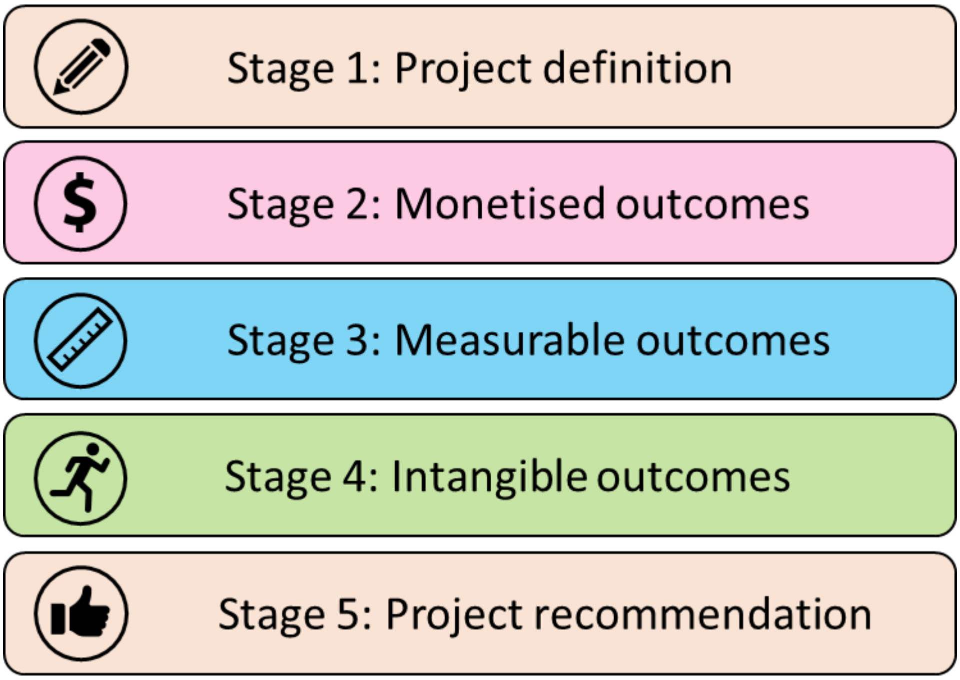

Figure 1. Five-stage GI Assessment Framework

2. Templates

Stage 1: Project definition

Question	Answer
Project description	
What is the project and what are the key elements?	
What phase is the project at, planning, concept, functional or detailed design?	
Project purpose and objectives	
What is the main purpose of the project?	
What objectives are trying to be achieved?	
Alignment with council strategy	
What council policy and strategy does the project support?	

Stage 2: Monetised outcomes

Question	Answer
Monetised costs	
What are the capital costs ($) of the project?	
What is the establishment costs ($) of the project?	
What are the maintenance costs ($) of the project?	
What are the renewal costs ($) of the project?	
Monetised benefits	
What is the value of the Total Nitrogen (TN) load reduction ($/kg/yr)	
What is the value of the reduction in mains water use ($/kL/yr)	

Stage 3. Measurable outcomes

Question	Answer
Measurable benefits	
How much evapotranspiration is provided (mm/yr or kL/yr)?	
What are the stormwater pollutant load reductions (kg/yr)? - Total suspended solids - Total phosphorous	
What is the stormwater runoff reduction (kL/yr)?	
How much tree canopy is provided (m^2)?	
How much permeable surface area is provided (m^2)?	
How much ground-level vegetation is provided (m^2)?	

Stage 4. Intangible outcomes

Question	Answer
Intangible costs	
What potential risks to council and/or businesses does the project bring?	
What potential risks to surrounding assets does the project bring?	
Intangible benefits	
Is biodiversity enhanced via the diverse use of indigenous plants?	
Will air quality conditions be improved?	
Will greenhouse gas emissions (GHG) be lessened?	
Is community education incorporated in the project?	
Does the project provide additional street amenities?	
Does the project improve accessibility by promoting safer car, bicycle and/or pedestrian movements?	

Stage 5. Project recommendation

Question	Answer
Recommendation	
Is the GI project recommended over a business as usual approach?	

Project Assessment Table

Outcomes	Category		Results: GI asset project	Results: Business as usual or 'do nothing' approach
Monetised	Stormwater pollutant load reductions	Total Nitrogen ($/kg/yr)		
Monetised	Mains water reduction (kL/yr)			
Monetised	Capital cost (planning, design & construction) ($)			
Monetised	Establishment cost ($)			
Monetised	Maintenance cost ($/yr)			
Monetised	Renewal cost ($)			
Measurable	Stormwater pollutant load reductions (kg/yr)	Total Suspended Solids		
Measurable	Stormwater pollutant load reductions (kg/yr)	Total Phosphorus		
Measurable	Stormwater runoff reduction (kL/yr)			
Measurable	Tree canopy (m^2)			
Measurable	Ground-level vegetation (m^2)			
Measurable	Evapotranspiration (kL/yr)			
Measurable	Permeable surface (m^2)			

Outcomes	Category		Results	
			GI asset project	*Business as usual or 'do nothing' approach*
Intangible	Environmental	Biodiversity		
		Air quality		
		Greenhouse gas emissions		
	Community	Awareness and education		
		Amenity		
		Accessibility		
	Risks	Council / business		
		Surrounding assets		

3. Method

3.1 Stage 1. Project definition

Stage 1: Project definition

This stage provides prompting questions to clarify the Green Infrastructure (GI) project opportunity and understand the drivers for its implementation. Answers are to be inserted into the Stage 1 template.

Table 1. Stage 1 - Project definition

Question	Consult	Example
Project description		
What is the project and what are the key elements?	Project manager	*It is proposed that ten raingardens be retrofitted along this existing road corridor (predominantly within median strips) on Opportunity Street.*
What phase is the project at, planning, concept, functional or detailed design?	Project manager	*This project is at the conceptual stage of analysis, as such, a high-level assessment of feasibility has informed the development of this business case.*
Project purpose and objectives		
What is the main purpose of the project?	Project manager	*Ten raingardens would capture and treat stormwater runoff from adjacent commercial properties, footpaths and roadways. This would reduce the level of pollution entering the Yarra River and Port Phillip Bay, both receiving water bodies are considered significant and high value assets.*
What objectives are trying to be achieved?	Project manager	*Reducing nitrogen loads to protect the Bay is a key objective.*
Alignment with council strategy		
What council policy and strategy does the project support?	Sustainability Officer	*This project has a stormwater quality focus and will help progress council towards achieving their vision and targets identified in the Stormwater Quality Strategy.* *The project also supports the delivery of the City Plan 2013 – 2017 (by enhancing and protecting natural areas and ecosystem health), the Environment Management Strategy 2014 – 2017 (by tracking local watercourse pollution) and the Open Space Strategy (via the installation of vegetated treatment systems in a highly urbanised district).*

3.2 Stage 2. Monetised outcomes

Stage 2: Monetised outcomes

This stage provides prompting questions to understand the benefits and costs associated with Green Infrastructure (GI) projects that can be readily quantified and have a widely accepted monetary value. Many of these benefits are quantified in the conceptual design stage of a GI project and through modelling programs such as eWater MUSIC. It is recommended a MUSIC model is prepared to support a detailed design project to accurately quantify the performance and guide design parameters. However, projects at a concept design stage simple estimates may be used where deemed appropriate. Answers are to be inserted into the Stage 2 template.

Monetised costs

Table 2 below provides high level construction and maintenance costs for typical GI assets (i.e. raingardens and tree pits) by Melbourne Water. The cost estimates provided should be considered as a starting point only and represent the best cost estimates available based on current information (Oct 2013). Table 3 provides asset costs for structural soil systems.

Table 2 and Table 3 are provided to estimate the project's capital, establishment, maintenance and renewal costs. To begin using these tables and inserting calculated estimates into the Table 6, the approximate surface area (m^2) of the project is required. If structural soil or structural cell systems are to be used for enhanced soil volumes, an approximate soil volume (m^3) is also required.

High-level estimates for the projects costs are achieved by selecting the size category of the project under **'asset parameters'** and multiplying the GI surface area (m^2) by the corresponding capital, maintenance, and renewal costs. For example, a series of new street raingardens with a combined surface area of **100 m^2** will have a:

- capital cost of $100,000 (e.g.**100 m^2** x $1000/$m^2$),
- maintenance cost of $1,500/yr (e.g.**100 m^2** x $15/$m^2$/yr),
- establishment cost of $10,500 over two years (e.g. $1,500/yr x 2yrs x 3.5), and a
- renewal cost of $7,500 after 25 years for a minor restoration (e.g. **100 m^2** x $75/$m^2$).

Establishment costs are approximately two to five times ongoing maintenance cost and minor restorations for raingardens vary between $50/$m^2$ to $100/$m^2$. In this example, an establishment factor of 3.5 and a minor restoration cost rate of $75/$m^2$ is used. However, it should be noted that renewal costs per metre squared are largely unknown for GI assets. Typically, a percentage of the construction costs (i.e. 80%) is used as an approximate value. This is recommended for standard tree pits, porous pavement, and complete raingarden restorations. The average number of years to renewal for GI assets is 25 years. This is a conservative estimation and with regular maintenance, GI asset lifetimes are expected to exceed this value.

Table 2. Cost of GI assets (Melbourne Water, 2013)

Asset	Asset parameters	Capital (planning, design & construction)	Establishment factor (2 years)	Maintenance (ongoing)	Renewal
On-street raingarden (tree optional)	< 50 m^2 50 to 1000 m^2 > 1000 m^2 Area of filter media at bottom of extended detention	$2,000/$m^2$ $1,000/$m^2$ $500/$m^2$	Two times to five times ongoing maintenance cost	$30/$m^2$/yr $15/$m^2$/yr $10/$m^2$/yr	Minor restoration = $50/$m^2$ to $100/$m^2$
Standard tree pit	Typical tree pit (12 m^3 effective soil volume)[1]	$6,000 - $15,000 /tree pit[2]		No access issues = $150/asset/yr. Traffic issues or specialist equipment required = $500/asset/yr.	*
Porous pavement	Engineered porous pavers[3]	400/m^2		No access issues = $250/asset/yr. Traffic management required = $500/asset/yr.	*

Table 3. Structural soil system costs

Asset	Manufacturer	Capital (planning, design & construction)	Maintenance	Renewal
Structural soil	Structural soil	$800 – 1,400 /$m^3$	N/A	*
Structural cell systems	Citygreen Strataflow	$1,200 – 1,800 /$m^3$	N/A	*

*Typically, a percentage of the construction costs (i.e. 80%) is used as approximate value. The average number of years to renewal for GI assets is 25 years.

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[1] *Although 15 m^3 or more of effective soil volume is desirable for canopy development, onsite constraints (i.e. underground services) will often limit effective soil volume to 10m^3 or less. For a typical design, this represents a soil volume footprint of 12 m^2 (1 metre deep) and an area below extended detention of 1.5 m^2*

[2] *The lower price range represents tree pit installations as part of larger civil works, whilst the upper price range represents smaller scale, custom design responses.*

[3] *Based on City of Yarra estimates for standard road pavements. The rate includes all associated works with the pavement works (i.e. traffic management service pit adjustments etc)*

Monetised benefits

Total Nitrogen (TN) load reduction is commonly monetised as part of GI applications into greenfield site developments around Melbourne. This benefit is monetised by multiplying annual load reductions achieved by a GI project by the cost of offsite nitrogen treatment. The costs of offsite treatment are based on past stormwater treatment works constructed by Melbourne Water. The current rate, plus an administration fee of 8.9% is provided in Table 5 (Melbourne Water, 2013). *It is important to note that this rate is based on the capital (and ongoing) cost of removing nitrogen, not the potential benefits of preventing that nitrogen entering downstream aquatic environments, these benefits are likely to be much greater.*

To calculate the value of the nitrogen reduction benefit, an approximate catchment (m^2) and soil area (treatment area) (m^2) of the project is required. These values can then be used to produce a **'Treatment to Catchment Area Ratio (TCAR)'** (Figure 2) for the project. The TCAR value[4] can then be used with Figure 3. Total Nitrogen (TN) % removal to predict the potential % reduction of Total Nitrogen (TN) removal.

Treatment to Catchment Area Ratio (TCAR)

$$\text{TCAR (\%)} = \frac{\text{Treatment Area (m}^2\text{)}}{\text{Catchment (m}^2\text{)}}$$

Figure 2. TCAR ratio formula

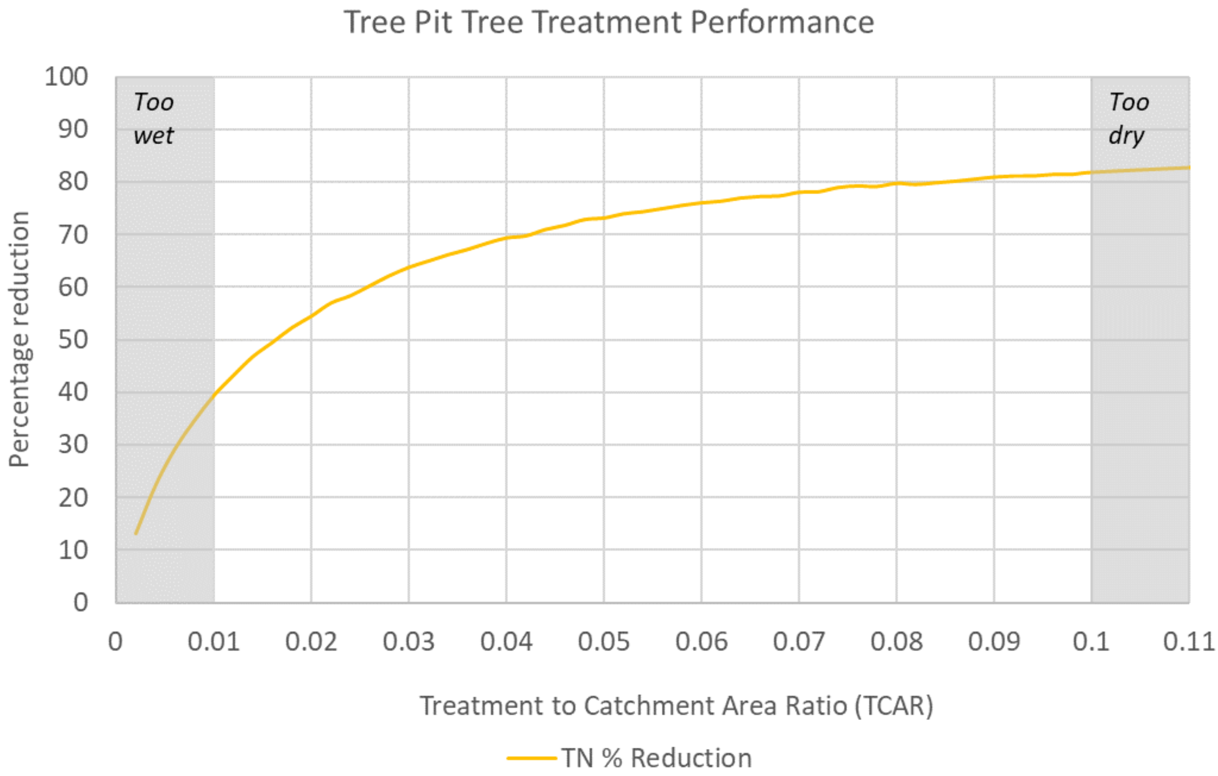

Figure 3. Total Nitrogen (TN) % removal

[4] *Note: TCAR values below 0.01 are at risk of the asset being too wet and TCAR values greater than 0.1 are at risk of being too dry. These risks can result in vegetation failure, asset damage and reduced stormwater treatment performance. Figure 3 is based on a 1 ha, 100% impervious, mixed use urban catchment and a tree pit with filter media depth of 0.6m, sandy loam soil, and a high-water use tree (i.e. Wattle)*

The percentage reduction value can then be multiple by the TN pollutant runoff value provided in Table 4 to estimate the amount of TN (kg/yr) removed by the project. This value can then be multiplied by the nitrogen reduction value in Table 5 to monetise the pollution reduction.

Table 4. Total Nitrogen (TN) load conveyed in stormwater runoff[5]

Rainfall	Total upstream catchment area generating runoff (ha)	Mean annual TN load (kg/year)
Melbourne	1	10.7

If a GI project is expected to result in reduced mains water use for irrigation of streetscape projects through passive irrigation design considerations, then the resulting dollar savings should be included. Local water charges should be used to calculate these savings with the expected annual reduction in mains irrigation use (Table 5).

Table 5. Monetised benefits

Benefit type	Annual value
Nitrogen reduction value (includes an administration fee of 8.9%)	$7,246 / kg/yr
Mains water savings	Local water charges (kL/yr) multiplied by the reduction in annual streetscape mains irrigation (kL/asset/yr)

Table 6. Stage 2 - Monetised outcomes

Question	Consult	Example
Monetised costs		
What are the capital costs ($) of the project?	Project manager, Table 2, Table 3	*Capital $250,000*
What is the establishment costs ($) of the project?	Project manager, Table 2, Table 3	*Establishment $13,000,*
What are the maintenance costs ($) of the project?	Project manager, Table 2, Table 3	*maintenance $3,750/year,*
What are the renewal costs ($) of the project?	Project manager, Table 2, Table 3	*renewal $18,750 per 25 years.*
Monetised benefits		
What is the value of the Total Nitrogen (TN) load reduction ($/kg/yr)	Drainage engineer, Table 5, Table 4, Figure 3. Total Nitrogen (TN) % removal	*$99,675/year of nitrogen removal*
What is the value of the reduction in mains water use ($/kL/yr)	Water engineer, Open space officer	*No water savings are associated with this project*

3.3 Stage 3. Measurable outcomes

Stage 3. Measurable outcomes

This stage provides prompting questions to understand the benefits and costs associated with Green Infrastructure (GI) projects that can be readily quantified but currently do not have a widely accepted monetary value. It is recommended a MUSIC model is prepared to support a detailed design project to accurately quantify the performance and guide design parameters. However, projects at a concept design stage simple estimates may be used where deemed appropriate. Answers are to be inserted into the Stage 2 template. Answers are to be inserted into the Stage 3 template.

Measured benefits

Urban cooling (evapotranspiration)

GI assets provide urban cooling via evapotranspiration. Rain gardens and tree pits evapo-transpire more than twice as much water than equivalent areas of conventional planting. This absorbs heat energy radiated from surrounding roads and buildings and helps to reduce surrounding temperatures.

With a known project soil area (treatment area) (m²), Figure 4 below can be used to estimate the amount of evapotranspiration losses. These calculations are based on vegetated raingarden systems. The incorporation of trees into these systems will enhance evapotranspiration losses.

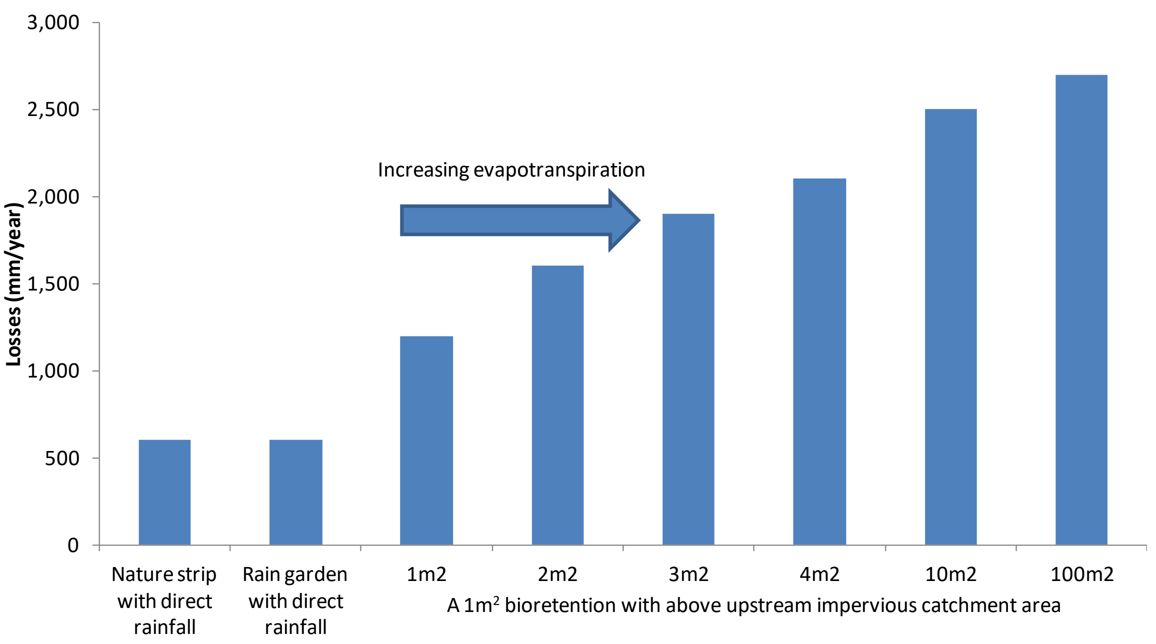

Figure 4. Evapotranspiration from a raingarden system at a range of scales relative to catchment

Stormwater pollutant reductions

GI systems can be used to treat stormwater. Typical urban stormwater pollutants (other than Total Nitrogen (TN)) are total suspended solids (TSS) and total phosphorus (TP). These pollutants are commonly used as a proxy to represent the efficient removal of other pollutants (such as hydrocarbons and metals).

To calculate the amount of TSS and TP (kg/yr) that is removed by the project, an approximate catchment (m^2) and treatment (m^2) area of the project is required. These values can then be used to produce a **'Treatment to Catchment Area Ratio (TCAR)'** (Figure 5) for the project. The TCAR value[6] can then be used with Figure 6 to predict the potential % reduction of TSS and TP removal.

Treatment to Catchment Area Ratio (TCAR)

$$\text{TCAR (\%)} = \frac{\text{Treatment Area (m}^2\text{)}}{\text{Catchment (m}^2\text{)}}$$

Figure 5. TCAR ratio formula

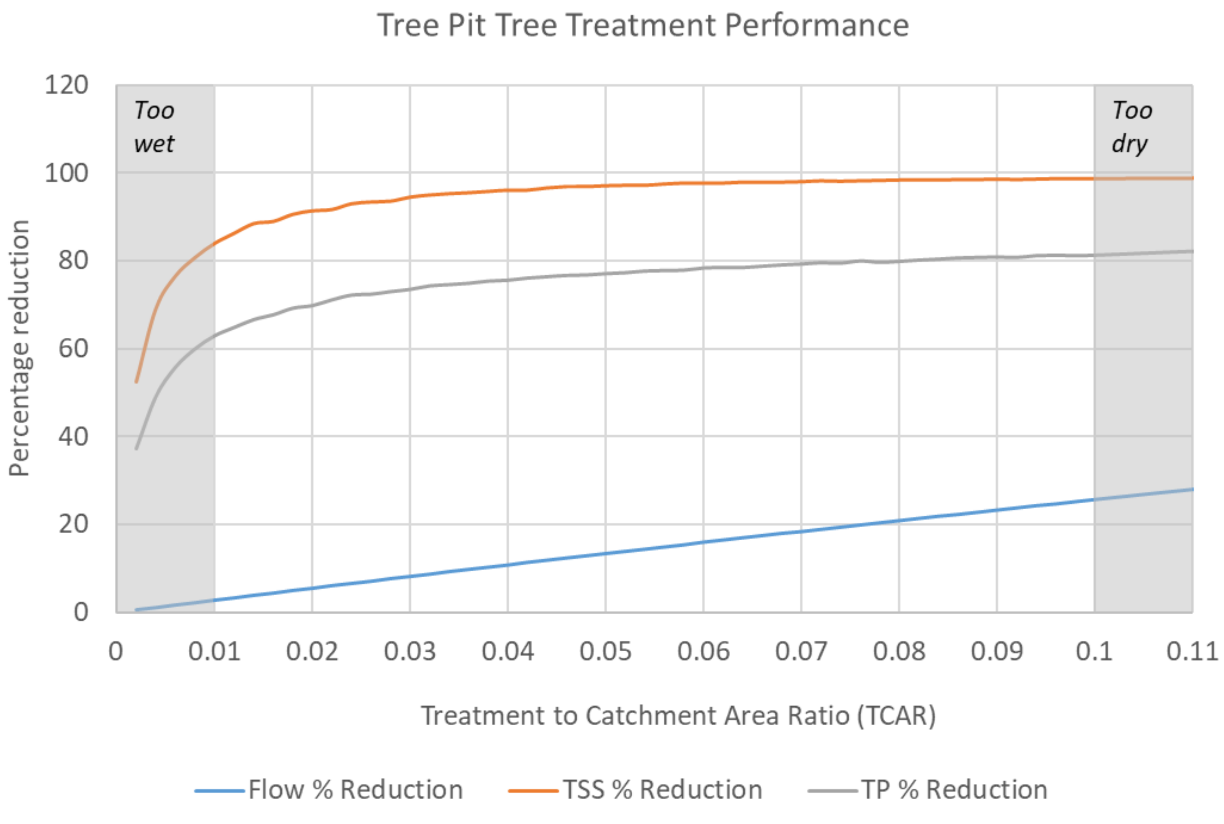

Figure 6. Total Suspended Solids (TSS) and Total Phosphorus (TP) % removal

[6] *Note: TCAR values below 0.01 are at risk of the asset being too wet and TCAR values greater than 0.1 are at risk of being too dry. These risks can result in vegetation failure, asset damage and reduced stormwater treatment performance. Figure 3 is based on a 1 ha, 100% impervious, mixed use urban catchment and a tree pit with filter media depth of 0.6m, sandy loam soil, and a high-water use tree (i.e. Wattle)*

The percentage reduction values can then be multiple by the TSS and TP pollutant runoff values provided in **Error! Reference source not found.** to estimate the amount of TSS and TP (kg/yr) removed by the project.

Table 7. Total Suspended Solids (TSS) and Total Phosphorus (TP) loads conveyed in stormwater runoff[7]

Rainfall	Total upstream catchment area generating runoff (ha)	Mean annual TSS pollution load (kg/year)	Mean annual TP pollution runoff (kg/year)
Melbourne	1	764	1.54

Stormwater runoff reduction

Storage of water in soil layers can provide reduction of peak runoff flows to local drainage systems. To calculate the reduction in stormwater runoff provided by a GI project, an approximate catchment (m^2) and treatment (m^2) area of the project is required. These values can then be used to produce a **'Treatment to Catchment Area Ratio (TCAR)'** (Figure 5) for the project.

The TCAR value[8] can then be used with Figure 6 to predict the potential % reduction of stormwater runoff. The percentage reduction value can then be multiple by the stormwater runoff value provided in Table 8 to estimate the amount of stormwater removed (kL/yr) by the project.

Table 8. Total stormwater runoff volume[9]

Rainfall	Catchment area (ha)	Stormwater runoff volume (kL/year)
Melbourne	1	3680

Permeable surface area

Passively irrigated GI assets promote a re-balance of the natural water cycle by removing existing hard surfaces and allowing rainwater to soak into the ground. Through greater permeability, these assets can reduce the effects of frequent but relatively minor nuisance flooding events by providing runoff detention and reduction.

To calculate the amount of permeable area produced by a GI project, use the approximate area of the project's exposed soil (m^2).

Urban greening area

GI assets can increase street amenity and character through enhanced ground-level street vegetation. To calculate the amount of ground vegetation produced by a GI project, use the approximate area of the project's designated ground-level planting area (m^2).

[8] *Note: TCAR values below 0.01 are at risk of the asset being too wet and TCAR values greater than 0.1 are at risk of being too dry. These risks can result in vegetation failure, asset damage and reduced stormwater treatment performance. Figure 3 is based on a 1 ha, 100% impervious, mixed use urban catchment and a tree pit with filter media depth of 0.6m, sandy loam soil, and a high-water use tree (i.e. Wattle)*

Shade (tree canopy)

GI assets with the incorporation of trees provide streets with valuable protection from the sun, wind and rain. The amount of shade (or canopy) provided by a tree is related to many factors. However, soil volume and the frequency of irrigation is widely regarded as key to long-term tree health and canopy development. Figure 7 below illustrates this relationship across three scenarios; no irrigation, monthly irrigation, and weekly irrigation. As GI assets are designed to regularly receive passive irrigation from stormwater runoff, the **'grey'** line in Figure 7 is the most representable canopy diameter to soil volume relationship for tree pits.

To calculate the canopy area (m^2) produced by a GI project, an approximate soil volume (m^3) is required. With an approximate soil volume, a canopy diameter can be estimated with Figure 7 and an area can be calculated with the following circle equation:

Canopy area (m^2) = $\pi \times (D / 2)^2$

Where:
π = Pi = 3.14159…
D = Diameter (m)

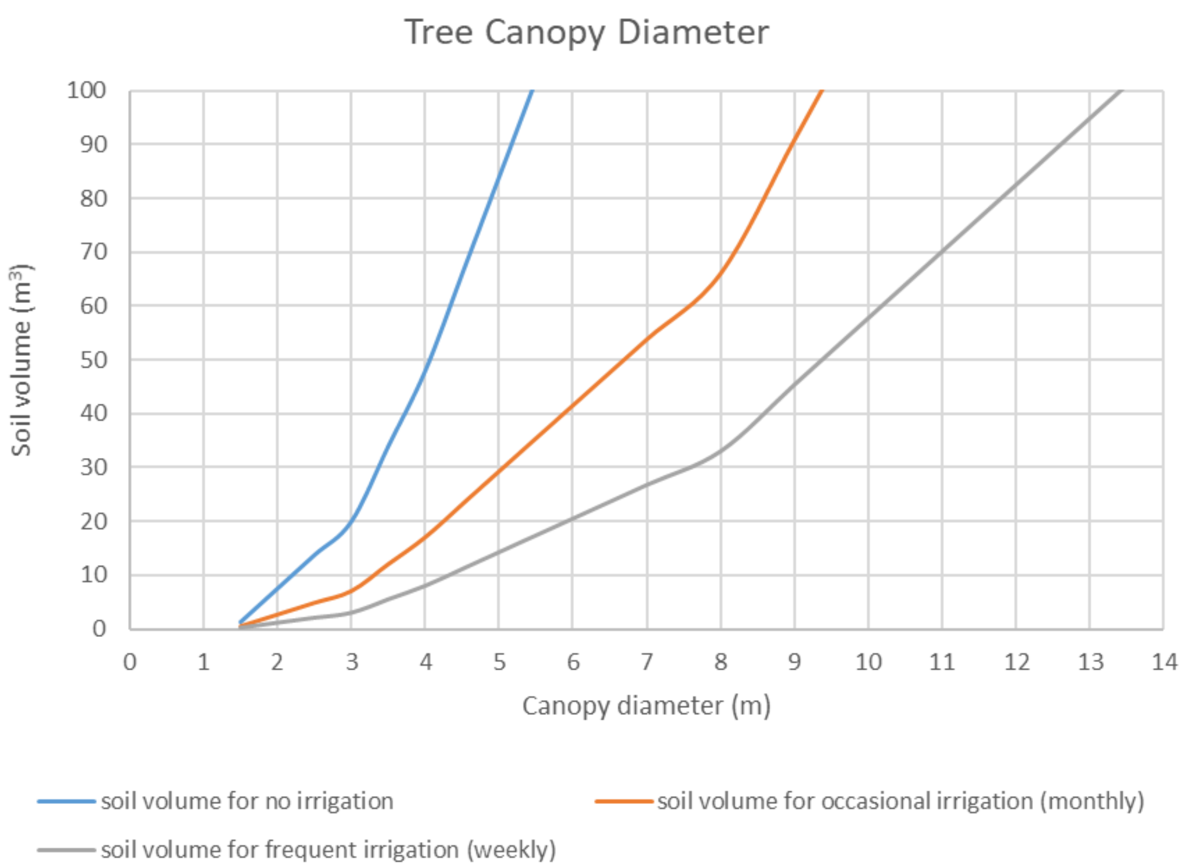

Figure 7. Canopy diameter to soil volume relationship

Table 9. Measurable outcomes

Question	Consult	Example
Measurable benefits		
How much evapotranspiration is provided? (mm/yr or kL/yr)	Drainage engineer, Figure 4	*Local evapotranspiration was increased by 119 kL/yr. This improves urban cooling outcomes.*
What are the stormwater pollutant load reductions (kg/yr)? - Total suspended solids - Total phosphorous	Drainage engineer, Figure 6	*Annual reductions of 1,500 kg of suspended solids and 2 kg of phosphorus*
What is the stormwater runoff reduction (kL/yr)?	Drainage engineer, Figure 6	*130 kL of runoff is captured.*
How much tree canopy is provided (m^2)?	Arborist, Horticulturalist, Figure 7	*The project delivers 200 m^2 of canopy cover*
How much permeable surface area is provided (m^2)?	Project manager, Landscape architect	*The project delivers 150 m^2 of permeable surface area*
How much ground-level vegetation is provided (m^2)?	Project manager, Landscape architect	*The project delivers 50 m^2 of ground-level vegetation.*

3.4 Stage 4. Intangible outcomes

Stage 4. Intangible outcomes

This stage provides prompting questions to understand the benefits and costs associated with GI projects that are difficult to quantify and do not have a widely accepted monetary value. These benefits and costs are captured through narrative descriptions of the outcomes. Answers are to be inserted into the Stage 4 template.

Table 10. Intangible outcomes

Question	Consult	Example
Intangible costs		
What potential risks to council and/or businesses does the project bring?	Project manager	*Adjacent businesses with outdoor dining may be affected during the construction.*
What potential risks to surrounding assets does the project bring?	Civil engineering	*Overhead powerlines exist. Only small trees will be suitable.*
Intangible benefits		
Is biodiversity enhanced via the diverse use of indigenous plants?	Arborist, Horticulturalist	*Showy Daisy Bush and Dwarf Native Myrtle are included in the planting palette. These attract pollinators and other beneficial insects (i.e. butterflies, bees).*
Will air quality conditions be improved?	Arborist, Horticulturalist	*A variety of vegetation, including trees, will be planted along roadside to capture pollutants.*
Will greenhouse gas emissions (GHG) be lessened?	Arborist, Horticulturalist	*Multiple trees will be planted to capture CO2 and provide afternoon shade to neighbouring businesses.*
Is community education incorporated in the project?	Open space Urban design	*The prominent location of this project creates a significant opportunity for improved community engagement and education. Educational signage is incorporated.*
Does the project provide additional street amenities?	Urban design Landscape architect	*Seating and bicycle hoops will be incorporated.*
Does the project improve accessibility by promoting safer car, bicycle and/or pedestrian movements?	Urban design Civil engineering	*Asset will act as a traffic calming mechanism.*

3.5 Stage 5. Project recommendation

Stage 5. Project recommendation

This stage pulls together all the gathered outcomes of the GI project and compares them to the business as usual or 'do nothing' approach. This comparison provides a holistic overview for council to make an assessment and project recommendation.

To complete this stage, all the project outcomes from Stages 2,3 and 4 are to be inserted into the project assessment table template. The equivalent outcome for a business as usual or 'do nothing' approach for each stage is to also be inserted. A completed example of a GI project assessment is provided in Table 12.

Depending on the outcomes of the two project alternatives, the project that delivers the greater value for council and its priorities should be selected. The results are to be inserted into the Stage 5 template.

Table 11. Project recommendation

Question	Consult	Example
Recommendation		
Is the GI project recommended over a business as usual approach?	Project Team, Table 12	*The costs of this project are justified given the multiple environmental and community benefits that can be achieved. To do nothing would risk failure on council's behalf to respond to its own vision and objectives outlined in its Water Plan.*

Table 12.GI project assessment

Outcomes	Category		Results	
			GI asset project	*Business as usual or 'do nothing' approach*
Monetised	Stormwater pollutant load reductions	Total Nitrogen ($/kg/yr)	$99,675/year (15 kg/yr)	No benefit
	Mains water reduction ($/yr)		n/a	No benefit
	Capital cost (planning, design & construction) ($)		$250,000	Business as usual cost or no internal resources used.
	Establishment cost ($)		$13,000	Business as usual cost or no internal resources used.
	Maintenance cost ($/yr)		$3,750/yr	Business as usual cost or no internal resources used.
	Renewal cost ($)		$18,750	Business as usual cost or no internal resources used.
Measurable	Stormwater pollutant load reductions (kg/yr)	Total Suspended solids	1,531 kg/yr	0 kg/yr
		Total Phosphorus	2.1 kg/yr	0 kg/yr
	Stormwater runoff reduction (kL/yr)		130 kL/yr	0 kL/yr
	Tree canopy (m^2)		200 m^2	0 m^2
	Ground-level vegetation (m^2)		50 m^2	0 m^2
	Evapotranspiration (kL/yr)		119 kL/yr. Minor urban cooling due to increased evapotranspiration.	Hard surfaces and lack of vegetation contribute to urban heat island effect.
	Permeable surface (m^2)		150 m^2	0 m^2

Outcomes	Category		Results	
			GI asset project	*Business as usual or 'do nothing' approach*
Intangible	Environmental	Biodiversity	A variety of native vegetation, including trees, will be planted for habitat	No benefit.
		Air quality	A variety of vegetation, including trees, will be planted along roadside to capture pollutants	No benefit.
		Greenhouse gas emissions	Several trees will be planted to capture CO2 and provide afternoon shade to neighbouring businesses	No benefit.
	Community	Awareness and education	Prominent location creates a great opportunity for community engagement.	No benefit.
		Amenity	Improved boulevards and integrated seating promote interaction and street activity.	No benefit.
		Accessibility	Urban greening (~550m² planted area) and integrated pedestrian and cycling crossing promotes active transport and walkability.	No benefit.
	Risks	Council / business	Liability for slips, trips and falls. Lack of maintenance can create an eyesore.	Lack of action could result in council failing to meet its targets.
		Surrounding assets	Reduced risk for tree root intrusion with enhanced soil moisture and volume.	Trees could pose risk to surrounding infrastructure over the long term

Appendix A. Other Outcome Considerations

Monetised costs

Cost of streetscape GI assets

The costs of streetscape GI measures can vary greatly depending on the nature of the project, the street typology and the integration of GI within a broader project. Factors that can reduce the cost are:

- Integration of GI with other planned works to minimise attributable costs of traffic management, disturbance and earthworks and to generate other benefits such as improved amenity value or reduced irrigation requirements for street trees
- Good design to resolve issues such as safety, interactions with services and ensure appropriate levels are achievable
- Effective communication with affected residents during project planning to ensure community support

Factors that may increase the cost or result in difficulties are:

- Work in constrained areas such as tree pits in shopping strips or on busy intersections
- GI implemented in isolation from other projects
- Lack of communication of the intent and operation of the treatment system with the whole project team including designers, engineers, contractors and maintenance staff.

Measurable benefits

Stormwater pollutant load reduction

Urban areas generate litter, nutrients, heavy metals and sediments which are washed into stormwater drains and into local waterways, harming the aquatic environment. Green Infrastructure (GI) systems can be used to treat stormwater, utilising soil to trap pollutants (i.e. rubbish, sediment, hydrocarbons, metals and pathogens) while allowing plants to absorb nutrients (i.e. nitrogen and phosphorous). The table below provides a comparison of beneficial outcomes for several streetscape GI assets. These benefits can be modelled and quantified via an eWater MUSIC model.

Summary of hydrology and water quality benefits and costs

GI asset treatment measure and catchment characteristics			Flow reduction and/or water conservation benefit (kL/yr)	Pollutant reduction (kg/yr)		
GI asset treatment	Catchment	Size of treatment measure		TSS	TP	TN
Rain garden (lined)	1 km road*	40 m²	110	750	1.165	6.27
Rain gardens with submerged zone (or tree pits)	1 km road	40 m²	110	760	0.96	6.37
Infiltration rain gardens*	1 km road	40 m²	370	750	1.2	6.4
Tree pits	1 km road	40 m²	12	750	1.2	6.3
Infiltration tree pits*	1 km road	40 m²	41	750	1.2	6.5
Swale (min. infiltration)	1 km road	70 m²	0	764	1.1	2.5
Swale*	1 km road	70 m²	240	767	1.1	3

Note: Assumes road pavement is 7m wide, 100% impervious

**Infiltration rate of 3.6 mm/hr assumed*

Monash University have undertaken research to understand people's willingness to pay for different types of services. Brent et al. (2016) conducted a choice experiment in Melbourne to understand people's willingness to pay for different types of services. They found that people in Melbourne were willing to pay $278 per year for improvements in local stream health.

These values are being increasingly incorporated into the business case for GI/WSUD projects and waterway restoration projects when applied extensively across a precinct or catchment. However, incorporation of the monetised benefits is difficult to capture for a single project or streetscape upgrade incorporating GI assets.

Microclimate and thermal comfort

Monash University have undertaken research to understand people's willingness to pay for different types of services. Brent et al. (2016) conducted a choice experiment in Melbourne to understand people's willingness to pay for different types of services. They found that people in Melbourne were willing to pay $81 per year for decreased peak urban temperatures. These values are being increasingly incorporated into the business case for GI/WSUD projects and waterway restoration projects when applied extensively across a precinct or catchment. However, incorporation of the monetised benefits is difficult to capture for a single project or streetscape upgrade incorporating GI assets.

Measurable costs

Internal resources

All projects involve drawing on internal resources. Internal resources can include in-kind contribution of staff time to the design and approval process of projects and other council resources being utilised for the project (i.e. technologies and meeting rooms). These could be measured and document, if considered important and beyond resources used for conventional streetscape works.

Intangible benefits

Amenity value

Trees and urban greening enhance public amenity. Amenity values that could be associated with GI assets are greater street character and attractiveness. The value of these benefits may be reflected in an increase in surrounding property values. The effect is locally specific, with increases observed ranging from 1-15% but generally treelined streets are more attractive to home buyers. Greener areas are also good for business viability due to greater land desirability and foot traffic. There is a difficulty in applying the proportion of monetised value that is associated with the GI asset components (as opposed to a standard street tree or garden bed). Caution should be adopted if such values are included.

Related research

- Rossetti (2013) analysed a large set of property sales data from 2000 to 2010 across Australian cities combining annually aggregated postcode level enhanced vegetation index (EVI) as a proxy to green infrastructure. He found that for every house in a postcode that gains green infrastructure equivalent to 1 standard deviation change in enhanced vegetation index resulted in gain of $32,000-58,000 per property.
- A study conducted in 52 residential suburbs in Brisbane using data on house sales of 2010 revealed that 1% increase in foot path tree cover within 100 m represents 0.082-0.103% premium of property value (Plant *et al*., 2017).
- According to another study carried out in central part of Perth metropolitan area, it was found that 10% increase in tree canopy cover on the adjacent public space represent property price premium of about AU$ 14,500 in 2009 (Pandit *et al*., 2014).

Increasing streetscape asset lifetime

The lifetime of a tree planted in a constrained urban environment without sufficient soil area or watering is 13 years. Comparing this standard tree, with an expanded soil area (25 m^2) which also incorporated passive watering from stormwater, the lifetime was estimated to be 50 years (The Kestral Design Group , n.d.). This can save councils on tree renewal costs, prevent pre-mature tree deaths during drought periods, and deliver significant canopy cover and shade benefits.

Shady trees can also increase the useful life of asphalt pavement by at least 30%, which can be of considerable value in the hot climate of Australia where asphalt degrades quickly (Moore, 2009).

Related research

- Over a 15-year period, trees planted in a conventionally constrained soil pit delivered an average canopy coverage of 7.5 m². In contrast, a tree planted in a structural soil system with enhanced soil volumes delivered an average canopy coverage of 50 m² over a four-year period (Citygreen, n.d.).

Ecological improvement and biodiversity

Green infrastructure within streetscapes could increase biodiversity through providing habitat for native animals such as birds, beetles and macro-invertebrates. Appropriate selection of plants could provide small and regular refuges potentially helping ground dwelling species to migrate between more significant stands of vegetation located across broader open space network (such as, parks and waterway corridors). These benefits could be described but are difficult to quantify or monetise. According to the US Forest Service, a large tree with a trunk diameter 10 times larger than a small tree produces 60- 70 times the ecological services (MCPHERSON, et al., 1994).

Improved air quality

Trees absorb air pollutants that have major health effects in cities. Larger trees and certain species have a greater effect and can be very beneficial in highly trafficked and polluted areas. Trees remove air pollution by the interception of particulate matter on plant surfaces and the absorption of gaseous pollutants through the leaf stomata. These benefits could be described but are difficult to quantify or monetise. Some associated research is provided below:

- A case study of the value of the Canberra urban forest with particular reference to pollution mitigation was estimated at US$20–$67 million (or $66–$223/resident) between 2008 and 2012 (Brack, 2002).
- A number of studies have estimated air pollution removal benefits by urban trees and shrubs in the United States. For example, Nowak et al. (2006) estimated pollution (O3,PM10,NO2,SO2, CO) removal from urban green space in the US as 711,000 metric tons using pollution concentration data from across the coterminous US in 1994 which was worth of $3.8 billion.
- A study conducted in 10 US cities in 2010 modelled PM².5 concentrations and human health (Nowak et al., 2013). According the study estimates the total amount of PM².5 removed annually by trees varied from 4.7 tonnes in Syracuse to 64.5 tonnes in Atlanta with annual values varying from $1.1 million in Syracuse to $60.1 million in New York City.
- A study conducted in 2010 using computer simulations with local environmental data in US found that trees and forests in the conterminous United States removed 17.4 million tonnes (t) of air pollution in 2010. Using U.S. EPA's BenMAP program, the total annual pollution removal was valued as US$ 6.8 billion (Nowak et al., 2014).

Reduced greenhouse gas emissions, increased CO2 sequestration

GI projects that result in increased vegetation contribute to CO2 sequestration. When valuing carbon that has been sequestered, it is necessary to account for the fact that sequestration may be temporary and somewhat insecure. Studies have shown that having urban trees in the neighbourhood reduce electricity consumption especially during summer time due to the shading and cooling effect provided by trees. This reduces the generation of greenhouse gas emissions and electricity costs to households and businesses. These benefits could be described but are difficult to quantify or monetise, especially in regard to the proportion of enhanced sequestration or energy use changes that are attributed to the GI asset aspects of the design contributing to potentially larger/healthy canopy compared to a standard street tree. Some associated research is provided below:

- In Australia, a value for CO2-e of around A$20-25 per tonne was previously in place before the carbon tax was abandoned.
- The value carbon sequestration by urban forests (about 400,000 trees) in Canberra during the period 2008–2012 was estimated at US$ 300,000 (Brack, 2002). Davies et al. (2011), also estimated carbon storage of a typical British city, Leicester, by surveying vegetation across the entire urban area. They found that urban vegetation stored 231,521 tonnes of carbon (16 kg C m-2 of urban area).
- Donovan and Butry (2009), reported that a London plane tree, planted on the west side of a house, can reduce carbon emissions from summertime electricity use by an average of 31% over 100 years.
- Moore (2009) assumes 12.5 tonnes/yr of carbon is removed by a large mature urban tree over 50 years. Moore has also shown the shade from a large mature urban tree can reduce a building energy use by 30kWh/year.
- The value of services provided by trees in Allan Gardens, a historic public park in downtown Toronto, Canada was examined by Millward and Sabir (2011). On a per-tree basis, CO2 removal benefits were derived from Scotch Elm was $10/tree. Silver Maple and Black Walnut reduced carbon emissions worth of $6/tree each, while Norway maple reduced emissions worth of $5/tree.
- Soares et al. (2011) evaluated benefits of urban trees in Lisbon, Portugal using thee computer tool i-Tree STRATUM. Carbon emission reductions per tree was valued at $0.33/tree.
- Soares et al. (2011), evaluated benefits of urban trees in Lisbon, Portugal using the computer tool i-Tree STRATUM. The value of energy savings was recorded as $6.20/tree.
- Donovan and Butry (2009), estimated the effect of shade trees on the summertime electricity savings of 460 single-family homes in Sacramento, California. Their results show that trees located in west and south sides of a house reduced summertime electricity use by 185 kWh (5.2%).
- McPherson and Simpson (2003) carried out a study in California using tree canopy cover data from aerial photographs simulated energy savings of buildings from existing trees and new plantings. Existing trees were projected to decrease annual air conditioning energy use by 2.5% with a wholesale value of $ 485.8 million in 2010. Peak load reduction by existing trees saved utilities 10% valued at $ 778.5 million annually, or $ 4.39/tree.

Other community benefits (i.e. community cohesion)

Learning from visible local examples and knowledge is important in helping raise environmental awareness and understanding of the role of stormwater treatment in protecting their local waterways and beaches. More broadly this contributes to building social capital and engaging the community better on sustainable water management practices. This could be achieved through making water visible in the landscape and providing educational measures such as signage.

Provision of urban green space can enhance various measures of social cohesion. Mechanisms may include provision of an environment that fosters greater interaction between community members and bringing people together to participate in projects that establish or enhance green space. Provision of amenities within the green space that attract citizens can provide a level of surveillance to help deter crime.

These benefits could be described but are difficult to quantify or monetise.

Improved community physical and mental health

Several studies explore the link between green space and both physical and mental health. These benefits could be described but are difficult to quantify or monetise, especially in regard to the proportion of improved community physical or mental health that are attributed to the GI asset aspects of the design contributing to potentially larger/healthy canopy compared to a standard street tree. Some associated research is provided below:

- A study undertaken in Perth, Western Australia from a cross sectional survey of residents in 2003 and 2005 concluded that residents in neighbourhoods with high quality public open space had higher odds of low psychosocial distress than residents of neighbourhoods with low quality public open space (Francis et al., 2012).
- Sugiyama et al. (2008) examined the link between green space and both physical and mental health in Adelaide. Their findings suggested that those who perceived their neighbourhood as highly green had 1.37 and 1.60 times higher chance of having better physical and mental health, respectively, compared with those who perceived the lowest greenness.
- A few studies examined the link between access to neighbourhood green space and mental health. Alcock et al. (2014) analysed British Household Panel Survey with mental health data from 1992 to 2008 and found that individuals who moved to greener areas had significantly better mental health in all three post move years while individuals who moved to less green areas showed significantly worse mental health in the year preceding the move.
- A study conducted in 10 US cities in 2010 modelled PM^2.5 concentrations and human health (Nowak et al., 2013). The average health benefit value per hectare of tree cover was estimated about $1,600 but varied from $500 in Atlanta and Minneapolis to $3800 in New York.

Intangible costs

Council, business, financial or reputational risk

Projects could pose business, financial or reputational risks to council. Issues such as public safety or perception issues with caught litter, etc. could pose a risk to council. How will the community interact with this asset? Are there safety, noise, odour or visual issues? Will the community lose something (e.g. parking or grassed areas) because of the project? What is the probability and result of asset failure? Often insufficient maintenance can result in poor performance. What is the impact if no action is taken? It is valuable to have a high-level understanding of these potential risks and mitigate them where possible. These risks could be described.

Risk to surrounding assets (i.e. root intrusion)

Provision of good soil moisture around trees can reduce pavement and underground utility damage caused by root intrusion as trees seek out water, reducing hazards and maintenance costs. Ensuring that a significant volume of water can soak into the soil layers allows water to be 'banked' for vegetation to draw on in drier times. These risks could be described.

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