Valuing the ecosystem services of living infrastructure using the SEEA framework

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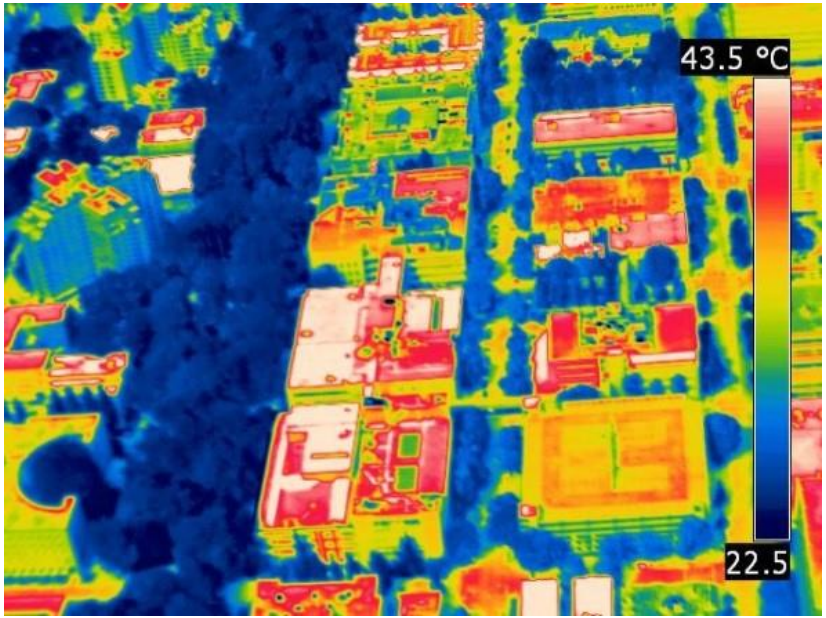
Picture source: https://upload.wikimedia.org/wikipedia/commons/0/0c/Glebe_Park%2C_Canberra.jpg

Background

- Natural assets, such as parks, trees, and lakes, are a type of city assets called ***living infrastructure***.

- Living infrastructure provides multiple socioeconomic, cultural, and environmental benefits to urban dwellers.
  - Mitigate the impacts of climate change e.g. **cooling effects** of living assets can reduce the negative impacts of extreme heat days.
  - Provide recreational and health benefits.
  - Offer habitat connectivity for wildlife.



Source:Thermography of the Portlan State University campus,August 2011
http://usir.salford.ac.uk/id/eprint/49735/1/PSU.pdf

Urban street trees have multiple ecosystem services, one of which is cooling.

This Sydney street stays cooler than others during a heatwave — here's why

abc.net.au

Background

- Most of the benefits are not directly consumed or experienced by people, and they are often overlooked or undervalued in strategic city planning decisions.

- This could result in the gradual deterioration of living assets, reduction of the provision of ecosystem services, and increasing liabilities and risks.

- By considering living infrastructure as part of a city's built infrastructure, more comprehensive planning, design, maintenance and renewal of the urban environment can be pursued.

https://www.smh.com.au/national/nsw/large-tree-falls-in-sydney-cbd-closing-york-street-20190202-p50vb2.html

Research objectives

- Evaluate the whole-of-life net benefit of publicly managed trees and irrigated open spaces (e.g. cooling benefits of trees).

- Estimate the net social benefit per additional unit of living infrastructure (e.g. per additional ha of urban forest or irrigated open spaces).

- Assess the monetised benefit to society for every dollar invested in establishing and maintaining living infrastructure.

Section 1:

Ecosystem services of green living infrastructure

A summary of ecosystem services benefits of urban trees and irrigated open spaces

Services	Trees	Irrigated open spaces
Provisioning	Food	Recreational value
	Shade	Sporting value (user fee)
	Oxygen	Oxygen
Supporting	Habitat connectivity/corridors	Habitat connectivity/corridors
	Habitat for wildlife	
	Species diversity/Biodiversity	
Regulating	Climate regulation/amelioration (cooling)	Climate regulation/amelioration (cooling)
	Carbon sequestration	Carbon sequestration
	Air quality	Noise reduction
	Noise reduction	Flood control/Stormwater run-off
	Flood control/Stormwater run-off	Water pollution reduction
	Water pollution reduction	Erosion control
	Erosion control	
Cultural	Recreational value	Recreational value
	Property price premium	Property price premium
	Cultural heritage	Cultural heritage
	Symbolic/Spiritual values	Symbolic/Spiritual values
	Mental/Physical health benefits	Mental/Physical health benefits
	Aesthetic enjoyment	Aesthetic enjoyment
	Reduce socio-economic inequalities	Reduce socio-economic inequalities

Section 2:
Methodology

System of Environmental-Economic Accounting (SEEA)

- Was produced and released by the UN, the European Commission, the FAO, the OECD, IMF and the World Bank Group.

- Is a framework that integrates economic and environmental data to capture the interrelationships between the economy and the environment.

- Contains internationally agreed standard concepts, definitions, classifications, accounting rules and tables for producing internationally comparable statistics and accounts.

System of Environmental-Economic Accounting (SEEA)

- In 2016, the Australian government, as represented by Australia's environment ministers, representing all nine federal and state jurisdictions, agreed to adopt the SEEA framework as standard national approach to environmental accounting in Australia (United Nations, 2017).

- 28 July 2017, COAG (Commonwealth, State and Territory Environment Ministers) endorsed a common national approach to environmental-economic accounting and the free and open sharing of environmental data between jurisdictions.

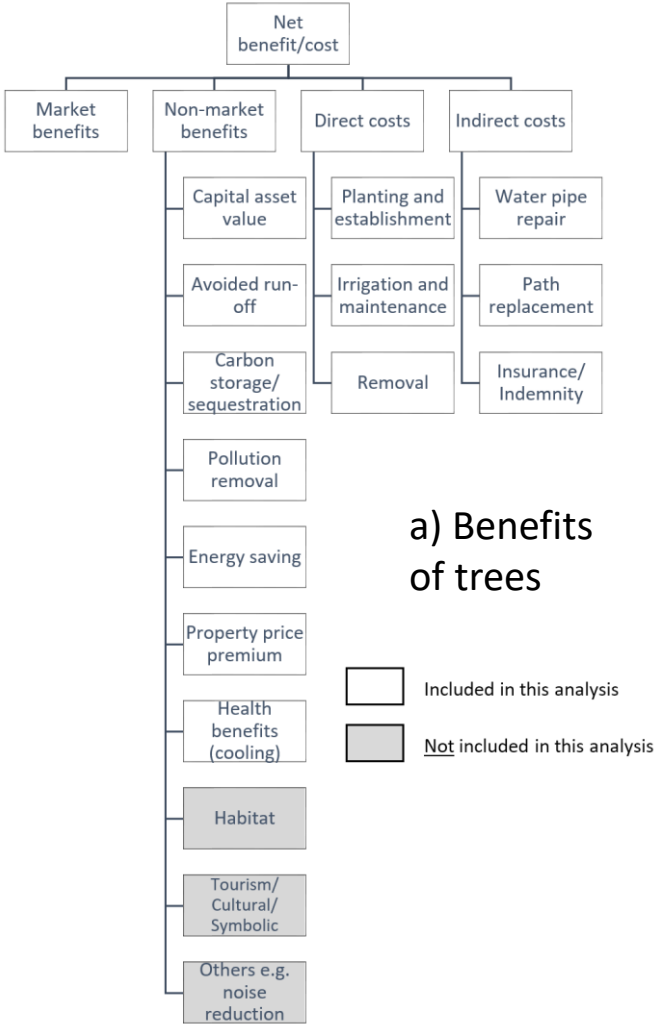
System of Environmental-Economic Accounting (SEEA)

- The SEEA establishes baseline values and tracks changes in ecosystem assets (through changes in extent and ecosystem stocks and flows) (OECD, 2013).

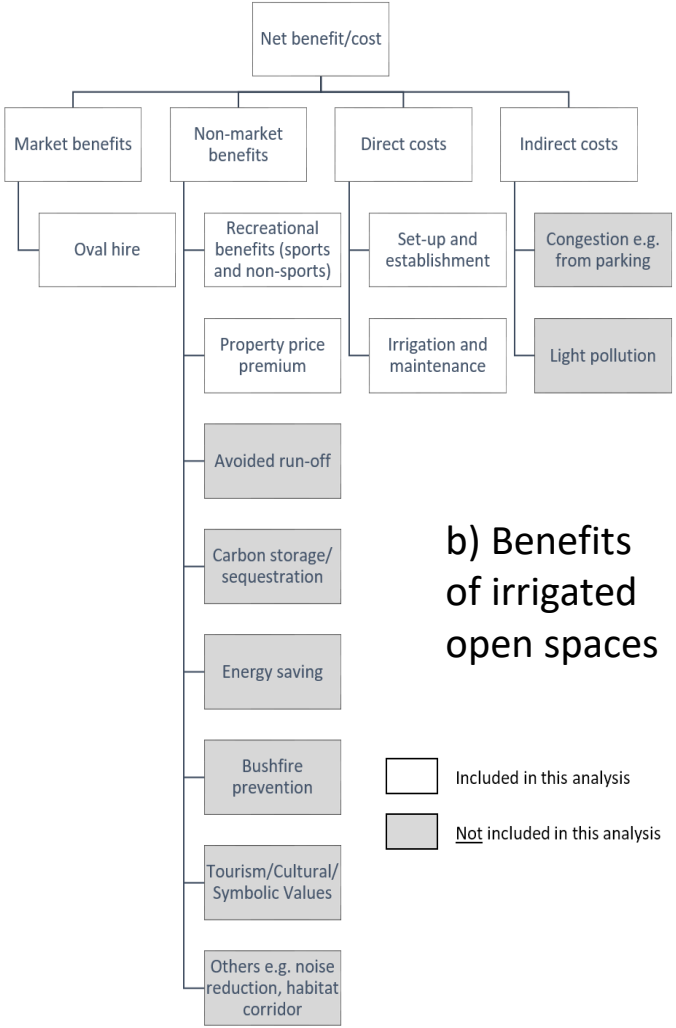
- By valuing ES in monetary terms, it is possible to better recognize their important contribution to human well-being and economic growth.

Measurement and valuation of ecosystem services

Benefits	Biophysical flows	Total value ($)
Carbon sequestration	?? tonnes of CO_2	??
Avoided stormwater runoff	?? m^3	??
Pollution removal	?? tonnes	??
Building energy savings	?? MWh	??
Avoided energy emissions	?? tonnes of CO_2	??
Land rate premium	?? houses	??
Health	??	??
Wildlife habitat	??	??
Recreation	??	??
Tourism/Cultural	??	??



a) Benefits of trees



b) Benefits of irrigated open spaces

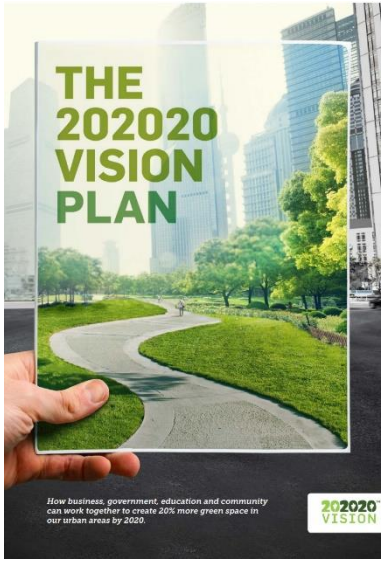
Measurement and valuation of ecosystem services

Benefits	Biophysical flows	Total value ($)
Carbon sequestration	?? tonnes of CO_2	??
Avoided stormwater runoff	?? m^3	??
Pollution removal	?? tonnes	??
Building energy savings	?? MWh	??
Avoided energy emissions	?? tonnes of CO_2	??
Land rate premium	?? houses	??
Health	??	??
Wildlife habitat	??	??
Recreation	??	??
Tourism/Cultural	??	??

i-Tree valuation of ecosystem services

What is i-Tree?

- State-of-the-art, peer-reviewed software suite developed by the USDA Forest in August 2006.
- Quantifies forest structure and flows and values of key environmental benefits provided by trees.
- i-Tree Eco has been customised for Australian cities (e.g. population, pollution, energy costs).
- Australia 202020 Vision have chosen i-Tree Australia as Australia's standard measurement tool.
- Free



i-Tree valuation of ecosystem services

Asset condition and extent (*Stock*)

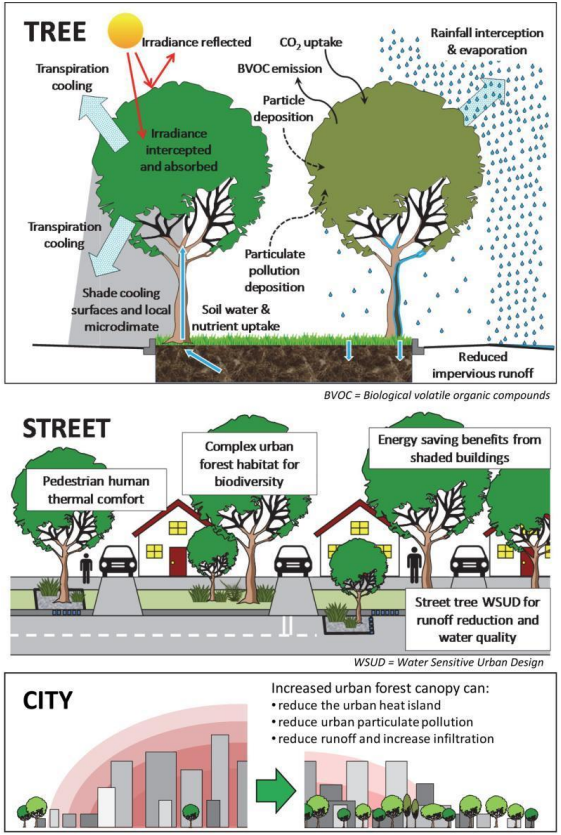
- Replacement cost

Flow of services

- Avoided stormwater runoff
- Carbon storage/sequestration
- Pollution removal
- Building energy savings
- Avoided energy emissions

Flow of other services ??

- Property price premium
- Heat related morbidity



Scenario analysis

Trees

- Scenario 1. Business as usual (BAU)
- Scenario 2. Maintaining the current extent of the urban forests
- Scenario 3. Expanding canopy cover to 30% by 2045.

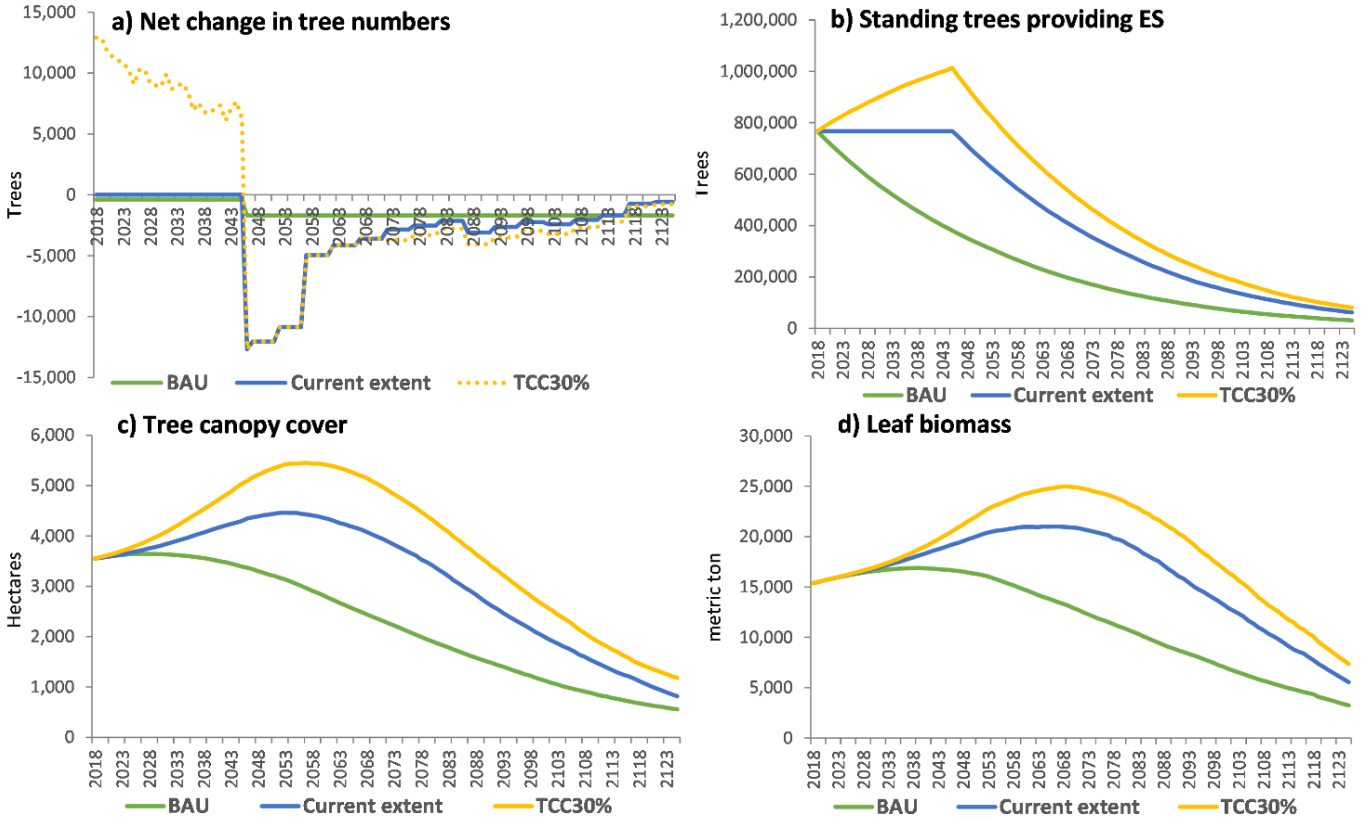
Irrigated Open Space

- Scenario 1. Business as usual (BAU)
- Scenario 2. 50% increase in the area of irrigated open spaces

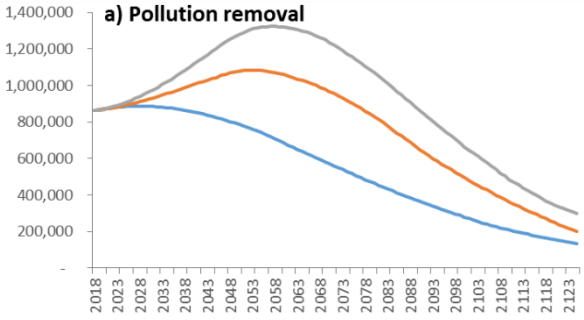
Section 3:
Results

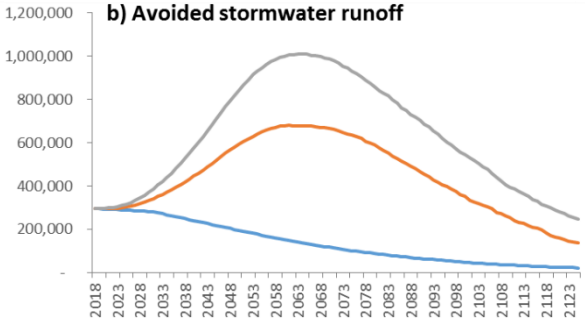
Estimated value of the services provided by public forests in 2018

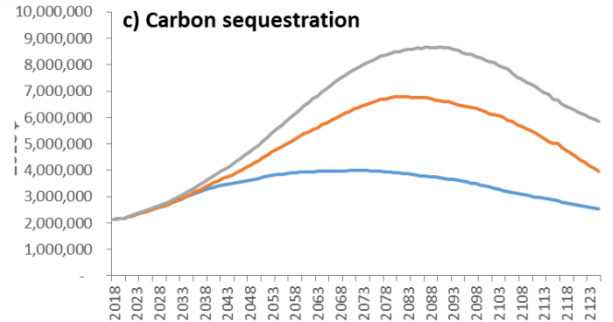
Benefits	Biophysical flows	Total value (2018 $)	Per tree basis (2018 $)
Carbon sequestration[1]	39,068 tonnes of CO_2	2,145,011	2.79
Avoided stormwater runoff[2]	236,355 m^3	295,402	0.38
Pollution removal[3]	154 tonnes	863,382	1.12
Building energy savings[4]	120,369 MWh	9,096,938	11.85
Avoided energy emissions[5]	33,319 tonnes of CO_2	514,392	0.67
Land rate premium[6]	105,518 houses	14,191,296	18.98
Cooling effect (avoided heat-related morbidity) [7]	Assumed 3 hot days	12,644	0.01

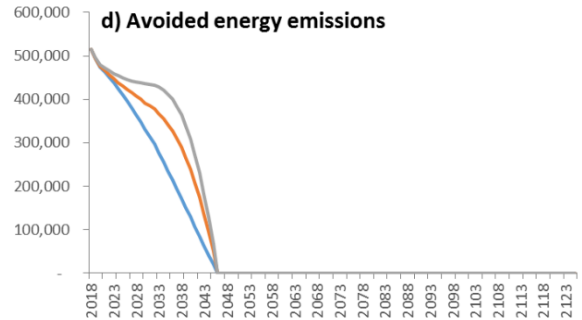


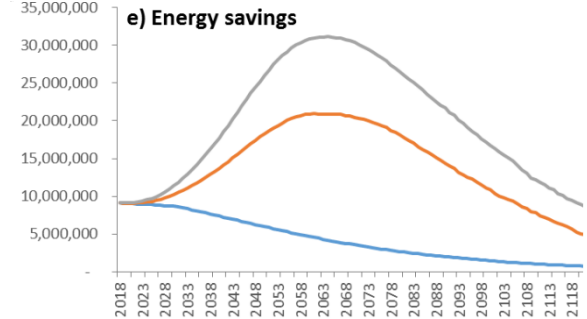
Annual net change in tree stock, standing forests, tree canopy and leaf biomass.

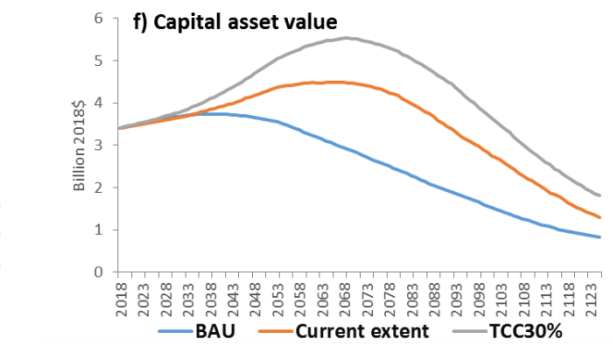












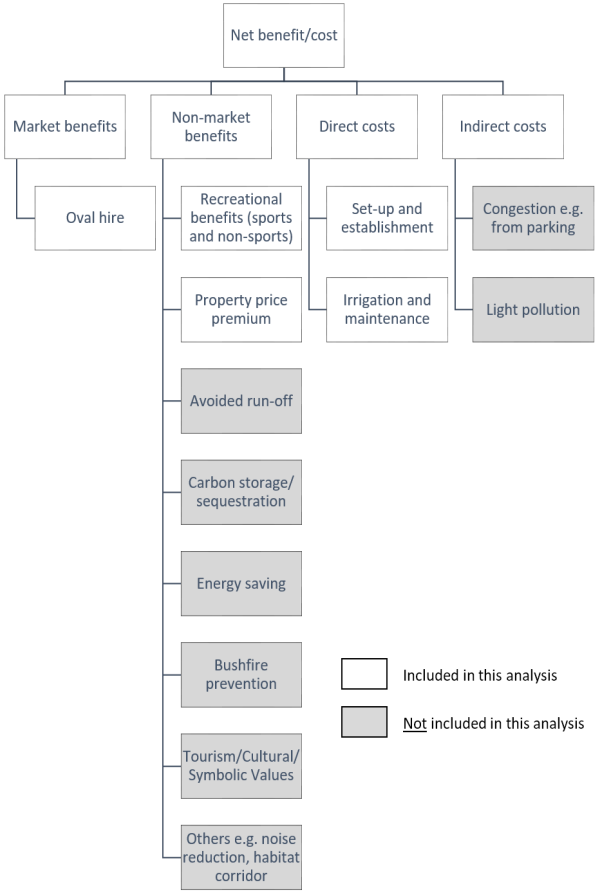
Ecosystem services and capital asset value under modelled urban forest management scenarios (2018-2125)
Plantings are assumed to stop under all management scenarios by 2045.

Results for the BAU and alternative scenarios for public trees (NPV $ 2018-2125)

	Discount rate	Total cost ($M)	Total benefit ($M)	BCR
BAU	3%	$774.56	$502.64	0.65
Maintain	3%	$1,342.33	$1,375.75	1.02
30% Canopy cover	3%	$1,659.47	$1,977.11	1.19

Results for the BAU and alternative scenarios for irrigated open spaces (NPV $ 2018-2125)

	Discount rate	Total cost ($M)	Total benefit ($M)	BCR
BAU	3%	$432.16	$1,142.72	2.64
50% more IOS	3%	$547.53	$1,339.26	2.44

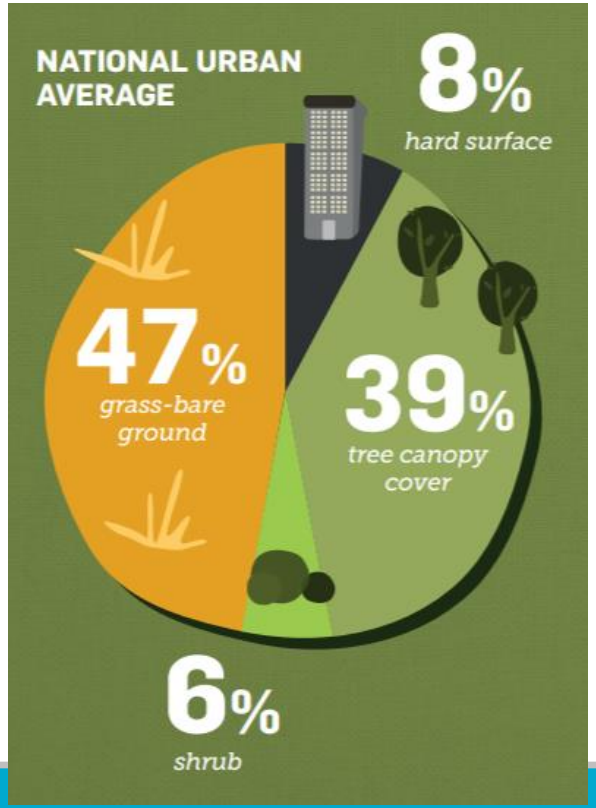


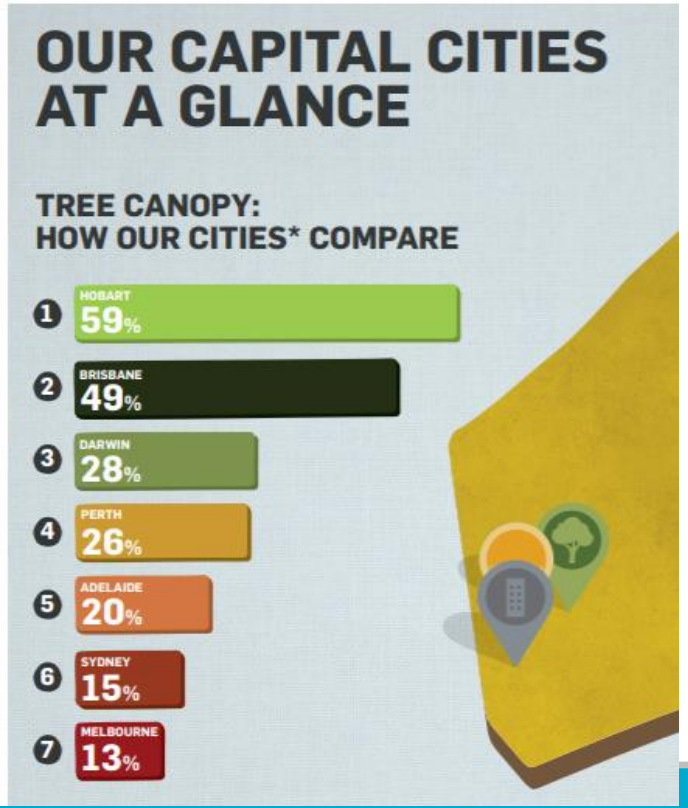
Section 4:
Conclusion and implications

Summary

- Green infrastructure has significant capital asset value and provides important direct and indirect benefits to the city.
- The tree management scenario that aims to expand tree canopy cover has the highest benefit-cost ratio (BCR).
- For irrigated spaces, the benefit figure is potentially a lower-bound estimate, as many other benefits were not estimated.
- We can demonstrate the economic benefits of trees and green space to decision makers.

Application for Darwin: Percent tree distribution by place of origin



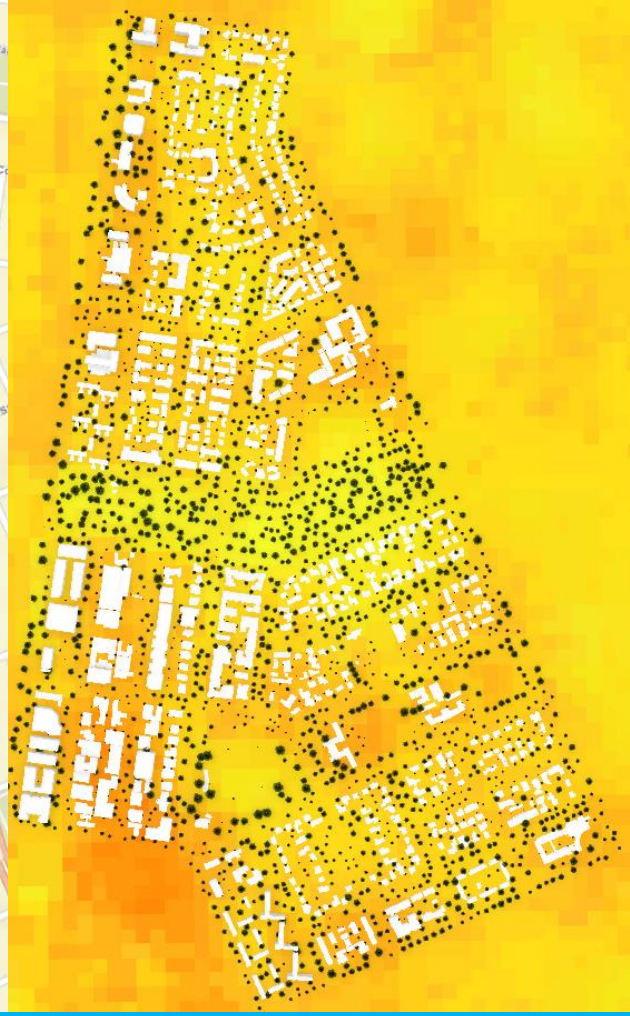


BUT A FAVOURABLE MIX OF GRASS-BARE AND HARD SURFACE GROUND SUGGESTS THAT THERE IS AMPLE OPPORTUNITY FOR URBAN GREENING PROJECTS IN THE TERRITORY.

Data requirement

- Biophysical/Ecological
- Economic
- Cultural
- Social
- Health
- Costs - Establishment, maintenance and removal costs of trees and irrigated opens spaces
- Spatially explicit information

Applications in Darwin: Interaction between green and grey infrastructure

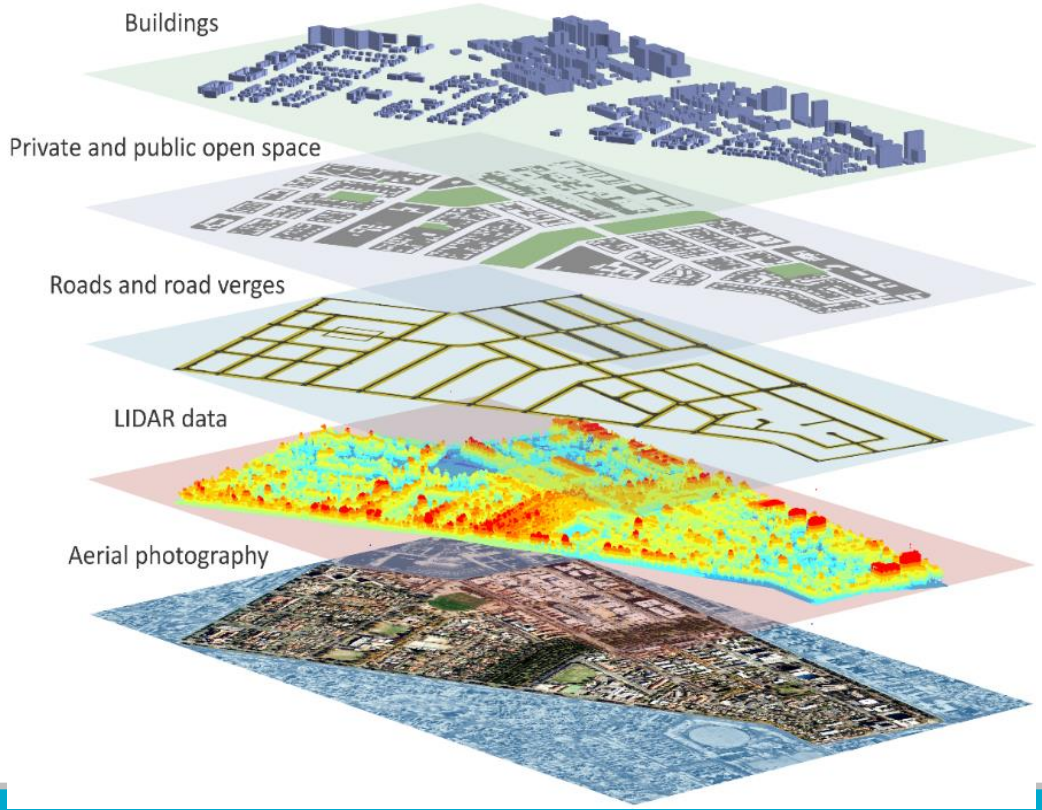


Living environment

Digital twin

Surface temperature

Understanding the urban system



Make investment decisions, find co-benefits and make trade-offs between

- Environment/Ecology
- Economy
- Health and well-being
- Liveability
- Sustainability

to maximize adaptability, resilience, and social welfare.

Thank you

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Key questions

1. How does green infrastructure influence people's sense of place (sense of identity, attachment, and belonging).
2. How do we manage trees when funds are limited?

System of Environmental-Economic Accounting Examples

1. Experimental Ecosystem Accounts for the Central Highlands of Victoria (2016)

2. Experimental Environmental-Economic Accounts for the Great Barrier Reef (2017)

About this research project

- A pilot study to value Canberra's public urban forest and irrigated open spaces using the SEEA framework and understand the complexities and requirements for such a study.
- It's only a first step in exploring the potential application of this framework and identify gaps.
- Focussed on the publicly managed trees and irrigated open spaces only.
- Trees in nature reserves were not included in the analysis.

Whole of life benefits and costs

- Costs
  - Planting, maintenance, removal costs, and others (e.g. insurance)
- Benefits
  - Stock –> i-Tree
  - Flow –> i-Tree, benefit transfer, non-market valuation
- Cost-benefit analysis
  - @Risk (account for uncertainty in parameter values)

Net cost per person for each of the two IOSs management scenarios (2018 $)

	m^2 per person		Cost per person		Cost/person/week	
Year	2018	2045	2018	2045	2018	2045
BAU	11.52	7.87	60.38	41.29	1.16	0.79
50% more irrigated open space	11.52	11.81	67.27	46.00	1.29	0.88