Grow Green

Green cities for climate and water resilience, sustainable economic growth, healthy citizens and environments

Presentation of the Compendium of Nature-based and 'grey' solutions to address climate- and water-related problems in European cities

Foivos Petsinaris

3rd December 2021

This project has received funding from the European Union's Horizon 2020 Research and Innovation Programme under Grant Agreement No 730283

Part I

Presentation of the compendium

Introduction to the Compendium

- Developed to guide our *Market Analysis* work for GrowGreen
- Presents 36 nature-based and 32 'grey' solutions that can address climate- and water-related challenges in European cities:

	NBS	'Grey' solutions
Heat stress	8	5
River flooding	9	10
Surface water flooding	18	9
Coastal flooding	5	12
Water scarcity	13	4
Water quality	16	1
Total	**36**	**32**

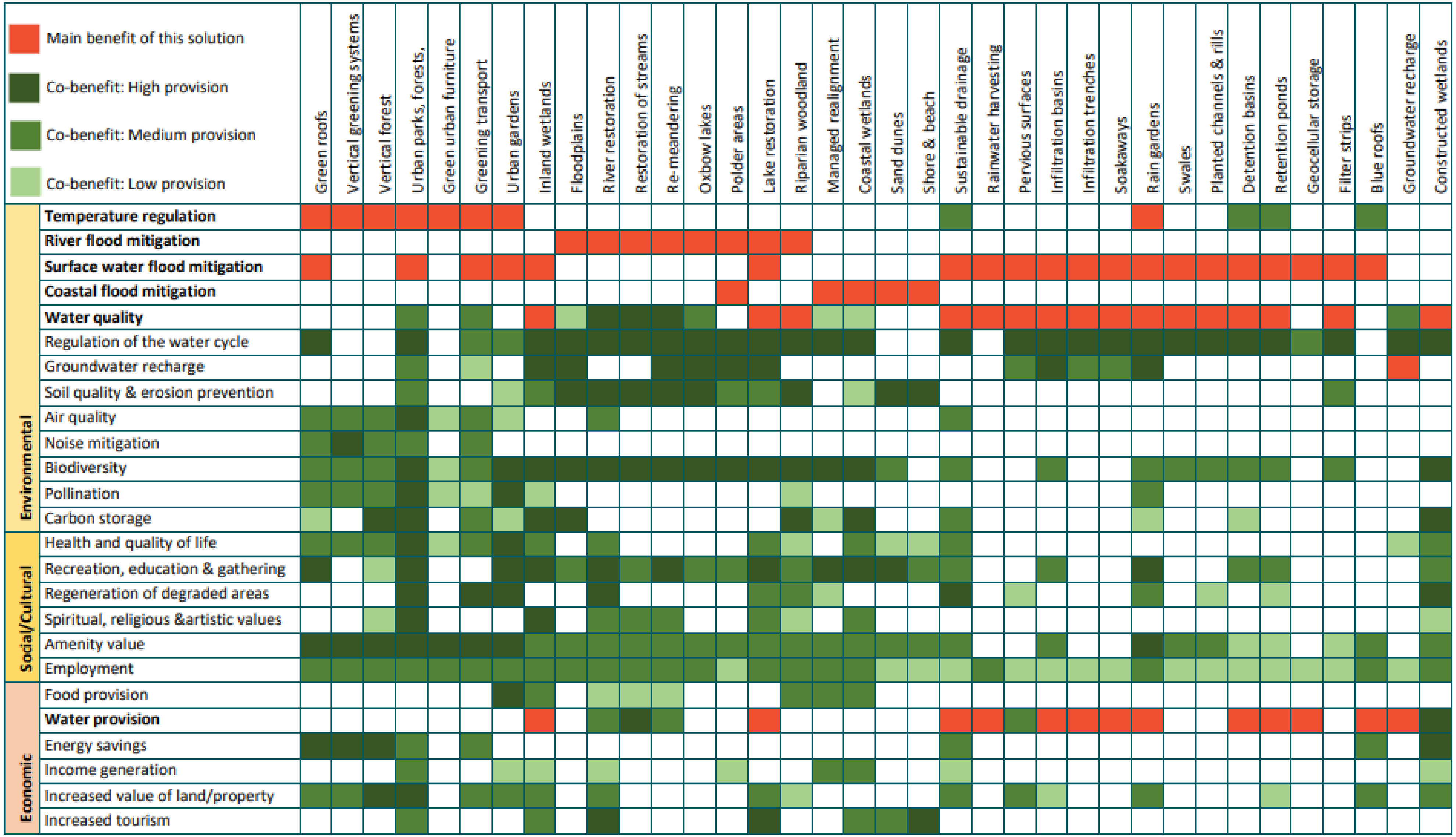
- The solutions are presented in individual factsheets
- Serve as a reference for local authorities and other stakeholders

NBS and 'grey' solutions summary tables

Nature-based solutions	Heat	Floods			Water	
		River	Surface water	Coastal	Scarcity	Quality
1. Green roofs	■		■			
2. Vertical Greening Systems	■					
3. Vertical forest	■					
4. (Peri-)Urban parks and other green spaces	■		■			
5. Green urban furniture	■					
6. Greening linear transport infrastructure	■		■			
7. Urban gardens	■		■			
8. Restoration and management of inland wetlands		■			■	■
9. Restoration and management of floodplains		■				
10. River restoration for flood control		■				
11. Restoration and reconnection of seasonal streams		■				■
12. Re-meandering		■				
13. Reconnection of oxbow lakes		■				
14. Re-naturalization of polder areas		■		■		
15. Lake restoration		■	■		■	■
16. Floodplain and riparian woodland creation		■				■
17. Managed realignment				■		
18. Restoration and management of coastal wetlands				■		
19. Sand dunes construction and strengthening				■		
20. Shore and beach nourishment				■		
21. Sustainable Drainage Systems (SuDS)			■		■	■
22. Rain water harvesting			■		■	
23. Pervious surfaces			■			■
24. Infiltration Basins			■		■	■
25. Infiltration trenches			■		■	■
26. Soakaways			■		■	■
27. Rain Gardens	■		■		■	■
28. Swales			■			■
29. Planted channels and rills			■			■
30. Detention Basins			■		■	■
31. Retention Ponds			■		■	■
32. Geocellular systems			■		■	
33. Filter strips						■
34. Blue roofs			■		■	
35. Subsurface groundwater recharge systems					■	
36. Constructed wetland						■

Grey solutions	Heat	Floods			Water	
		River	Surface water	Coastal	Scarcity	Quality
1. Passive cooling of buildings	■					
2. Cool or white roofs	■					
3. Cool facades	■					
4. Cool pavements	■					
5. Cooling water fountains	■					
6. Dikes		■				
7. Floodwalls		■				
8. Longitudinal barriers (Dams)		■				
9. Temporary and demountable barriers		■		■		
10. High-water channel		■				
11. Compartmentalisation		■		■		
12. Storm surge barriers (or gates)				■		
13. Groynes, breakwaters and artificial reefs				■		
14. Higher quays				■		
15. Quay walls / sheet pile walls				■		
16. Sluices and pumping stations		■		■		
17. Dry flood-proofing		■		■		
18. Wet flood-proofing		■		■		
19. Floating and amphibious housing				■		
20. Floating or elevated roads		■	■	■		
21. Raising coastal land				■		
22. Upgrading drainage systems / increasing pipe capacity			■			
23. Flow regulators			■			
24. Smart regulation of the sewage system			■			
25. Flood control channels			■			
26. Surface water storage			■		■	
27. Underground water storage			■		■	
28. Backflow blocker			■			
29. Pump well with check valve			■			
31. Greywater recycling systems					■	
32. Desalination					■	■

General overview of (co-)benefits table



NBS and 'grey' solution factsheets

- The factsheets for both the NBS and the 'grey' solutions provide the following information:
  - Description of the solution
  - Problems (climate hazards) addressed
  - Scale
  - Effectiveness
  - Typical co-benefits
  - Cost information
  - Potential disadvantages/ negative impacts/ trade-offs
  - Challenges/requirements for implementation
  - References and other relevant sources

Who and how to use the compendium

- An index for all the available NBSs that address certain climate and water problems and some corresponding ‘grey’ solutions
- The users of the compendium could be local authorities, companies and researchers
- How to use:
  1. Identify the climate/water-related problem to be addressed
  2. Use the summary tables to identify all the potential NBSs that can tackle it
  3. Read their description and characteristics to spot the NBSs that fit local needs and specificities
  4. Identify which of the competing NBSs can offer the greatest (co-)benefits
  5. Select the most suitable NBS
  6. (Compare with the benefits and costs offered by ‘grey’ solutions)

Part II

Selected solutions for Modena

Green roofs (I)

- **Description:** Two main types of green roofs:
  - <u>Intensive</u>: Deep substrate that can sustain large vegetation (high maintenance; regular irrigation; fertilizers; considerable weight)
  - <u>Extensive</u>: Swallower substrate for self-sustaining plants (low maintenance; usually no irrigation/fertilizers; lower weight)
- **Problems addressed:** Heat; Surface water flooding
- **Scale:** Building level
- **Effectiveness:**
  - Green roofs can reduce summer cooling load at building level up to 58%
  - At neighbourhood level, temperatures can be reduced up to 3°C
  - Green roofs can retain from 40% to more than 90% of rainfall

Green roofs (II)

- Typical co-benefits:

Environmental	Social/Cultural	Economic
Regulation of the water cycle	Health and quality of life	Reduced energy consumption
Improvement of air quality	Recreation, environmental education	Increased value of land/property
Noise mitigation	Enhanced amenity value	
Biodiversity (for extensive green roofs)	Employment enhancement	
Pollination (for extensive green roofs)		
Carbon storage		

- Cost information: Reported costs are estimated in the range of \$100 to \$300 per m^2 for extensive green roofs, and \$200 per m^2 for the intensive
- Potential disadvantages: Cities with scarce rainfall, the cost of irrigating green roofs can outweigh the savings from reduced energy demand for air-conditioning
- Challenges:
  - Different techniques for higher roof slopes
  - Vegetation specifically selected for local climates
  - Restrictions on some building areas
  - Large weight may require substantial structure reinforcement
  - Require regular maintenance to continue operating to design performance standards

Pervious surfaces (I)

- **Description:** Pervious surfaces allow rainwater to infiltrate through the surface into underlying layers, including groundwater. There are two types:
  - Porous surfaces (infiltrate across the entire surface)
  - Permeable surfacing (infiltrates through holes on impervious material)
- **Problems addressed:** Surface water flooding; Water quality
- **Scale:** Public space
- **Effectiveness:**
  - 10% to 100% run-off reduction
  - 12% to 90% peak flow reduction
  - ‘Good’ performance in terms of water quality treatment

Pervious surfaces (II)

- Typical co-benefits:

Environmental	Social/Cultural	Economic
Regulation of the water cycle	Regeneration of degraded areas	Water provision (if designed to allow infiltration to underlying soils or groundwater)
Groundwater recharge	Employment enhancement	Increased value of land/property

- Cost information: Reported capital costs are estimated in the range of €40 to €90 per m^2 and maintenance costs of €1 to €5 per m^2. The capital cost of permeable paving is about 10-15% higher than standard paving.
- Potential disadvantages: Effectiveness can decrease significantly over time in the absence of sediment management.
- Challenges:
  - Cannot be used where large sediment loads may be carried onto the surface
  - Should be regularly cleaned of silt and other sediments
  - Should not be used in areas where the soil or geology has low permeability, groundwater levels are high, or the underlying substrate is contaminated

Swales (I)

Grow Green

- **Description:** Swales are shallow, broad and vegetated channels which store and/or convey runoff and could remove pollutants and promote infiltration. There are three types:
  - Standard conveyance swale (only convey runoff)
  - Enhanced dry swale (accommodates water treatment)
  - Wet swale (accommodates prolonged water treatment)
- **Problems addressed:** Surface water flooding; Water quality
- **Scale:** Public space
- **Effectiveness:**
  - About 50% runoff reduction
  - Reported peak flow reductions of 52% and 65%
  - effective at removing suspended pollutants

Swales (II)

- Typical co-benefits:

Environmental	Social/Cultural	Economic
Regulation of the water cycle	Enhanced amenity value	
Biodiversity	Employment enhancement	

- **Cost information:** Reported capital costs are estimated in the range of €15 to €80 per m^2 and maintenance costs of €0,5 to €4 per m^2. The highest costs are attributed to 'enhanced' swales with an underdrain filter bed.
- **Potential disadvantages:** Involve higher land uptake than conventional drainage solutions. Limits opportunities to use trees for landscaping.
- **Challenges:**
  - Difficult to incorporate into dense urban developments where space is limited
  - Risks of blockages in connecting pipe work
  - Not suitable for areas where shading would limit vegetation growth
  - Require regular maintenance to continue operating to design performance standards

Rainwater harvesting (I)

- **Description:** Rainwater harvesting is the collection and storage of rainwater, from roofs or other impermeable surfaces, for later use. The water is stored in water butts, underground cisterns, or storage tanks. There are three types of rainwater harvesting approaches:
  - for water storage (supply) only
  - for water storage (supply) and surface water management, passive systems (water level in the tank is not actively managed)
  - for water storage (supply) and surface water management, active systems (water level in the tank is managed to ensure sufficient tank volume available to cope with extreme rainfall)
- **Problems addressed:** Surface water flooding, Water quality, Water scarcity
- **Scale:** Building level, Public space, Peri-urban, Rural

Rainwater harvesting (II)

- Effectiveness:
  - Water butts are effective to provide supplementary water (garden irrigation), but rather small to control runoff
  - Cisterns and tanks, if appropriately designed, can have ‘high performance’ in peak flow reduction and volume reduction
- Typical co-benefits:

Environmental	**Social/Cultural**	**Economic**
	Employment enhancement	

- Cost information: Reported capital costs are estimated in the range of €5 to €60 per m^2 of roof area and maintenance costs of €0,25 to €1 per m^2 of roof area.
- Potential disadvantages: Rainwater depends on the seasons and weather conditions; therefore, it is an uncertain water supply. Inappropriate management and maintenance practices of the harvesting systems can result in low water quality. Investment costs may be higher than using other water supplies.
- Challenges:
  - Large scale deployment requires substantial investment in infrastructure
  - Risks of contaminants found on roofs
  - Availability of space for large tanks in urban areas is limited
  - Incentives are needed to encourage wider application

Sustainable Drainage Systems (I)

- **Description**: Sustainable drainage systems (SuDS) are a set of measures that use natural features and processes to slow down and reduce the volume of surface water runoff in order to manage downstream flood risk and reduce the risk of runoff-caused pollution. They consist of interconnected components that work together to manage, treat and make best use of surface water. SuDS components can be classified into five categories: 1) Source control, 2) Infiltration systems, 3) Conveyance systems, 4) Storage systems, and 5) Treatment systems.
- **Problems addressed:** Surface water flooding; Water quality; Water scarcity
- **Scale:** Building level, Public space
- **Effectiveness:**
  - Highly effective in attenuating runoff flow before it enters a watercourse, providing areas for water storage, and allowing water to infiltrate into the ground
  - Effective in reducing sediment and contaminants from runoff.

Sustainable Drainage Systems (II)

- Typical co-benefits:

Environmental	Social/Cultural	Economic
Regulation of the water cycle	Health and quality of life	Reduced energy consumption
Groundwater recharge	Regeneration of degraded areas	Income generation
Improvement of air quality	Recreation, environmental education	Increased value of land/property
Temperature regulation	Enhanced amenity value	
Biodiversity	Employment enhancement	
Carbon storage		

- Cost information: Construction costs of SuDS may be up to 30% lower than traditional drainage systems, however for challenging sites the costs can be 5% higher. Maintenance costs can be higher, but vary according to site and component.
- Potential disadvantages: Involve higher land uptake than conventional drainage solutions.
- Challenges:
  - For SuDS to maximize their effectiveness, need to have a widespread implementation throught the urban infrastructure
  - Implementation usually requires coordination between different departments of the local public authority

Thank you for your attention!