INU
Istituto Nazionale di Urbanistica
Sezione Lombardia

Con il patrocinio
del Comune di Milano

LA DIMENSIONE ECOLOGICA NEL PROGETTO DI CITTA' E TERRITORI

Martedì 22 Novembre 2016 – Auditorium Acquario Civico di Milano

Nature Based Solution - uno strumento per nuovi piani e progetti

Luca Bisogni, *biologo ambientale, NQA srl, A.A.A.*

LE NBS UN TERMINE EMERGENTE

Per affrontare le sempre maggiori sfide che si presentano, come ad esempio quelle poste dagli effetti del cambiamento climatico, le società si sono sempre più affidate a strategie tecnologiche basate su scenari prevedibili e possibili, create e progettate per massimizzare la semplicità, la replicabilità e la gestione.
L'approccio emergente è quello di gestire i sistemi socio – ecologici riconoscendone la complessità, il dinamismo, l'autorganizzazione e mutabilità e le capacità associate di resistenza e resilienza, secondo un approccio comprensivo volto a sostenere e potenzialmente aumentare la fornitura di Servizi Ecosistemici alla popolazione umana.

GLI NBS SI CONCENTRANO SUI BENEFICI SULLE PERSONE E L'AMBIENTE AL FINE DI CONSENTIRE SOLUZIONI SOSTENIBILI CHE SIANO CAPACI DI RISPONDERE AI CAMBIAMENTI ED AI RISCHI AMBIENTALI A LUNGO TERMINE.

gli NBS sono fortemente connessi a idee come Natural Systems Agriculture (Jakson, 2002), natural solutions (Dudley et al. 2010) ecosystem-based approaches (Cowan et al.2010) green infrastructures (Benedict and McMahon 2006), e ecological engeenering (Borsje et al.2011)

Le NBS si basano su nuovi sistemi ecologici che forniscono servizi che sarebbero altrimenti forniti tramite l'ingegneria più convenzionale basata su risorse non rinnovabili

Nature-Based Solutions (NBS)

Nature-based solutions (green and blue infrastructure, green roofs and vertical walls, natural water retention measures, salt marshes and dunes, floodplains etc.):

- Are **Multi-purpose**, **multi-functional** and **multi-beneficial**, inspired and supported by nature;
- Use the **properties** and **functions** of ecosystems to provide **ecosystem services** (water regulation, flood risk protection, climate change adaptation, etc.) => **living solutions**;
- Are designed to bring more nature and natural features and processes into cities, landscapes and seascapes, through **systemic interventions** => **engineered solutions**;

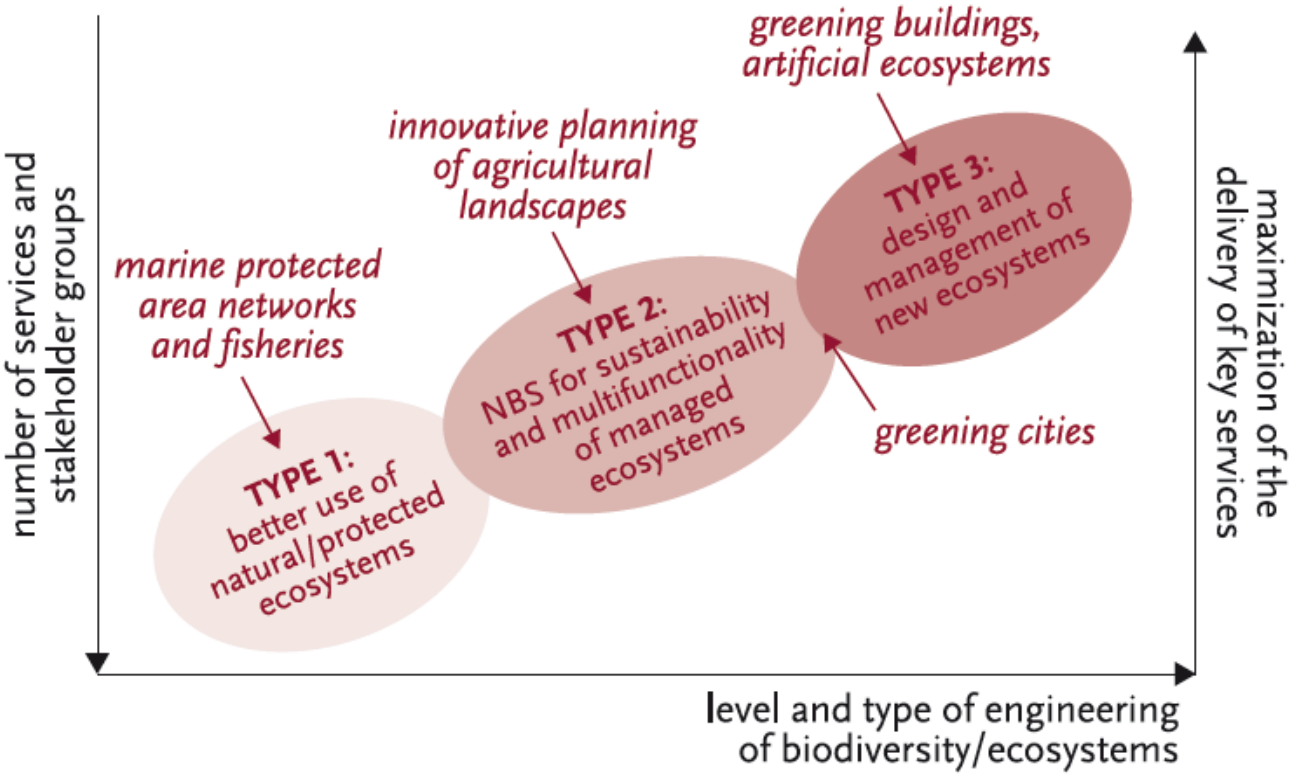
=> **NO bio-mimicry**, **NO bio-materials**

le Infrastrutture verdi sono il risultato della sinergia fra due possibili categorie di azione integrate fra loro :

- **il mantenimento di unità ecosistemiche (capitale naturale) in grado di produrre servizi ecosistemici;**
- **la realizzazione di unità ecosistemiche naturaliformi in grado di svolgere funzioni e servizi ecosistemici**

La forte integrazione tra infrastrutture verdi e riconoscimento e valorizzazione dei servizi ecosistemici è uno strumento efficace per aumentare la resilienza territoriale (Green Infrastructure and territorial cohesion".- European Environment Agency, 2011)

Le infrastrutture verdi, essendo basate sullo sviluppo di funzioni ecosistemiche sono uno strumento per sviluppare i servizi ecosistemici secondo specifici obiettivi di riequilibrio ambientale



Modificato da: Nature-based Solutions: New Influence for Environmental Management and Research in Europe | *GAIA* 24/4 (2015): 243 – 248

GI provides multiple functions

Source: Ecotec & NENW, 2008.

Spatial analysis of green infrastructure in Europe - EEA Technical report No 2/2014 - ISSN 1725-2237

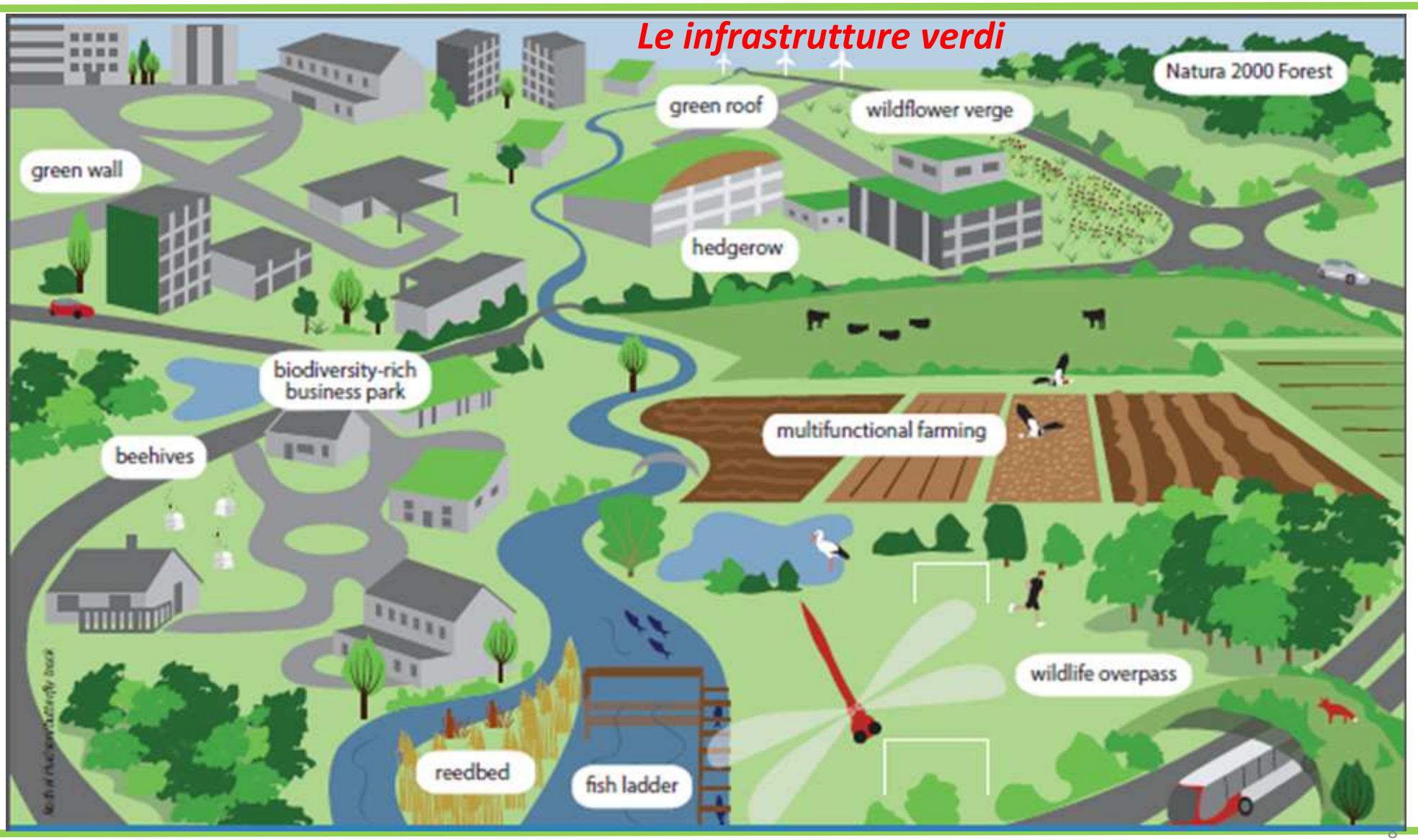
le caratteristiche delle infrastrutture verdi

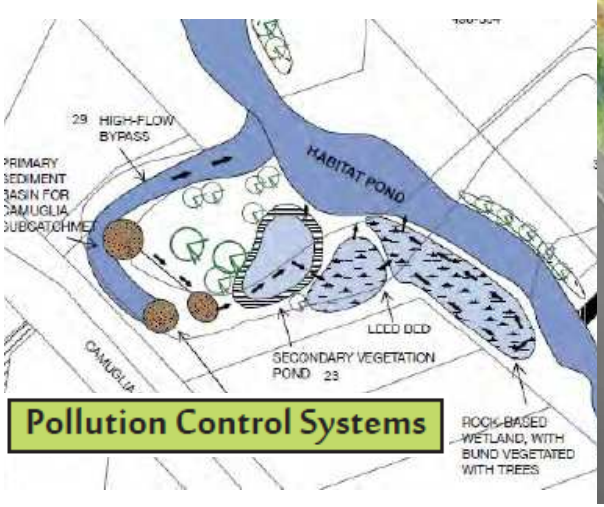
- Massa critica
- Vantaggi per le persone
- Multifunzionalità
- Sostituibilità con le infrastrutture grigio
- Interventi Coordinati

Naumann, Sandra, McKenna Davis, Timo Kaphengst, Mav Pieterse and Matt Rayment (2011): Design, implementation and cost elements of Green Infrastructure projects. Final report to the European Commission, DG Environment, Contract no. 070307/2010/577182/ETU/F.1, Ecologic institute and GHK Consulting.

La piena integrazione delle NBS nei progetti e nei piani può determinarne una loro maggiore efficacia in termini di resilienza e sostenibilità e può generare una nuova morfologia della sostenibilità sia in ambito urbano che rurale.

Le infrastrutture verdi





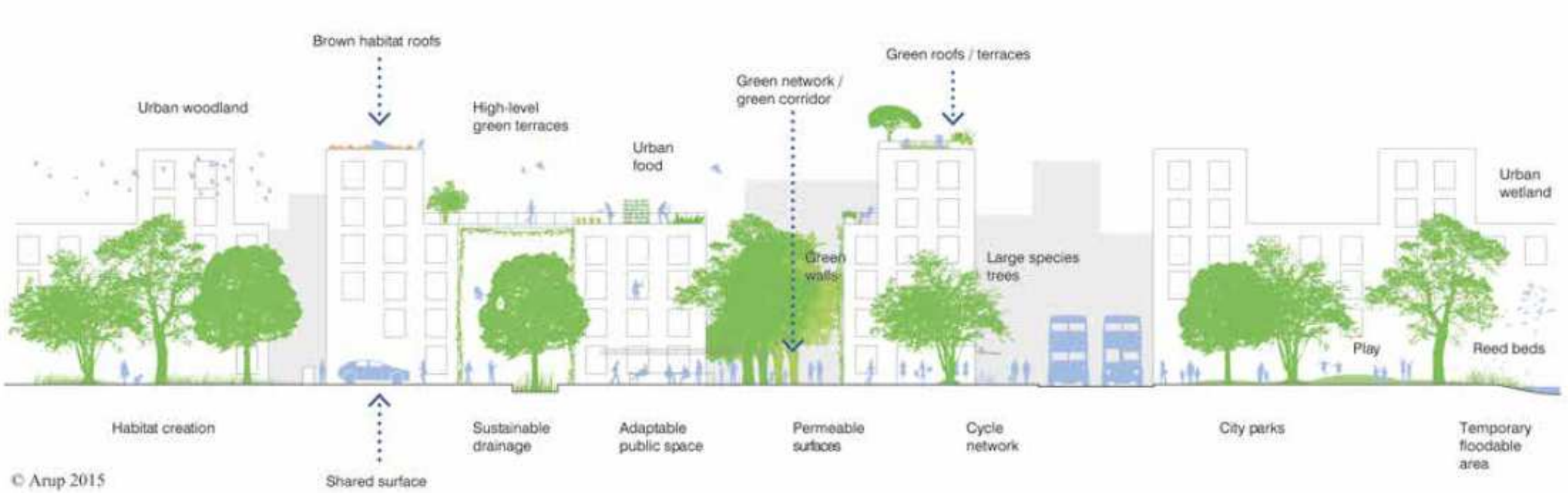
Australian Green Infrastructure Council

Australian Green Infrastructure Council

PARCO AGRICOLO-URBANO DELLA VALLE DELLA VETTABBIA

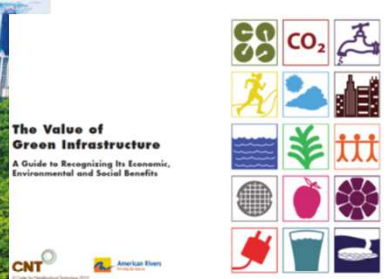
L'INTEGRAZIONE NEL PAESAGGIO URBANO

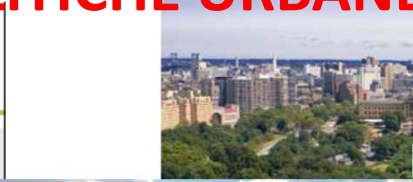
Example of Green Infrastructure integrated into an urban landscape (Adapted by ©Arup – from 'Cities Alive' http://www.arup.com/Homepage_Cities_Alive.aspx)

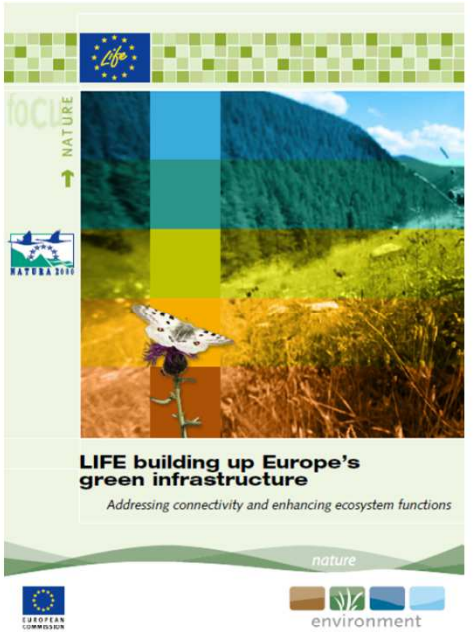


UK Green Building Council. DEMYSTIFYING GREEN INFRASTRUCTURE. Full Report february 2015

LE POLITICHE URBANE DI INTEGRAZIONE







LE POLITICHE URBANE DI INTEGRAZIONE

NRDC ISSUE BRIEF

JANUARY 2015
IB:14-12-B

WANTED: GREEN ACRES

How Philadelphia's Greened Acre Retrofit Program is catalyzing low-cost green infrastructure retrofits on private property

AUTHORS

Alisa Valderrama
Paul Davis
Natural Resources Defense Council

Figure 1: Reaching Philadelphia's Green Acre Goals

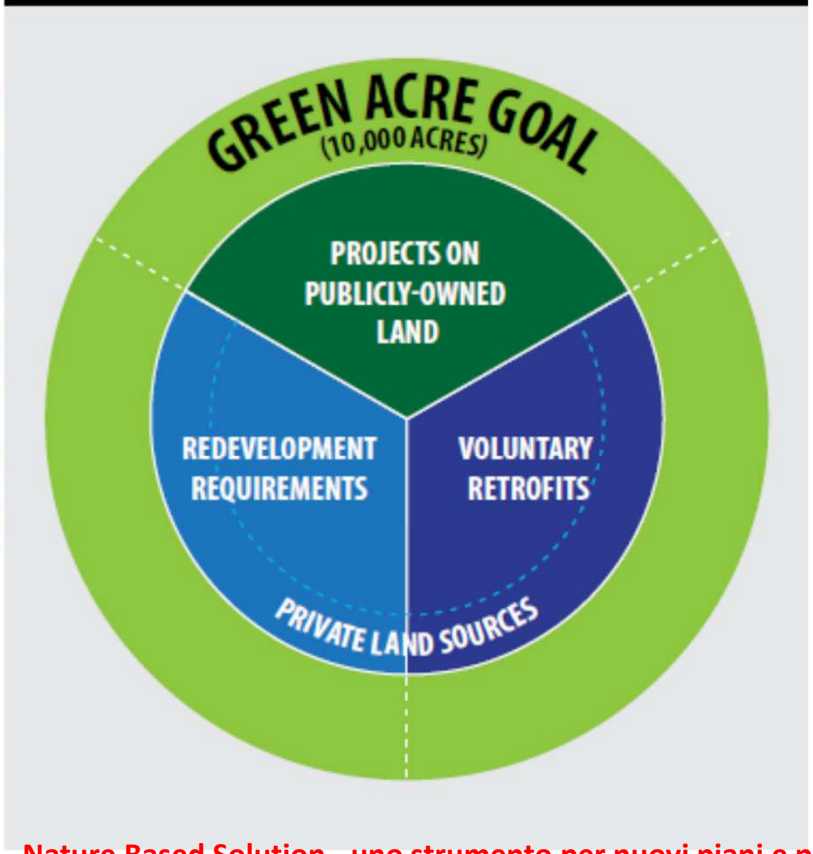


Table 1. Examples of Municipal Green Infrastructure Subsidy Programs

City	Subsidy Program
Seattle, WA	Seattle Public Utilities' Rainwise Program provides rebates to property owners who install rain gardens or cisterns on their property. Rebates can be as high as $3.50 per square foot of impervious area managed.[2]
Louisville, KY	Louisville Metropolitan Sewer District offers a Capital Recovery Stipend, which provides customers rebates up to $1.50 per square foot of impervious area managed.[3]
Palo Alto, CA	City of Palo Alto Storm Drain Utility offers rebates to residents, businesses, and city departments for the installation of qualifying green infrastructure measures.[4]
Montgomery County, MD	The Water Department's Rainscapes Rewards Rebate program provides rebates to both residential (up to $2,500) and commercial property owners (up to $10,000) for installation of green infrastructure measures.[5]
Milwaukee, WI	Milwaukee Metropolitan Sewerage District (MMSD) offers reduced stormwater fees for property owners who manage stormwater on-site. MMSD's Green Infrastructure Partnership Program will pay up to 50 percent of the cost of capturing stormwater on-site.[6]
Washington, D.C.	D.C.'s District Department of Environment's RiverSmart Homes, RiverSmart Communities and Green Roofs programs offer capital cost-share incentives to private property owners for installing green infrastructure projects.[7]

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LE POLITICHE URBANE DI INTEGRAZIONE

Figure 2: Green Infrastructure Project Successes under SMIP

Greene Street Friends Playground Retrofit

Before

After

Greene Street Friends School, a private charter school, had a roughly one-acre parking lot that served as the students' playground. Seen as a subpar recreational area, the school worked with PWD to replace half of the blacktop with a grass field, and installed a rain garden at the edge of the field to manage the remaining parking/play area runoff. This project illustrates the opportunity to produce multiple benefits with green infrastructure (enhanced play area for children, reduced stormwater runoff, and lower monthly fees), and also how creative project design can reduce runoff from the remaining impervious area.

By the Numbers

TOTAL GREENED ACRES: 0.92 acres

RUNOFF MANAGED:
Designed to manage runoff from 1.2 in. storm.

SMIP REBATE: $91,080

COST TO PWD PER GREENED ACRE: $99,000

Cardone Industries

Before

After

Cardone Industries is the largest private-public partnership stormwater project in Philadelphia, as well as a model for a cost-effective retrofit project. The retrofit consists of a series of underground and above ground detention basins as well as a vegetated swale. Soil excavated on-site for the retrofit was mixed with topsoil in vegetated areas, saving on disposal costs.

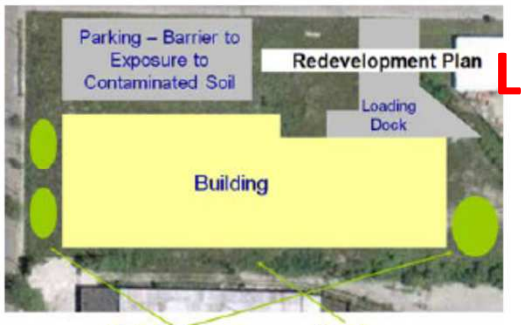
By the Numbers

TOTAL GREENED ACRES: 68.7

RUNOFF MANAGED:
Designed to manage runoff from 1.33 in. storm.

SMIP REBATE: $3.4 million

COST TO PWD PER GREENED ACRE: ~ $49,000



Example redevelopment plan using green infrastructure while placing barriers over contaminated soils.

Low Probability of a contaminated site ⟷ **High Probability of a contaminated site**

Park - Farm - Residential - Retail - Commercial - Service Station/Dry Cleaners - Industrial

Past and Present Property Use

EPA United States Environmental Protection Agency

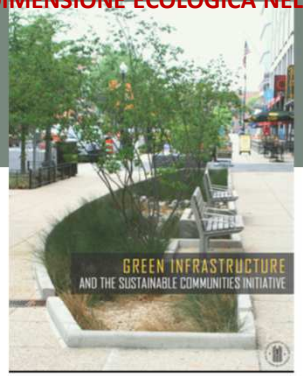
EPA Publication Number 905F13001
July 2013

LE POLITICHE URBANE DI INTEGRAZIONE

Implementing Stormwater Infiltration Practices at Vacant Parcels and Brownfield Sites

U.S. Environmental Protection Agency
Office of Water
Office of Solid Waste and Emergency Response

Decision Flowchart for the Use of Stormwater Infiltration at Brownfield Sites



Office of Economic Resilience
Office of Community Planning and Development
United States Department of Housing and Urban Development
hud.gov/resilience
March 2015

HUD SCI GRANT PROGRAMS*

The Sustainable Communities Initiative at HUD is comprised of two grant programs: the **Sustainable Communities Regional Planning Grant program** and the **Community Challenge Planning Grant program.** A brief overview of these programs is described below, highlighting the number of grants, level of funding, and type of plans produced.

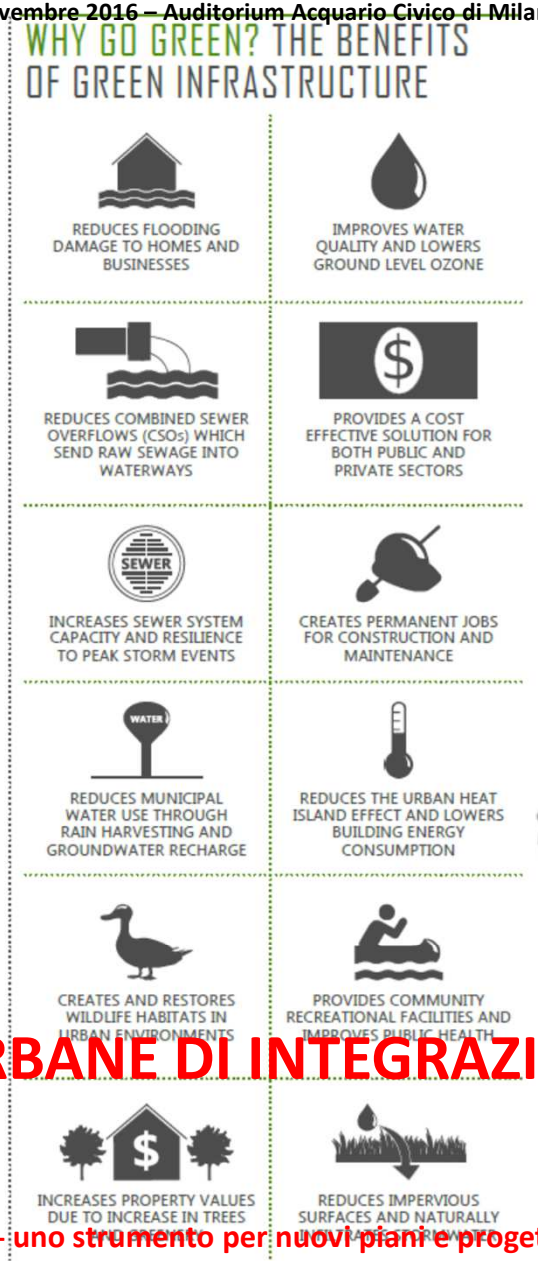
SUSTAINABLE COMMUNITIES REGIONAL PLANNING GRANTS

- 74 Regions
- $165 million in funding
- Multi-jurisdictional consortiums develop a regional plan for sustainable development

COMMUNITY CHALLENGE PLANNING GRANTS

- 69 Communities
- $70 million in funding
- Corridor, neighborhood, city-wide, and station area plans

* No FY2012-FY2015 appropriation



LE POLITICHE URBANE DI INTEGRAZIONE

Chiavi del successo per i progetti di Green Infrastructure

- Massimizzare l'uso di soluzioni olistiche - non solo benefici ambientali, ma anche sugli aspetti socio-economici e vantaggi (Ad esempio, la crescita e l'occupazione)
- Ampio coinvolgimento dei diversi soggetti interessati in tutte le fasi
- Utilizzo dei fondi diversi
- Buona comprensione delle esigenze e dei benefici della GI
- Inclusione della GI nella pianificazione territoriale
- Coinvolgimento dei cittadini nella progettazione e realizzazione del progetto
- Armonizzazione giuridica tra i diversi livelli di governo (I.n. comunali, provinciali, nazionali, UE)
- Scambio di esperienze e tenere conto delle lezioni apprese da altri progetti
- Networking con esecutori di progetti simili
- Misurazione e individuazione adeguata dei molteplici benefici del progetto
- Una buona comunicazione dei benefici delle soluzioni di GI per ottenere il sostegno

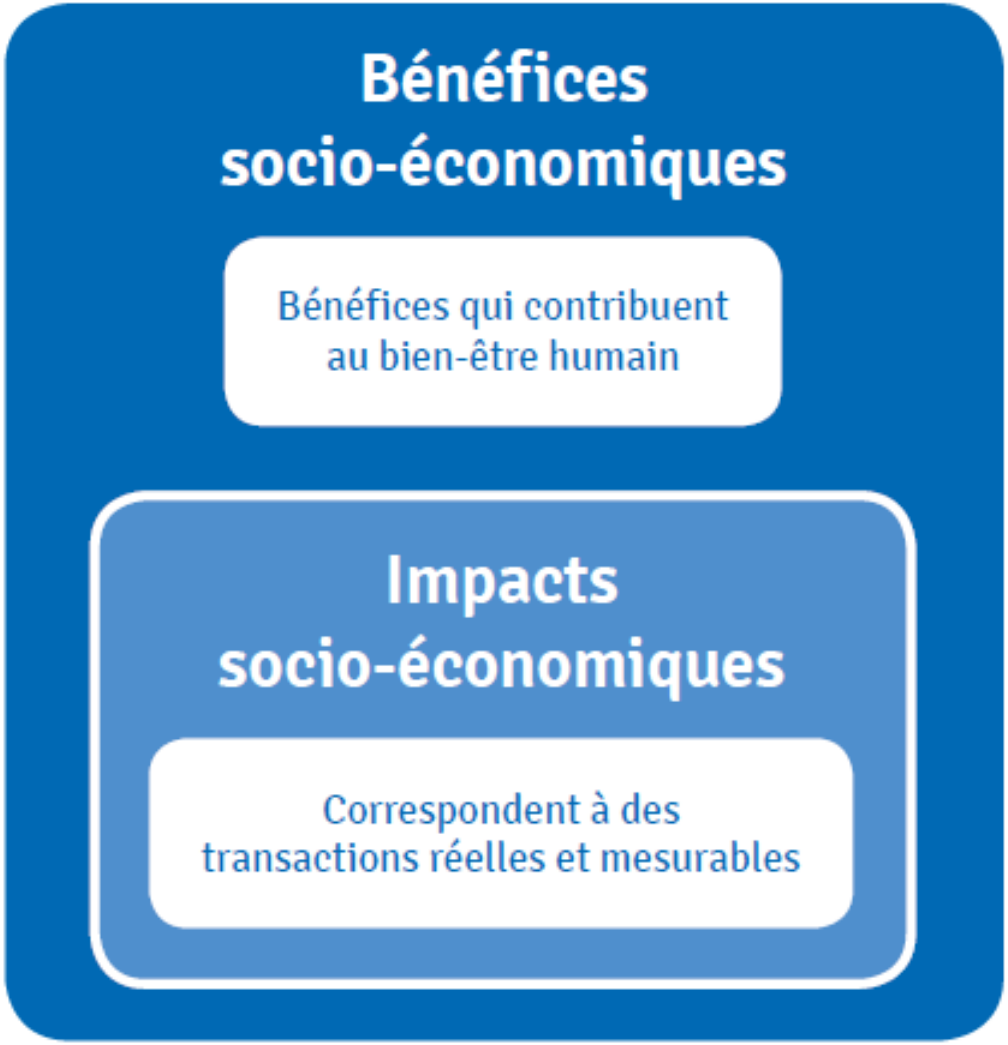
LA CITTA' FUTURA

Manifesto della *Green Economy* per l'architettura e l'urbanistica

1. RENDERE LE CITTÀ PROTAGONISTE DELLO SVILUPPO DELLA *GREEN ECONOMY*
2. PUNTARE SULLA RIGENERAZIONE URBANA E SULLA RIQUALIFICAZIONE DEL PATRIMONIO ESISTENTE
3. AFFRONTARE LA SFIDA CLIMATICA CON MISURE DI ADATTAMENTO E DI MITIGAZIONE CENTRATE SULLA RIQUALIFICAZIONE BIOCLIMATICA ED ENERGETICA
4. FARE DELLA QUALITÀ ECOLOGICA E DELLA TUTELA DEL CAPITALE NATURALE LE CHIAVI DEL RILANCIO DELL'ARCHITETTURA E DELL'URBANISTICA
5. TUTELARE E INCREMENTARE IL CAPITALE CULTURALE, LA BELLEZZA E LA QUALITA' DELLE CITTÀ
6. QUALIFICARE GLI EDIFICI PUBBLICI QUALE VOLANO DEL CAMBIAMENTO E PER LA DIFFUSIONE DI PROGETTI INNOVATIVI BASATI SULL'APPROCCIO DEL CICLO DI VITA
7. PROGETTARE UN FUTURO DESIDERABILE

- Attraverso la produzione di servizi ecosistemici, le infrastrutture verdi sono sorgente di **benefici socio – economici per le popolazioni**
- É conveniente identificare e isolare le conseguenze delle infrastrutture verdi in termini di ricchezza misurabile ed osservabile: definirne l' **impatto socio – economico**
- Questo approcio risulterà « di **particolare interesse per le agenzie di sviluppo economico, gli investitori privati, le collettività pubbliche, ecc.** « (Natural Economy Northwest et al., 2010), **perchè fornisce argomenti concreti per l'investimento negli spazi naturali urbani.**

Costruire nuove catene di valore

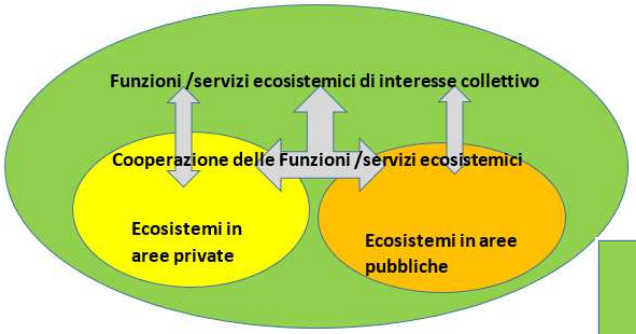


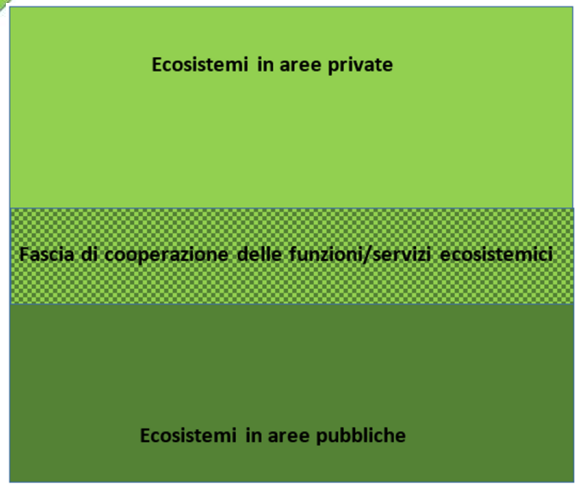
Legame tra benefici e impatti socio – economici

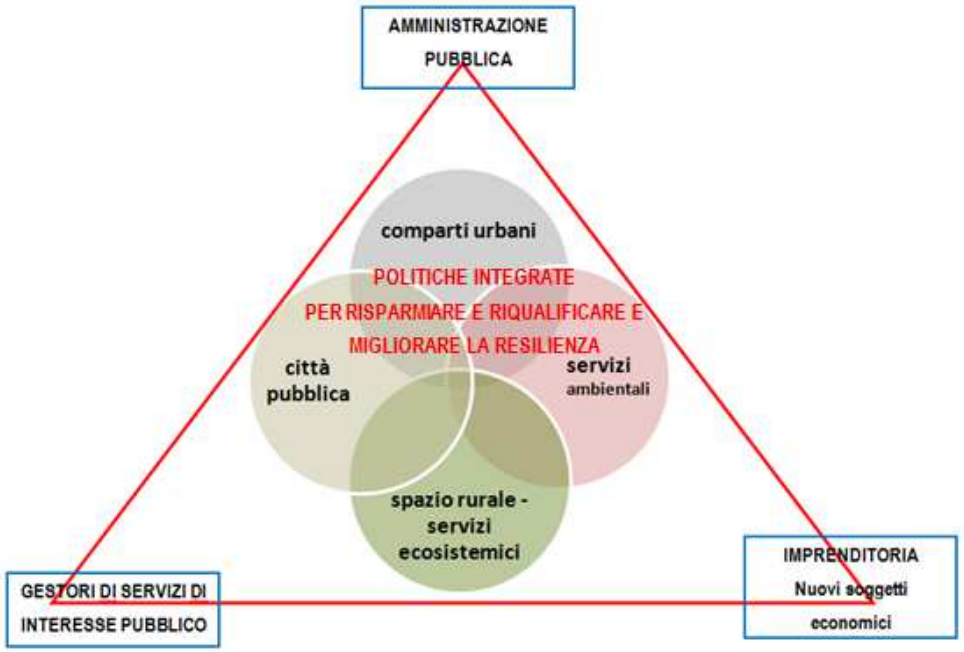
Source : basé sur Naumann et al., 2011a

LES CAHIERS DE BIODIV'2050- COMPRENDRE N°5 - Mars 2015

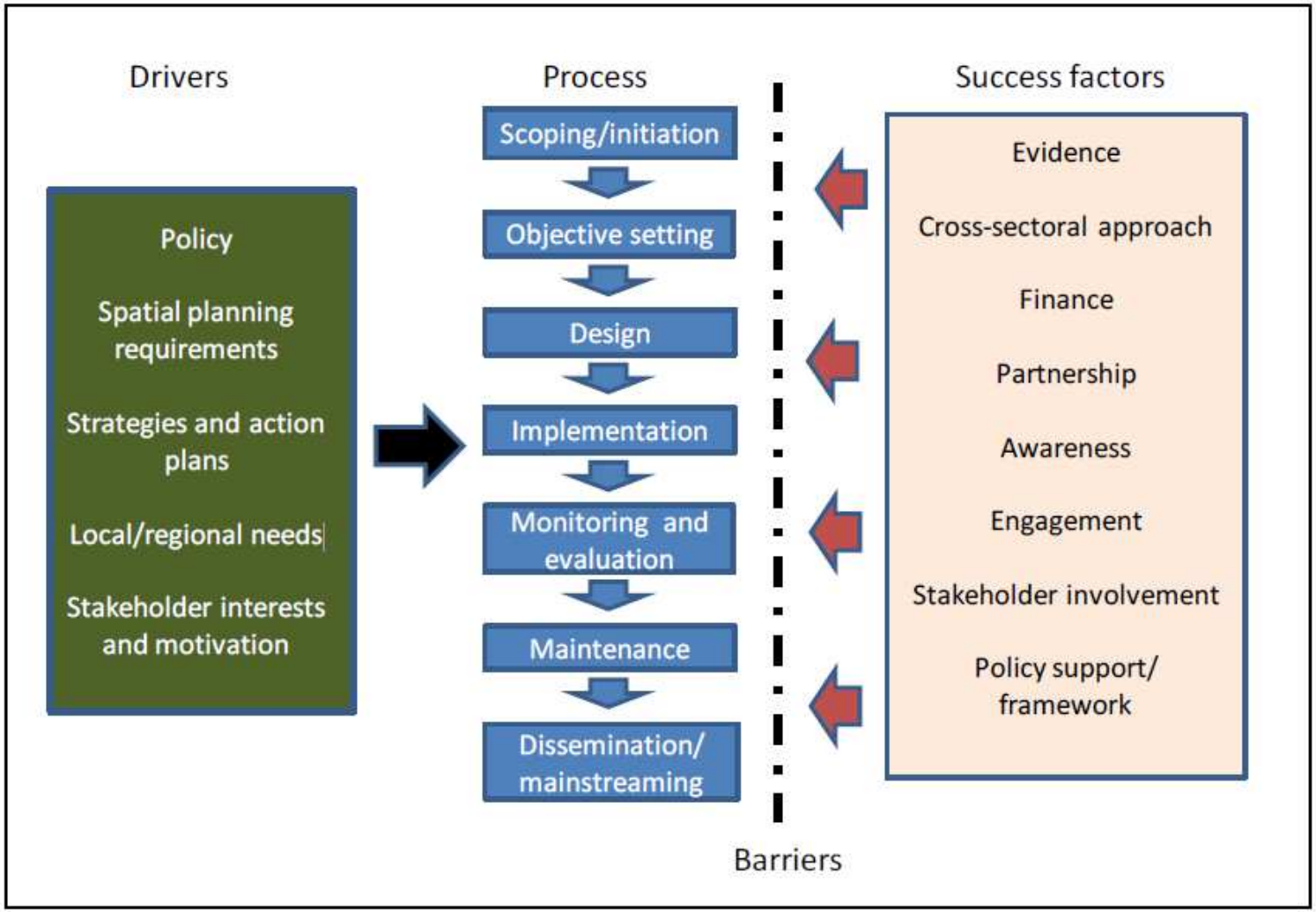
Le NBS sono strutture collaborative, cioè necessitano della collaborazione di più soggetti sia nella fase di progettazione che di gestione; un aspetto cruciale per aumentare le chance di successo è il riconoscimento e coinvolgimento degli stakeholder potenzialmente interessati coi quali costruire nuove filiere di valore per la distribuzione dei vantaggi che possono essere generati.





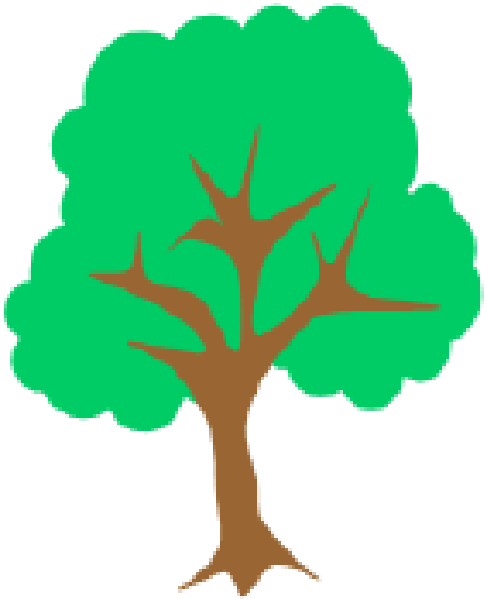


Elements of green infrastructure project design and implementation



Costruire nuove catene di valore

Translating green infrastructure intervention into monetised benefit values

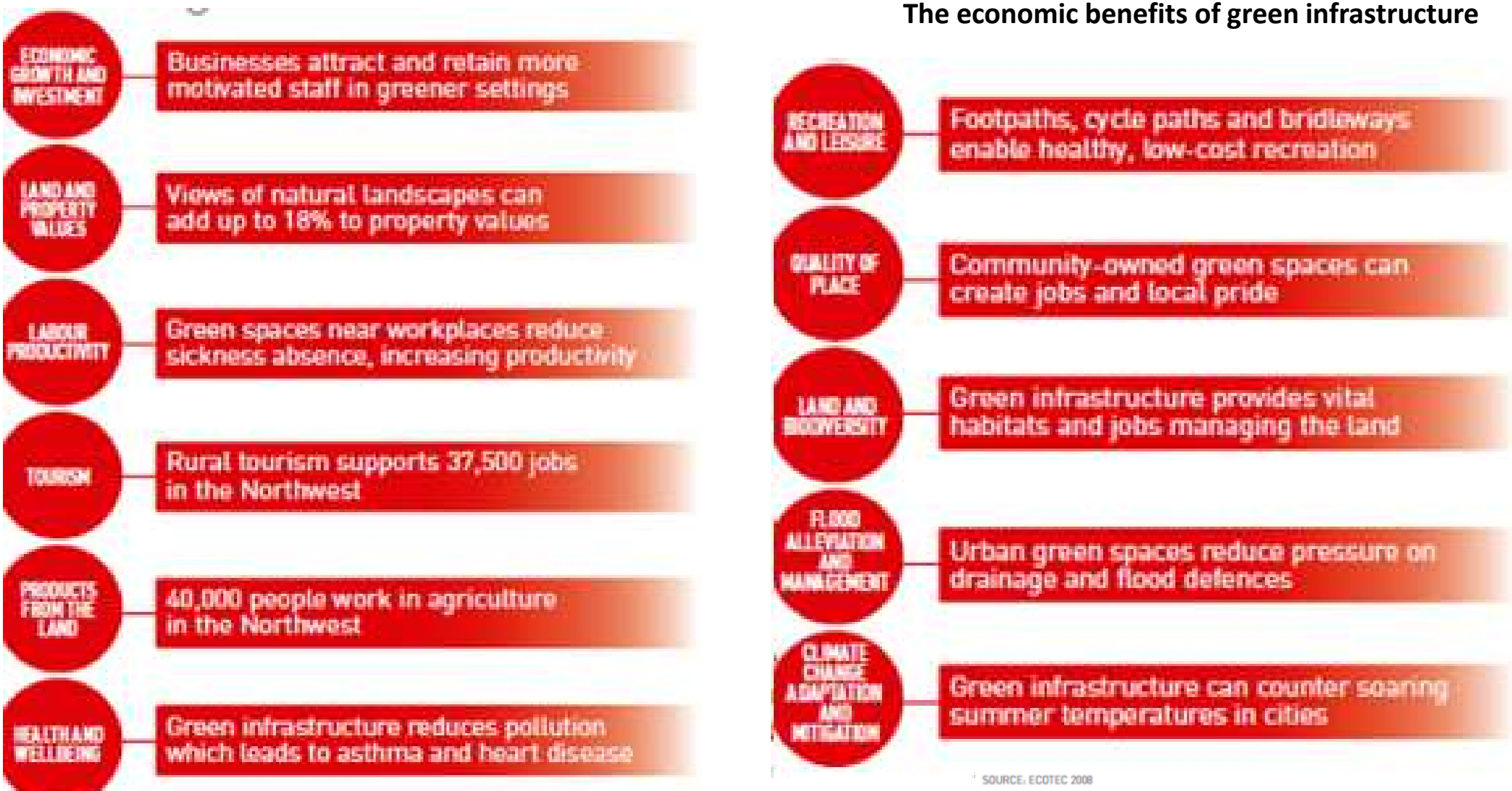


EVAPO-TRANSPIRATION	→	CLIMATE CHANGE ADAPTATION - URBAN COOLING	→	£ REDUCED AIRCONDITIONING COSTS/HEALTH
CARBON SEQUESTRATION	→	CLIMATE CHANGE MITIGATION	→	£ MARKET VALUE OF CO_2 STORED
PARTICULATE FILTERING	→	IMPROVED AIR QUALITY	→	£ REDUCED HEALTH COSTS

GREEN INFRASTRUCTURE ASSET / INTERVENTION	→	GREEN INFRASTRUCTURE FUNCTION	→	GREEN INFRASTRUCTURE BENEFIT	→	GREEN INFRASTRUCTURE VALUE (£)

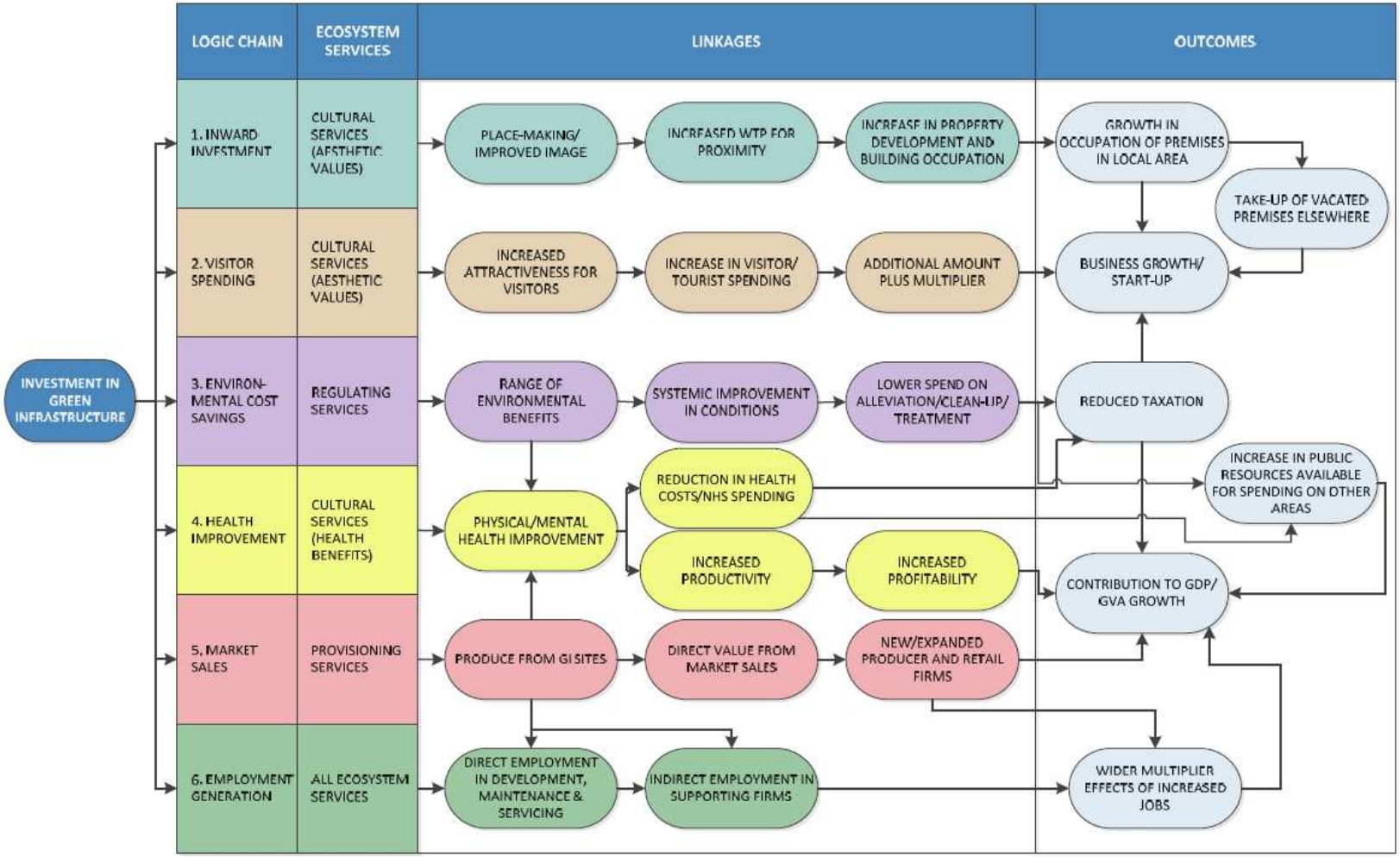
Building natural value for sustainable economic development: The green infrastructure valuation toolkit user guide

The economic benefits of green infrastructure



Costruire nuove catene di valore

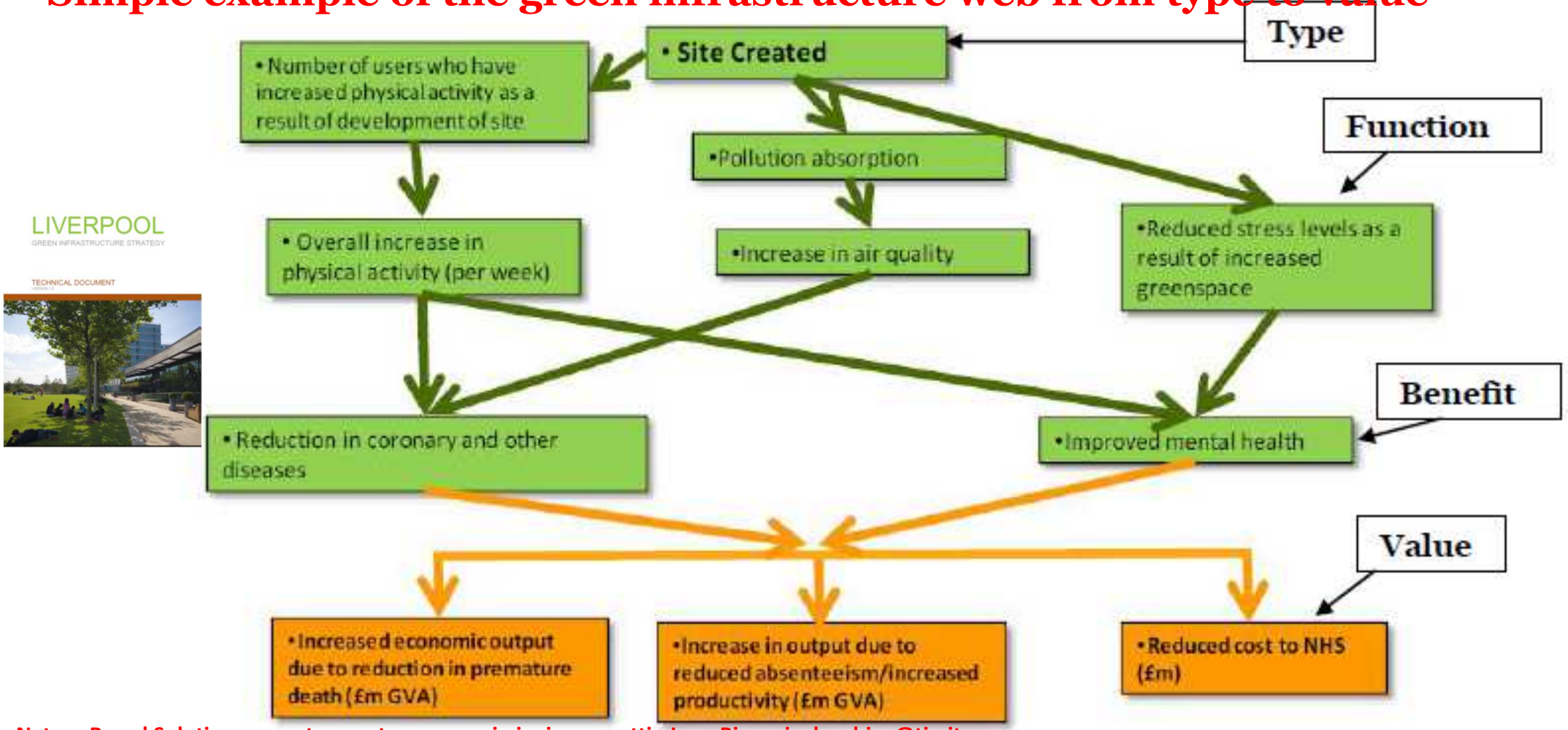
Green Infrastructure and Economic Growth Logic Chains



Green Infrastructure's contribution to economic growth: a review A Final Report for Defra and Natural England July 2013

type → functions → benefit

Simple example of the green infrastructure web from type to value



Benefits of green infrastructure All city stakeholders benefit from green infrastructure.
This chart shows some typical groups involved and the economic, social and environmental benefit to each. © Arup

foresight

Cities Alive

Rethinking green infrastructure

ARUP

top five and top ten ranked components assuming the intention is to maximise the BCR (as opposed to focusing on particular environmental or social priorities).

Table 20: Top-ranked components when aim is to maximise the benefit-cost ratio

Top 5 ranked components			Top 10 ranked components		
Component	Uncertainty		Component	Uncertainty	
	Costs	Benefits		Costs	Benefits
Natura 2000 sites	Moderate	Very high	Natura 2000 sites	Moderate	Very high
Extensive agricultural landscapes	High	High	Extensive agricultural landscapes	High	High
Regional and National parks	Moderate	High	Regional and National parks	Moderate	High
Multi-functional sustainable managed agricultural landscapes	High	High	Multi-functional sustainable managed agricultural landscapes	High	High
Wilderness zones	High	Very high	Wilderness zones	High	Very high
			High nature value farmland	Moderate	High
			Metropolitan park systems	High	Moderate-low
			City reserves	High	Moderate-low
			Ecological networks with cross-border areas	High	High
			Storm ponds and sustainable urban drainage systems	High	Very-high
Overall BCR	**High**	**Very high**	**Overall BCR**	**High**	**Very high**

LEGGE 28 dicembre 2015 , n. 221 . Disposizioni in materia ambientale per promuovere misure di *green economy* e per il contenimento dell'uso eccessivo di risorse naturali.

Art. 70.- *Delega al Governo per l'introduzione di sistemi di remunerazione dei servizi ecosistemici e ambientali*

1. Il Governo è delegato ad adottare, entro sei mesi dalla data di entrata in vigore della presente legge, senza nuovi o maggiori oneri per la finanza pubblica, uno o più decreti legislativi per **l'introduzione di un sistema di pagamento dei servizi ecosistemici e ambientali (PSEA).**

2. I decreti legislativi di cui al comma 1 sono adottati, previa intesa in sede di Conferenza unificata di cui all'articolo 8 del decreto legislativo 28 agosto 1997, n. 281, e successive modificazioni, nel rispetto dei seguenti princìpi e criteri direttivi:

a) **prevedere che il sistema di PSEA sia definito quale remunerazione di una quota di valore aggiunto derivante, secondo meccanismi di carattere negoziale, dalla trasformazione dei servizi ecosistemici e ambientali in prodotti di mercato, nella logica della transazione diretta tra consumatore e produttore, ferma restando la salvaguardia nel tempo della funzione collettiva del bene**;

b) **prevedere che il sistema di PSEA sia attivato, in particolare, in presenza di un intervento pubblico di assegnazione in concessione di un bene naturalistico di interesse comune, che deve mantenere intatte o incrementare le sue funzioni;**

c) **prevedere che nella definizione del sistema di PSEA siano specificamente individuati i servizi oggetto di remunerazione, il loro valore, nonché i relativi obblighi contrattuali e le modalità di pagamento;**

d) **prevedere che siano in ogni caso remunerati i seguenti servizi: fissazione del carbonio delle foreste e dell'arboricoltura da legno di proprietà demaniale, collettiva e privata; regimazione delle acque nei bacini montani; salvaguardia della biodiversità delle prestazioni ecosistemiche e delle qualità paesaggistiche; utilizzazione di proprietà demaniali e collettive per produzioni energetiche;**

***e)* prevedere che nel sistema di PSEA siano considerati interventi di pulizia e manutenzione dell'alveo dei fiumi e dei torrenti;**

***f)* prevedere che sia riconosciuto il ruolo svolto dall'agricoltura e dal territorio agroforestale nei confronti dei servizi ecosistemici, prevedendo meccanismi di incentivazione attraverso cui il pubblico operatore possa creare programmi con l'obiettivo di remunerare gli imprenditori agricoli che proteggono, tutelano o forniscono i servizi medesimi;**

***g)* coordinare e razionalizzare ogni altro analogo strumento e istituto già esistente in materia;**

***h)* prevedere che beneficiari finali del sistema di PSEA siano i comuni, le loro unioni, le aree protette, le fondazioni di bacino montano integrato e le organizzazioni di gestione collettiva dei beni comuni, comunque denominate;**

i) introdurre forme di premialità a beneficio dei comuni che utilizzano, in modo sistematico, sistemi di contabilità ambientale e urbanistica e forme innovative di rendicontazione dell'azione amministrativa;

l) ritenere precluse le attività di stoccaggio di gas naturale in acquiferi profondi.

3. Gli schemi dei decreti legislativi, corredati di relazione tecnica che dia conto della neutralità finanziaria dei medesimi, sono trasmessi alla Camera dei deputati e al Senato della Repubblica affinché su di essi siano espressi, entro trenta giorni dalla data di assegnazione, i pareri delle Commissioni competenti per materia e per i profili finanziari.

Decorso tale termine, i decreti possono essere comunque emanati. Qualora il termine per l'espressione dei pareri parlamentari di cui al presente comma scada nei trenta giorni che precedono o seguono la scadenza del termine previsto al comma 1, quest'ultimo è prorogato di tre mesi.

Examples of Economic Analysis Comparing Green and Grey Infrastructure (Schmidt & Mulligan 2013)

Clean Water Services, Tualatin River, Oregon, USA (2006)	Niemi et al. (2007) compared the costs of reducing thermal pollution of the Tualatin River in Oregon for GI and grey infrastructure options. The study found that the grey option, installing two mechanical chillers to cool water before it is discharged to a stream, would cost USD 60 to USD 150 million. The GI option, establishing riparian forests to shade water and augmenting stream flows with releases from upstream reservoirs, was estimated to cost USD 6 million but came in at USD 4.6 million, realizing a savings of USD 50.4 to USD 145.4 million, relative to the built alternative.
New York City Department of Environmental Protection, New York, USA (2006)	In the late 1990s, in the face of growing development pressures in its largely privately-owned Catskill-Delaware watershed, New York City initiated a plan to protect its source water and avoid the cost of a filtration plant by investing in its 2,000 square mile watershed. A filtration plant would have cost the city USD 8 to USD 10 billion in current dollars - roughly USD 6 billion to build and USD 250 million annually to maintain. In contrast, the cost of securing GI in the watershed was estimated at USD 1.5 billion. The watershed programme has staved off the need to build a filtration plant and provided an annual USD 100 million injection to the rural economy in the upper reaches of the watershed by providing supplemental income to farmers and forestland owners, paying local contractors to install septic systems and set up stormwater protection measures, and by promoting ecotourism (Kenny 2006).
Portland Water District, Portland, Maine, USA (2013)	In the Crooked River Watershed, the World Resources Institute estimates the Portland Water District would save an expected USD 12 million - and possibly as much as USD 110 million - over the next 20 years by investing in GI alternatives to a membrane filtration plant, including conservation easements, reafforestation, culvert upgrades, riparian buffers and forest certification (Talberth et al. 2013b).

2014 United Nations Environment Programme- Green Infrastructure Guide for Water Management: Ecosystem-based management approaches for water-related infrastructure projects - ISBN: 978-92-807-3404-1 -Job Number: DEP/1827/NA

Examples of Economic Analysis Comparing Green and Grey Infrastructure (Schmidt & Mulligan 2013)

Northern Vietnam (2012)	The International Federation of Red Cross and Red Crescent Societies conducted a benefit-cost analysis of a 17-year community-based disaster risk reduction effort by the Viet Nam Red Cross that planted mangroves for shoreline protection. The actual costs of project implementation totaled USD 8.88 million. Estimated benefits of the project include avoided risks to communities (USD 15 million), direct economic benefits through enhanced aqua production and honeybee farming (USD 0.344 to 6.7 million), and avoided CO_2 emissions (USD 218 million) (IFRC 2012).
City of Philadelphia, Pennsylvania, USA (2009)	The City of Philadelphia conducted a benefit-cost analysis comparing several green and grey infrastructure options for controlling combined sewer overflow events in four watersheds (Stratus Consulting 2009). Green options such as tree planting, permeable pavement and green roofs were compared with conventional grey options such as storage tunnels within a benefit-cost framework that considered a wide range of non-market benefits. The net present value (NPV) of GI ranged from USD 1.94 billion to USD 4.45 billion, compared to net grey infrastructure benefits of USD 0.06 billion to USD 0.14 billion over a 40 year period.
Northeast England, UK (2007)	Turner et al. (2007) conducted a benefit-cost analysis to evaluate the economic efficiency of green and grey options for reducing coastal flood risk within the Humber estuary in Northeast England. Many of the flood defense structures along the English coastline are reaching the end of their design lives, and given concerns about sea level rise and increasing severity and frequency of storms on these structures, planners are considering alternative options, namely, managed realignment. Managed realignment involves the repositioning of an existing hard sea defense to a more landward location, thereby allowing more space for the creation of intertidal habitat. The "extended deep green" scenarios that emphasized managed realignment had positive NPVs over a longer timeframe, indicating that managed realignment can be more economically efficient than holding the line through repair and maintenance of sea walls over a period of 25 years.

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Benefit	Step 1: **Benefit Quantification** resource unit(s)	Step 2: **Benefit Valuation** resource unit * price	Annual Benefit $
Reduces Stormwater Runoff	**Annual Stormwater Retention Performance:** 71,100 gal retained *(Example 1.1)*	**Value of Annual Avoided Treatment Cost:** 71,100 gal * $0.0000919/gal = $6.53 *(Example 1.6)*	$6.53
Reduces Energy Use	**Annual Building's Cooling (electricity) Savings (kWh):** 1,122 kWh *(Example 2.1)*	**Value of Annual Building's Cooling Savings:** 1,122 kWh* $0.0959/ kWh = $107.60 *(Example 2.5)*	
	Annual Building's Heating Natural Gas Savings (Btu): 36,158,750 Btu *(Example 2.2)*	**Value of Annual Building's Heating Savings:** 36,158,750 Btu * $0.0000123/Btu = $444.75 *(Example 2.5)*	
	Annual Off-site Water Treatment Electricity Savings (reduced treatment needs of 71,100 gal): 110.77 kWh *(Example 2.4)*	Annual Off-site Water Treatment Electricity Savings will not be valued here because the value has already been accounted for above *(Example 1.6)*.	
	Total Annual Electricity Savings (kWh, from on-site and off-site benefits): ∑ 1,122 kWh in cooling savings + 110.77 kWh in water treatment electricity savings = 1,232.77 kWh	The Total Annual Electricity Savings will not be valued here to prevent double counting. Instead, it is used to quantify "Air" and "Climate" benefits.	$107.60 + $444.75
Improves Air Quality *Note: The figures used here only account for the benefits of reduced NO_2. Similar steps should be performed for the other criteria pollutants, when possible.*	**Annual Direct NO_2 Uptake:** Lower Bound = 1.50 lbs NO_2 Upper Bound = 2.39 lbs NO_2 Average = 1.95 lbs NO_2 *(Example 3.1)*	**Value of Total Annual NO_2 Benefit:** 30.19 lbs NO_2 * $3.34/lb NO_2 = $100.83 *(Example 3.6)*	
	Annual Indirect Reduction in NO_2 Emissions (from reduced electricity and natural gas): 28.24 lbs NO_2 *(Example 3.5)*		
	Total Annual NO_2 Benefit (Direct uptake using the average NO_2 uptake value + Indirect avoided emissions): ∑ 1.95 lbs NO_2 + 28.24 lbs NO_2 = 30.19 lbs NO_2 *(Example 3.6)*		$100.83
Reduces Atmospheric CO_2	**Total Annual Indirect Benefit** (from electricity and heating natural gas savings): 1,639.58 lbs CO_2 + 4,226.6 lbs CO_2 = 5,866.18 lbs CO_2 *(Example 4.5)*	**Value of Total Annual Climate Benefit:** 6,486.41 lbs CO_2 * $0.00756/ lb CO_2 = $49.04 in total annual climate benefits *(Example 4.6a)*	
	Annual Direct Carbon Sequestration Benefit in CO_2 Equivalent (multiplying lbs C from Example 4.1 by conversion factor): = 620.23 lbs CO_2 *(Example 4.6)*	*Note: Here the lower bound (EU's ETS Carbon Price) of the range of carbon pricing was used. Keep in mind that this provides a conservative estimate of the economic, environmental and other social values of carbon abatement.*	
	Total Annual Climate Benefit (Direct + Indirect): ∑ 620.23 lbs CO_2 + 5,866.18 lbs CO_2 = 6,486.41 lbs CO_2 *(Example 4.6)*		$49.04
		Total Annual Benefit (∑ Annual Benefits)	**$708.75**

The Value of Green Infrastructure A Guide to Recognizing Its Economic, Environmental and Social Benefits

Building natural value for sustainable economic development: the green infrastructure valuation toolkit user guide

Appendix 3: Tool index

Benefit groups	Functions	Tools	Tool Outputs: Monetary	Quantitative	Qualitative		Recommended timeframe for value assessment
1. CLIMATE CHANGE ADAPTATION & MITIGATION	Shelter from wind	1.1 Reduced building energy consumption for heating	□	□	■	*Monetization and quantification functional for residential properties only*	10 years
		1.2 Avoided carbon emissions from building energy saving for heating	□	□	■	*Monetization and quantification functional for residential properties only*	10 years
		1.3 Avoided damage from wind and storms	X	X	■	*Monetization and quantification require further research*	t.b.d.
	Reduction of urban heat island effect	1.4 Reduction of peak summer surface temperatures	X	■	■	*Monetization requires further reserch*	t.b.d.
	Cooling through shading and evapo- transpiration	1.5 Reduced energy consumtion for cooling	■	■	■		10 years
		1.6 Avoided carbon emissions from building energy saving for cooling	□	□	■	*Monetization and quantification functional for green roofs only*	10 years
	Carbon storage and sequestration	1.7 Carbon stored and sequestered in woodland and forests	□	□	■	*Monetization and quantification functional for broadleaf woodland only*	50 years, benefit accrual period 20-25 years with new tree planting
		1.8 Carbon stored and sequestered in non-woodland based landscapes	X	X	■	*Monetization and quantification require further research*	
2. WATER MANAGEMENT & FLOOD ALLEVIATION	Interception, storage and infiltration of rainwater	2.1 Energy and carbon emissions savings from reduced stormwater volume entering combined sewers	■	■	■		
		2.2 Reduced wastewater treatment costs for domestic and commercial water customers	■	■	■		
		2.3 Avoided costs of traditional water drainage infrastructure	X	X	■	*Monetization and quantification requires access to avera construction costs data*	
3. PLACE & COMMUNITIES	Catalyst for community cohesion and pride	3.1 Willingness to pay for a view of urban green space	X	X	■	*Monetization and quantification requires further researc*	
		3.2 Increase in volunteering	X	□	■	*Monetization requires bespoke appraisal. Quantificatio requires access to good project data.*	
4. HEALTH & WELLBEING	Provision of attractive opportunities for exercise	4.1 Health costs savings from increase in physical activity	X	X	■	*Monetization and quantification require further research*	
		4.2 Reduced mortality from increased walking and cycling	■	■	■		
	Stress and mental illness alleviation	4.3 Health cost savings from mental health disorders	X	X	■	*Monetization and quantification require further research*	
	Healing time reduction	4.4 Health cost savings from reduced in-patient stays	X	X	■	*Monetization and quantification require further research*	
	Air pollution removal	4.5 Reduced mortality from respiratory illnesses	X	X	■	*Monetization and quantification require further research*	
		4.6 Avoided costs for air pollution control measures	■	■	■		
5. LAND AND PROPERTY VALUES	Setting for higer value residential and commercial properties	5.1 Residential land and property values uplift	■	■	■		n.a.
		5.2 Commercial land and property values uplift	X	□	■	*Monetization requires further research. Quantification requires access to good project data.*	t.b.d.
6. INVESTMENT	Setting for inward investment	6.1 Private sector investment levered	X	X	■	*Monetization and quantification require further research*	10 years
		6.2 Employment creation	X	X	■	*Monetization and quantification require further research*	10 years
		6.3 Image enhancement	X	X	■	*Monetization and quantification require further research*	10 years
7. LABOUR PRODUCTIVITY	Reduction of absenteism from work	7.1 Savings from reduced employee turnover	X	X	■	*Monetization and quantification require further research*	10 years, benefit accrual period first 5 years
	Labor productivityimprovement	7.2 Increase in labour productivity	X	X	■	*Monetization and quantification require further research*	10 years
	Attraction and retaintion of high quality staff	7.3 Savings from reduced absenteism from work	□	□	■	*Monetization and quantification based on proportion of workforce cycling or walking to work*	5 years
8. TOURISM	Tourism attraction	8.1 Tourism expenditure	■	■	■		10 years
		8.2 Employment supported by tourism	□	□	■	*Monetization and quantification require good project data.*	10 years
9. RECREATION & LEISURE	Provision of recreation opportunities	9.1 Recreational use by the local population	■	■	■		10 years
10. BIODIVERSITY	Provision, protection and enhancement of natural habitats	10.1 Willingness to pay for protection or enhancement of biodiversity	■	■	■		10 years
11. LAND MANAGEMENT	Production of food, timber and industrial crops	11.1 Market value of products	X	X	■	*Monetization and quantification require bespoke appraisal*	10 years
	Land management	11.2 Employment suported by land management	■	■	■		8 years

GRAZIE PER L'ATTENZIONE