



Università di Catania



AGRICOLTURA, ALIMENTAZIONE E AMBIENTE



Energy and Water Agency



Comune di Aci Castello



Rabat Local Council



Regione Siciliana
Assessorato Regionale delle Infrastrutture e della Mobilità - Dipartimento Regionale Tecnico



Ministero della Giustizia



Associazione Idrotecnica Italiana ETS
Dal 1923 L'ASSOCIAZIONE PER IL BENE
Sezione Sicilia Orientale
Dal 1969 IN SICILIA PER L'ACQUA



Ordine Regionale Geologi Sicilia



Centro Studi di Economia applicata all'Ingegneria



Regione Siciliana
Assessorato dei beni culturali e dell'identità siciliana - Dipartimento dei Beni Culturali e dell'Identità Siciliana



Fondo Europeo di Sviluppo Regionale
European Regional Development Fund

Green Infrastructures to mitigate Flood risks in Urban and sub-urban areas and to Improve the quality of rainwater Discharges

Le soluzioni basate sulla natura per la gestione dei deflussi in ambito urbano e suburbano: dai risultati del progetto GIFLUID alle attività del progetto CARDIMED

Prof. Giuseppe CIRELLI



AGRICOLTURA, ALIMENTAZIONE E AMBIENTE

Ing. Anacleto Rizzo



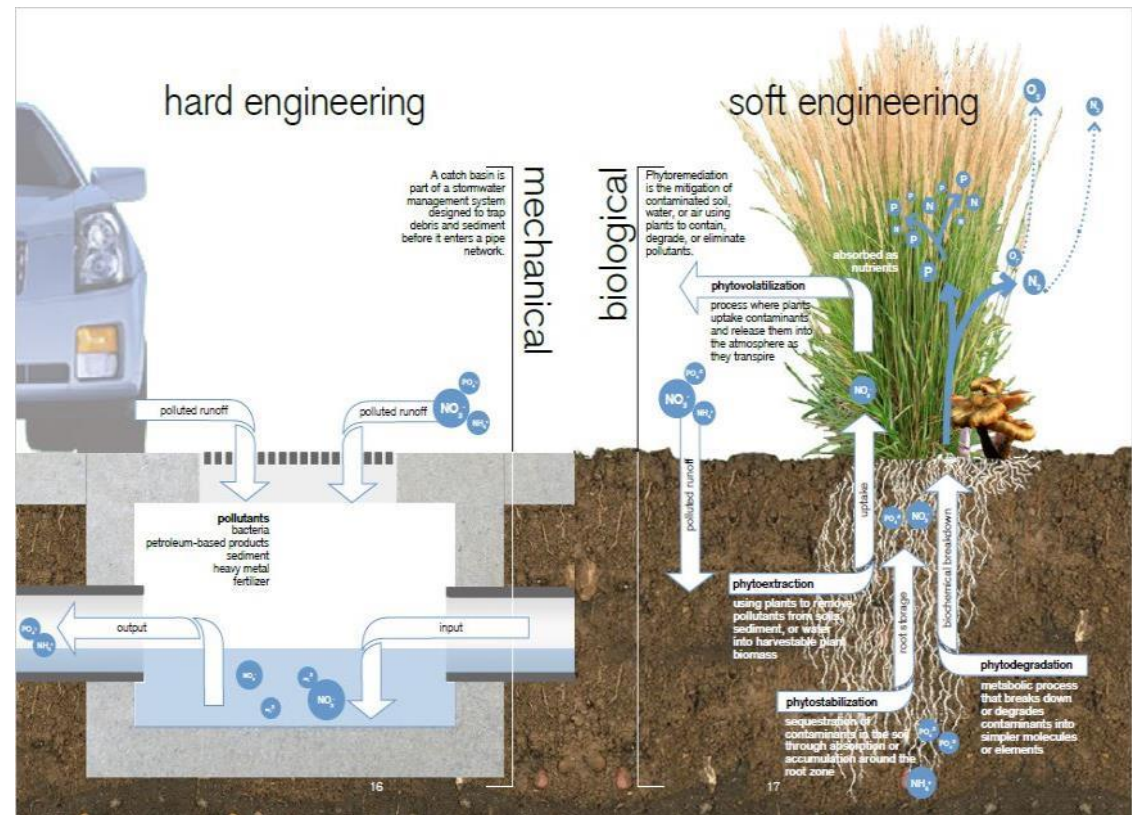
Aula Magna del Polo Bioscientifico

Venerdì 17 novembre 2023

- **Introduzione e definizioni**
- **Tecniche e Scale di applicazione SuDS**
- **Da GIFFLUID a CARDIMED**



Introduzione e definizioni

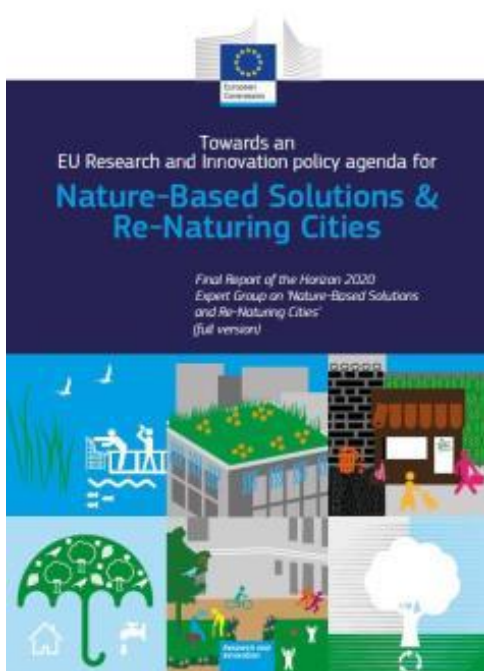


Fonte: Huber, J., 2010. *Low Impact Development: a Design Manual for Urban Areas*

Introduzione e definizioni

Nature-based solutions

*“La Commissione Europea definisce le **Nature-based Solutions (NbS)** come risposte alle sfide sociali che sono ispirate e sostenute dalla natura, che sono economicamente efficaci, forniscono simultaneamente benefici ambientali, sociali ed economici e aiutano a costruire la resilienza.”*



Introduzione e definizioni

Città spugna

Sponge city (città spugna) è un termine coniato in Cina e riguarda lo sviluppo di città in grado di assorbire l'acqua piovana come delle "spugne", e quindi di ridurre i rischi di allagamento in ambiente urbano dovuti all'eccessiva impermeabilizzazione

Can 'sponge cities' solve China's urban flooding problem?

WADE SHEPARD JULY 28, 2016

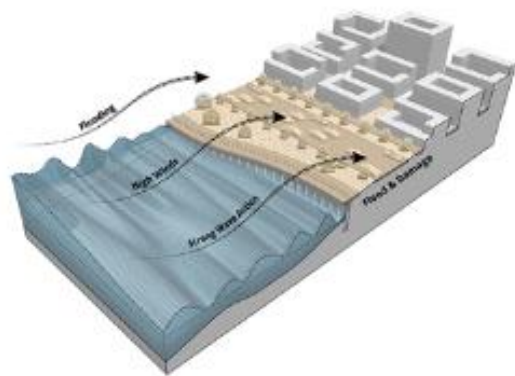


Floods in cities across China this year have caused as much as US\$45 billion worth of damage. (Paul Gonzalez/flickr/cc)



Introduzione e definizioni

Cambiamenti climatici e allagamenti



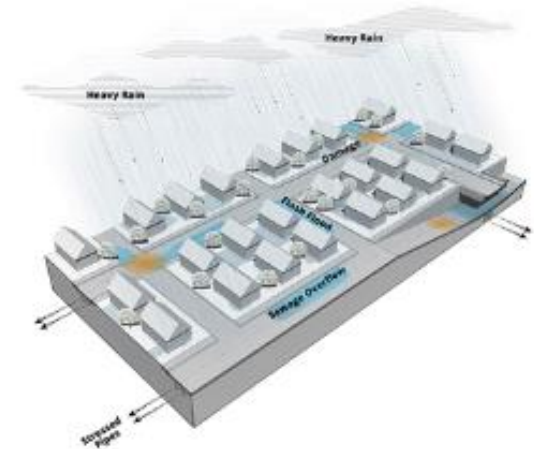
COASTAL FLOODING

Flooding to coastal areas caused by waves / storm surge during a storm



RIVERINE FLOODING

Flooding caused by high river levels



STORMWATER FLOODING

Localized flooding in a community caused by heavy rains

 Naturally **RESILIENT** Communities

<https://nrcsolutions.org/>

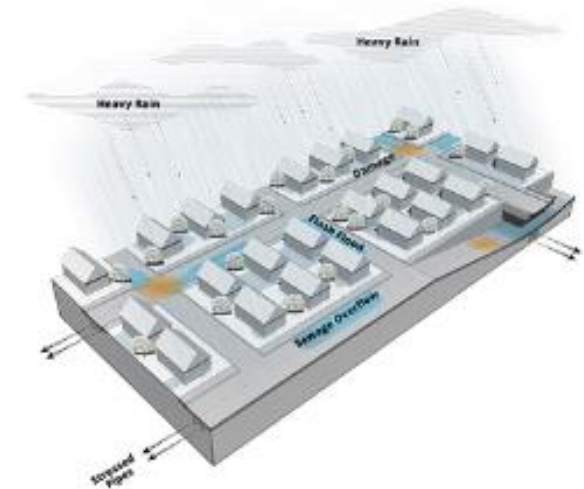
Introduzione e definizioni

Drenaggio urbano sostenibile

Conosciuta con diverse parole chiave:

- SuDS Sustainable drainage systems
- WSUD Water Sensitive Urban Design
- LID Low impact development
- BMP Best management practices

Urban Water Journal, 2014
<http://dx.doi.org/10.1080/1573062X.2014.916314>

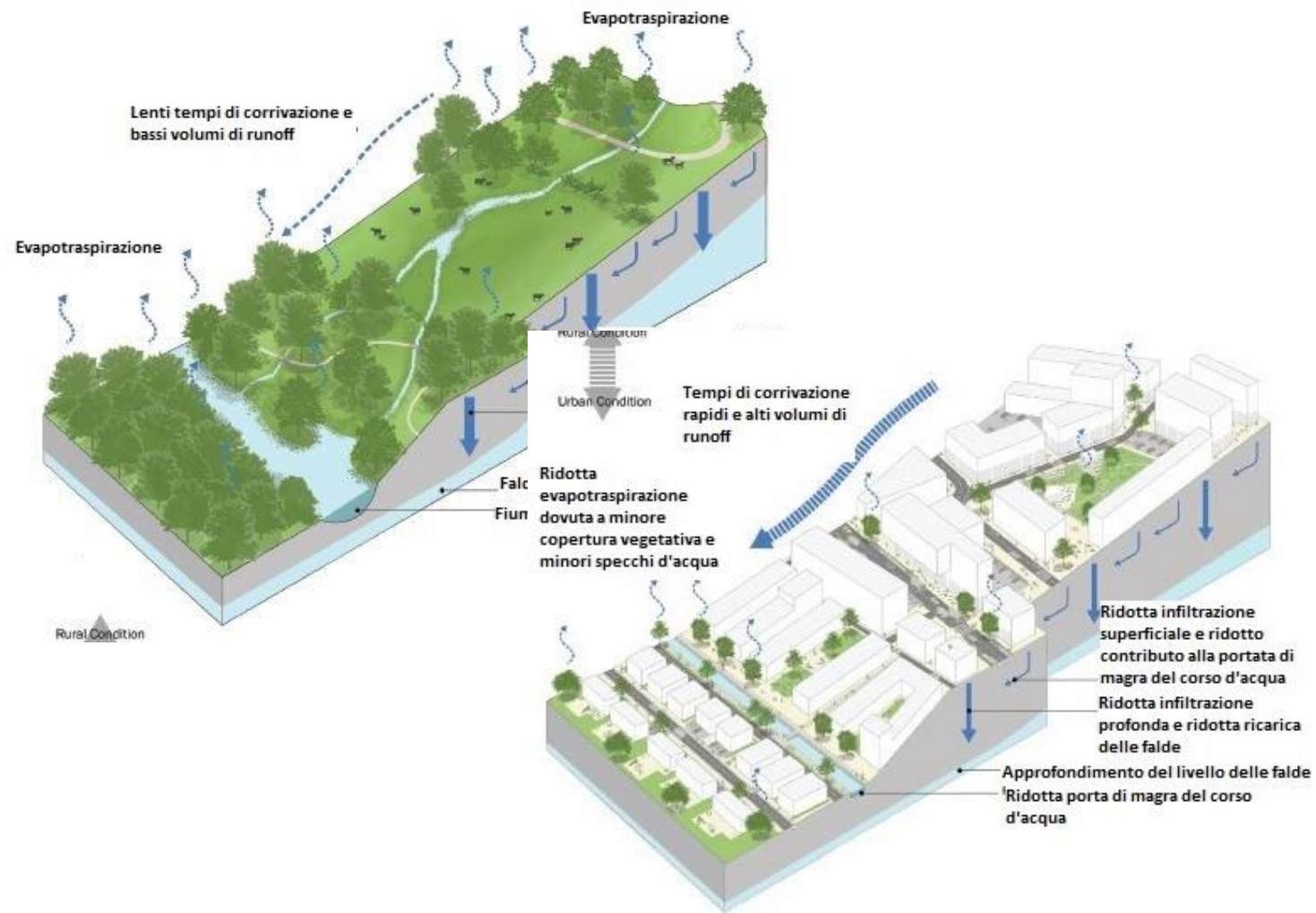


STORMWATER FLOODING

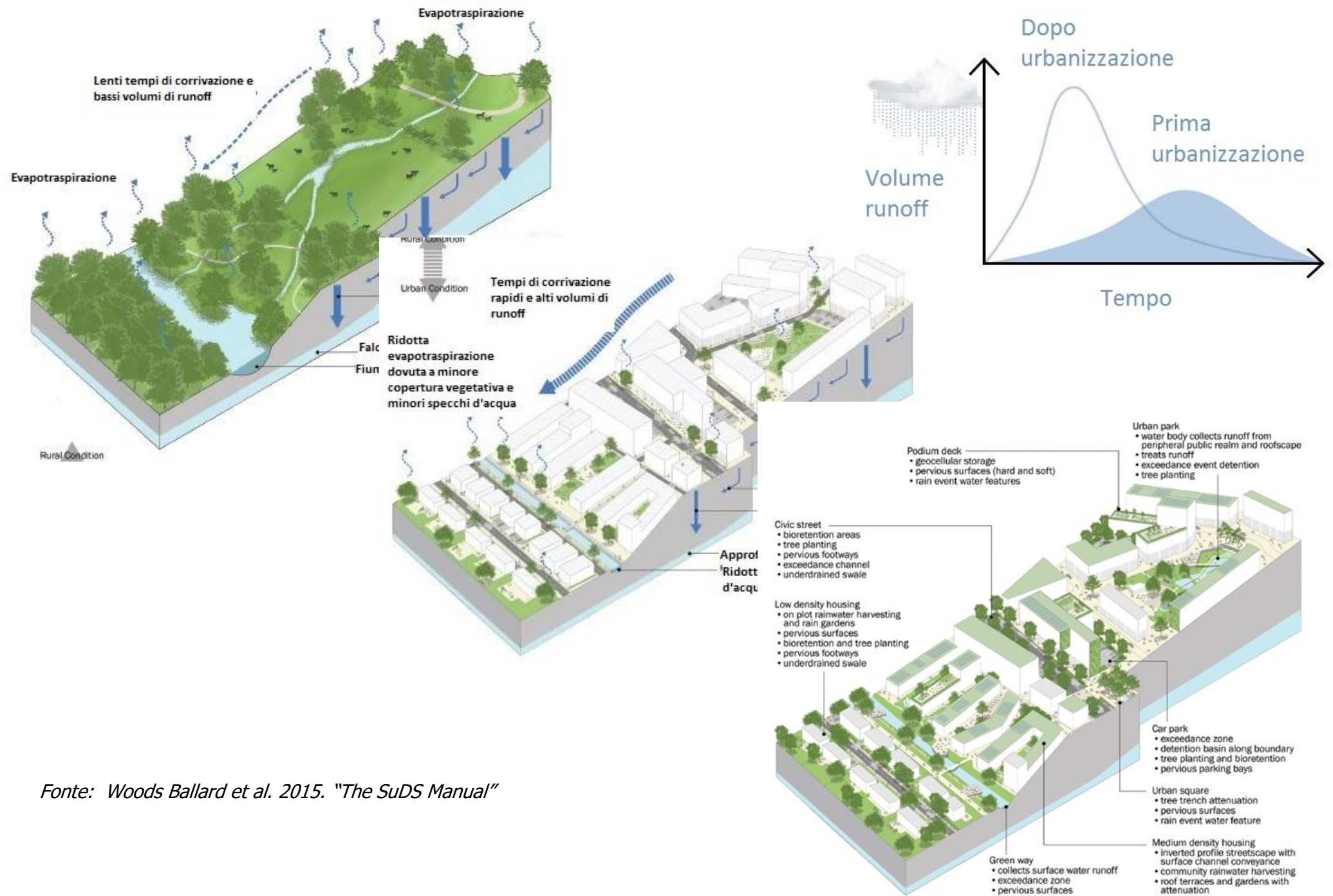
RESEARCH ARTICLE

SUDS, LID, BMPs, WSUD and more – The evolution and application of terminology surrounding urban drainage

Tim D. Fletcher^{a*}, William Shuster^b, William F. Hunt^c, Richard Ashley^d, David Butler^e, Scott Arthur^f, Sam Trowsdale^g, Sylvie Barraud^h, Annette Semadeni-Daviesⁱ, Jean-Luc Bertrand-Krajewski^h, Peter Steen Mikkelsen^j, Gilles Rivard^k, Mathias Uhl^l, Danielle Dagenais^m and Maria Viklanderⁿ



Fonte: Woods Ballard et al. 2015. "The SuDS Manual"

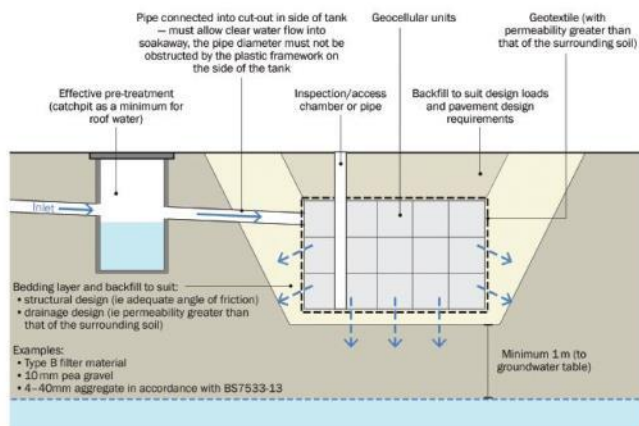


Fonte: Woods Ballard et al. 2015. "The SuDS Manual"

Introduzione e definizioni

Infrastrutture grigie

Pozzi perdenti



Sistemi di trattamento tecnologici



Pavimentazioni permeabili e porose



Vasche di laminazione interrata

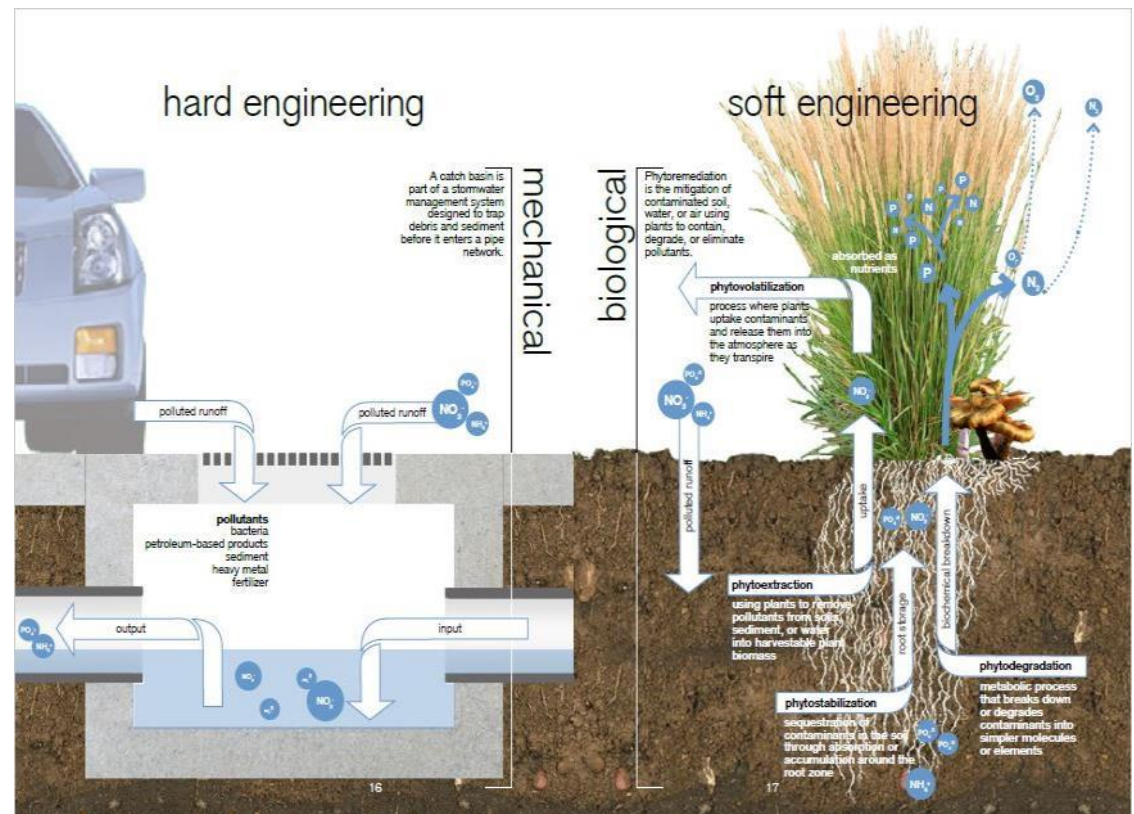
Fonte: Woods Ballard et al. 2015. "The SuDS Manual"

Introduzione e definizioni

Servizi ecosistemici

13 esempi di **Servizi Ecosistemici** forniti da soluzioni naturali - *Soft Engineering* - per il drenaggio urbano delle acque di pioggia rispetto agli approcci tradizionali - *Hard Engineering*:

1. regolazione atmosferica
2. regolazione climatica
3. regolazione idrica
4. recupero delle acque
5. controllo dell'erosione e trattamento dei sedimenti
6. formazione di suolo
7. bilanciamento cicli dei nutrienti
8. riduzione carico inquinante sfruttando i processi naturali
9. pollinazione
10. aumento biodiversità
11. produzione di biomasse
12. aumento aree ricreative
13. educazione ambientale



Fonte: Huber, J., 2010. *Low Impact Development: a Design Manual for Urban Areas*

Introduzione e definizioni

Infrastrutture verdi e NBS

Tetti verdi



*Trincee infiltranti e bacini di
detenzione asciutti*



Canali



Aree di bioritenzione (rain garden)



Box alberati filtranti



Stagni



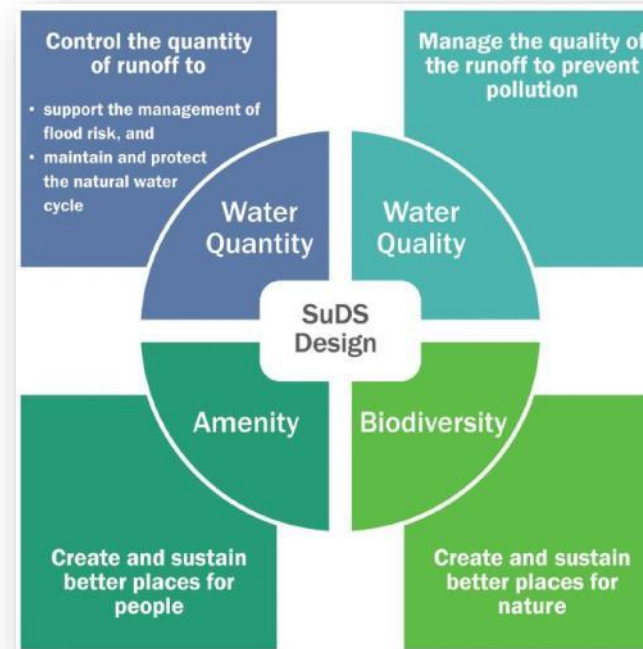
Fonte: Woods
Ballard et al. 2015.
"The SuDS
Manual"

Introduzione e definizioni

Progettazione multiobiettivo

TABLE 7.1 SuDS component delivery of design criteria

| Component type | Description | Collection mechanism | Design criteria | | | | | |
|-------------------------------|--|----------------------|------------------------------|----------------|---|---------------------------|---------------------|--------------------------|
| | | | Water quantity (Chapter 3) | | | Water quality (Chapter 4) | Amenity (Chapter 5) | Biodiversity (Chapter 6) |
| | | | Peak runoff rate | Runoff volumes | | | | |
| | | | Small events (Interceptions) | Large events | | | | |
| Rainwater harvesting systems | Systems that collect runoff from the roof of a building or other paved surface for use | P | | • | • | | • | |
| Green roofs | Planted soil layers on the roof of buildings that slow and store runoff | S | ○ | • | | • | • | • |
| Infiltration systems | Systems that collect and store runoff, allowing it to infiltrate into the ground | P | • | • | • | • | • | • |
| Proprietary treatment systems | Subsurface structures designed to provide treatment of runoff | P | | | | • | | |
| Filter strips | Grass strips that promote sedimentation and filtration as runoff is conveyed over the surface | L | | • | | • | ○ | ○ |
| Filter drains | Shallow stone-filled trenches that provide attenuation, conveyance and treatment of runoff | L | • | ○ | | • | ○ | ○ |
| Swales | Vegetated channels (sometimes planted) used to convey and treat runoff | L | • | • | • | • | • | • |
| Bioretention systems | Shallow landscaped depressions that allow runoff to pond temporarily on the surface, before filtering through vegetation and underlying soils | P | • | • | • | • | • | • |
| Trees | Trees within soil-filled tree pits, tree planters or structural soils used to collect, store and treat runoff | P | • | • | | • | • | • |
| Pervious pavements | Structural paving through which runoff can soak and subsequently be stored in the sub-base beneath, and/or allowed to infiltrate into the ground below | S | • | • | • | • | ○ | ○ |
| Attenuation storage tanks | Large, below-ground voided spaces used to temporarily store runoff before infiltration, controlled release or use | P | • | | | | | |
| Detention basins | Vegetated depressions that store and treat runoff | P | • | • | | • | • | • |
| Ponds and wetlands | Permanent pools of water used to facilitate treatment of runoff – runoff can also be stored in an attenuation zone above the pool | P | • | | | • | • | • |



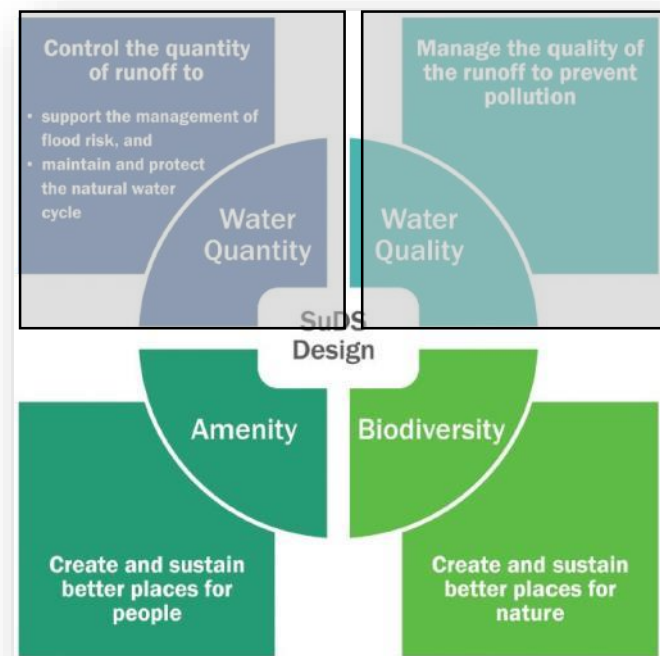
Fonte: Woods Ballard et al. 2015. "The SuDS Manual"

Introduzione e definizioni

Progettazione multiobiettivo

TABLE 7.1 SuDS component delivery of design criteria

| Component type | Description | Collection mechanism | Design criteria | | | | | |
|-------------------------------|--|----------------------|------------------------------|----------------|---|---------------------------|---------------------|--------------------------|
| | | | Water quantity (Chapter 3) | | | Water quality (Chapter 4) | Amenity (Chapter 5) | Biodiversity (Chapter 6) |
| | | | Peak runoff rate | Runoff volumes | | | | |
| | | | Small events (Interceptions) | Large events | | | | |
| Rainwater harvesting systems | Systems that collect runoff from the roof of a building or other paved surface for use | P | | • | • | | • | |
| Green roofs | Planted soil layers on the roof of buildings that slow and store runoff | S | ○ | • | | • | • | • |
| Infiltration systems | Systems that collect and store runoff, allowing it to infiltrate into the ground | P | • | • | • | • | • | • |
| Proprietary treatment systems | Subsurface structures designed to provide treatment of runoff | P | | | | • | | |
| Filter strips | Grass strips that promote sedimentation and filtration as runoff is conveyed over the surface | L | | • | | • | ○ | ○ |
| Filter drains | Shallow stone-filled trenches that provide attenuation, conveyance and treatment of runoff | L | • | ○ | | • | ○ | ○ |
| Swales | Vegetated channels (sometimes planted) used to convey and treat runoff | L | • | • | • | • | • | • |
| Bioretention systems | Shallow landscaped depressions that allow runoff to pond temporarily on the surface, before filtering through vegetation and underlying soils | P | • | • | • | • | • | • |
| Trees | Trees within soil-filled tree pits, tree planters or structural soils used to collect, store and treat runoff | P | • | • | | • | • | • |
| Pervious pavements | Structural paving through which runoff can soak and subsequently be stored in the sub-base beneath, and/or allowed to infiltrate into the ground below | S | • | • | • | • | ○ | ○ |
| Attenuation storage tanks | Large, below-ground voided spaces used to temporarily store runoff before infiltration, controlled release or use | P | • | | | | | |
| Detention basins | Vegetated depressions that store and treat runoff | P | • | • | | • | • | • |
| Ponds and wetlands | Permanent pools of water used to facilitate treatment of runoff – runoff can also be stored in an attenuation zone above the pool | P | • | | | • | • | • |



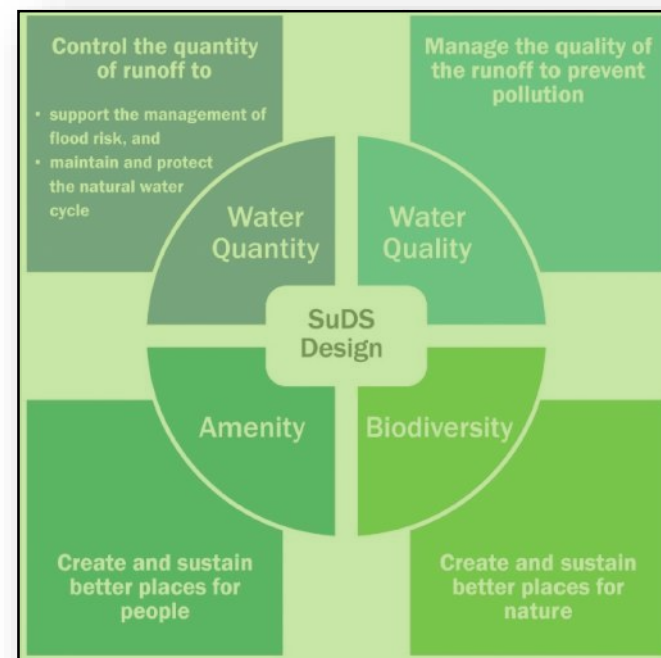
Fonte: Woods Ballard et al. 2015. "The SuDS Manual"

Introduzione e definizioni

Progettazione multiobiettivo

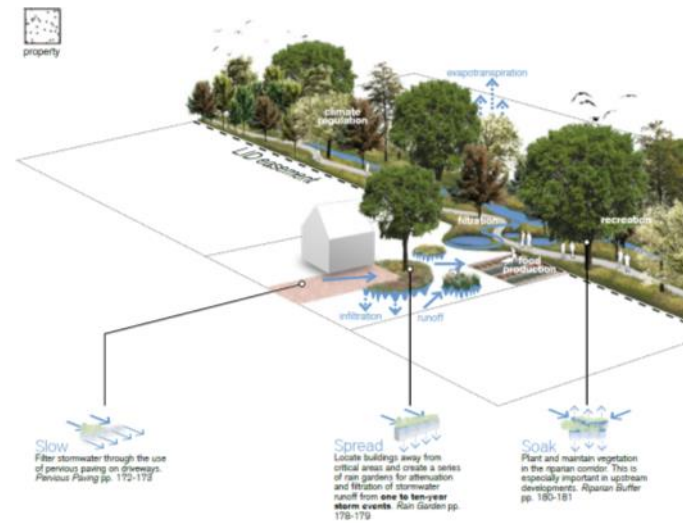
TABLE 7.1 SuDS component delivery of design criteria

| Component type | Description | Collection mechanism | Design criteria | | | | | |
|-------------------------------|--|----------------------|------------------------------|----------------|---|---------------------------|---------------------|--------------------------|
| | | | Water quantity (Chapter 3) | | | Water quality (Chapter 4) | Amenity (Chapter 5) | Biodiversity (Chapter 6) |
| | | | Peak runoff rate | Runoff volumes | | | | |
| | | | Small events (Interceptions) | Large events | | | | |
| Rainwater harvesting systems | Systems that collect runoff from the roof of a building or other paved surface for use | P | | • | • | | • | |
| Green roofs | Planted soil layers on the roof of buildings that slow and store runoff | S | ○ | • | | • | • | • |
| Infiltration systems | Systems that collect and store runoff, allowing it to infiltrate into the ground | P | • | • | • | • | • | • |
| Proprietary treatment systems | Subsurface structures designed to provide treatment of runoff | P | | | | • | | |
| Filter strips | Grass strips that promote sedimentation and filtration as runoff is conveyed over the surface | L | | • | | • | ○ | ○ |
| Filter drains | Shallow stone-filled trenches that provide attenuation, conveyance and treatment of runoff | L | • | ○ | | • | ○ | ○ |
| Swales | Vegetated channels (sometimes planted) used to convey and treat runoff | L | • | • | • | • | • | • |
| Bioretention systems | Shallow landscaped depressions that allow runoff to pond temporarily on the surface, before filtering through vegetation and underlying soils | P | • | • | • | • | • | • |
| Trees | Trees within soil-filled tree pits, tree planters or structural soils used to collect, store and treat runoff | P | • | • | | • | • | • |
| Pervious pavements | Structural paving through which runoff can soak and subsequently be stored in the sub-base beneath, and/or allowed to infiltrate into the ground below | S | • | • | • | • | ○ | ○ |
| Attenuation storage tanks | Large, below-ground voided spaces used to temporarily store runoff before infiltration, controlled release or reuse | P | • | | | | | |
| Detention basins | Vegetated depressions that store and treat runoff | P | • | • | | • | • | • |
| Ponds and wetlands | Permanent pools of water used to facilitate treatment of runoff – runoff can also be stored in an attenuation zone above the pool | P | • | | | • | • | • |



Fonte: Woods Ballard et al. 2015. "The SuDS Manual"

Tecniche e Scale di applicazione SuDS



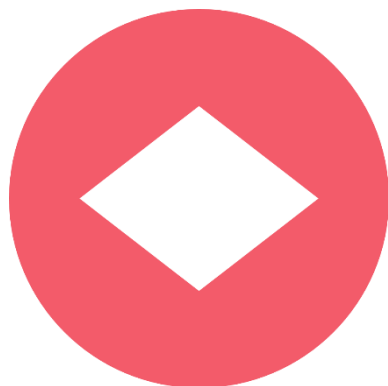
Fonte: Huber, J., 2010. *Low Impact*

Development: a Design Manual for Urban Areas



Drenaggio urbano sostenibile

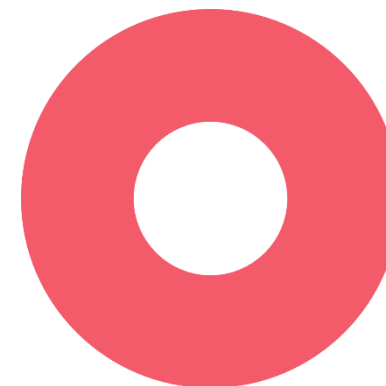
Classificazione tecniche



**Soluzioni
superficiali**



**Soluzioni
lineari**



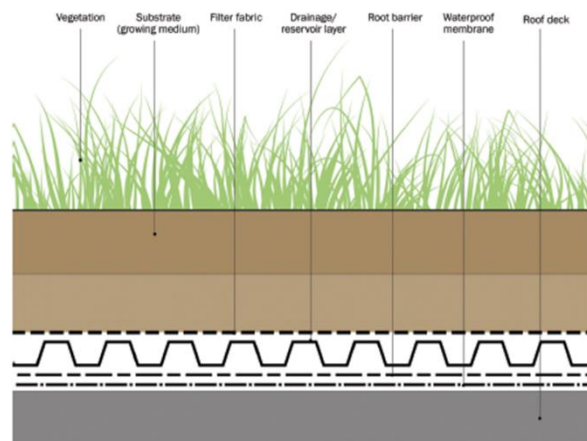
**Soluzioni
puntuali**



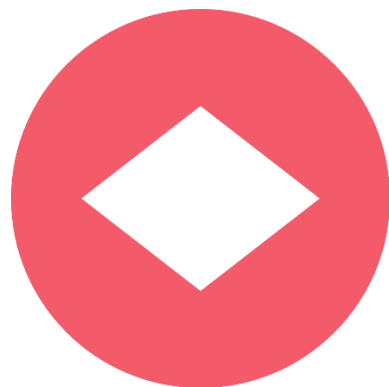
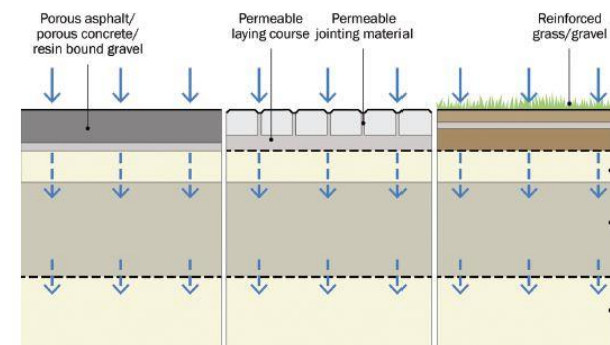
Drenaggio urbano sostenibile

Classificazione tecniche

Tetti verdi



Pavimentazioni permeabili



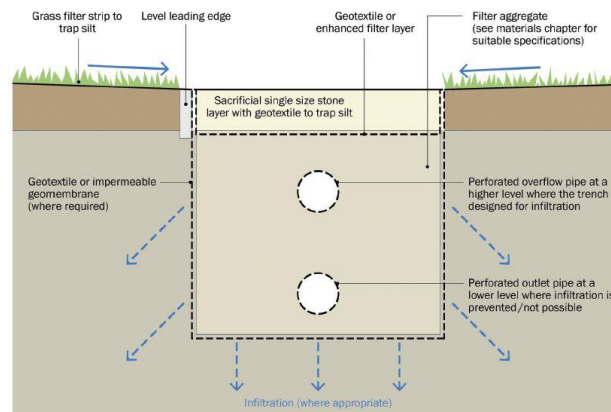
Soluzioni superficiali

Fonte: Woods Ballard et al. 2015. "The SuDS Manual"

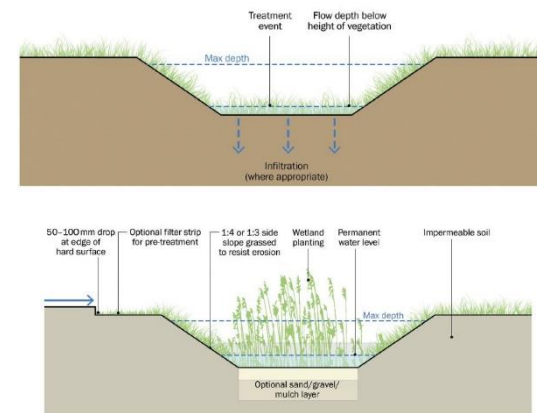
Drenaggio urbano sostenibile

Classificazione tecniche

Dreni filtranti



Canali



Soluzioni lineari

Fonte: Woods Ballard et al. 2015. "The SuDS Manual"



Drenaggio urbano sostenibile

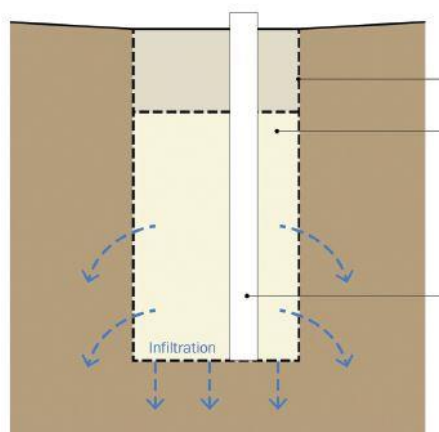
Classificazione tecniche



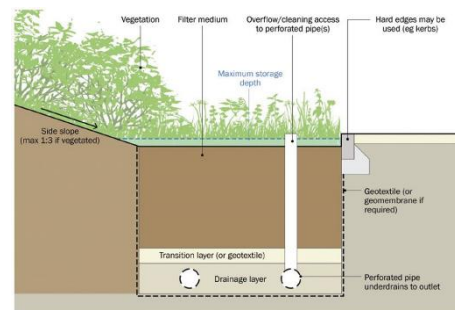
Soluzioni puntuali (Infiltrazione)

Fonte: Woods Ballard et al. 2015. "The SuDS Manual"

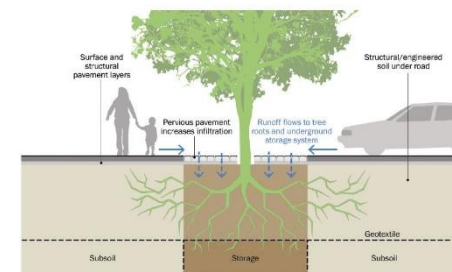
Trincee infiltranti



Aree bioritenzione (Rain garden)



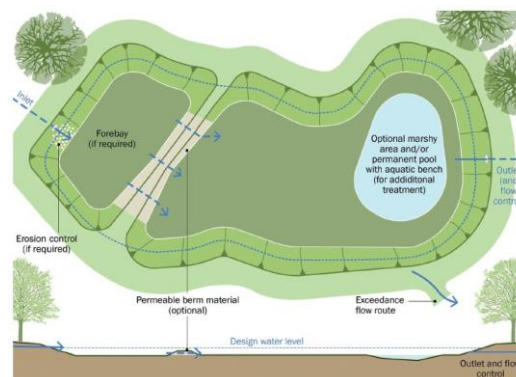
Box alberati filtranti



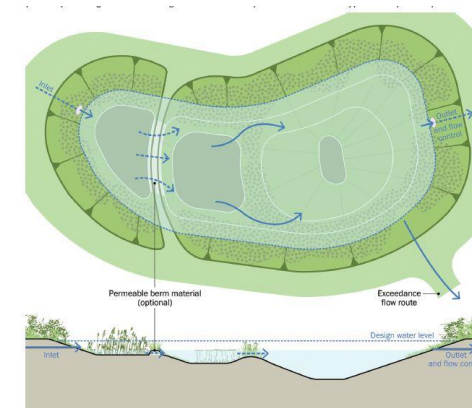
Drenaggio urbano sostenibile

Classificazione tecniche

Bacini di detenzione asciutti



Stagni e zone umide



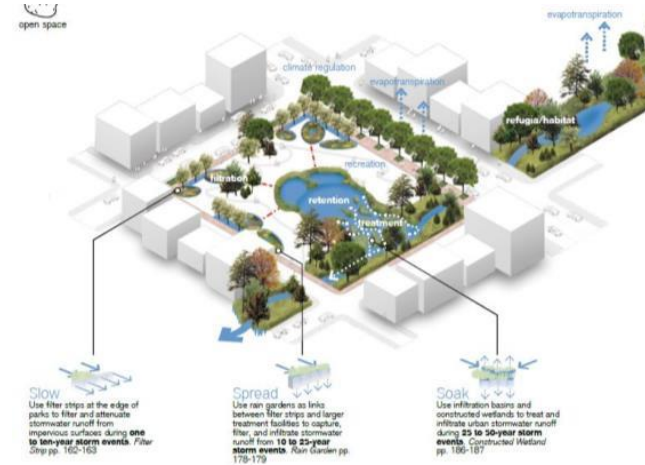
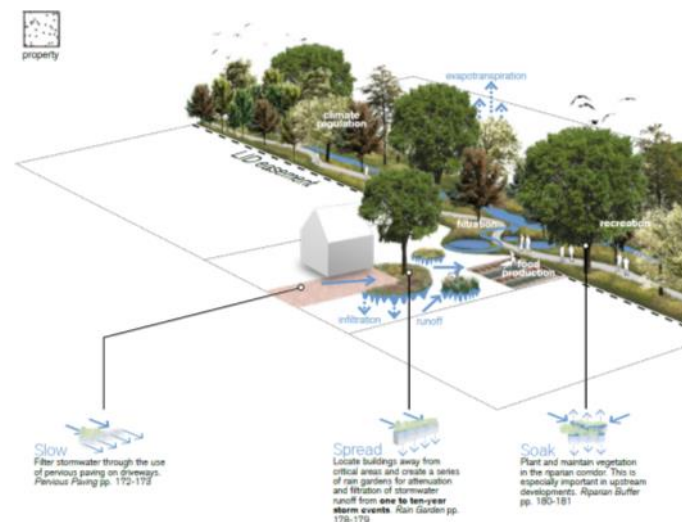
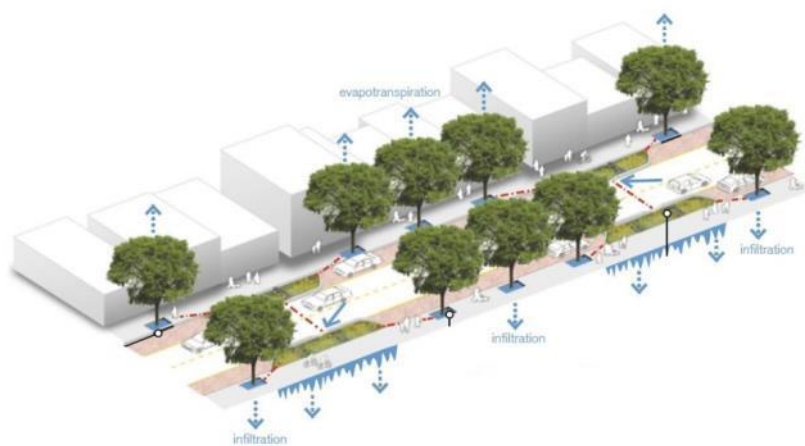
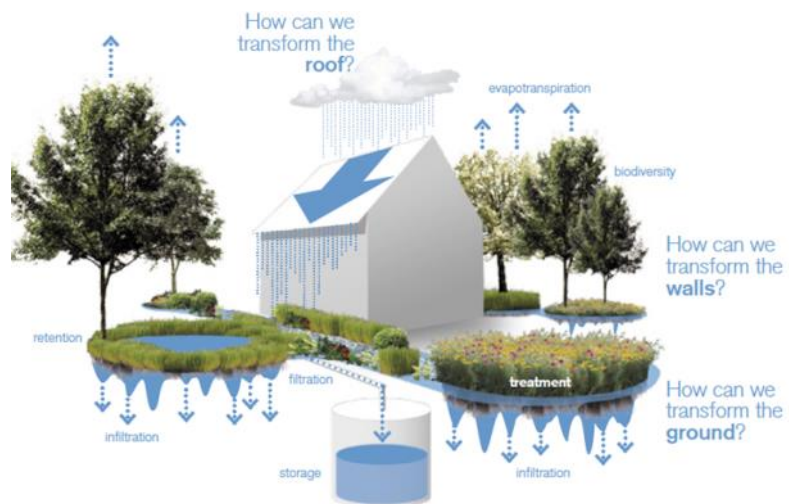
Soluzioni puntuali (Laminazione)



Fonte: Woods Ballard et al. 2015. "The SuDS Manual"

Drenaggio urbano sostenibile

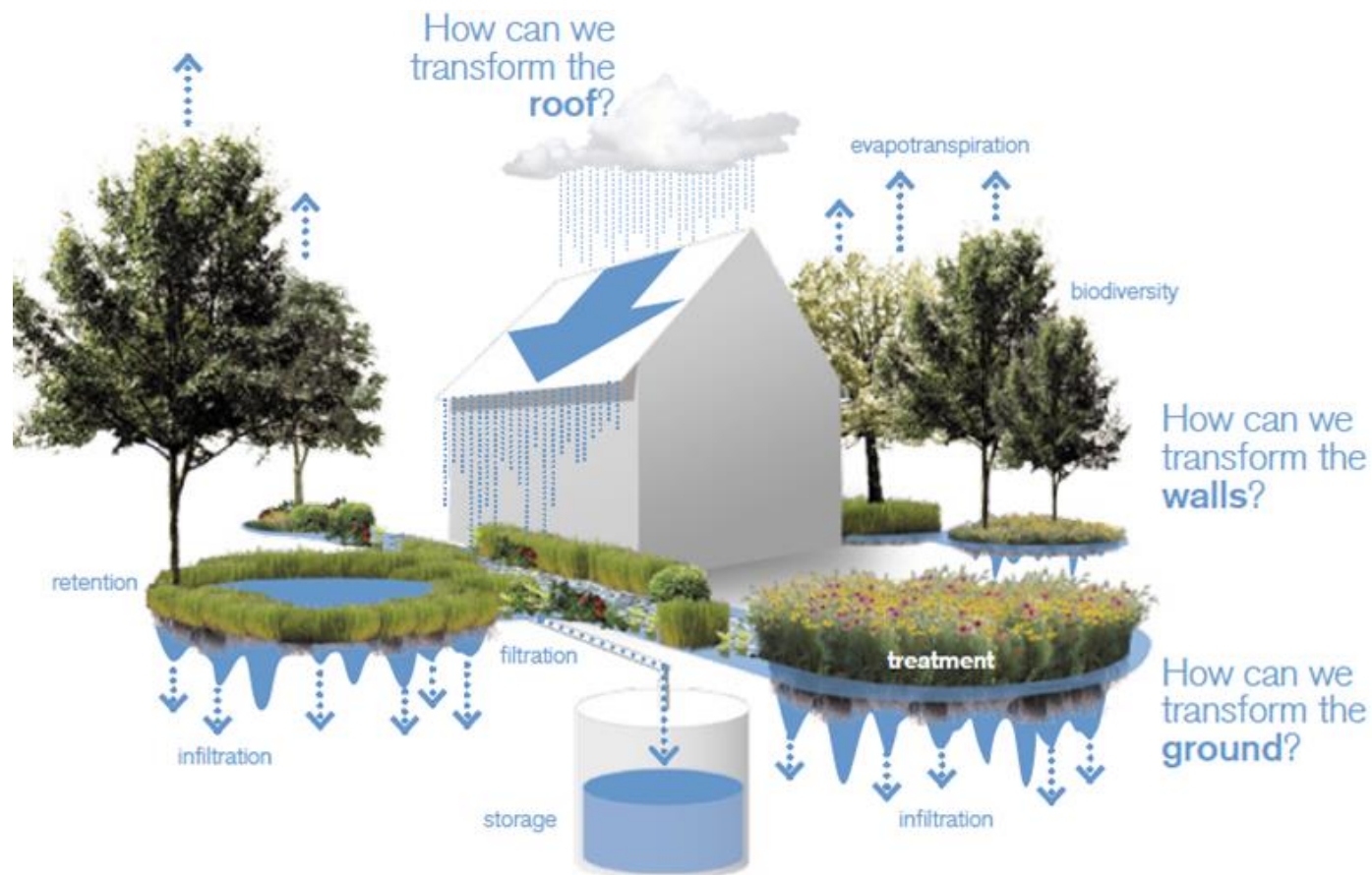
Scale di applicazione



Fonte: Huber, J., 2010. *Low Impact Development: a Design Manual for Urban Areas*

Drenaggio urbano sostenibile

Singola abitazione



Fonte: Huber, J., 2010. *Low Impact Development: a Design Manual for Urban Areas*

Drenaggio urbano sostenibile

Centro ricerche Kerakoll



Drenaggio urbano sostenibile

Centro ricerche Kerakoll



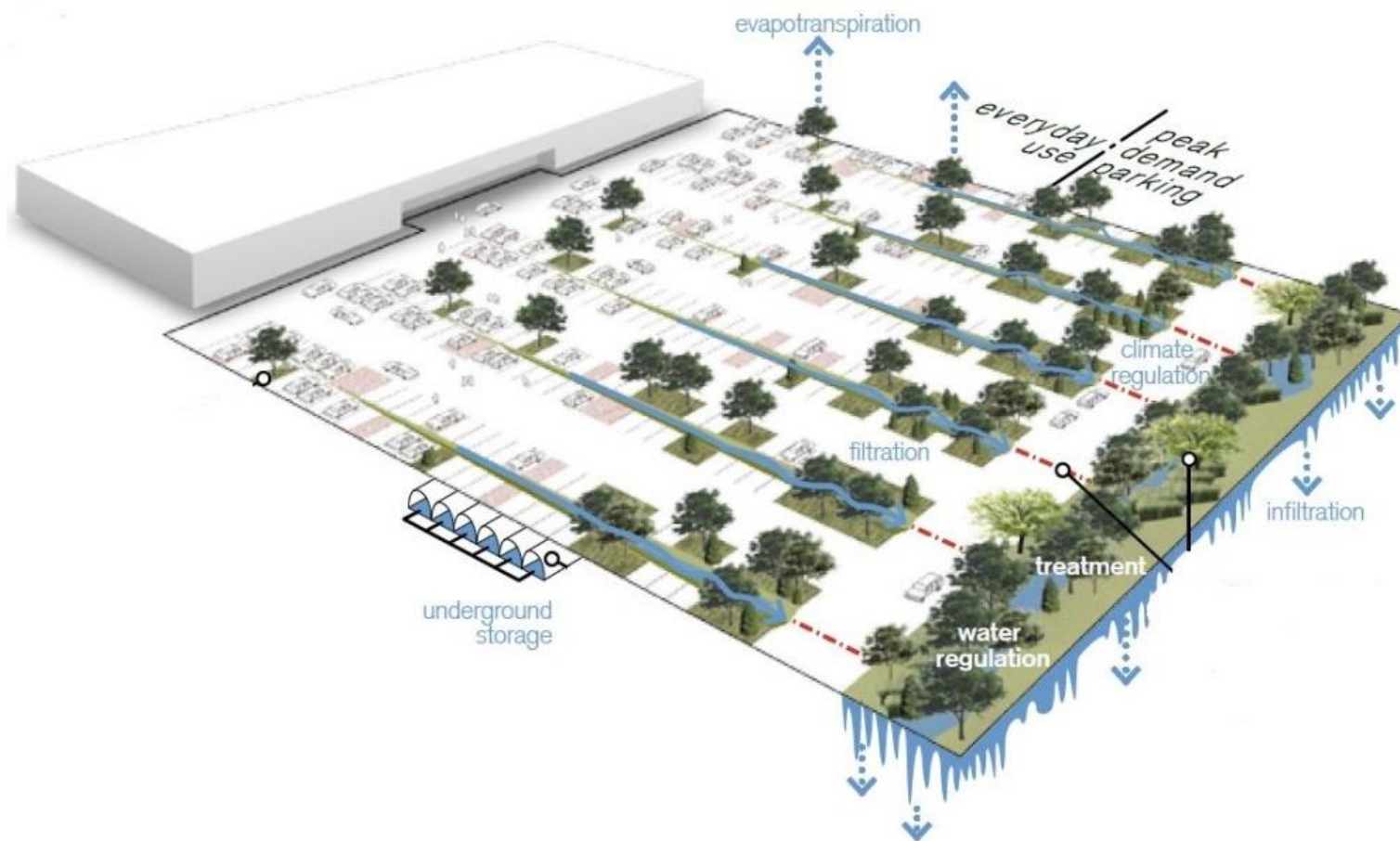
Drenaggio urbano sostenibile

Centro ricerche Kerakoll



Drenaggio urbano sostenibile

Parcheggi



Fonte: Huber, J., 2010. *Low Impact Development: a Design Manual for Urban Areas*

Drenaggio urbano sostenibile

CMM Spugna



- Fondi PNRR, 92 Interventi in 4 lotti progettuali
- Lotto 2 (26 interventi. Progettazione DEF IRIDRA – retrofitting SuDS strade e parcheggi

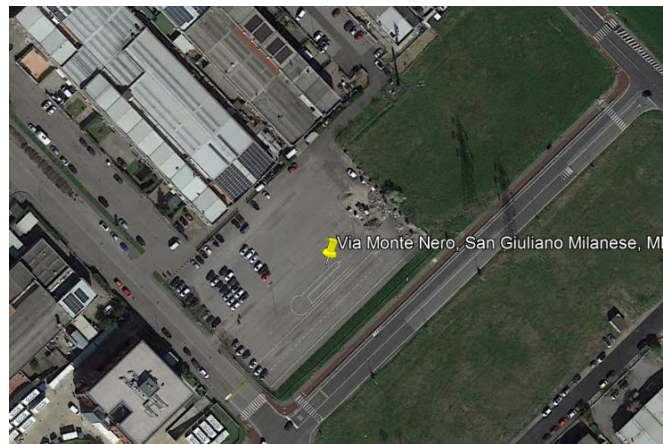


Città
metropolitana
di Milano



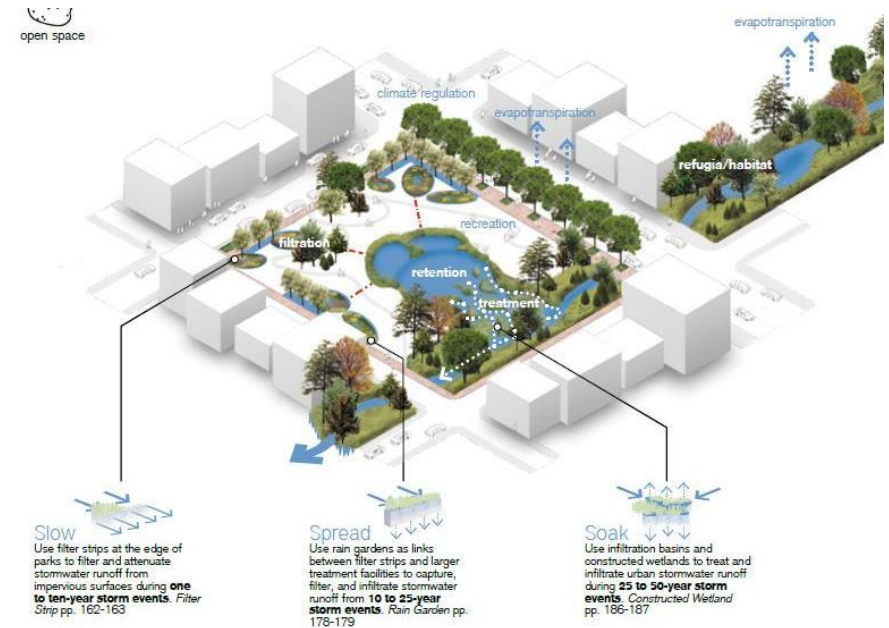
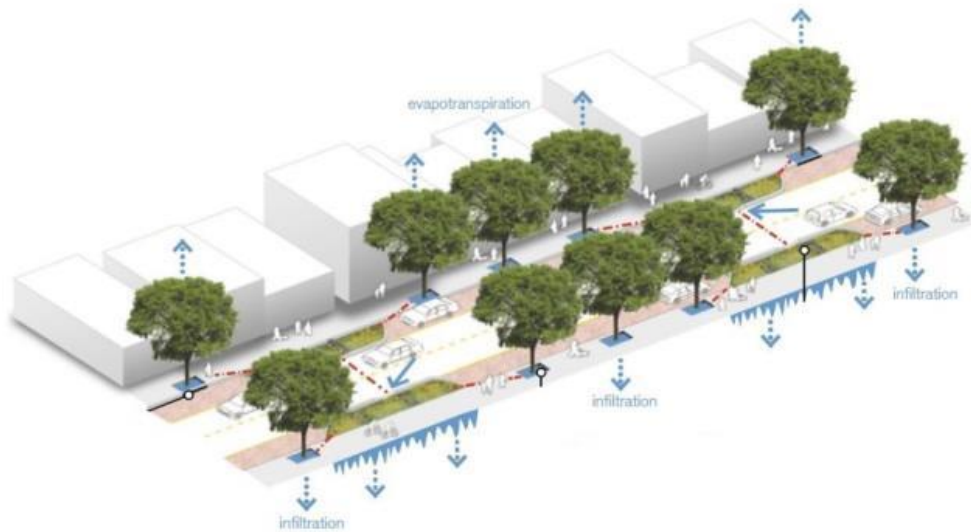
Drenaggio urbano sostenibile

S. Giuliano Milanese – Via M. Nero



Drenaggio urbano sostenibile

Strade e spazi pubblici



Fonte: Huber, J., 2010. *Low Impact Development: a Design Manual for Urban Areas*

Drenaggio urbano sostenibile

Bovisio Masciago – via Matteotti



Tra i pali della luce



Lungo la strada



Sui marciapiedi

Drenaggio urbano sostenibile

Bovisio Masciago – via Matteotti

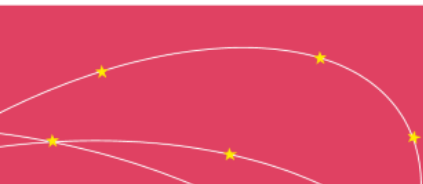


Incroci



Rotonde

DA GIFLUID A CARDIMED



CARDIMED

Informazioni generali

- **Call:** HORIZON-MISS-2022-CLIMA-01
- **Type:** Horizon Innovation Action
- **Duration:** 54 Months
- **Start:** 1st September 2023
- **# of Partners:** 51 (14 countries)
 - 10 Universities & 7 Research Organizations
 - 9 SMEs, 1 large Company and 8 NGOs
 - 6 Regions and 5 Municipalities
 - 5 Authorities/Utilities
- **# of Affiliated Organizations:** 3
- **Budget:** € 20 806 271,44



CARDIMED

Kick off meeting Settembre 2023

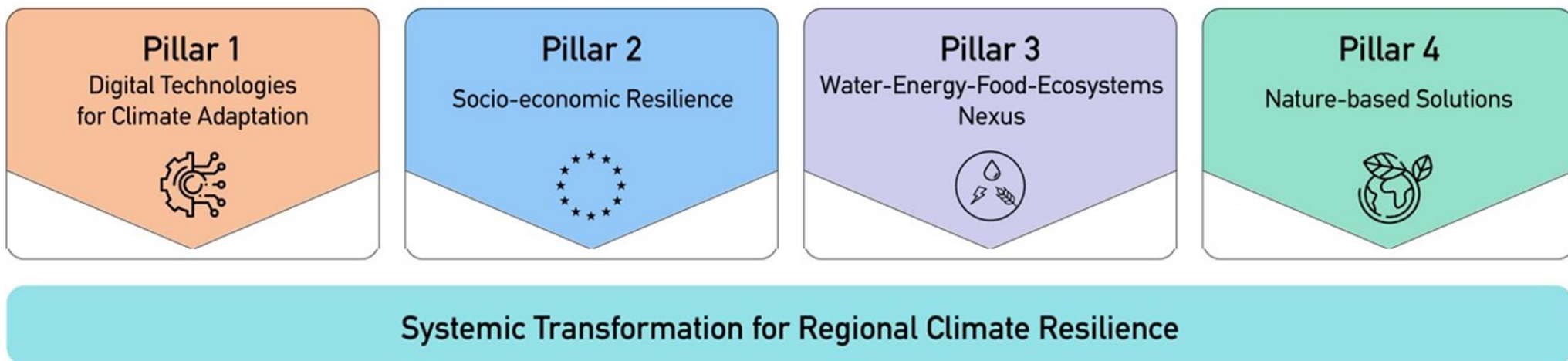
 **Interreg**
Italia-Malta
gifluid



Fondo Europeo di Sviluppo Regionale
European Regional Development Fund



Studiare una trasformazione sistemica della Regione Mediterranea in termine di Resilienza Climatica, unendo e rendendo di uso comune le NBS insieme ad altre infrastrutture ingegneristiche



*La principale sfida non è sviluppare ogni pillar singolarmente, ma **connetterli in modo olistico e a livello sistemico***

CARDIMED Interventi

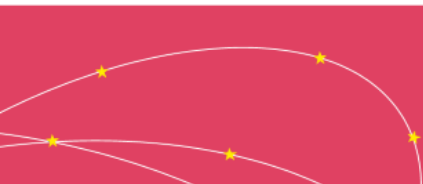
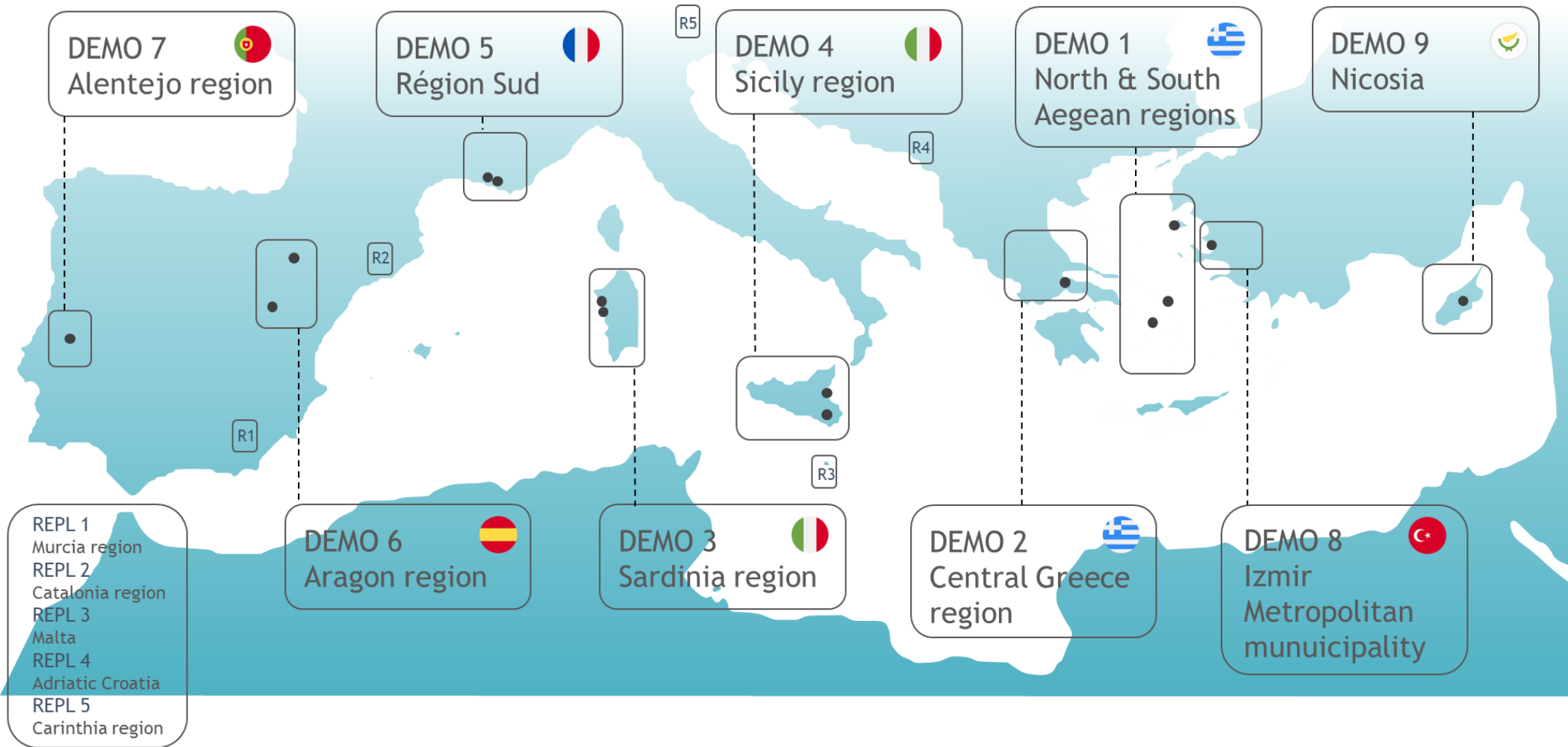
| Classification | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 |
|---|---|----|----|----|----|----|----|----|----|
| (River) Restoration | (28) River restoration | | | | | | | | |
| | (29) Floodplain | | | | | | | | |
| | (32) Coastal erosion control | | | | | | | | |
| Soil & Water Bioengineering | (33) Soil improvement and conservation | | | | | | | | |
| | (34) Erosion control | | | | | | | | |
| | (35) Soil reinforcement to improve root cohesion and anchorae | | | | | | | | |
| (Public) Green Space | (36) Riverbank engineering | | | | | | | | |
| | (37) Green corridors | | | | | | | | |
| | (38) Green belt | | | | | | | | |
| | (39) Street trees | | | | | | | | |
| Food & Biomass Production | (40) Large urban park | | | | | | | | |
| | (41) Pocket/garden park | | | | | | | | |
| | (43) Green transition zones | | | | | | | | |
| | (44) Aquaculture | | | | | | | | |
| | (45) Hydroponic and soilless technologies | | | | | | | | |
| Rainwater Management | (48) Photo Bio Reactor | | | | | | | | |
| | (49) Productive garden | | | | | | | | |
| | (50) Urban forest | | | | | | | | |
| | (51) Urban farms and orchards | | | | | | | | |
| | (1) Infiltration basin | | | | | | | | |
| | (2) Infiltration trench | | | | | | | | |
| | (3) Filter strips | | | | | | | | |
| | (4) Filter drain | | | | | | | | |
| | (5) (Wet) Retention pond | | | | | | | | |
| | (6) (Dry) Detention pond | | | | | | | | |
| | (7) Bioretention cell | | | | | | | | |
| | (8) Bioswale | | | | | | | | |
| Vertical Greening Systems & Green Roofs | (10) Tree pits | | | | | | | | |
| | (11) Vegetated grid pavement | | | | | | | | |
| | (12) Riparian buffer | | | | | | | | |
| | (S1) Rainwater Harvesting | | | | | | | | |
| | (S2) Detention vaults and tanks | | | | | | | | |
| | (13) Ground-based green facade | | | | | | | | |
| | (14) Wall-based green facade | | | | | | | | |
| Remediation, Treatment & Recovery | (15) Pot-based green facade | | | | | | | | |
| | (16) Vegetated pergola | | | | | | | | |
| | (17) Extensive green roof | | | | | | | | |
| | (20) Mobile green and vertical mobile garden | | | | | | | | |
| | (21) Treatment wetland | | | | | | | | |
| | (22) Waste stabilization pond | | | | | | | | |
| | (26) Anaerobic treatment | | | | | | | | |
| | (27) Aerobic (post) treatment | | | | | | | | |
| | (23) Composting | | | | | | | | |
| (25) Phytoremediation | | | | | | | | | |
| (S5) Disinfection (for water recovery) | | | | | | | | | |
| (S6) Biochar/Hydrochar production | | | | | | | | | |
| (S7) Physical unit operations for solid/liquid separation | | | | | | | | | |
| (S9) Adsorption | | | | | | | | | |

83 interventions of 47 different NBS types across 10 regions (9 DEMOS) on 20 locations involving 28 communities.

- RAINWATER MANAGEMENT
- VERTICAL GREENING SYSTEMS & GREEN ROOFS
- TREATMENT & RECOVERY
- RIVER RESTORATION
- SOIL & WATER BIOENGINEERING
- PUBLIC GREEN SPACES
- FOOD PRODUCTION

Fonte: Langergraber et al., 2021

CARDIMED Demo



CARDIMED

Partenariato Cluster Sicilia



Fondo Europeo di Sviluppo Regionale
European Regional Development Fund



CARDIMED

Demo 4: Catania

Obiettivi del Demo:

- Infiltrazione delle acque di pioggia
- Contribuire a ridurre e ritardare il picco idraulico durante gli eventi a rischio di allagamento

Tipologia NBS

- Aree di bioritenzione (rain garden)



Viale della Circonvallazione e Tondo Gioieni



*Recenti interventi di retroSuDS in Regione Lombardia –
Progettazione e DDLL IRIDRA*

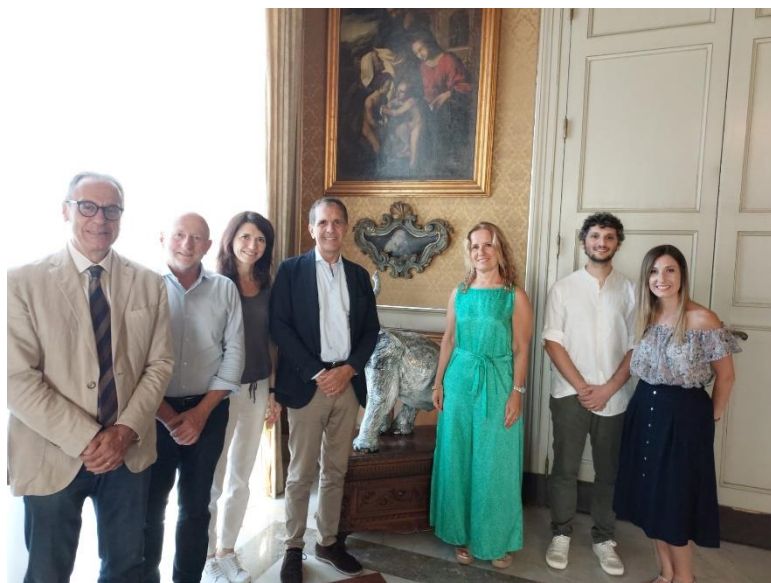
Allagamenti in Via Etnea

CARDIMED

Demo 4: Catania

Attività preliminari GIFLUID

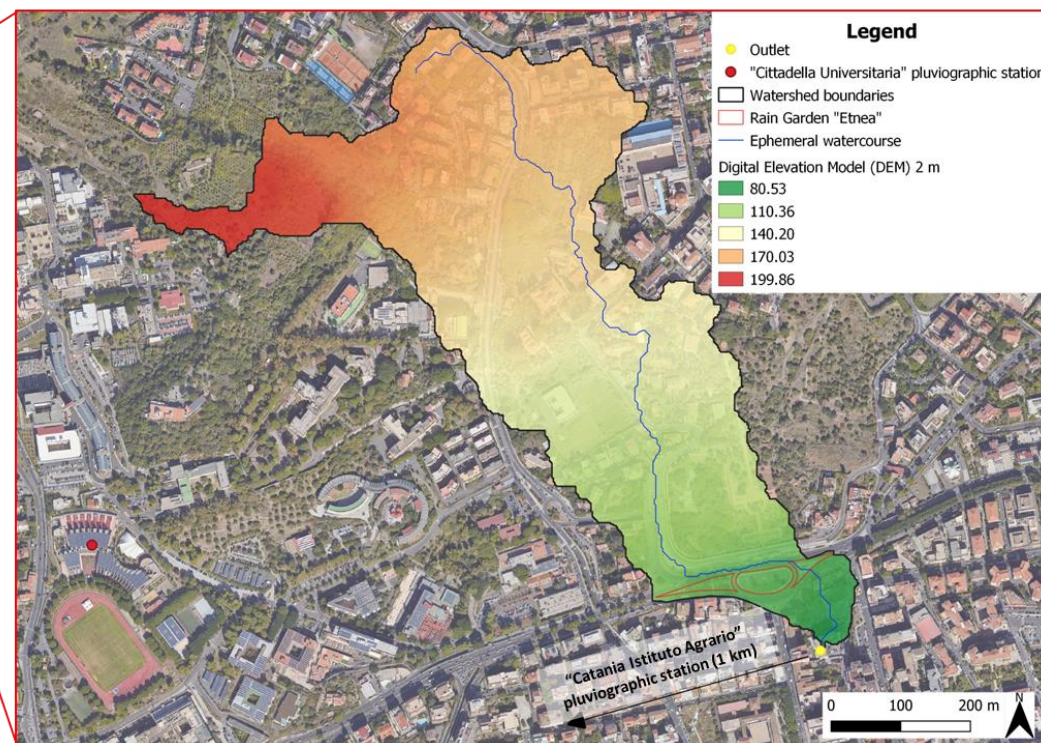
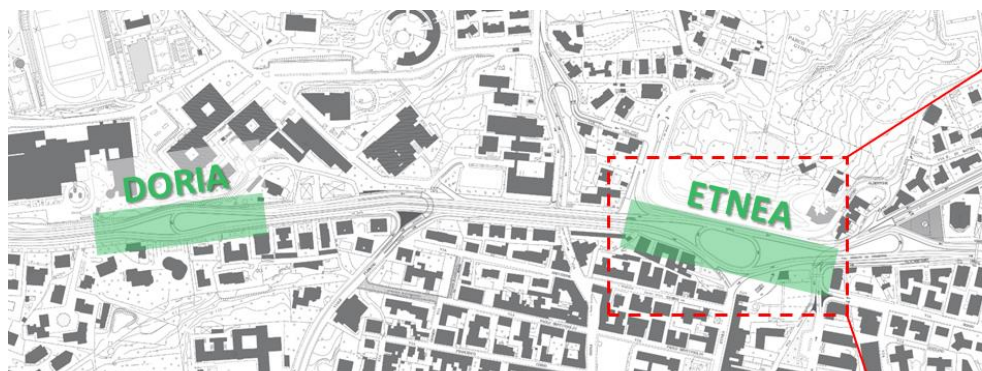
- GREENLAB Luglio 2023: stato di fatto e proposte progettuali preliminari con tavoli di lavoro misti studenti/professionisti
- Incontro preliminare con Sindaco, Vicesindaco e Ufficio Ambiente il 2 Agosto 2023



CARDIMED

Demo 4: Catania

Modellazione idrologica-idraulica (Università di Catania)



Morphological and Orographical Parameters

- Area (A) = 0.29 km²
- Perimeter (P) = 4.65 km
- Main stream Length (L) = 1.46 km
- Max Height (Q_M) = 199.73 m.a.s.l.
- Min Height (Q_m) = 77.38 m.a.s.l.
- Average Height (H_m) = 145.03 m.a.s.l.
- Gradient (ΔQ) = 122.35 m
- Main stream slope (i) = 8.38 %

CARDIMED

Demo 4: Catania

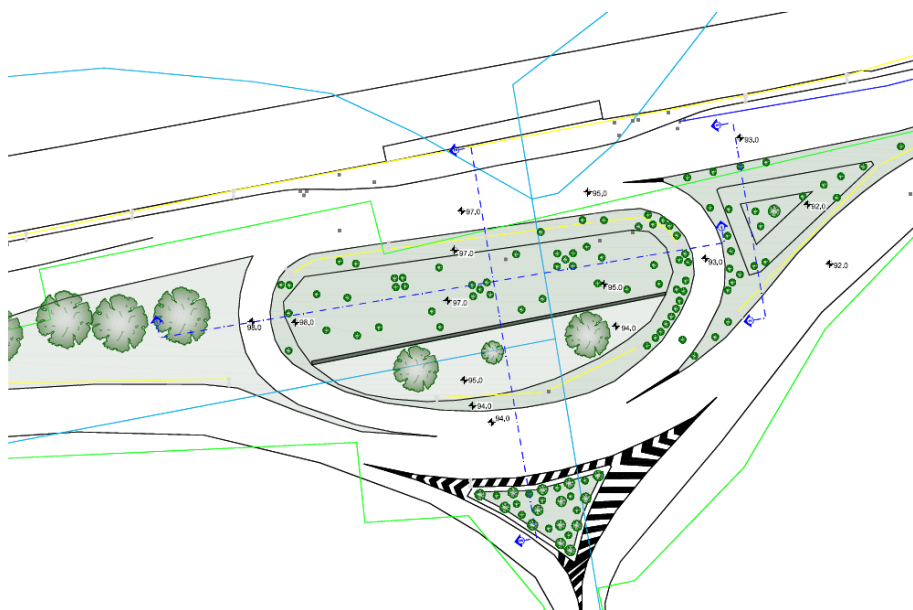
Studio di Fattibilità (IRIDRA, Università di Catania)



CARDIMED

Demo 4: Catania

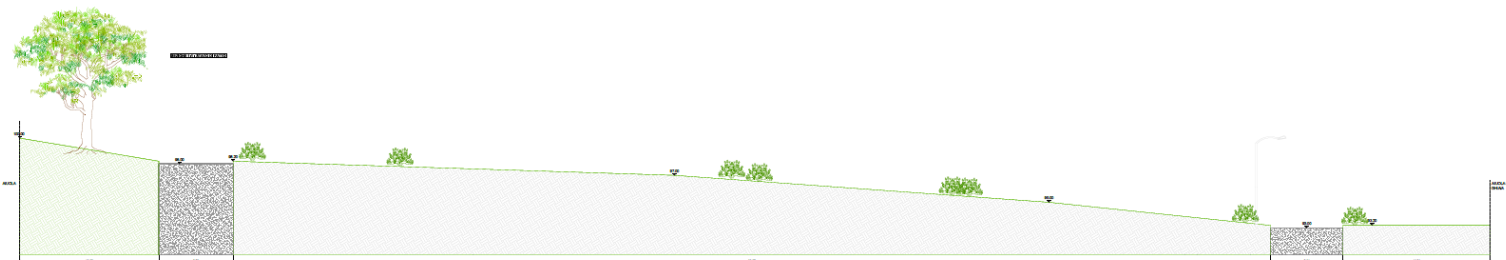
PFTE, PE, DDLL (IRIDRA, Università di Catania, Comune di Catania)



| LEGENDA | |
|--|---------------------------------|
|  | Rete acquedotto* |
|  | Rete gas metano* |
|  | Rete fognatura separata* |
|  | Sottoservizi_Rete elettrica* |
|  | Caditoia esistente |
|  | Pozzetto con chiusino esistente |
|  | Illuminazione esistente |
|  | Alberatura o arbusti esistenti |
|  | Area verde esistente |
|  | Aiuola con ghiaia esistente |
| 0,00  | Quote del terreno** |



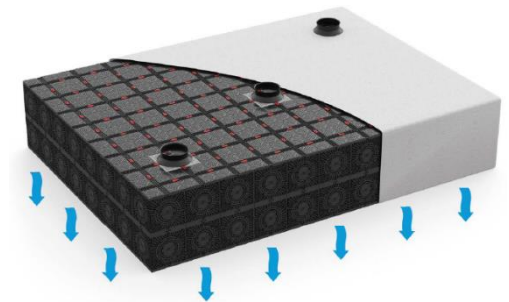
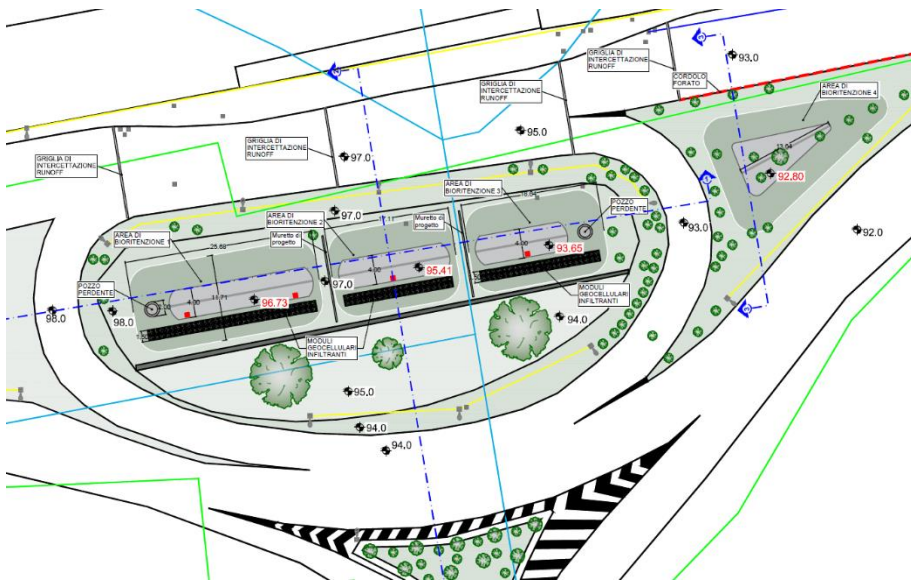
Stato di Fatto



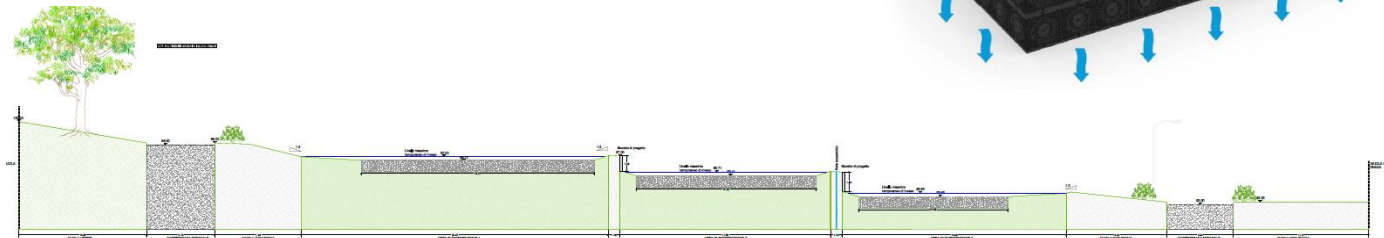
CARDIMED

Demo 4: Catania

PFTE, PE, DDLL (IRIDRA, Università di Catania, Comune di Catania)



Proposte preliminari
stato di progetto



CARDIMED

Demo 4: Catania

Attività disseminazione (Comune di Catania, Regione Sicilia, IRIDRA)

- Workshops
- Focus group
- Esibizioni all'area aperta
- Community of Practice (CoP) innovazione sociale
- CARDIMED Resilience Alliance

