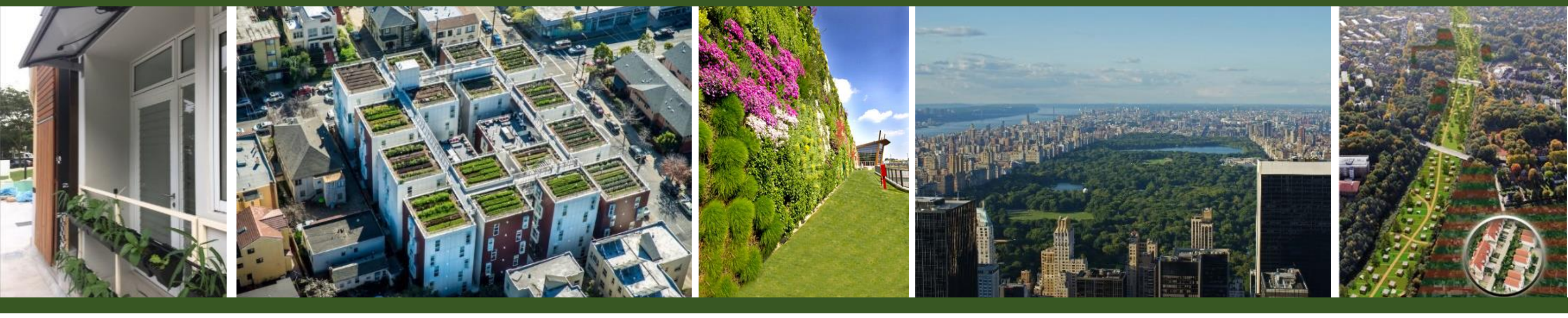
POLITECNICO MILANO 1863

CATALOGUE OF NATURE-BASED SOLUTIONS FOR URBAN REGENERATION



ENERGY & URBAN PLANNING WORKSHOP

Fall semesters 2018 & 2019
School of Architecture Urban Planning and Construction Engineering
Master of Science in Urban Planning and Policy Design
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Pre-Final Report

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Preface

This catalogue, in its current version, is the outcome of the collaborative ongoing work conducted with and by the students of the Energy & Urban Planning Design Studio at the Politecnico di Milano during the fall semesters of 2017 and 2018.

It collects a number of Nature-Based Solutions (NBS), which is not exhaustive of course. The work still requires peer reviews and double checks, but it already offers enough material to be used as a tool during design and co-design activities.

During the elaboration of this work, we faced several challenges, hence opening up many questions to further development. Firstly, how broad shall we go with the definition of NBS[1], or how deep into practical measures? Which are the boundaries to define nature-based solutions and does this include mainly – or exclusively – green (vegetation-based) solutions? Or shall we include other natural elements, like water, or even sun, which are characterized by natural processes, according to a biomimicry approach that focuses on nature-inspired solutions?

Secondly, how to group NBS to create a sound taxonomy? Many taxonomies have been proposed; we decided to select the one proposed by Klimatek in 2017[2] because we found it suitable for supporting decision makers and planners for putting in practice physical interventions.

We are planning to expand the list of Nature-Based Solutions and achieve an incremental, possibly open and collaborative guidance for cities, policy makers and planners.

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[1] We basically relied on the European Commission definition as: "actions inspired by, supported by or copied from nature that aim to help societies address a variety of environmental, social and economic challenges in sustainable ways." European Commission. (2015). *Towards an EU Research and Innovation policy agenda for Nature-Based Solutions & Re-Naturing Cities*. https://doi.org/10.2777/765301

[2] Klimatek Project. (2017). *Nature-based solutions for local climate adaptation in the Basque Country*. Bilbao. Retrieved from http://growgreenproject.eu/wp-content/uploads/2018/05/NBS-Climate-Adaptation-Basque-Country.pdf

Building-Scale Interventions

Green Roofs

Definition

“Green roof” refers to the space on the top of a building that is covered partially or entirely with vegetation that is planted in a growing substrate. Green roofs are constructed for multiple purposes such as rainwater retention, biodiversity and garden roof.


<table>
<tr><td>Measure responding to</td><td colspan="6">Adaptation
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☒</td></tr>
<tr><td>Scale of application</td><td colspan="4">City
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<tr><td>Related secondary SDG, if any</td><td colspan="4"></td><td colspan="4">Specific associated targets</td><td colspan="4"></td></tr>
<tr><td>Addressed themes</td><td colspan="3">Accessibility
☐</td><td colspan="3">Energy
☒</td><td colspan="3">Environment
☒</td><td colspan="3">People
☒</td></tr>
<tr><td>Main strategy addressed</td><td colspan="12">Main: more efficient water management
Secondary: reduce energy consumption, reduce noise and air pollution, increase urban biodiversity</td></tr>
<tr><td>Dimensional data</td><td colspan="12">Green roofs systems retain 60-100% of the storm water they receive</td></tr>
<tr><td>Space usage</td><td colspan="6">Monofunctional
☐</td><td colspan="6">Multifunctional
☒</td></tr>
<tr><td>Construction costs</td><td colspan="12">100-250 €/mq</td></tr>
<tr><td>Maintenance / management costs</td><td colspan="12">10-15 €/mq per year</td></tr>
<tr><td>Quantification / metrics</td><td colspan="12">Retention capacity (mm), Energy savings (kw)</td></tr>
</table>

Detailed description

Green roofs might contribute to the increased absorbance capacity of a city. The retention effect of a green roof is larger with small/average rain showers and it is minor with longer and prolonged showers. There are two main kinds of green roof: intensive green roofs and extensive green roof. The former have a medium depth of 13 cm, it supports a variety of vegetation and it has high requirement in terms maintenance. The latter are thinner and lighter (at least 2 cm), they support only limited types of vegetation and they have high requirements in terms of maintenance.

Best practices

Rotterdam and the Green Roof Policy

The city of Rotterdam, thanks to the adoption of an ambitious Green Roof Policy as part of the Rotterdam Climate Proof program, achieved an important milestone in 2012: 100,000 m2 of green roofs in the city. The systematic spread of green roofs forms a buffer to absorb excess rainwater and to filter dust particles from the atmosphere. As a positive spill over effect today more owners' associations in the city are willing to install a green roof.

Green Business Center in Hyderabad

The Green Business Center in Hyderabad (India) was constructed in 2003 and it is the first LEED Platinum certified building outside US. It is characterized by the presence of an extensive green roof of about 1000 m^2. The green cover is part of a runoff recycling system (Net-Zero Water system) in which the water is retained and then treated into ponds located on the roof. The water is then used as potable water and for irrigation during the dry seasons.

Reference

Musy, M. (2017), Lecture on *Ilots de chaleur urbains at adaptation climatique*, Ecole Centrale Nantes, Nantes, France.

Kantor, D. (2017), Life Cycle Cost Analysis of Extensive Green Roofs in Switzerland and Netherlands, Jorunal of Living Architecture, 4(1), pp. 14-25.

www.growinggreenguide.org
www.urbangreenbluegrids.com
http://www.greenroof.hrt.msu.edu/benefits/index.html

Green Walls (GW)

Definition

A green wall is comprised of plants grown in supported vertical structure attached to an internal or external wall or freestanding. The structures vary from modular systems to sheet or board-based structures with felt pockets to contain soil or other growing medium based on hydroponic principles and irrigation systems to provide the water and nutrient required for the plants to stay alive.

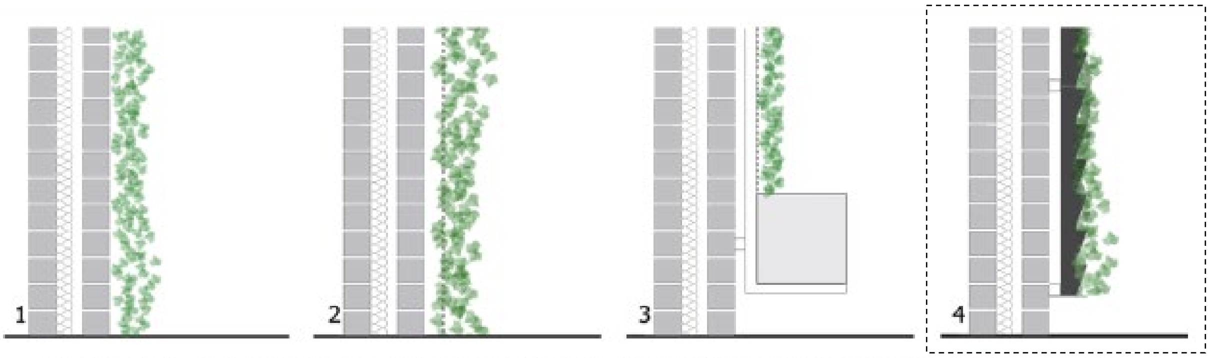

Figure 01. *1. Direct green facade, 2. Indirect green facade, 3. Indirect green facade combined with planter boxes, 4. Living wall system (Source: Perini, K. et.al 2013 Cost-benefits for green facades and living walls systems).*

<table>
<tr><td>Measure responding to</td><td colspan="6">Adaptation
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<tr><td>Scale of application</td><td colspan="4">City
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☐</td></tr>
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☐</td><td colspan="4">Medium term (10 yr)
☐</td><td colspan="4">Long term (50 yr)*
☒</td></tr>
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<tr><td>Related secondary SDG, if any</td><td colspan="4">SDG 11</td><td colspan="4">Sustainable cities and communities</td><td colspan="4">11.6, 11.B</td></tr>
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☒</td><td colspan="3">Environment
☒</td><td colspan="3">People
☐</td></tr>
<tr><td>Main strategy addressed</td><td colspan="12">Reducing energy consumptions – Improving building insulation ENE 24
Improve outdoor urban environmental quality - Urban air quality ENV 22</td></tr>
<tr><td>Dimensional data</td><td colspan="12">(Case study) 1263 square meters (more than 44,000 types of mosses and plants).</td></tr>
<tr><td>Space usage</td><td colspan="6">Monofunctional
☐</td><td colspan="6">Multifunctional**
☒</td></tr>
<tr><td colspan="4">Construction costs</td><td colspan="9">(Case study total cost) 1 million euros ($1.3m).</td></tr>
<tr><td colspan="4">Maintenance / management costs</td><td colspan="9">(2^{nd}-50^{th} year) €4493 (worst scenario) - €4303 (best scenario) per year.</td></tr>
<tr><td colspan="4">Quantification / metrics</td><td colspan="9">Internal insulated wall (15cm of polystyrene with 30cm of concrete) reduction in cooling energy consumptions 4.7- 6.2%.</td></tr>
</table>

Detailed description

GW apart from having an important aesthetic effect making the area attractive while affecting positively people´s psychological and physical well-being, can contribute to the improvement of the air quality (capturing fine particulate matter and reducing Co2 levels), the reduction in the urban heat island effect and the creation of habitats to conserve and preserve biodiversity.

GW acts as an insulation layer, reducing heat losses in winter and avoiding gaining on summer, diminishing the energy usage for cooling and heating systems; reduce street noise and internal reverberation and can help prolonging the life of the structure reducing the damage generated by UV radiation and temperature fluctuations.

Best practices

Centro Commerciale "Il Fiordalizo" (Rozzano, Milan, Italy)

Living wall system (pre vegetated panels) installed in September 2010 on the external wall of "Il Fiordaliso" shopping center and designed by architect Francesco Bollani. According to the designers it assists with regulating the temperature inside the shopping center, reduce ambient noise and CO2 levels from the traffic; also it can be easily dismantled and reused.

It has been recognized by the Guinness World Records as the world's largest vertical garden.

The design consists of a wire mesh within which were placed 200 different species of perennial plants cultivated on a sphagnum moss growing medium (brought from Chile´s forests) and an automatic irrigation system, equipped with dispensers.

http://wisesociety.it
https://inhabitat.com
http://www.peverelli.it

***Figure 02**. Image of the living Wall (Source: http://fioriefoglie.tgcom24i)*

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PERINI, K., OTTELE, M., HAAS, E.M., & RAITERI, R. (2011). Greening the building envelope, façade greening and living wall systems. Open *Journal of Ecology*, 01, 1-8.
PERINI, K., ROSASCO, P. (2013). Cost-benefits for green facades and living walls systems. Elsevier Journal, Building and Environment *(*Check tables for costs and performances)*.
TAKEBAYASHI, H., MORIYAMA, M. (2007). Surface heat budget on green roof and high reflection roof for mitigation of urban heat island. Building and Environment, 42(8), 2971-2979.

http://www.treebox.co.uk/building-benefits.html
http://www.growinggreenguide.org
https://www.urbangreening.info
http://www.urbangreenbluegrids.com/measures/green-facades/

The data is referred to the case study presented in best practices.
**The lifespan of the measure is according to the use of perennial species of plants, in the absence of any problem regarding to the irrigation system or others.*
***The Living wall is not used as an insulation device to regulate the internal temperatures, it also reduces CO2 levels and has an important esthetic factor.*

Nano Gardens

Definition

Nano gardens or square meter or balcony gardens are gardening techniques which allows people to grow plants using the constructed house space and does not require separate green areas for gardening practices.

Measure responding to	Adaptation ☒		Mitigation ☐	
Scale of application	City ☐	Neighbourhood ☐	Building ☒	
Expected efficacy of the measure	Immediate (< 1 yr) ☒	Medium term (10 yr) ☐	Long term (50 yr) ☐	
Lifespan of the measure (durability)	Short term (< 1 yr) ☐	Medium term (10 yr) ☐	Long term (50 yr) ☒	
Related primary SDG, if any	SDG 12	Specific associated targets	12.2	
Related secondary SDG, if any	-	Specific associated targets	-	
Addressed themes	Accessibility ☐	Energy ☐	Environment ☒	People ☐
Main strategy addressed	• To Avoid land consumption • Landscape management and improvement			
Dimensional data	General sizes: 8 – 32 sqft			
Space usage	Monofunctional ☐		Multifunctional ☒	
Construction costs	€ 7 / sqft + cost of plants used			
Maintenance / management costs	It depends on the space, light and exposure and the amount of time, energy.			
Quantification / metrics	Land Use Reduction $=\frac{land\ used\ by\ conventional\ garden - land\ used\ by\ nanogarden}{land\ used\ by\ conventional\ garden} * 100\%$			

Detailed description

Conventional gardens require an extra land other than the land where the house has been constructed to grow flowers, fruits, vegetables, etc. However, with increasing urbanisation and rise in property prices, it is becoming increasingly difficult to be able to have extra land for gardening. Also, high rise apartment buildings do not allow its dwellers to have “external” gardens. Keeping this issue in mind unconventional gardening practices were introduced termed collectively Nano-gardens here. These concepts allow using balcony, garage or indoor space of a house to be used for gardening practices. Thus, people fond of having flowers or having vegetables from their own gardens can still have all of this without having out-door conventional gardens.

There are three main concepts involved in Nano-gardens which might be used separately or in conjunction:

Balcony Gardens - A balcony garden can be as complicated or simple as one want and with plant and container choices it can be made either a relatively low maintenance, easy balcony garden, or a full-on farm.

Square Meter Garden- Sometimes called patchwork gardening, as different crops are planted in series of squares, there are normally 9-12 squares in each one meter bed. It is based on intensively planting a variety of crops in a grid pattern, in a raised planter or container.

Indoor Gardens- These rely on hydroponics i.e. the method of growing plants without soil, using mineral nutrient solutions in a water solvent. Window farming kits generally involve a hybrid, hydroponic gardening system that's made out of recycled materials and hung vertically in your window.

Best practices

Balcony garden will be best suitable for small size plants that can be placed in a pot or a planter. It will not require lots of maintenance except watering on a daily basis. The interaction between people and plants will only be limited by the acquaintances of the owner. But visitors still can enjoy the diversity of vegetation on each balcony and interact with the owner while he or she is out there taking care of the plants as incorporated in Milano Santa Monica.

Advantages:

balcony garden shows personal characteristics of residents
balcony garden does not require too much maintenance with pot plants
balcony garden brings nature close to the units and the community
balcony garden circulates fresh air into the building.

Disadvantages:

balcony garden tends to grow small plants in the pot or planters
balcony garden compromises resident’s privacy
balcony garden is hard for visitors to interact with plants.

https://www.dezeen.com/2014/05/15/stefano-boeri-bosco-verticale-vertical-forest-milan-skyscrapers/

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Tips for starting a balcony garden. (n.d.). Retrieved November 2, 2017, from https://www.thespruce.com/tips-for-starting-a-balcony-garden-847801
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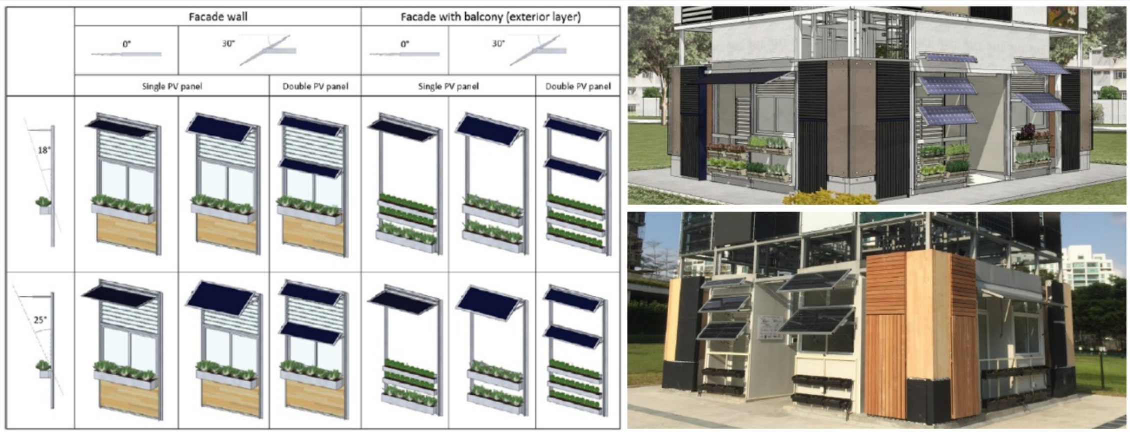
Square foot (or meter) gardening! (2010, August 05). Retrieved October 30, 2017, from https://giiablog.wordpress.com/2010/06/01/square-foot-or-meter-gardening/
Mok, K. (2017, September 12). Assemble Your Own Windowfarm: Edible Urban Garden In A Kit (Video). Retrieved November 3, 2017, from https://www.treehugger.com/sustainable-product-design/assemble-your-own-windowfarm-edible-urban-garden-in-a-kit-video.html
Mok, K. (2017, September 12). Sleek hydroponic unit lets you grow a garden in your kitchen. Retrieved November 3, 2017, from https://www.treehugger.com/sustainable-product-design/kitchen-nano-garden-hydroponic-hyundai.html

Productive facade systems

Definition: Productive facade systems are used for energy and food harvesting. Facade elements that enhance indoor daylight conditions, shading, and thermal performance, and wind permeability and productivity benefits (food, alternate energy source or air-conditioning).



Measure responding to	Adaptation ☒		Mitigation ☒	
Scale of application	City ☐	Neighborhood ☒	Building ☒	
Expected efficacy of the measure	Immediate (< 1 yr.) ☒	Medium term (10 yr.) ☐	Long term (50 yr.) ☐	
Lifespan of the measure (durability)	Short term (< 1 yr.) ☐	Medium term (10 yr.) ☒	Long term (50 yr.) ☐	
Related primary SDG, if any	SDG 11	Reduce the adverse per capita environmental impact of cities	11.6,11.C,11. C.1	
Related secondary SDG, if any	SDG 07, SDG 12	Ensure access to affordable, reliable, sustainable and modern energy for all, Ensure sustainable consumption and production patterns	7.2, 7.2.1,12.8, 12.2.2	
Addressed themes	Accessibility ☐	Energy ☒	Environment ☒	People ☐
Main strategy addressed	Reducing energy consumptions – Improving building insulation Improve outdoor/ indoor urban environmental quality - Urban air quality			
Dimensional data	Modular productive facade prototypes that can be factory made in different dimensions (Height: 900-700mm). The systems can be assembled/installed as a retrofitting measure in existing buildings.			
Space usage	Monofunctional ☐		Multifunctional ☒	
Construction costs	N/A			
Maintenance / management costs	N/A			
Quantification / metrics	% of efficiency Lowest Irradiance / m^2 (kWh) Electricity Generation (kWh) / vegetable production (kg / year)			

Detailed description

The integration of solar and farming systems contributes to the productive role of buildings involving the implementation of Building Integrated Photovoltaics (BIPV) and Building Integrated Agriculture (BIA) systems. In addition to the final food and energy yield, the design optimization considers the impact that arrangements, geometrical forms and types of facade elements may have on the indoor daylight conditions, shading and thermal performance, and wind permeability. Efficiency of the modular systems are measured in terms of daylight performance, thermal performance, natural ventilation, and electricity production.
Emerging Productive facade systems in the market that focuses on various approaches for designing sustainable facade includes Bio-photovoltaic panels & Moss Voltaic*, I-facades** that can be integrated with the efficient structural system as prefabricated or precast facades.
*Bio-photovoltaic panels & Moss Voltaic: Produce energy from microbial natural process and implement in urban scale.
**I-facades: capable of generation electricity and charging devices wirelessly.at macrolevel integration of similar skins in buildings with central control system will help reducing dependency on city's grid supply, distribution and management of electricity energy.

Best practices

Case study: Housing and Development Board (HDB), Singapore Urban farming construction model on the vertical building also to support green building development in the Sleman, Indonesia. Singapore has committed to reduce greenhouse gases emissions and seek alternative solutions to reduce high dependency on food imports by increasing locally produced food and energy in future. Target year to reach city's self-sufficiency being 2030 which is the commitments of the United Nations Framework Convention on Climate Change Paris Agreement (United Nations, 2015). The implementation of the façade system is in design optimization stage.
Performance indicators for the facade type is measured for Daylight Autonomy, Energy Flow (heat gain-heat loss), Electricity potential, Farming Potential and view angle of the system, where facade orientation and arrangement play a crucial role. Design considerations and specifications of units are decided based on avoidance of overshadowing of upper PV panels on the green productive panel underneath and assurance best access of sunlight to the planter panel.

References

Productive facade systems:
Tablada, A., Kosorić, V., Huang, H., Chaplin, I., Lau, S., Yuan, C., & Lau, S. (2018). Design Optimization of Productive Façades: Integrating Photovoltaic and Farming Systems at the Tropical Technologies Laboratory. *Sustainability,10*(10), 3762. doi:10.3390/su10103762
Tablada, A., Chaplin, I., Huang, H., Kosoric, V., Lau, S. K., Yuan, C., & Lau, S. (2017). Assessment of Solar and Farming Systems Integration on Tropical Building Facades. *Proceedings of SWC2017/SHC2017*. doi:10.18086/swc.2017.12.11
Emerging systems:
F & F Media and Publications, & Wfm-india. (2017, December). Window & Facade Magazine - November/December 2017 issue. Retrieved November 03, 2018, from https://issuu.com/wfm-india/docs/wfm_magazine_vol._4_issue_2
Moss Voltaics - The Institute for Advanced Architecture of Catalonia. (n.d.). Retrieved November 03, 2018, from https://iaac.net/project/moss-voltaics/

Urban Rooftop Farming

Definition

Urban rooftop farms are the spaces/areas located on the building's rooftops, used for growing vegetables, fruits and herbs generating benefits such as reduction of the urban heat-island effect, avoided storm water runoff, nitrogen fixation, pest control, and energy savings.


Measure responding to	Adaptation ☒		Mitigation ☒	
Scale of application	City ☐	Neighbourhood ☐	Building ☒	
Expected efficacy of the measure	Immediate (< 1 yr) ☒	Medium term (10 yr) ☐	Long term (50 yr) ☐	
Lifespan of the measure (durability)	Short term (< 1 yr) ☐	Medium term (10 yr) ☐	Long term (50 yr) ☒	
Related primary SDG, if any	SDG 13	Specific associated targets	13.1, 13.2	
Related secondary SDG, if any	SDG 11	Specific associated targets	11.6, 11.A, 11.B	
Addressed themes	Accessibility ☐	Energy ☒	Environment ☒	People ☒
Main strategy addressed	Improve outdoor urban environmental quality - Urban Air Quality – ENV22			
Dimensional data	20-40mm / 75-150mm depth 60kg/ m² load			
Space usage	Monofunctional ☐		Multifunctional ☒	
Construction costs	$10-$25 per square foot of roof space			
Maintenance / management costs				
Quantification / metrics	Global warming (kg CO2 eq), water depletion (m3), cumulative energy demand (MJ), human toxicity (kg 1,4-DB eq)			

Detailed description

Urban rooftop farming (URF) involves the development of farming activities on ther top of buildings by taking advantage of the availability of terraces and roofs. This technique can be developed through open air or protected technologies and can be used in multiple purposes.
URF has been spreading over cities in developed countries usually like rooftop farms and rooftop greenhouses, most of the cases dominated by commercial initiatives, providing local food in an environmentally-friendly way and devoted to the community.

Best practices

Le Cordon Bleu, Paris

The prestigious cooking school "Le Cordon Bleu" opened its new headquarters in Paris in June 2016, its remarkable four-storey building is visited every year by more than 1 000 students from more than 100 countries. The garden at the roof of the building with a size of 800 m² is part of the educational program and is proposed to show students how fruits, vegetables and herbs are cultivated in an urban environment. Also, the roof houses 4 beehives, an insect hotel, a composting machine for garden and kitchen waste as well as a water pump for irrigation.

Rooftop Farm in Zuidpark, Amsterdam

The "Zuidpark" is composed of two office buildings and in 2012 was completely renovated and improved to today's technical standards. Vegetables and fruits are being grown on the approximately 30 x 100 m large roof. The staff of this commercial complex has the opportunity to grow and preserve their own fruits and vegetables on one part of the roof surface. On the rest of the surface, vegetables are also being grown, the sames that are used in the company canteen. Here the system build-ups "Urban Rooftop Farming" on the proven Floradrain® FD 40-E element as well as "Sedum Carpet" with Fixodrain® XD 20 have been applied.

Source*: Zinco greenroof website*

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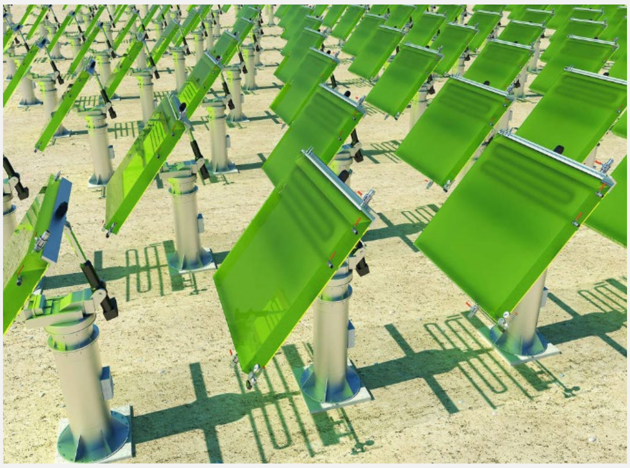
- Esther Sanyé-Mengual, Francesco Orsini, Jordi Oliver-Solà, Joan Rieradevall, Juan Ignacio Montero, Giorgio Gianquinto. (2017). *Techniques and crops for efficient rooftop gardens in Bologna, Italy.* Retrieved Nov 2, 2018, from https://hal.archives-ouvertes.fr/hal-01532265/document

Algae Production

Definition

In the process of growing, algae consume CO_2, as well as producing an oil that can be turned into an environmentally-friendly fuel. At the end of its lifecycle, the biomass of the algae can be processed into an organic fertiliser.



Measure responding to	Adaptation ☐	Mitigation ☒		
Scale of application	City ☒	Neighbourhood ☒	Building ☒	
Expected efficacy of the measure	Immediate (< 1 yr) ☐	Medium term (10 yr) ☒	Long term (50 yr) ☐	
Lifespan of the measure (durability)	Short term (< 1 yr) ☐	Medium term (10 yr) ☒	Long term (50 yr) ☐	
Related primary SDG, if any	SDG 7	Specific associated targets	7.2	
Related secondary SDG, if any	SDG 11	Specific associated targets	11.6, 11.b	
Addressed themes	Accessibility ☐	Energy ☒	Environment ☒	People ☐
Main strategy addressed	Sustainable energy production, and a reduction of CO_2 concentrations.			
Dimensional data	(Depends on the scale of implementation)			
Space usage	Monofunctional ☐	Multifunctional ☒		
Construction costs	$9 per Kg (compared to $4 for soybean, as current technology is not so efficient)			
Maintenance / management costs	--			
Quantification / metrics	Algae can produce up to 15 000 litres of oil per acre (compared to 200 from Soybean)			

Detailed Description

There are many advantages for the cultivation of algae. One advantage is that it does not compete with the production of food, because of the fact that it can be grown in areas that are unsuitable for food production. Algae cultivation does not require either freshwater resources or soil for growth, and can even be grown in aqueous saline suspension. And so, whilst the production of biofuels from crops such as corn creates problematic competition between food consumption and fuel, algae grow in saltwater and do not require arable land or pesticides.

Algae have a considerably rapid growth rate, producing up to 10 times higher yields per hectare, per year in comparison to other biofuels.
Algae can either grow in open ponds or in enclosed photobioreactors, and whilst the latter are more costly, they promote faster growth and are more efficient.
As algae need a concentrated source of carbon dioxide, large-scale algae operations could significantly reduce emissions from nearby industries that would otherwise be released into the surrounding atmosphere.

Best practices

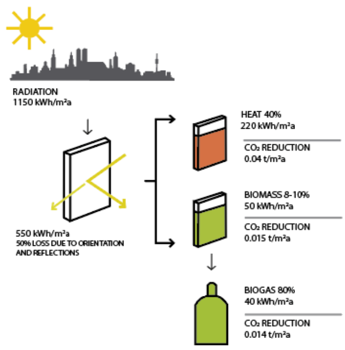
Name: The Algae House
Location: Hamburg, Germany, at the International Building Exhibition (IBA)
Scale: Building
Method: Photobiorector Façade

This case study presents the world's first algae bioreactor façade. This multi-storey residential building employs a prototypical method of producing energy and regulating light and sun shading.

Due to the hybrid functionality of the algae façade, the building combines various processes of regenerative energy production to create a sustainable circulation system of: solar heat, geothermal energy, biomass and a fuel cell, that together form three storable energy sources in the form of: heat, electricity and biogas.

The containers are able to store CO_2 and produce biogas. The biogas generates 4500 kWh per year, in addition to the bioreactors solar thermal function, which produces 32 MW heat per year. The energy generated can be used directly in house, fed into the local power network or temporarily stored underground.

The façade also fulfills the functions expected of conventional cladding; acting as a thermal and sound insulation, whilst also providing a function as a sun shield.



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Facilities for birds and other fauna

Definition

Introduce more facilities for fauna in the urban context to increase biodiversity. Include fauna in general in urban planning.

Measure responding to	Adaptation ☐		Mitigation ☒	
Scale of application	City ☐	Neighbourhood ☐	Building ☒	
Expected efficacy of the measure	Immediate (< 1 yr) ☐	Medium term (10 yr) ☒	Long term (50 yr) ☐	
Lifespan of the measure (durability)	Short term (< 1 yr) ☐	Medium term (10 yr) ☐	Long term (50 yr) ☒	
Related primary SDG, if any	SDG 15	Specific associated targets	15.5, 15.9, 15.a	
Related secondary SDG, if any		Specific associated targets		
Addressed themes	Accessibility ☐	Energy ☐	Environment ☒	People ☐
Main strategy addressed	Enhancement of natural capital and biodiversity			
Dimensional data	Variates a lot depending on the type and the amount of wildlife the intervention is aimed for			
Space usage	Monofunctional ☒		Multifunctional ☐	

Construction costs	Variates a lot depending on the type of intervention
Maintenance / management costs	Variates a lot depending on the type of intervention
Quantification / metrics	An example of quantification could be seen in the high-tech app 'the SGBioAtlas' developed by The National Biodiversity Centre. This allows all members of the public to take a photo of a plant, bird or animal. The app geotags it and uploads it into their central database (UN environment, 2018).

Detailed description

Cities are growing at a faster rate than any other habitat on Earth. They may seem an unlikely place for animals to prosper, but there lays a surprising opportunity in them. Animals and wildlife are mostly attracted by food and shelter when they choose cities over a more natural environment. The high concentration of humans in cities entails a lot of food waste. Thanks to the heath island effect the birds and other wildlife are tempted by the city, where they find a lot of shelter options.
Some small scale and low cost interventions may already notably increase the biodiversity. In those cases, we think of installing birdhouses, implementing bat facilities, providing insect hotels, storing green waste and compost piles to offer homes for hedgehogs and other diverse animals, planting nectar-producing berry- and fruit-bearing plants to attract insects and birds, etc. As the architects of this environment will we choose to build cities that create a home for both us and for wildlife? Some examples that want to increase the biodiversity on a much bigger scale by a single but large scale intervention are pointed out in the following section 'best practices'.

Best practices

1. Gardens by the Bay, Singapore – *image 1*
The Gardens by the Bay consist of forest environments created within buildings and in open spaces in the city. It includes 'Supertree Grove' which are tall tree structures between 25 meters and 50 meters high built on reclaimed land that integrate animal-friendly flora into its systems and architecture. This could be one example of how wildlife might be brought into the cityscape on a 'building' scale level (Tosi, 2017).

2. Bosco Verticale, Milan – *image 2 & 3*
The Bosco Verticale is a model of vertical densification of nature within the city. The first realized example hosts 900 trees and over 2000 plants from a wide range of shrubs and floral plants. This helps to set up an urban ecosystem where different kinds of vegetation create a vertical environment which can also be colonized by birds and insects, and thus becomes both a magnet for and a symbol of the spontaneous recolonization of the city by vegetation and by animal life. The creation of a number of Vertical Forests in the city could make it possible to create a network of environmental corridors which will give life to the main parks in the city, bringing the green space of avenues and gardens and connecting various spaces of spontaneous vegetation growth in between which the wildlife can find their habitat (Stuart, 2016).

1

2

3

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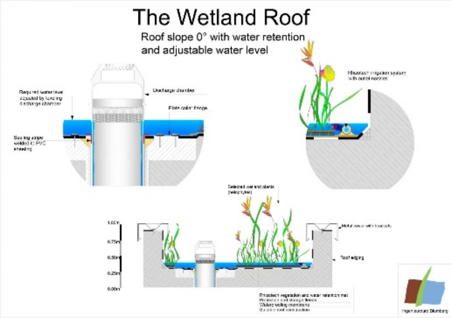
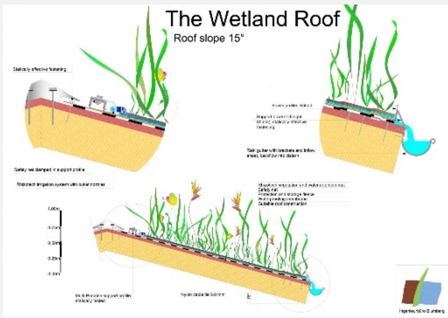
Wetland Roofs

Definition

A special type of extensive green roof which is evenly planted with wetland or marsh plants. It can help slow things down and spread the impact of heavy rain out over a longer period along with rainwater collectors.





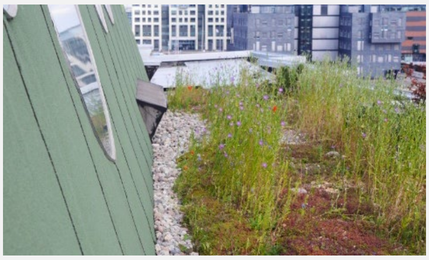
Measure responding to	Adaptation ☒		Mitigation ☒	
Scale of application	City ☐	Neighbourhood ☐	Building ☒	
Expected efficacy of the measure	Immediate (< 1 yr) ☒	Medium term (10 yr) ☐	Long term (50 yr) ☐	
Lifespan of the measure (durability)	Short term (< 1 yr) ☐	Medium term (10 yr) ☐	Long term (50 yr) ☐	
Related primary SDG, if any	SDG 13	Specific associated targets	13.1	
Related secondary SDG, if any	SDG 6	Specific associated targets	6.4, 6.7	
Addressed themes	Accessibility ☐	Energy ☐	Environment ☒	People ☐
Main strategy addressed	Strategies for a more efficient water management			
Dimensional data	1.Roofs are installed with varied substrate depth to support plant diversity, ranging from 80 mm – 300 mm. 2.The depth of materials used as water storage and plant carrier mats is 300 mm.			
Space usage	Monofunctional ☐		Multifunctional ☒	
Construction costs	N/A			
Maintenance / management costs	N/A			
Quantification / metrics	N/A			

Detailed description

1.One kind of roofs is installed with varied substrate depth to support native plant diversity. The main component of the green roof substrate used is crushed bricks and green waste compost. The main roofs substrate depth will in itself absorb a lot of rainwater. Rainwater from the large roof top is also led down to the wetland roof, which has a high capacity of storing water. The roof has a rim of 150 mm where the waterproofing is pulled up on the sides and the drainage point is located 120 mm above the roof surface. Thus the roof will have a high capacity of both holding rainwater and also slow down the run off speed.
2. Special textile water storage mats planted with moisture preferring plants are installed on the roof. The selected types of wetland or marsh plants will be pre-cultivated on mats of non-woven material for one year. The automatic watering of the wetland roof is steered by an irrigation computer. The rainwater usually stored by cisterns will be pumped on the plant mats in intervals, thus ensuring a sufficient water supply. Surplus water will be collected in the rain gutters, conveyed back into the rainwater cistern and will then be pumped back on the roof.

Best practices

1.Malmo, Sweden
The roofs are installed with varied substrate depth to support plant diversity. The substrate is at some parts mixed with a little bit of shingle. The limestone will make phosphorus less available to the plants and thus in this areas of the roof potentially “support” the less competitive meadow plants. The wetland roof has some small areas with open ponding water which is a potential water resource for insects and birds. Rainwater from the large roof top is led down to the wetland roof, which has a high capacity of storing water. At the large roof on top of the main building a roof deck and orangery is available the whole year for all tenants living in the house. The wetland roof is viable for most of the tenants.



2.Zofingen, Switzerland
Wetland roofs are used for retention and purification of stormwater and are also an option for greywater treatment. The effluent water may be reused for irrigation, for groundwater recharge by seepage into the ground or for sanitary facilities by greywater recycling. Wetland or marsh plants are especially appropriate for the filtration of airborne particles, due to their active vegetation mainly during the summer months. Dust particles accumulate on the surface of the vegetation layer and will then be rinsed into the mats by rainwater. There, most of the nutrients are absorbed and incorporated into the plant biomass. The protection of the roof skin by the permanent plant cover increases the durability of the roof. The selected types of wetland or marsh plants will be pre-cultivated on mats of non-woven material for one year before becoming part of a wetland roof structure. For the cultivation, these non-woven or textile based mats are equipped with suitable plants and are raised in a plant nursery for one vegetation period. After approximately six months pre-cultivation, the plant carrier mats are completely penetrated by roots and the mat strips are then ready to be installed on the roof. The mats have a considerable water storage capacity (10L/m²), thereby ensuring a water supply for the plants for at least one week in case of failure of the irrigation pump.

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Vertical Farming

Definition

"Vertical Farming", "Z Farming" or Horizontal Growing is the practice of using stereoscopic space to grow plants by utilizing concept of cultivating plants or animal life within skyscrapers or on vertically inclined surfaces.

Measure responding to	Adaptation ☒		Mitigation ☒	
Scale of application	City ☐	Neighbourhood ☐	Building ☒	
Expected efficacy of the measure	Immediate (< 1 yr) ☒	Medium term (10 yr) ☐	Long term (50 yr) ☐	
Lifespan of the measure (durability)	Short term (< 1 yr) ☐	Medium term (10 yr) ☐	Long term (50 yr) ☒	
Related primary SDG, if any	SDG 11	Specific associated targets	11.6	
Related secondary SDG, if any	SDG 13	Specific associated targets	13.2	
Addressed themes	Accessibility ☐	Energy ☒	Environment ☒	People ☒
Main strategy addressed	Strategy for concept of "Food Security" to have more "Resilient Food System" within a community			
Dimensional data	Construction cost and exependitures of one skyscraper utilized for production of indoor food vary according to number of floors and types of materials used for construction. As an example, for one 37 floor vertical farming skyscraper expenditures and construction cost is around 100- 200 million $.			
Space usage	Monofunctional ☐		Multifunctional ☒	
Construction costs	$ 100- 200 million (Depending on the number of floors)			
Maintenance / management costs	--			
Quantification / metrics	--			

Detailed description

Vertical farming is concept of **combination of technology and agriculture** all together in a way that scatters and provides food for **large scale in and on buildings** in urban areas. This innovative type of urban agriculture is based on opportunities resulting from **reusing and recycling** of resources from waste.

A 30 story vertical farm with different floors that different types of vegetable are grown by using diverse growing technologies. Producing energy and power for growing different plants are done by aids of solar cells which absorb solar energy as well as, incineration of plant waste dropped from each floor. Irrigation system is connected directly to Cleansed city wastewater and provide sufficient water for growing food instead of connecting to being dumped into the environment. The role of sun and other artificial illumination is to provide light required for growth and then incoming seeds would be tested in a lab and germinate in a nursery (Hong M. Khoo 2015). Eventually, the ground floor of a vertical farm needs to be a grocery store or a restaurant in which the fresh and organic food would be sold to the public by restaurant and grocery, supplying organic nutrients. What makes such products unique is their freshness since they are provided for the customers upon being harvested. They are also much cheaper than ordinary crops because the cost does not include that of transportation or storage.

In total a 30 story vertical farms contain 30 floors which offers four growing seasons doubled the plants density and it could produce 2400 acres of food.

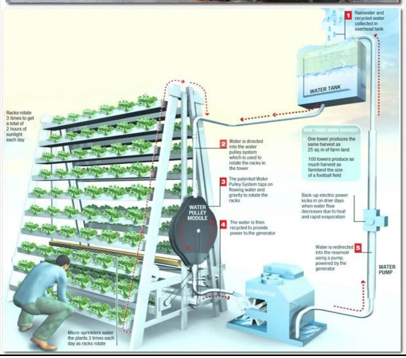
Best practices

"Vertical Farming" example in Singapore: "Sky Urban Solution" Company

Idea of starting up a company named as "Sky Urban Solution" brought up primarily with vertical-farming prototype "A-Go-Gro" in 2011. It was believed that usage of this method could be utilized as the high-tech **solution for crop yields and food security** concerns in densely-populated urbanized regions (Hong M. Khoo 2015).

Idea of Vertical Farming in Singapore has had positive reflection. Geographical location and natural disasters that threat the city, prevent from self- reliance of food production within the city and make to import foods and even fuel from nearby countries. Therefore, utilizing sky urban green solution has numerous advantages of elimination the need for fossil fuels used for plowing, fertilizing, seeding, weeding and harvesting, elimination of air contamination due to heavy traffic and haze by aims of well-qualified air, usage of renewable energy generation with sun, wind and environment-friendly biomass and waste incineration without any needs to farmland, declining harmful impacts on wildlife, protection of biodiversity and restoring ecosystem functions.

The sum of all benefits that vertical farms can bring to its operators, the city, consumers and the environment, are persuasive. A year-round, ecologically healthy food production without weather related crop failures generate completely controlled, safe food without the use of pesticides or herbicides. Faster growth rates and higher yields offer a fast return on the initial investment. The locally grown food brings new employment opportunities, drastically reduces. While traditional agriculture by using enormous amounts of pesticides, herbicides, fertilizers pollutes the air and damages the ecosystem and many other disadvantages that it has.



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Climate Façades

Definition

Climate façades help reduce energy consumption for interior climate using plants grown in supported vertical structure, cutting down heat loss in the winter and heat gain in the summer.


Measure responding to	Adaptation ☒		Mitigation ☒	
Scale of application	City ☐	Neighbourhood ☒	Building ☒	
Expected efficacy of the measure	Immediate (< 1 yr) ☒	Medium term (10 yr) ☐	Long term (50 yr) ☐	
Lifespan of the measure (durability)	Short term (< 1 yr) ☐	Medium term (10 yr) ☐	Long term (50 yr) ☒	
Related primary SDG, if any	SDG 11	Implement policies and plans towards mitigation and adaptation to climate change	11.B	
Related secondary SDG, if any	SDG 13	Strengthen resilience and adaptive capacity to climate-related hazards	13.1.1, 13.1.2, 13.1.3	
Addressed themes	Accessibility ☐	Energy ☒	Environment ☒	People ☐
Main strategy addressed	Reduce energy consumption for temperature adaptation indoors			
Dimensional data	850m² (Case study)			
Space usage	Monofunctional ☐		Multifunctional ☒	
Construction costs	€ 532 for 850m²			
Maintenance / management costs	Varies			
Quantification / metrics	Increase temperature by 6.81 °C in the winter Reduce temperature by 8.79 °C in the summer			

Detailed description

Climate façades “green” the building using pot bound plants for a variety of functions: They meet the residents demand for nature, they create ecological niches and habitats for many kinds of insects and birds, and have positive effects on the surrounding indoor and outdoor climates. Pot bound plants are generaly applied to balconies, loggias and terraces of apartment complexes but in this case they are integral part of a building’s facade they planted in rows of supporting structure and may be applied in any size at any height of a building.

Best practices

The headquarter building of the Municipality Department 48 ‘Waste Management’ of the City of Vienna was equipped with 850m² of a linear Living Wall system in autumn 2010. Since February 2011 the effects of the Living Wall concerning microclimate and building physics have been investigated in comparison to the original plaster facade. The tested Living Wall cools the building in summer (minus 5 - 10 °C) and warms it in winter (plus 5 - 8 °C). Accordingly, the heat flux was reduced by almost fifty percent. The surface temperature of the Living wall is 10 to 15 °C lower than the surface temperature of the plaster facade and hence the emissivity reduced significantly. The façade is intended to be more than a singular project for climate adaptation; it should serve as an example for other buildings to duplicate. It and the other projects it inspires create “green jobs” resulting from the care and maintenance of the façade, which do not cost more than the cost of cleaning of glass façades that would be otherwise necessary.

Figure 1: The façade of MA 48 shortly after construction in 2010

Figure 2: The façade of MA 48 today.

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Public and Urban Spaces Interventions

Bioswales

Definition

A bioswale is a long, channeled depression or trench that receives rainwater runoff and has vegetation and organic matter to slow water infiltration and filter out pollutants.

Measure responding to	Adaptation ☒		Mitigation ☐	
Scale of application	City ☐	Neighbourhood ☒	Building ☐	
Expected efficacy of the measure	Immediate (< 1 yr) ☒	Medium term (10 yr) ☒	Long term (50 yr) ☒	
Lifespan of the measure (durability)	Short term (< 1 yr) ☐	Medium term (10 yr) ☐	Long term (50 yr) ☒	
Related primary SDG, if any	SDG 15	Specific associated targets	15.9, 15.1	
Related secondary SDG, if any	SDG 6	Specific associated targets	6.3	
Addressed themes	Accessibility ☐	Energy ☐	Environment ☒	People ☐
Main strategy addressed	Efficient water management – filtration and natural drainage management			
Dimensional data	It could be used to serve areas with less than 10 acres and slopes no greater than 5%. The total surface area of the swale should be at least 1% of the area which receiving the stormwater.			
Space usage	Monofunctional ☐		Multifunctional ☒	

Construction costs	\$5.500/sq ft<\$15.000/sq ft<\$24.000/sq ft
Maintenance / management costs	\$0.060/sq ft<\$0.120/sq ft <\$0.210/sq ft
Quantification / metrics	Bioswale can reduce surface runoff by approximately 99%, and reduced nitrogen, phosphate, and total organic carbon loading by 99%, 99%, and 99%.

Detailed description

In bioswale systems, the water running off from roofs and roads does not flow into the sewers but instead is led into the bioswale via above-ground gutters and/or ditches. Bioswales can be incorporated into the green infrastructure and can help enhance biodiversity and quality of life.
The top layer consists of enhanced soil with plants. Below that layer is a layer of gravel, scoria or baked clay pellets packed in geotextile. These materials have large empty spaces, allowing the rainwater to drain off. The layer is packed in geotextile to prevent the layer from becoming clogged by sludge or roots. An infiltration pipe/drainpipe is situated below the second layer. To prevent the bioswale from overflowing its banks during heavy rainfall, overflows are added that are connected directly to the infiltration pipe/drainpipe. Rainfall infiltrates into the ground via the ditch and the packed layer. If the water rises above the level of the overflow, the water runs through it to the drainpipe. The bioswale's dimensions should be sufficient to ensure that this occurs no more than once every two years. If the drain and the overflow both fill up, the bioswale acts as an above-ground drainage system and leads the water directly to surface water.

Best practices

Seattle Public Utilities constructed a drainage project at 2nd Avenue NW known as a Street Edge Alternatives (SEA Streets) project. It involved the complete reconstruction of the street and its drainage system to reduce impervious area and install stormwater detention ponds. It was completed in the spring of 2001, and designed to provide drainage that more closely mimics the natural landscape prior to development than traditional piped systems. To accomplish this, Seattle reduced impervious surfaces to 11% less than a traditional street, provided surface detention in swales, and added over 100 evergreen trees and 1100 shrubs.
The results of this natural drainage system are:

- a better water quality aside of the reduction of flooding and damaging flows,
- an aesthetic benefit for the landscape in addition to the management of the rainfall,
- a porous sidewalk which allows stormwater infiltration and reduced runoff volume,
- a design which helps slow traffic creating an area more attractive to pedestrians and bicycles,
- an increasing feeling of safety in the neighborhood that reinforce the sense of community,
- a more cost-effective result. The construction costs 25% less than traditional roadside stormwater systems. (Matsuno 2001)

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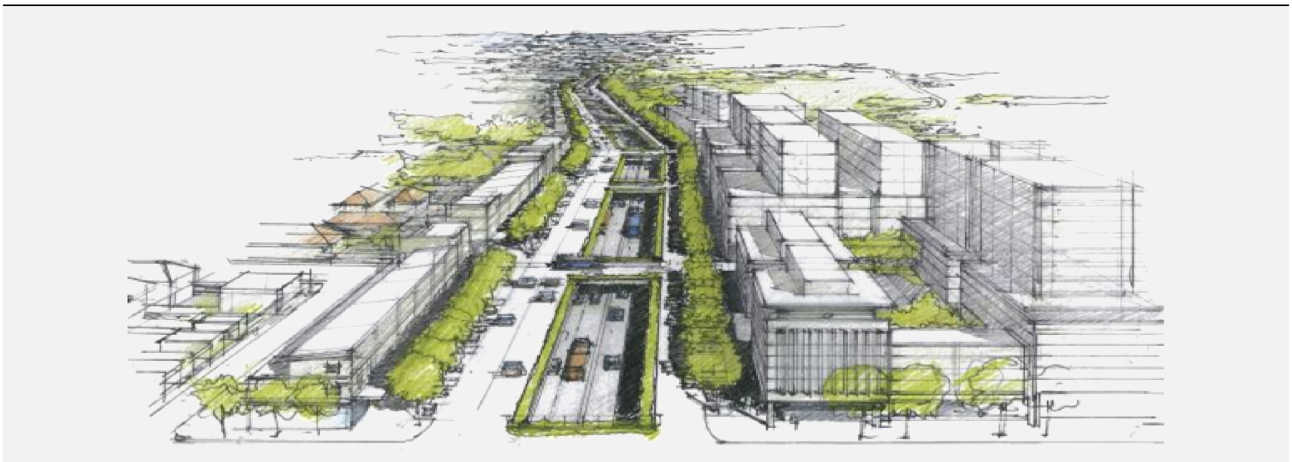
Tree-lined streets

Definition

A tree-lined road or street is the street that has trees on either side.



Measure responding to	Adaptation ☒		Mitigation ☒	
Scale of application	City ☒	Neighbourhood ☒		Building ☐
Expected efficacy of the measure	Immediate (< 1 yr) ☐	Medium term (10 yr) ☒		Long term (50 yr) ☐
Lifespan of the measure (durability)	Short term (< 1 yr) ☐	Medium term (10 yr) ☐		Long term (50 yr) ☒
Related primary SDG, if any	Climate Action	Support positive economic, social and environmental links between urban, peri-urban by strengthening national and regional development planning		Sustainable cities and communities
Related secondary SDG, if any	Life on Land	Specific associated targets		Good Wealth and well-being
Addressed themes	Accessibility ☐	Energy ☒	Environment ☒	People ☐
Main strategy addressed	ENV 22 urban air quality			
Dimensional data	$50 per tree			
Space usage6k	Monofunctional ☐		Multifunctional ☒	

Construction costs	$50 per tree
Maintenance / management costs	For every 1,000 trees that die in a year, the city will have to spend $450,000 to replace them
Quantification / metrics	A fast-growing plant that can reach up to 20-25 metres tall. It can store 3,660 kg of CO2 in 20 years and effectively absorb and capture pollutants.

Detailed description

This project focuses on the effect of tree-line streets on the psychology of pedestrians and urban design quality. It was suggested a respected paradigm to explore the effect of roadside landscape on behavior of street users and car drivers. The measure developed for use in simulation was derived from Berlyne's theory of visual complexity in the field of environmental psychology and Lynch's work in the aesthetic dimensions of city legibility.

Best practices:
American Association of State Highway and Transportation Officials and reiterated in municipal manuals and standards in USA.

The center pane of the simulation pairs used for the drive-through shows the difference with and without curbside street trees.
In this pilot study, the results from the driving trials in the simulator indicated that the street tree effect may provide positive safety benefits for drivers.

Confronted with public demand for street trees, a workable set of engineer-friendly, evidence-based design guidelines that consider the positive effects of street trees on road operations is needed. Design standards regarding placement, tree species, the size and spacing of underground "soil ducts," city "floor" detailing and many others needed to protect necessary public investment should reflect a consideration of the safety effect. This requires development of regionally specific guidelines with input from the traveler, the arborist and the transportation engineer. A national process needs to be developed to facilitate this multi-disciplinary input that considers the positive effects of street trees on the transportation network.

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Car parks with green area

Definition

An environmental friendly car parking, where the greenery is integrated in the design and taking a big part of the parking lots.

Measure responding to	Adaptation ☒	Mitigation ☐		
Scale of application	City ☒	Neighbourhood ☒	Building ☒	
Expected efficacy of the measure	Immediate (< 1 yr) ☒	Medium term (10 yr) ☐	Long term (50 yr) ☐	
Lifespan of the measure (durability)	Short term (< 1 yr) ☐	Medium term (10 yr) ☒	Long term (50 yr) ☐	
Related primary SDG, if any	SDG 9	9.1 develop quality, reliable, Sustainable and resilient infrastructure	X.X, X.X	
Related secondary SDG, if any	SDG XX	Specific associated targets	X.X, X.X	
Addressed themes	Accessibility ☒	Energy ☐	Environment ☒	People ☐
Main strategy addressed	Strategies for landscape management and improvement ENV 17 Green coverage) Strategies to improve outdoor urban environmental quality (ENV 22 Urban air quality)			
Dimensional data	N/A			
Space usage	Monofunctional ☐	Multifunctional ☒		

Construction costs	N/A
Maintenance / management costs	N/A
Quantification / metrics	N/A

Detailed description

An environmental friendly car parking. There the greenery is integrated in the design and taking a big part of the parking lots. It can be semi-paved and have trees and grass planted on it. The main goal is to reduce the heat by vegetation, to lower the temperature. The Industrial estates, harbors and business estates are some of the hottest urban areas.

In additional, this green parking is enhancing air quality. The green plants and trees will absorb the emissions which is generated by cars. Moreover, the cars will stay cooler inside when they park over. An Overall view, this integration between car parking pavement and green vegetation consider as a cool island in the city.

Best practices

Derbyshire County UK
Cricket club parking with area 1820 sq.m

Now days sport arena carries a much wider demand for use than for match day alone. Because now more than one event arranged at this place. Which means a big demand and pressure on the large parking space. The aim is to create green environment. By using A reinforced concrete system with voids created by styrene void formers. A permeable paving layer with grass thickness 76 mm fills the void.

- It can be walked over and driver over immediately
- Rapid laying of large areas
- Resists differential settlement

More other ideal uses:

- Protecting slopes
- Landscaping on lawns which can be driver over
- Highways verges and pull-ins

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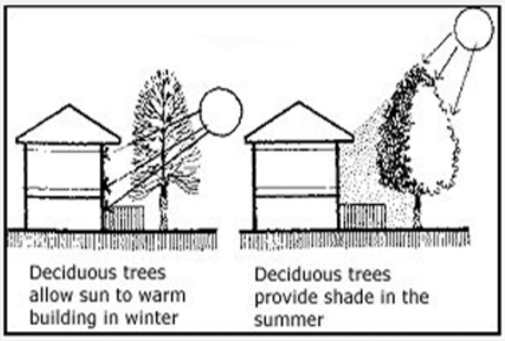
On the world wide web
http://www.urbangreenbluegrids.com/measures/car-parks-with-green-areas/
http://www.ttesysteem.nl/tte_direct_groen.html
http://www.grasscrete.com/pdfs/projectProfiles/Grasscrete/GCDerby.pdf

Shade Provided by Vegetation

Definition

Planting vegetation on streets, squares, parks creates shade and evapotranspiration and therefore has a cooling effect.



Measure responding to	Adaptation ☒		Mitigation ☐	
Scale of application	City ☐	Neighbourhood ☒	Building ☒	
Expected efficacy of the measure	Immediate (< 1 yr) ☒	Medium term (10 yr) ☐	Long term (50 yr) ☐	
Lifespan of the measure (durability)	Short term (< 1 yr) ☐	Medium term (10 yr) ☐	Long term (50 yr) ☒	
Related primary SDG, if any	SDG 11	Specific associated targets	11.7	
Related secondary SDG, if any		Specific associated targets		
Addressed themes	Accessibility ☐	Energy ☐	Environment ☒	People ☐
Main strategy addressed	Increasing Tree Coverage of Streets			
Dimensional data	Trees of different crown sizes have different dimensional datas.			
Space usage	Monofunctional ☒		Multifunctional ☒	

Construction costs	$.50 -.85 for one tree sapling to be grown at a nursery
Maintenance / management costs	$.10 - $.22 ongoing maintenance of trees
Quantification / metrics	Vegetation coverage ratio: Area of green area / Total area

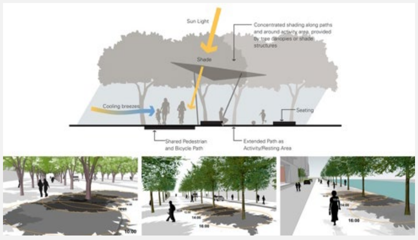
Detailed description

Strategically positioned trees and vegetation on the outsides of buildings can block out sunlight and thus limit the extent to which buildings heat up and need to be cooled. The positive effect is that plants that shed their leaves keep the sun out in summer while nevertheless letting the winter sun in. Non-deciduous plants on buildings can reduce transmission loss in winter by forming an additional insulating layer of air and limiting the amount of heat radiating off the building.
Nevertheless, there may be some negative effects if not placing the vegetation scientifically. Dense foliage over busy roads is not beneficial, since the emissions from the vehicles tend to become trapped under the foliage. The right type of tree and the right shape of tree top can help prevent pollutants from accumulating. The type of tree should be chosen to suit the local moisture system.

Best practices

Lulu Island in Abu Dhabi:
Lulu Island is a 469 hectare man-made island constructed of reclaimed sand. The plan features a robust sustainability management strategy to ensure the environmental, economic, and social sustainability of the island for the next 20 years, and beyond.

The majority of streets are oriented northwest to southeast to minimize heat gain and buildings are designed to mitigate harsh weather conditions and create microclimates and areas of shade and comfort. Along the main roads, trees are planted with a well-calculated density to ensure that there is continuous shadow for people to walk even in the noon. And trees of different sizes of crown have different planting density.



References

http://www.urbangreenbluegrids.com/measures/shade-provided-by-vegetation/
http://icity.ikcest.org
http://www.sasaki.com/project/37/Lulu%20Island%20Detailed%20Master%20Plan/

Community Gardens

Definition

A community Garden is an urban, suburban or rural piece of land in which it can grow flowers, vegetables or a community. It can be one community plot or many individual plots which are located at different scales such as school, hospital, or in a neighborhood.

Measure responding to	Adaptation ☒		Mitigation ☐	
Scale of application	City ☐	Neighbourhood ☒	Building ☒	
Expected efficacy of the measure	Immediate (< 1 yr) ☒	Medium term (10 yr) ☐	Long term (50 yr) ☐	
Lifespan of the measure (durability)	Short term (< 1 yr) ☐	Medium term (10 yr) ☒	Long term (50 yr) ☐	
Related primary SDG, if any	SDG 2,15	Specific associated targets	2.1, 2.4, 15.9	
Related secondary SDG, if any	SDG 1	Specific associated targets	1.4	
Addressed themes	Accessibility ☐	Energy ☐	Environment ☒	People ☒
Main strategy addressed	strategies to avoid land consumption, strategies for landscape management and improvement			
Dimensional data	20 volunteers is a workable number for a garden of 15.000 s			
Space usage	Monofunctional ☐		Multifunctional ☒	

Construction costs	Initial costs could run about $3,750 to $7,500 if you have a nearby source of water
Maintenance / management costs	About $50-$100 per year
Quantification / metrics	average size of 125 metres square

Detailed description

A community garden can help improve food security for participants by increasing physical and economic access to adequate amounts of healthy food. Community gardens are often used in urban neighborhoods to alleviate the food desert effect. Food deserts often serve lower-income neighborhoods usually in which residents are forced to rely on unhealthy food options.
Community gardens provide health, economic, educational, social. And environmental benefits to participants and the community at large. There are two main cathegory of these gardens which are Collective community gardens and Allotment Community gardens in four main action scales which are neighborhood gardens, residential gardens, institutional gardens, and demonstration gardens.

Best practices

-Alemany Farm empowers San Francisco residents to grow their own food, and through that process encourages people to become more engaged with their communities. They grow organic food and green jobs for low-income communities, while sowing the seeds for economic and environmental justice.

Alemany Farm accomplishes this mission through four main goals:

1. Ecological-Economic Development: Growing jobs for Alemany residents.
2. Food Security: Providing organic, healthy food to local community members.
3. Environmental Education: Introducing children and adults to the wonders of the natural world and the importance of local food production.
4. Building People's Power: Engaging residents in decision-making processes and activities that foster community involvement to organize for social, economic, and environmental justice.

-The Fifth Quarter was named as eco community group. It is a community group established by local residents in 2011 with the aim of involving local people in developing edible community gardens and organic waste recycling schemes in central Norwich. The community garden movement in UK is of more recent provenance than allotment gardening, with many such gardens built on patches of derelict land, waste ground or land owned by the local authority or a private landlord that is not being used for any purpose. They tend to be situated in a built-up area and is typically run by people from the local community as an independent, non-profit organization.

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- Henry Doubleday research association. . Retrieved November 5, 2017 from www.gardenorganic.org.uk
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Urban Fruit trees

Definition

A fruit tree is a tree which bears fruit that is consumed or used by humans and some animals.

Measure responding to	Adaptation ☒		Mitigation ☐	
Scale of application	City ☐	Neighbourhood ☒	Building ☒	
Expected efficacy of the measure	Immediate (< 1 yr) ☐	Medium term (10 yr) ☒	Long term (50 yr) ☒	
Lifespan of the measure (durability)	Short term (< 1 yr) ☐	Medium term (10 yr) ☒	Long term (50 yr) ☒	
Related primary SDG, if any	SDG 15	Specific associated targets	15.9	
Related secondary SDG, if any	SDG 2	Specific associated targets	2.3	
Addressed themes	Accessibility ☐	Energy ☐	Environment ☒	People ☒
Main strategy addressed	strategies to improve outdoor urban environmental quality: ENV 22 strategies for landscape management and improvement: ENV 16,18,19			
Dimensional data	---			
Space usage	Monofunctional ☒		Multifunctional ☐	
Construction costs	Around € 15 per tree			
Maintenance / management costs	15 € per hour: average cost of a professional gardener			
Quantification / metrics	VA(viali alberati)=[Lc/Ls] x 100 Lc=“Lunghezza corridoi Verdi” and Ls=unghezza sezioni stradali			

Detailed description

Planting fruit trees in urban areas is a strategy to promote urban agriculture, enhancing existing ecological value. Particularly interesting is using germplasms of native fruit trees with low water requirements. Using native species leads to sustainable use of water and soil resources.

Best practices

Calgary Community Orchards RP

Since 2009, Calgary has been planting fruit trees and shrubs in locations around the city as part of a community orchard research project in order to increase opportunities for local food production activities.
orchard has been incorporated into existing parks, which already housed a few fruit trees, tucked in behind the community association building and tennis courts. The Community Orchard Research Project was developed in accordance with the ImagineCalgary Plan for long range sustainability by educating Calgarians about the benefits of growing locally and is intended to:

-**Encourage** local food production.
-**Foster** community involvement.
-**Educate** Calgarians about techniques related to fruit tree care as well as methods for preserving and storing fruit.
-**Demonstrate** and test a range of fruit trees and shrubs.

References

www.theorchardproject.org.uk

On Case Study:
www.calgary.ca/CSPS/Parks/Pages/Programs/Community-orchards.aspx
www.belocal.org/about-us/what-we-do/community-orchards

Green Bus Shelters

Definition

Bus shelter provided with green roof for water retention and cooling and with all the smart facilities that make waiting times more comfortable

Measure responding to	Adaptation ☒	Mitigation ☐

Scale of application	City ☒	Neighbourhood ☒	Building ☐
Expected efficacy of the measure	Immediate (< 1 yr) ☒	Medium term (10 yr) ☐	Long term (50 yr) ☐
Lifespan of the measure (durability)	Short term (< 1 yr) ☐	Medium term (10 yr) ☒	Long term (50 yr) ☐
Related primary SDG, if any	SDG 11	Specific associated targets	11.2
Related secondary SDG, if any	SDG 7	Specific associated targets	7.2

Addressed themes	Accessibility ☐	Energy ☒	Environment ☒	People ☒

Main strategy addressed	Reduce energy consumption – produce energy from the sun; Increase urban biodiversity; Improve outdoor urban environment.
Dimensional data	Dimensions are equal to a standard bus shelter; average: cm 270 x 160 x 260h

Space usage	Monofunctional ☐	Multifunctional ☒

Construction costs	$14.500 (according to GoGreen Solar – Bus Shelter) equal to the price of having solar panels on bus shelters
Maintenance / management costs	Management costs are related to solar panels, smart facilities and green roof
Quantification / metrics	-35% energy consumption (according to JCDecaux Bus Shelters)

Detailed description

Green Bus Shelters can refer to a various range of bus shelters whose main aim is to adapt the city and its main facilities (including the transportation system and infrastructure) to the climate change by reducing energy consumption and in some cases by contributing to the water retention in case of heavy rain (using the technique of the green roof).
Green bus shelters are provided with photovoltaic technology that contribute to the autonomy of the object in terms of lighting (in case of suburban location) and operation of all the smart facilities that it could be provided with. They are often associated with real-time information panels, touch screen computers (searching for information while waiting), WiFi connection, USB ports for the recharge of electronic devices and the facilities for the recharge of electric bikes and push scooters
Green bus shelters can then be completed with green roofs on the top, which contribute to the cooling of the object itself, the improvement of the biodiversity in city, allowing water retention and the slow release of water in case of heavy rain.

Best practices

JCDecaux's sustainable bus shelters in Paris
The company developed some years ago a new kind of bus shelter for the city of Paris. The innovation is applied at the scale of the very big city (2.000 new-generation bus shelters). The most interesting element is that in the single object both the environmental, energy efficiency and smartness are combined; the result is a bus shelter provided with different features and characteristics:
- 35% less energy consumption (more efficient lighting technologies and activity-responsive light intensity for advertising);
- 100 bus shelters have been fitted with solar panels;
- 50 of them have green roofs in order to help water retention;
- touch-screen computers with searchable maps and information;

Fonatsch- and Green4Cities' station
The Austrian company invented this new generation completely autonomous of bus shelter, which gets the energy from the sun through the photovoltaic technology installed in the structure. The energy makes some smart devices work, such as the touch screen which provides information as if the bus shelter were an infopoint; the recharge service (for electronic devices and shared means of transportation, such as bikes and push scooters; the wireless network and the LED lightning (especially in case of suburban location).
The aim is to provide not only a bus shelter, but also a comfortable waiting space and an infopoint.

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The multi-faceted bus shelters of Paris. (2016, January 13). Retrieved from https://www.jcdecaux.com/blog/multi-faceted-bus-shelters-paris

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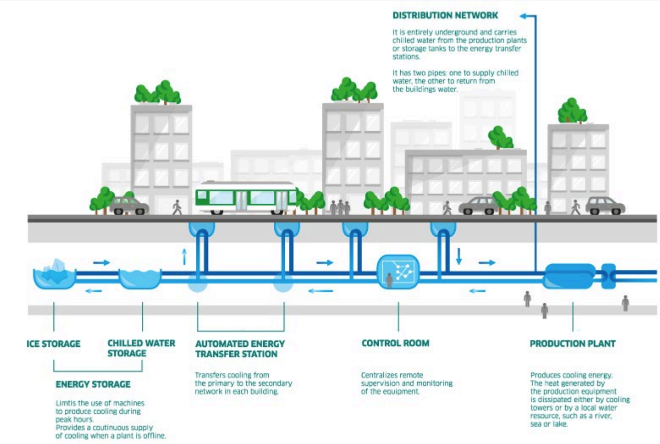
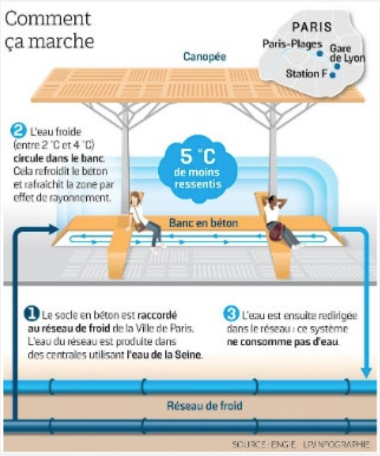
Islands of Coolness

Definition

Urban furniture, modular, mountable and dismountable in 24 hours. They work automatically, as soon as the ambient temperature exceeds 28ºC they provide a feeling of freshness through a radiation effect.





Measure responding to	Adaptation ☒		Mitigation ☐	
Scale of application	City ☐	Neighbourhood ☒	Building ☐	
Expected efficacy of the measure	Immediate (< 1 yr) ☒	Medium term (10 yr) ☐	Long term (50 yr) ☐	
Lifespan of the measure (durability)	Short term (< 1 yr) ☒	Medium term (10 yr) ☐	Long term (50 yr) ☐	
Related primary SDG, if any	SDG 13	Specific associated targets	13.1	
Related secondary SDG, if any	SDG 06	Specific associated targets	6.7	
Addressed themes	Accessibility ☐	Energy ☐	Environment ☒	People ☒
Main strategy addressed	Strategy for a more efficient water management			
Dimensional data				
Space usage	Monofunctional ☒		Multifunctional ☐	
Construction costs	N/A			
Maintenance / management costs	N/A			
Quantification / metrics	10 seat modular bench with a cross shape plan with a latticed wooden shade resembling a gazebo with a planting of ferns and lavender.			

Detailed description

These islands of freshness are part of the urban furniture. Concrete benches, covered with wood and protected from the sun by a wooden pergola as well. Modular, mountable and dismountable in 24 hours, they are connected to the cooling network of the City, via a concrete heat exchanger installed inside the bench. Their tree shaped design was developed in collaboration with engineers and experts in biomimicry.

The cooling network technology pumps cooled water from the river to supply water cooling plants and then provide chilled air to museums, ministries and other public buildings. This technology requires electricity to function, but consumes half of what is required for regular air conditioning, it works as a cycle and at the end then the water comes back to the river.

The islands of freshness work automatically. As soon as the ambient temperature exceeds 28ºC, they get the chilled water of the cooling network. They provide a feeling of freshness through a radiation effect. Using the inertia of concrete, which is the base of the bench, it is efficient and without water consumption.

Best practices

Three islands of freshness were installed in Paris for the months of July and August 2018. They are located in the heart of the River Gauche District, in Paris beaches on the park of the Rives de Seine, between the Pont Neuf and the Pont au Change and at Gare de Lyon.

Developed by Climespace using the cooling network installed in the city of Paris and developed by ENGIE. The aim was to fight urban heat islands, using out of conventional energy networks, the islands create and area of about 5ºC cooler.

The islands where dismantled in September 2018, and the Climespace relies on feedback from users to improve their performance thereafter as well as comfort.

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Eco Urban Furniture

Definition

ECO URBAN FURNITURE is designed-as a reminder about the important role of recycled materials and introduce new alternative use of trees embracing urban furniture to enhance CO^{2} absorption.


Measure responding to	Adaptation ☐	Mitigation ☒		
Scale of application	City ☒	Neighbourhood ☒	Building ☐	
Expected efficacy of the measure	Immediate (< 1 yr) ☒	Medium term (10 yr) ☐	Long term (50 yr) ☐	
Lifespan of the measure (durability)	Short term (< 1 yr) ☐	Medium term (10 yr) ☒	Long term (50 yr) ☐	
Related primary SDG, if any	SDG 11	Specific associated targets	11.7	
Related secondary SDG, if any		Specific associated targets		
Addressed themes	Accessibility ☐	Energy ☐	Environment ☒	People ☒
Main strategy addressed	Improve outdoor urban environment - ENV 22 urban air quality Increase urban biodiversity			
Dimensional data				
Space usage	Monofunctional ☐	Multifunctional ☒		
Construction costs	AVG 80€ per module and 250€ per tree (depends on the size)			
Maintenance / management costs	Occasional replacement of module			
Quantification / metrics	100cm length per module			

Detailed description

The goal of the ECO URBAN FURNITURE project is that of designing environmentally sustainable furniture objects to reduce the negative effects of waste and to enhance the CO2 absorption by introducing new trees in the urban area. At its core, ECO URBAN FURNITURE integrates different urban furniture objects like benches, tree containers and tables into a single modular entity. ECO URBAN FURNITURE follows modular design principles, allowing urban planners to rearrange the components in different shapes. Therefore the design is extremely flexible and suitable for every need.

Inspired by Ecodesign and Sustainable Design philosophies, ECO URBAN FURNITURE aims at minimizing its environmental impact by making use of reclaimed wooden pallets. Moreover, many modules include tree container, encouraging a wider dissemination of green in the city for CO2 absorption. Furthermore, ECO URBAN FURNITURE is designed to be accessible to everyone, regardless of age, gender or disabilty. Inclusivity is accomplished, for instance, by bench modules for different heights and table modules specifically designed to be comfortably used by users on a wheelchair.

Best practices

Eco-design is a concept developed by the Austro-American Designer Victor Papanek in the 70s. The concept focuses on the use of raw materials, (that is the form in which they are found in nature, without any human manipulation), and how such materials may affect the environment and public's quality of life. The design process must be conceived in a circular way: from creation, to distribution, to production. In a recycling strategy, consumers are also involved in the product design process.

The "brothers in benches'' is a range of reclaimed wooden pallets and planter elements that merge to form an infinite array of possibilities within urban furniture composition and arrangement. The idea was born to satisfy the immediate needs for urban furniture with an easy-to-install and cheap solution and to understand how the public would interact with the mobile furniture. By installing wheels and different modules, it is easy to be transformed based on the need.

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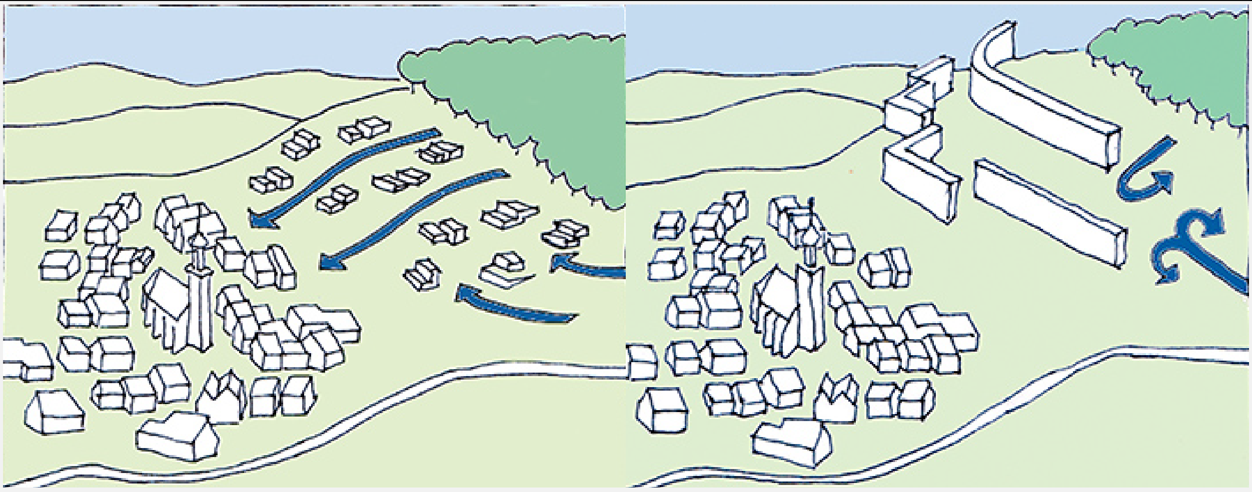
Green Ventilation Grids

Definition

A grid of parks and small areas of vegetation that are connected to one another which offer the possibility of have a favorable impact on the urban climate: in the summer they hold less heat and so offer cooler areas.



	Adaptation	Mitigation
Measure responding to	☒	☐

	City	Neighbourhood	Building
Scale of application	☒	☒	☐

	Immediate (< 1 yr)	Medium term (10 yr)	Long term (50 yr)
Expected efficacy of the measure	☒	☐	☐

	Short term (< 1 yr)	Medium term (10 yr)	Long term (50 yr)
Lifespan of the measure (durability)	☐	☐	☒

Related primary SDG, if any	SDG 13	Specific associated targets	Sustainable cities and communities
Related secondary SDG, if any	SDG 15	Specific associated targets	Good Wealth and Well-being

	Accessibility	Energy	Environment	People
Addressed themes	☐	☐	☒	☒

Main strategy addressed	ENV 22 Urban air quality
Dimensional data	1-10 m Building/street, 10-1000 m Urban design (location of buildings, roads and urban vegetation), 1-50 km The City Plan.

	Monofunctional	Multifunctional
Space usage	☐	☒

Construction costs	In a scale from 0-3 the average cost is 2/3
Maintenance / management costs	In a scale from 0-3 the average cost is 2/3
Quantification / metrics	Sqm- hectare

Detailed description

Green ventilation grids not only affect the microclimate and the residential buildings adjacent to the green areas, but in periods of heat stress will offer more pleasant places for city dwellers to be and a pleasant network for slow-moving traffic. Green grids in a town or city that are connected with the cooler countryside make it possible for air to move. The vegetation in these green grids should not be planted too close together, to make it possible for the wind to pass through them. In towns and cities situated in valleys, it is important to create corridors to allow cool air to flow in from green hills at night. [Ministerium für Klimaschutz NRW, 2011]

The concept of a lobe city was developed early in the 20th century. In the 1990s, Tjallingii studied the idea in relation to sustainability. His research showed that the lobe plan is suitable as the basis for sustainable urban development and for blue-green urban planning. Lobe cities offer the possibility of combining the benefits of compactness with those of more open and green development. For large urban conglomerates, green grids are a more viable solution. The blue-green fingers are attractive for residents to walk and cycle next door and they have a good influence on the urban climate, tempering the urban heat-island effect.

Best practices

Place de la République, Paris
The design maximises the proportion of trees and plants. Windflow has been incorporated to offer maximum ventilation and cooling in summer. An area of 12,000 m^2 of the 20,000 m^2 square is designed as an urban garden with dense vegetation. The area available to pedestrians has been increased by 50%. The design also ensures that sunlight reaches the pedestrian routes.

They were to become attractive in terms of connecting the metropolitan scale with the finely-meshed human scale of the square, but also in terms of focus on creating a pleasant urban climate. The city of Paris intends this square to show that its plans for the future involve working on designing urban space that more closely reflects the needs and expectations of the city’s populace.

London Green Grid
The purpose of this strategy is to create natural urban systems that support and permit growth. It is the intention that an urban landscape be realised that creates links between the areas where people live and work, public transport hubs, the Green Belt around London and the Thames.

These green-blue structures serve explicitly to buffer water, enhance the quality of the air and lower the air temperature. Opportunities for developing the green structures exist along the tributaries of the Thames, where industrial estates are opening up. Another measure is to connect as many areas of urban vegetation as possible through purchase or zoning changes.

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The Living Garden Concept

Definition

Concept developed by the Dutch Garden and Landscape Contractors Association in which green and sustainable gardens for private or public spaces are proposed, in which water, energy, soil and edible greenery are concentrated. With the aim of achieving water retention, heat stress prevention, biodiversity stimulation and the positive effect that greenery has on people´s health.


Measure responding to	Adaptation ☐		Mitigation ☒	
Scale of application	City ☒	Neighbourhood ☒	Building ☐	
Expected efficacy of the measure	Immediate (< 1 yr) ☒	Medium term (10 yr) ☒	Long term (50 yr) ☐	
Lifespan of the measure (durability)	Short term (< 1 yr) ☐	Medium term (10 yr) ☒	Long term (50 yr) ☒	
Related primary SDG, if any	SDG 11	Specific associated targets	11.7	
Related secondary SDG, if any	SDG 15	Specific associated targets	15.4. 15.5, 15.9	
Addressed themes	Accessibility ☐	Energy ☒	Environment ☒	People ☒
Main strategy addressed	Strategies for a more efficient water treatment, sustainable urbanization/restoration			
Dimensional data				
Space usage	Monofunctional ☐		Multifunctional ☒	
Construction costs	Approximate cost: solar panel 3 € per watt, green area 20 € Per sqm and structure 40 € per sqm			
Maintenance / management costs	N/A			
Quantification / metrics	N/A			

Detailed description

The concept was born form the need of users to include the concept of sustainability in the garden, to meet this need the Sector Association VHG developed the concept of *Living Garden* where the garden tackle 4 main concepts: *nature, climate, man and economics*.

These work as an umbrella to different objectives depending on the area of implementation. Climate responds to air quality, water and temperature. Nature to the use of sustainable materials, formation, biodiversity stimulation or conservation, edible greenery and soil. Men to safety, movement, meeting points, productivity, relax areas, sound, color and smell and Economics to benefit and maintenance.

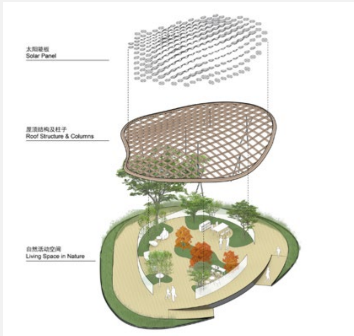
Best practices

"Home of the future", Project developed by MAD Architects in partnership with Hanergy for the 2018 China House Vision Exhibition.

The project has the aim to give inhabitants the feeling that they are living in the nature by breaking the boundaries between interior and exterior.

The curved floating roof slopes it's a grid like structure layered with translucent, waterproof glass that while works as a protection for the "interior" from the rain, also provides natural ventilation allowing sunlight to go inside. Solar panels from Hanergy are strategically placed above to capture the maximum amount of sunlight to provide enough electric energy to power the daily consumption of the home.

The "Living Garden" blends solar energy production, with nature and emphasizes human connection with nature by creating an architectural living landscape.



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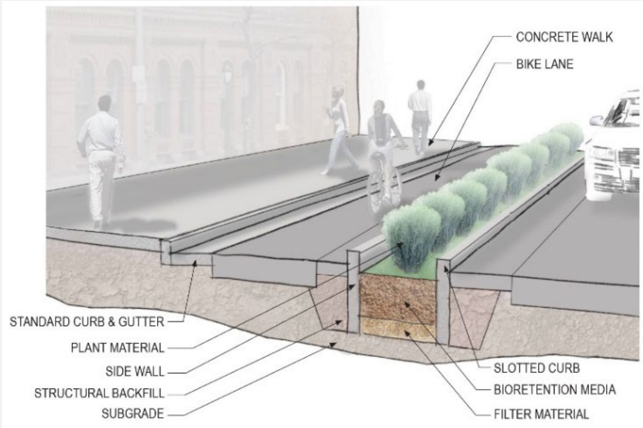
Interventions in Water Bodies and Drainage Systems

Gutters

Definition

Gutters are wide and shallow simple form of channels, which are above ground that carry the storm runoff in excess of the capacity of the minor drainage system from streets and squares.



Measure responding to	Adaptation ☒		Mitigation ☐	
Scale of application	City ☒	Neighbourhood ☒	Building ☐	
Expected efficacy of the measure	Immediate (< 1 yr) ☒	Medium term (10 yr) ☐	Long term (50 yr) ☐	
Lifespan of the measure (durability)	Short term (< 1 yr) ☐	Medium term (10 yr) ☐	Long term (50 yr) ☒	
Related primary SDG, if any	SDG 6	Specific associated targets	6.5	
Related secondary SDG, if any	N/A	Specific associated targets	N/A	
Addressed themes	Accessibility ☐	Energy ☐	Environment ☒	People ☐
Main strategy addressed	Strategies for a more efficient water management			
Dimensional data	Max length of gutters is in a direct relation among the longitudinal slope of the roadway and the vertical drop across the bio retention media.			
Space usage	Monofunctional ☒		Multifunctional ☐	

Construction costs	N/A
Maintenance / management costs	N/A
Quantification / metrics	The usual width is 30cm, Max length is approximately 50m, and max depth is 5cm. The normal sloped role is at least 0.5 cm/m.

Detailed description

Urban streets are usually characterized with curbs, gutters and inlets. The water draining through the gutter is transported to the surface water or infiltrated into the ground by means of an infiltration system. Currently, street gutters, which are most of the time in the sides of the streets, are principally designed for collecting and conveying dirt, litter, debris, storm water and other cast-off waste in lieu of a municipal sanitation system. There is variety type of Urban Gutters which mainly are Fluted gutters, Prefab Fluted gutters, open gutters, covered gutters, and finally Green Gutters.

Prefab Gutters: are installed on a curved ramp to drain surface runoff from the elevated outer shoulder to the inner gutter.

Fluted Gutters: which collect the surface overland flows from the pavement and create a concentrated flow at the downstream inlet.

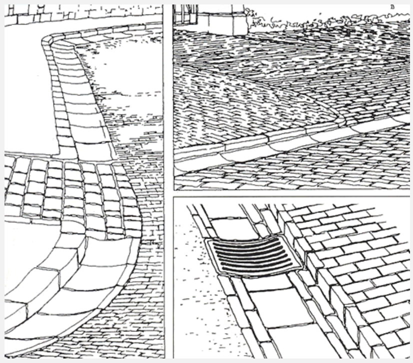
Open Gutters: are those type of independent gutters from slopes of the surface comparing to others and they have more depth in the ground and consequently so hard to be cleaned.

Covered Gutters: is a type of prefabricated gutters in a simple form and they usually being used in urban situation and make the roads and paths safer for cyclists and pedestrians.

Green Gutters: A green gutter is a type of bio retention facility located within a street section near the gutter line.

Best practices

1. The most traditional practice is in Edinburgh where granite setts were used for the carriageway, gutters and cross-overs, while the actual pavements were of sandstone. These materials have been retained in many parts of the city, and the tradition for laying these materials is a craft, which has continued uninterrupted to this day.
2. The next best example is called Wadis, which are used in order to improve the quality of the runoff before discharge to the canals. A Wadi is a grass-covered suppression with a top layer to retain pollutants and a soak away pit underneath. In Leidsche Rijn in Netherlands are the best example of these Wadis with different types were implemented over the last 10 years.
   The experience with maintenance of the wadis show, that only large dimensioned and long wadis are recognized as such and therefore maintained well. Experiences with the infiltration boxes installed in the wadis show that they are clogging and a proper maintenance of them is not possible. Therefore new wadis in the area of Leidsche Rijn are now built without infiltration boxes.





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Ditches

Definition

A ditch is a small to moderate channel depression created to channel water, installed as a mean of managing storm waters, improving water quality in surface and protecting fish habitat.


Measure responding to	Adaptation ☒	Mitigation ☐

Scale of application	City ☐	Neighbourhood ☒	Building ☐
Expected efficacy of the measure	Immediate (< 1 yr) ☐	Medium term (10 yr) ☒	Long term (50 yr) ☐
Lifespan of the measure (durability)	Short term (< 1 yr) ☐	Medium term (10 yr) ☒	Long term (50 yr) ☐
Related primary SDG, if any	SDG 6	Specific associated targets	6.B
Related secondary SDG, if any	SDG 13	Specific associated targets	13.1

Addressed themes	Accessibility ☐	Energy ☐	Environment ☒	People ☐

Main strategy addressed	Strategies for a more efficient water management: ENV 9, ENV 12, ENV 14
Dimensional data	---

Space usage	Monofunctional ☒	Multifunctional ☐

Construction costs	From € 7 to € 15 per linear foot
Maintenance / management costs	From € 0,50 to € 2,00 per linear foot
Quantification / metrics	"Mass Balance" of the ditch system: Do= Di -ˇ De -ˇ Dg (where Do is Ditch outflow, Di is Ditch inflow, De is Ditch evaporation and Dg is Ditch infiltration to groundwater)

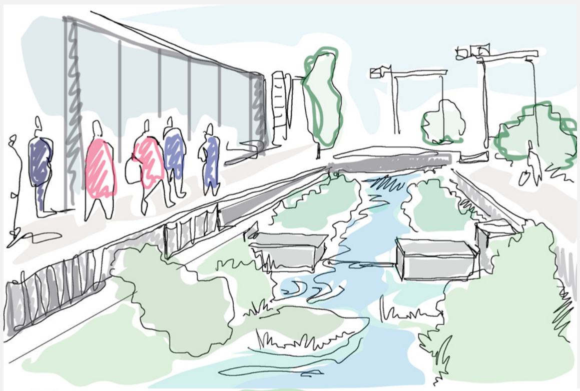
Detailed description

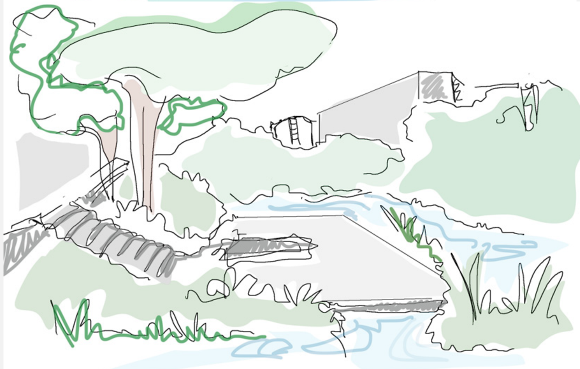
A ditch is a small to moderate channel depression created to channel water. Whether in an urban area or a rural area, ditches and drainage courses are installed as means of:
- **conveying** storm water. These drainage courses provide a critical outlet for public and private surface drainage, roadway sub-ˇgrade drainage as well as foundation drainage from private property.
- **managing** storm water from a quality and quantity perspective by filtering, attenuating peak flows and providing groundwater recharge and storage
- **improving** water quality in surface water bodies, contributing to the protection of fish habitat and working as refuges for urban wildlife.

Best practices

Bottière-Chenaie ecodistrict, Nantes 2005-2018

In the redevelopment of a peripheral area perceived as a “ghetto”, the municipality of Nantes promoted the realization of an “eco-ˇdistrict”, designed by Atelier Bruel Delm. The masterplan is based on the collection of rainwater, expressing the geography of the new site.
Ditches, canals and channels give meaning and direction to the public spaces. The public spaces are though occupied at more than 50% by vegetation that contribute to low down the local warming and bring a new ecological landscape in this eco-ˇdistrict.





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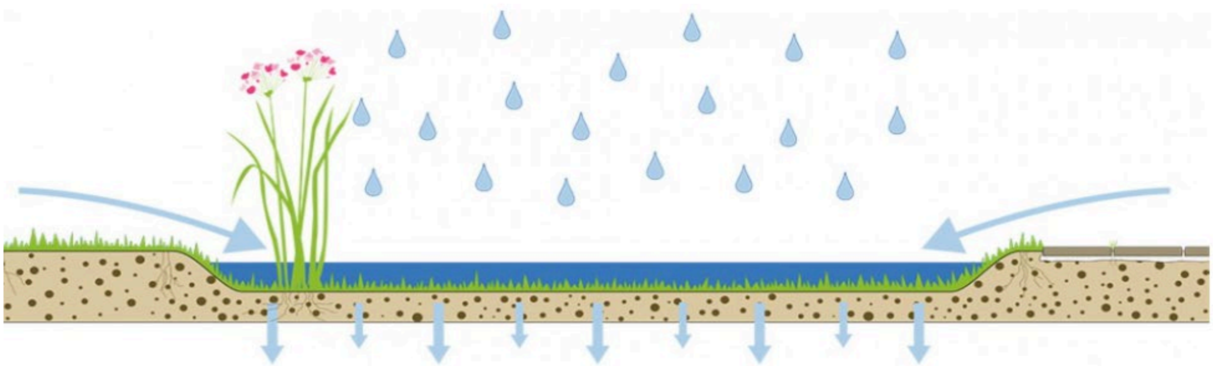
Infiltration strips and meadows

Definition

Infiltration strips and meadows are green or permeable areas that provide opportunities for slow transportation and infiltration of water.



Measure responding to	Adaptation ☒		Mitigation ☐	
Scale of application	City ☐	Neighbourhood ☒	Building ☐	
Expected efficacy of the measure	Immediate (< 1 yr) ☒	Medium term (10 yr) ☐	Long term (50 yr) ☐	
Lifespan of the measure (durability)	Short term (< 1 yr) ☐	Medium term (10 yr) ☒	Long term (50 yr) ☐	
Related primary SDG, if any	SDG 6	Specific associated targets	6.5, 6.6	
Related secondary SDG, if any		Specific associated targets		
Addressed themes	Accessibility ☐	Energy ☐	Environment ☒	People ☐
Main strategy addressed	ENV 9 - Filtration and natural drainage management			
Dimensional data				
Space usage	Monofunctional ☒		Multifunctional ☐	
Construction costs	1,73 €/lineal foot			
Maintenance / management costs	**Mow filter strips**: 45 €/per visit			
Quantification / metrics	**Infiltration area protection**: Silt fence cost (€/'foot) * Perimeter of infiltration area **Mowing**: Mowing Cost ($) * Mowing Frequency (6 times per year)			

Detailed description

An easy way to allow the water to seep from hard surfaces is adding ditches or fields next to the paved surfaces to temporarily deposit the wet.
In addition to the precipitation volume that needs buffering, the permeability of the soil is another factor that determines the size. Soil samples must be taken to evaluate permeability.
The infiltration systems with storage above the ground can be deep or superficial, and of course the depth and area determine the capacity of buffering. In residential areas, a maximum depth of 30 cm is sufficient to present less risk for children's play. The infiltration systems can be equipped with natural, gentle and safe verges. The roots and animal activity in the soil ensure that the permeability of the soil is maintained. These systems must be designed in such a way that they are not used too much by playing children or other intensive activities when they are dry, which could cause soil compaction and decreased infiltration capacity.

Best practices

In Portland there is an example of this kind of measure.
A concrete container system was developed for the highly urbanized areas of Portland.
The rainwater is transported from buildings and roads through gutters of land to these strips of infiltration. The infiltration strips buffer rainwater and release it slowly into the ground.
The water is partially filtered by gravel and vegetation before it infiltrates.
The soil must of course be suitable for infiltration.

City of Portland, Stormwater Managment Manual, 2016

www.portlandoregon.gov/bes/64040

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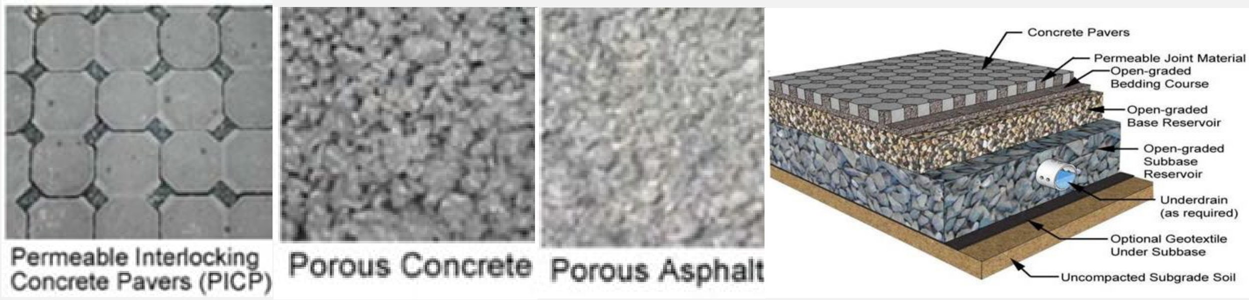
Porous Paving

Definition

Porous or permeable paving is a type of paving that allows fluids to seep through them and are commonly used on pedestrians and light vehicle pathways.



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☒</td><td colspan="6">Mitigation
☐</td></tr>
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☐</td><td colspan="4">Neighbourhood
☐</td><td colspan="4">Building
☒</td></tr>
<tr><td>Expected efficacy of the measure</td><td colspan="4">Immediate (< 1 yr)
☒</td><td colspan="4">Medium term (10 yr)
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☐</td></tr>
<tr><td>Main strategy addressed</td><td colspan="12">• Efficient water management</td></tr>
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<tr><td>Space usage</td><td colspan="6">Monofunctional
☒</td><td colspan="6">Multifunctional
☐</td></tr>
<tr><td colspan="4">Construction costs</td><td colspan="9">€4 - €8/ sqft</td></tr>
<tr><td colspan="4">Maintenance / management costs</td><td colspan="9">0,5 – 2 euro cents / sqft annually.</td></tr>
<tr><td colspan="4">Quantification / metrics</td><td colspan="9">ARV Reduction (RR)= $\frac{ARV\ before\ porous\ pavement - ARV\ after\ porous\ pavement}{ARV\ before\ porous\ pavement} * 100\%$
ARV= Annual Runoff Volume of storm water</td></tr>
</table>

Detailed description

The top layer of the pavement, called base in pavement design terminology, is either made up of a porous material or a non-porous material having small spaces between them to allow fluids to flow through them. Porous pavements not only reduce the surface runoff but also traps suspended solids therefore filtering pollutants from storm water. Examples include roads, paths, and parking lots that are subject to light vehicular traffic, such as cycle-paths, service or emergency access lanes, road and airport shoulders, and residential sidewalks and driveways.

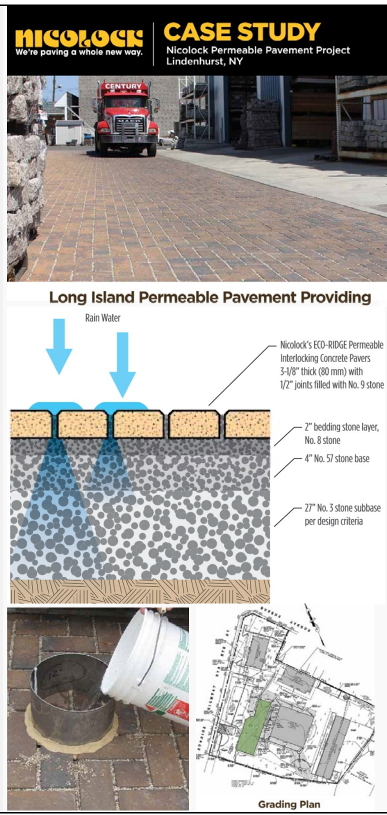
In general, there are three types of permeable pavements i.e porous concrete, porous asphalt and interlocking permeable pavements. They deal with three different scales, as far as building scale is concerned, interlocking permeable pavements is best suited for them. While the specific design may vary, all permeable pavements have a similar structure, consisting of a surface pavement layer, an underlying stone aggregate reservoir layer and a filter layer or fabric installed on the bottom. By using permeable materials, the ground can capture water runoff, absorb it and clean it during the process. By allowing the water to seep into the ground, the direct and surrounding areas will need much less man-produced irrigation. This will save money and reduce the amount of water used for everyday irrigation needs.

Best Practice

Lindenhurst, Long Island, New York (PERMEABLE PAVEMENT)
An 8,800 SF permeable interlocking concrete pavement (PICP) was installed in 2010 at a commercial facility at Century Building Materials, a construction supply yard in Lindenhurst, Long Island, New York. A PICP system was installed to manage stormwater in lieu of twenty dry wells. The innovative green project provided a real financial incentive along with an aesthetic heavy duty pavement to the property owner.

Site Specifics: The site is located over a glacial deposit of sands and gravels. The subgrade at the site was characterized by a sieve analysis and found to be poorly graded sand, which is known to be very permeable. The site is flat and the water table is approximately 10 ft below the ground surface. Conditions are ideal for direct vertical infiltration of stormwater.

Impact: The Town had no run-off for paving improvements to the site. Stormwater runoff from a rooftop and surrounding areas totaling 100,000 SF is managed completely by the PICP system. The contributing runoff area is 11 times the permeable pavement surface area. The system performs very well because, the base/subbase is properly sized for the design volume, the additional contributory runoff is sediment-free roof drainage delivered directly to the subbase and the subgrade is granular material ideal for infiltration.



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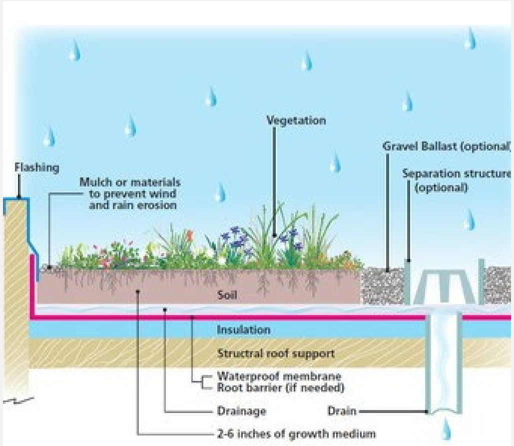
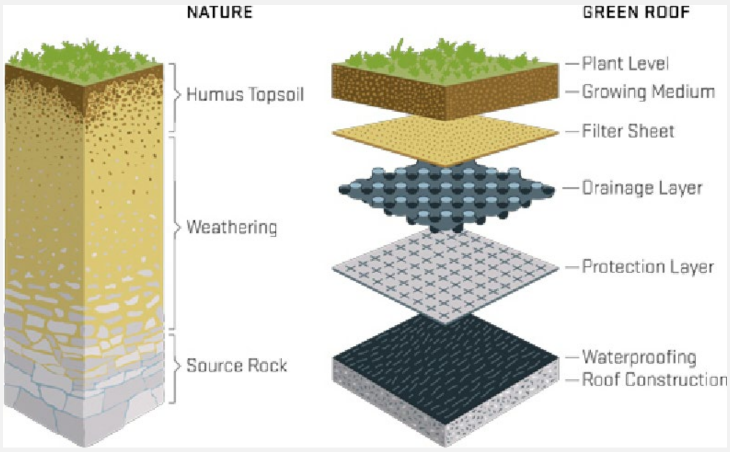
Water Ground Infiltration

Definition

The capacity of the soil to allow water movement into and through the soil profile, and reveling its quality, making it available for root uptake, plant growth and habitat for soil organisms.





Measure responding to	Adaptation ☐		Mitigation ☒	
Scale of application	City ☐	Neighbourhood ☐	Building ☒	
Expected efficacy of the measure	Immediate (< 1 yr) ☒	Medium term (10 yr) ☐	Long term (50 yr) ☐	
Lifespan of the measure (durability)	Short term (< 1 yr) ☒	Medium term (10 yr) ☒	Long term (50 yr) ☐	
Related primary SDG, if any	SDG 6	Ensure availability and sustainable management of water and sanitation for all	6.4. By 2030, substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals …	
Related secondary SDG, if any	SDG 12	Ensure sustainable consumption and production patterns	12.8 By 2030, ensure that people everywhere have the relevant information and awareness for sustainable development and lifestyles in harmony with nature	
Addressed themes	Accessibility ☐	Energy ☐	Environment ☒	People ☒
Main strategy addressed	ENV 9 Filtration and natural drainage management			
Dimensional data	Inches/ hour			
Space usage	Monofunctional ☒		Multifunctional ☐	
Construction costs	€ 30 – 50 / m2 (Europe) Green Roof $ €150 - $ 400/ m2 (America) Green Roof			
Maintenance / management costs	Similar to a normal garden maintenance			
Quantification / metrics	0.5 cm/m			

Detailed description

The velocity of the entry of water is the so called infiltration rate, expressed in inches per hour; a high infiltration rate is desirable for plant growth and the environment. It is important to maintain and improve ground infiltration by increasing vegetable cover, managing crop residues and increasing organic matter.

As example in the city, paved surfaces can infiltrate water to other areas, approximately is 50% of the connected surface area. According to the type of area the surface design requires a different space and maintenance frequency/ cost. The biggest the distances, the more gradient of the slope as design criterion. e.g. Roof, just to collect water, but also as urban garden, allowing better temperate conditions for the buildings.

Best practices

1. Oursecretgarden, Turin, Italy

Projected in 2010 by Studio999 and has the partnership of Harpo Seic Divisione Verde Pensile. It has been awarded in 2010 with the prize of Innovazione Amica dell'Ambiente.

An urban farm in the roof of a building inside a condominium, in a cohousing area in the district of San Salvario. The total intervention has 40 m2 and is subdivided in 10 small areas according the principles of the biologic agriculture.

Is the example of a new way to design and think about sustainability in a traditional city, without need of high technology also giving new uses to dismissed / unused areas, especially in a high density building. It creates new opportunities of socialization and activities that enhance the community life.

2. Hammarby Sjöstad, Stockholm, Sweden (2004 – 2016)

Water related district, proposed sustainable alternatives for water management (proper education and water saving appliances). The model shows that rainwater can be returned to the natural cycle.

Buildings have orientation towards the sea and the canals, to allow many houses as possible to profit from the view; also based on compact green town. Rainwater infiltrates the ground directly and/or is drained off through canals, which has impact on the building orientation and urban landscape. Also roof design are though as green one, that buffer much.
Runoff from roads is captured separately and drained off to treatment pools before being allowed to infiltrate the ground.

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Urban Wetland

Definition

A wetland is a zone where the distribution of living beings is mainly characterized by the presence of water, whatever its degree of salinity or its persistence during the year.

Figure 1 – Schematic representation of a typical constructed wetland

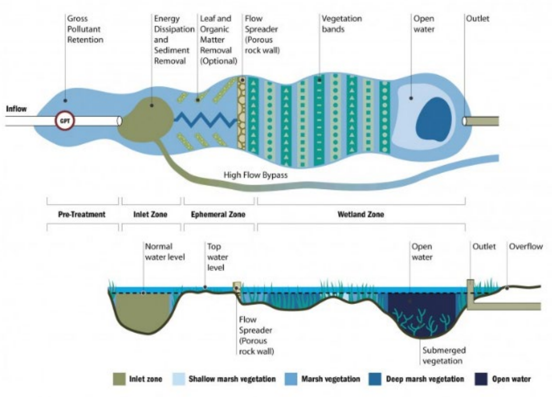

Figure 2 – Long section schematic representation of a typical constructed wetland system (above)

Measure responding to	Adaptation ☐	Mitigation ☒

Scale of application	City ☒	Neighbourhood ☒	Building ☐
Expected efficacy of the measure	Immediate (< 1 yr) ☐	Medium term (10 yr) ☒	Long term (50 yr) ☐
Lifespan of the measure (durability)	Short term (< 1 yr) ☐	Medium term (10 yr) ☐	Long term (50 yr) ☒
Related primary SDG, if any	Life on land	Specific associated targets	1,3,5,9,A
Related secondary SDG, if any	Clean water and sanitation	Specific associated targets	6,A

Addressed themes	Accessibility ☐	Energy ☐	Environment ☒	People ☒

Main strategy addressed	Preserving rivers wetlands in urban areas and reducing pollution of it by improving the water policy and working with population.
Dimensional data	

Space usage	Monofunctional ☐	Multifunctional ☐

Construction costs	N/A
Maintenance / management costs	N/A
Quantification / metrics	N/A

Detailed description

It is only since the end of the 20th century that wetlands are recognized for their functions.
Indeed, they are used like a natural sponge in order to have a coastal protection by regulating the water flux during inundation or a rainy event which allows in this case to limit the damage of water.
Wetland are also natural filter by eliminating a large part of the pollutants by plant life and settle in the sediment. This natural action will increase the quality of water released in the natural environment. This action is cheaper than the common way of cleaning water and efficiently despite the fact that urban wetlands are less effective than natural ones because they were created by humans
Wetland are recognized as ecological niches with an important, rich and diversified biodiversity. There are places of reproduction, feeding, refuge and rest.
Wetlands locally influence precipitation and atmospheric temperature related to evaporation phenomena. So, they play a role of controlling the temperatures.
Finally, despite the fact that these areas are protected by the international convention Ramsar (1971), wetlands can be a place of recreation and can also serve as educational support for raising awareness of the diversity and functioning of ecosystems.

Best practices

The first one is the urban wetland located in London. The main reason of this project was the increase of extreme weather situations (heavy rain, Thames floating) which had an impact on the wellbeing and health but also on animal and nature.
That’s why they decided to create a new wetland of 42 hectares in order to absorb and catch an important quantity of water, release it slowly in the time and also in order to reduce impact of water.
It also had an impact on the increase of biodiversity all around this site and is also open to the public and participate to the district livability.

The second project is located in Reims, France. The reasons of this project is trying to find a natural and ecologic way to treat and clean pre-treated waste water and rain water and to show its efficiency compared to the common way of cleaning water. This project will also create a new strong habitat for fauna and flora. This water will be treated during many natural processes including plants and animals.

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Helophyte filters

Definition

Helophyte filters, also known as planted soil filters, is a sand filter that is generally planted with reeds. The actual treatment is done by bacteria living in the roots.

Figure1. Helophyte filter on Erasmusgracht, Amsterdam

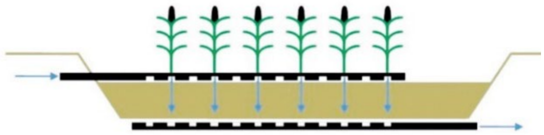


Figure2. Vertical helophyte filter

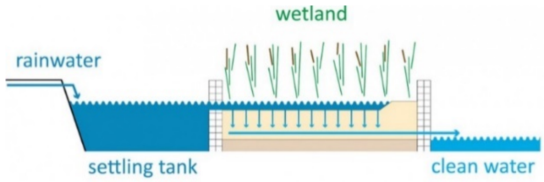


Figure3. Horizontal helophyte filter

Measure responding to	Adaptation ☒		Mitigation ☐	
Scale of application	City ☐	Neighbourhood ☒	Building ☐	
Expected efficacy of the measure	Immediate (< 1 yr) ☒	Medium term (10 yr) ☐	Long term (50 yr) ☐	
Lifespan of the measure (durability)	Short term (< 1 yr) ☐	Medium term (10 yr) ☐	Long term (50 yr) ☒	
Related primary SDG, if any	6.Water and sanitation	Specific associated targets	6.3, 6.B	
Related secondary SDG, if any	15. Sustainable development goal	Specific associated targets	15.1.2,15.3	
Addressed themes	Accessibility ☐	Energy ☐	Environment ☒	People ☐
Main strategy addressed	strategy for a more efficient water management			
Dimensional data	Dimensioning: 2,5-5 m²/IE; Depth: 100 cm (vertical helophyte filter), 80 cm (horizontal helophyte filter)			
Space usage	Monofunctional ☒		Multifunctional ☒	
Construction costs	€ 400/IE (at 4000 IE) | € 600/IE (at 4 IE)			
Maintenance / management costs	€ 4/IE/m²			
Quantification / metrics	The removal efficiencies of BOD_5, COD, TKN, NH_4^+ and P-total			

Detailed description

Helophyte filters can be distinguished into two different categories namely **horizontal helophyte filter** and **vertical helophyte filter**:

-**Vertical helophyte filter:** Spread the wastewater in a smooth layer several centimeters below the surface of the filter. The water is led into the filter below the surface to prevent unpleasant odors. The wastewater seeps through the layer of sand and the roots where it undergoes biological treatment. A drain is placed at the bottom of the sand filter to capture the treated wastewater. Iron or copper particles are generally added to the sand layer to bind phosphates. Films, layers of clay or concrete ensure that the helophyte filter is hydrologically completely sealed from the ground.

-**Horizontal helophyte filter:** These filters do not require drainpipes or pumps and are therefore simpler in their construction. As such, this type of filter requires less maintenance than vertical filters. Its uses include treating polluted runoff from roads and car parks.

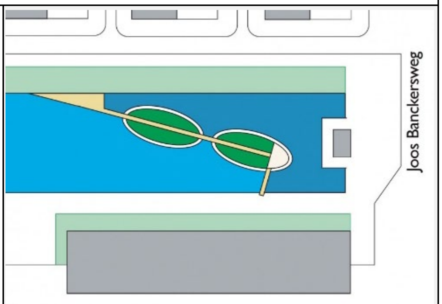
Best practices

Helophyte filter on Erasmusgracht, Amsterdam

In the project on Erasmusgracht, rainwater is discharged into a separate sedimentation reservoir in the canal, after which it passes through the helophyte filter. It is subsequently discharged into the canal. This decentralized facility has also proved itself to be considerably more efficient in terms of cost as well. In the same situation, realizing improved separate sewers would be over 50% more expensive over a ten-year period.

The two oval helophyte filters seal the sedimentation reservoir off from Erasmusgracht. The helophyte filters are lined by rock-filled gabions. The helophyte filters are open to the public and a bench has been placed by them. A sign on the bank explains the purpose and workings of the system.

The conclusion is that using a helophyte filter with a sedimentation reservoir as a peripheral facility is also an attractive alternative financially. Another benefit of this system is that it is not necessary to break open a series of streets. The space required might present an objection, although this system in fact demonstrates that it is easy to incorporate aesthetically and so enhances the quality of the surrounding area. Realizing only a sedimentation reservoir means that the costs and the space required can be reduced even further.



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Reconnecting rivers to floodplains

Definition

Give space to the river to expand safely during heavy rains periods

Measure responding to	Adaptation ☐	Mitigation ☒

Scale of application	City ☒	Neighbourhood ☐	Building ☐
Expected efficacy of the measure	Immediate (< 1 yr) ☒	Medium term (10 yr) ☐	Long term (50 yr) ☐
Lifespan of the measure (durability)	Short term (< 1 yr) ☐	Medium term (10 yr) ☐	Long term (50 yr) ☒
Related primary SDG, if any	SDG 11	Spatial quality and spatial security	11.5
Related secondary SDG, if any	SDG 13	Prevent flooding	13.1, 13.2

Addressed themes	Accessibility ☐	Energy ☐	Environment ☒	People ☒

Main strategy addressed	Prevent flooding and ensure spatial quality and spatial security
Dimensional data	Varies from situation to situation

Space usage	Monofunctional ☐	Multifunctional ☒

Construction costs	Varies from situation to situation
Maintenance / management costs	Varies from situation to situation
Quantification / metrics	Varies from situation to situation

Detailed description

The NBS called reconnect rivers to floodplain consist in the implementation of actions (lowering the flood plain, deepening the summer bed, water retention, dyke relocation, lowering perpendicular groynes and building attracting groynes, high water channel, depoldering, removing obstacles, strengthening dykes) in order to give more space to the river to expand during heavy rains. The river will be reconnected totally or partially to his natural floodplain.

The implementation of this policy will not only be about ensuring safety, but also about the amelioration of the spatial quality of the surrounding areas. This will be provided through the placing of recreational facilities on the river banks and through the beautification of the surrounding landscapes.

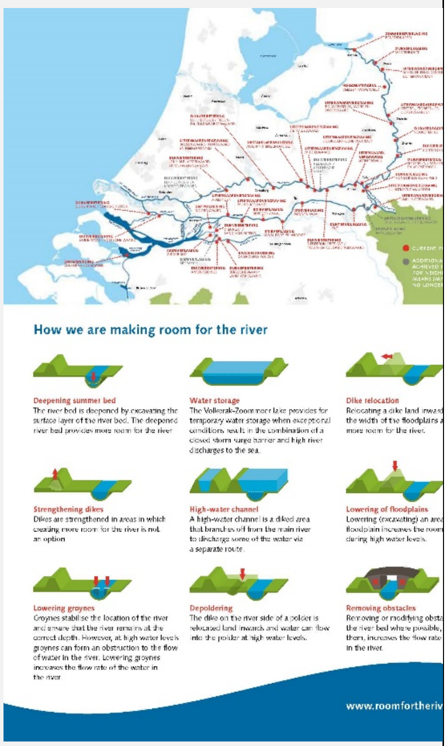
Best practices

The best example about this NBS is the "Room for the river" program in Netherlands started in 2007 and programmed to be finished in 2019 with a total budget of 2.3€ billion divided in 30 different projects spread through the country's rivers.
The project was considered fundamental after the 1993 and 1995 high water levels reached that put in danger 250.000 people and 1 million head of livestock.

The main objective of the project is to ensure security to the population, but at the same time to use the projects as opportunities to ameliorate the river side landscape, to renaturalize certain areas and to create professional competences inside the country in order to export the model abroad.

One of the application of this strategy is the "Room for the Waal" project between the cities of Nijmegen and Lent finished in 2016 with a total cost of 359 million of €.
This project was seen as necessary after the floods of the 1993 and 1995 and has the objective of lowering the level of the river and give space to enlarge during heavy rains in order to ensure security to the nearby cities. The pursuing of this objective also led to the improvement of the urban and natural qualities of the surrounding areas.

The project consisted in the relocation of the river dyke 350 meters inland (this was necessary because the river was only 400 meters wide comparing with the 1 km wideness of other parts) and in the creation of an ancillary river, this created a new island with the space for urban development and for the creation of a river park.



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Re-meander Rivers

Definition

Re-meander rivers (where they have been artificially straightened) to help reduce speed and height of flood peaks.

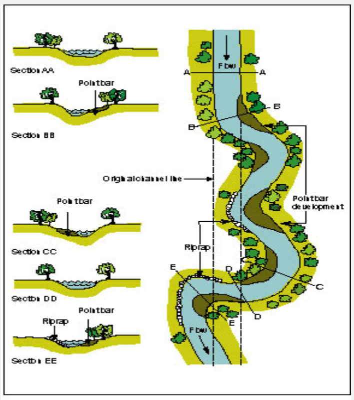
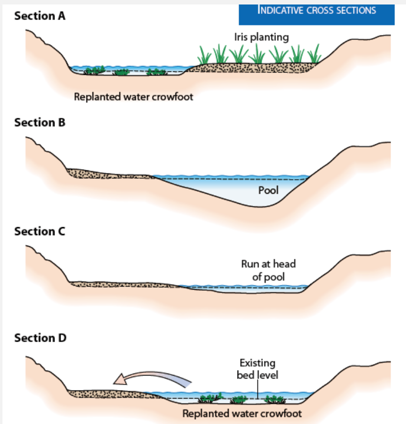


Figure: Diagram of re-meandering of channels.
(Adapted from Cowx & Welcomme, 1998)



Measure responding to	Adaptation ☒		Mitigation ☒	
Scale of application	City ☒	Neighbourhood ☒	Building ☐	
Expected efficacy of the measure	Immediate (< 1 yr) ☐	Medium term (10 yr) ☒	Long term (50 yr) ☐	
Lifespan of the measure (durability)	Short term (< 1 yr) ☐	Medium term (10 yr) ☒	Long term (50 yr) ☐	
Related primary SDG, if any	SDG 06	Specific associated targets	6.6	
Related secondary SDG, if any	SDG 15	Specific associated targets	15.1	
Addressed themes	Accessibility ☐	Energy ☐	Environment ☒	People ☐
Main strategy addressed	strategies for a more efficient water management			
Dimensional data				
Space usage	Monofunctional ☐		Multifunctional ☒	
Construction costs	£100-£300/m			
Maintenance / management costs	This measure removes the need of de-silting and reduces the maintenance of river.			
Quantification / metrics				

Detailed description

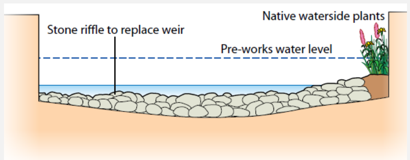
For centuries, European countries have built higher and higher dykes to protect cities from floods. However, the rise of awareness that this strategy could lead to unbearable costs without a guarantee for people’s safety, as the 1993 and 1995 floods showed, generated new political reflections. The method called “re-meandering straightened river” could be considered as a more gentle and adaptable way to solve flooding issues and the advantages of the method included: reducing speed and height of flood peaks, constructing a sinuous channel using local materials (including accumulated silt), providing diverse habitat features for fish, plants and invertebrate’s native to the river, improving the aesthetics of the reach within the urban area and increasing the opportunity for local people to encounter a range of river wildlife.

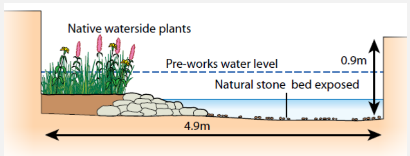
Restoring the sinuosity of a river can be achieved in a number of ways. As remeandering results in changes to channel processes, a thorough understanding of fluvial geomorphology is essential. The following types of approach have been identified: (1) Allowing a river to recover Sinuosity naturally, which suitable for artificially channelized streams with stream powers per unit width greater than 35 W/m2 (Brookes, 1987), (2) Improving sinuosity within a straightened river, (3) Reconnecting remnant meanders, (4) Constructing a meandering Channel adjacent to the straightened channel.

Best practices

River Ravensbourne
Natural re-meandering in an overwide urban channel, River Ravensbourne. A gravel point bar has formed and revegetated on the inside of meander bend. Both banks have timber toeboard. Removal of timber toeboarding on River Ravensbourne allowing natural adjustment on outside of meander bend and new depositional forms to develop.

River Somer - Somerset, England
The overall aim of sinuous low-flow course in an over-wide urban channel was to improve an over-wide and heavily silted reach of the River Somer running through Midsomer Norton High Street. This involved removal of three small weirs and constructing a new sinuous channel that had sufficient morphological dynamics to remove the need for regular de-silting, reducing maintenance costs and disturbance. The existing Midsomer Norton Flood Alleviation Scheme and flood relief channel was exacerbating the build-up of sediment by diverting higher "flushing" flow around the town center reach. However, this also presented an opportunity to create a design which was not heavily constrained by flood risk concerns, since the High Street typically only received local surface floodwaters. The pre-restoration reach had a mean water depth of 0.5m and a mean channel width of 4.5m.





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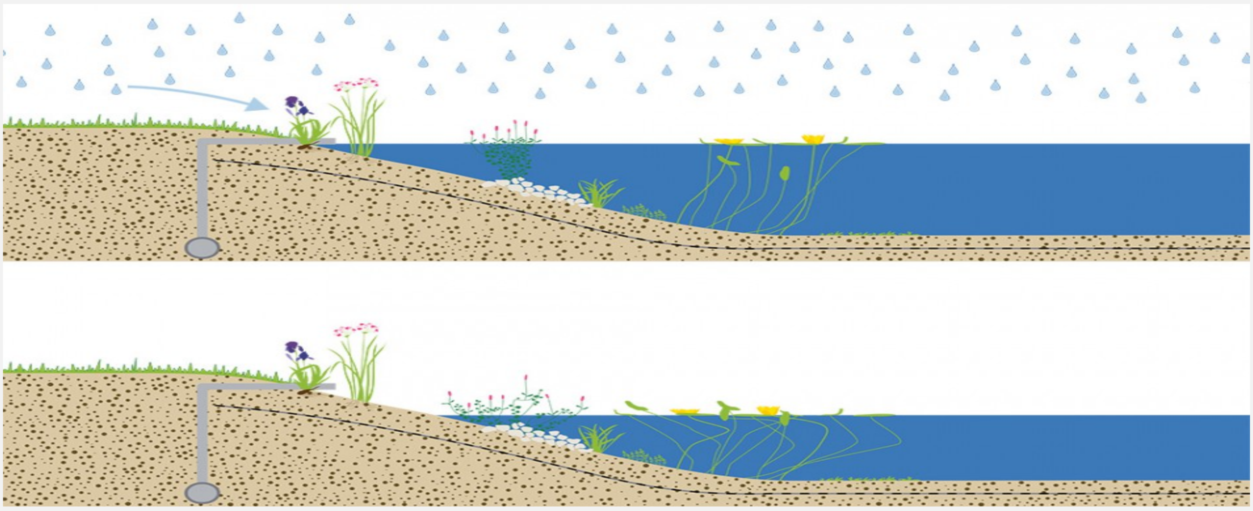
Rainwater Run-off Ponds

Definition

A system for purifying polluted rain and run-off water, preventing direct infiltration.



Measure responding to	Adaptation ☒	Mitigation ☒		
Scale of application	City ☒	Neighbourhood ☒	Building ☐	
Expected efficacy of the measure	Immediate (< 1 yr) ☐	Medium term (10 yr) ☒	Long term (50 yr) ☐	
Lifespan of the measure (durability)	Short term (< 1 yr) ☐	Medium term (10 yr) ☒	Long term (50 yr) ☐	
Related primary SDG, if any	SDG 06	Specific associated targets	6.3, 6.3.2	
Related secondary SDG, if any	SDG --	Specific associated targets	----	
Addressed themes	Accessibility ☐	Energy ☐	Environment ☒	People ☐
Main strategy addressed	Strategies for a more efficient water management			
Dimensional data	10% -20% of the connected surface area. 1,5 meters deep.			
Space usage	Monofunctional ☐	Multifunctional ☒		
Construction costs	---			
Maintenance / management costs	---			
Quantification / metrics	---			

Detailed description

This system is used to clean up polluted water through a water purification system. The water took into account can be rainwater, running off from busy streets or parking lots. The maximum height of the pond must be 1.5 meter, in this way it prevents the heating of the water during summer and in winter the water does not freeze on the bottom. The ground below is covered with a film that prevents direct infiltration.

The ponds made for temporary storage and purification use the vegetation because the pollutants settle on the bottom and the plants break down and absorb the pollutants. If the ground permits, the overflow from the pond can be designed to act as an infiltration system.
Thanks to the pre-purification, can be connected to surface water or an infiltration system. Only if no surface water is available in the immediate vicinity and infiltration is impossible should the overflow be connected to the sewer system.

Best Practice

Location: EVA-Lanxmeer, Culemborg, The Netherlands
Contact: Stichting EVA
Client: Municipality Culemborg
Urban design: Joachim Eble
Designer/water concept: opMAAT / Arcadis / Hyco Verhaagen
Scale: District
Realization state/year: 1999 - now

In Culemborg, a district with around 250 homes and small businesses has been realised with an extraordinary degree of integration. The sustainability in all respects and the unusual participation process in the realisation of the district and management are exceptional elements.

The design of the water system is an important foundation for the urban planning design of the residential district and the associated business locations. The district was designed around a water extraction site. The flow of clean water -rainwater runoff from roofs- is led off to the water extraction site, where it is captured in retention pools and rinse water is added. The flow of dirty water -street water, greywater and blackwater- is led away from the vulnerable water extraction area.
In addition, the commonly owned areas were designed and organised with input from the residents, and maintenance is also shared. It gives the district an exceptionally open, safe and child-friendly appearance.

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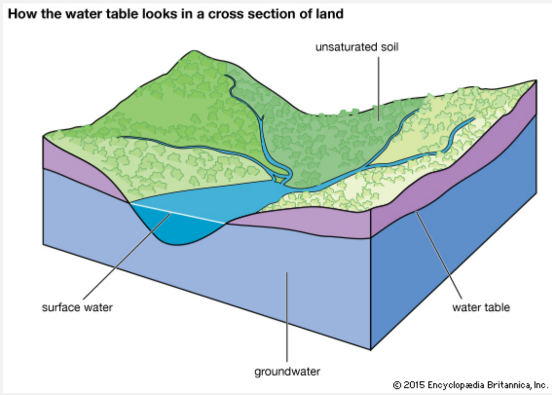
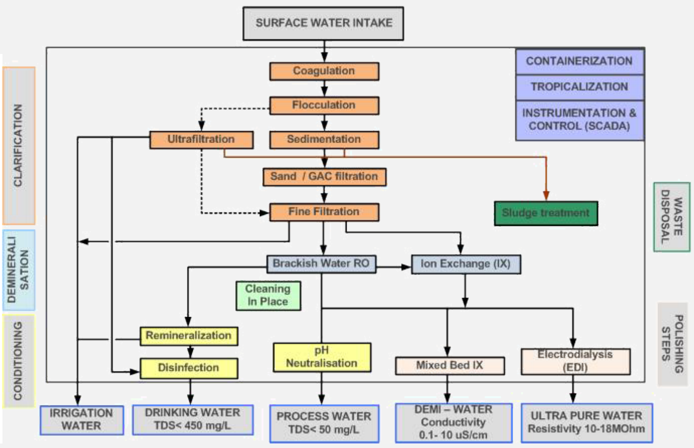
Usage Of Treated Surface Water

Definition

Surface water typically contains a high suspended solids content, bacteria, algae, organic matter, creating bad taste and odour. Normally the surface water needs to be treated before it has the required water quality.





Measure responding to	Adaptation X		Mitigation	
Scale of application	City X	Neighbourhood X	Building	
Expected efficacy of the measure	Immediate (< 1 yr) X	Medium term (10 yr)	Long term (50 yr)	
Lifespan of the measure (durability)	Short term (< 1 yr)	Medium term (10 yr)	Long term (50 yr) X	
Related primary SDG, if any	SDG 6	Specific associated targets	6.1, 6.3, 6.4, 6.6, 6.a	
Related secondary SDG, if any	SDG 12	Specific associated targets	12.2, 12.4,12.5,12.6,12.7,12.8,12.a,12.b	
Addressed themes	Accessibility	Energy	Environment X	People X
Main strategy addressed	Increase the efficiency in water management system in urban settlements			
Dimensional data				
Space usage	Monofunctional X		Multifunctional	
Construction costs	High Construction Costs			
Maintenance / management costs	High Management Costs			
Quantification / metrics				

Detailed description

Water is vital to human life, from agriculture to industrial products. Recently due to population increases, industrial development and transition to a modern consumer society, contamination of the water systems often occurred or treated sludge) suitable for disposal or reuse. Using advanced technology is now possible to reuse sewage effluent for drinking water.

Coagulation and Flocculation: Coagulation and flocculation are often the first steps in water treatment. Chemicals with a positive charge are added to the water. The positive charge of these chemicals neutralizes the negative charge of dirt and other dissolved particles in the water. When this occurs, the particles bind with the chemicals and form larger particles, called floc.

Sedimentation: During sedimentation, floc settles to the bottom of the water supply, due to its weight. This settling process is called sedimentation.

Filtration: Once the floc has settled to the bottom of the water supply, the clear water on top will pass through filters of varying compositions (sand, gravel, and charcoal) and pore sizes, in order to remove dissolved particles, such as dust, parasites, bacteria, viruses, and chemicals.

Disinfection: After the water has been filtered, a disinfectant (for example, chlorine, chloramine) may be added in order to kill any remaining parasites, bacteria, and viruses, and to protect the water from germs when it is piped to homes and businesses.

Best practice

Sungai Terip water treatment plant project is located in Seremban, Negeri Sembilan, Malaysia. Figure 1 showed the Sungai Terip water treatment plant. It has a capacity of about 136 Mld nominal, which can be increased to 179 Mld maximum. The source of water is from the Terip River. The project aimed to manage, operate, and maintain Terip dam as well as water treatment stored in its reservoir. A schematic view of the water storage is shown in the Figure 2. Sungai Terip dam is an earthfill dam to provide irrigation and water supply and was constructed in 1987. The maximum level is 103m corresponding to 47.4 Mm3 of water storage in the reservoir.

Water quality is the physical, biological and chemical characteristics of water. It is a measure of the condition of water relative to the requirements of one or more biotic species and/or to any human need or purpose. It is most frequently used by reference to a set of standards against which compliance can be evaluated. The most common
standards used to assess water quality relate to safety of human contact, drinking water, and for the health of ecosystems. Raw water is treated to obtain treated water which conforms to national drinking water standard.

Figure 1: Arial view of Sungai Terip water treatment plant

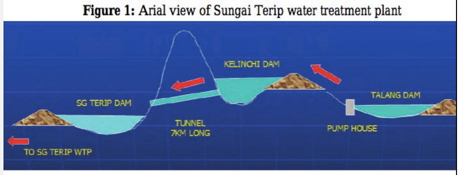


Figure 2: Schematic view of water storage

Figure 3: Three treatment phases in Sungai Terip water treatment plant

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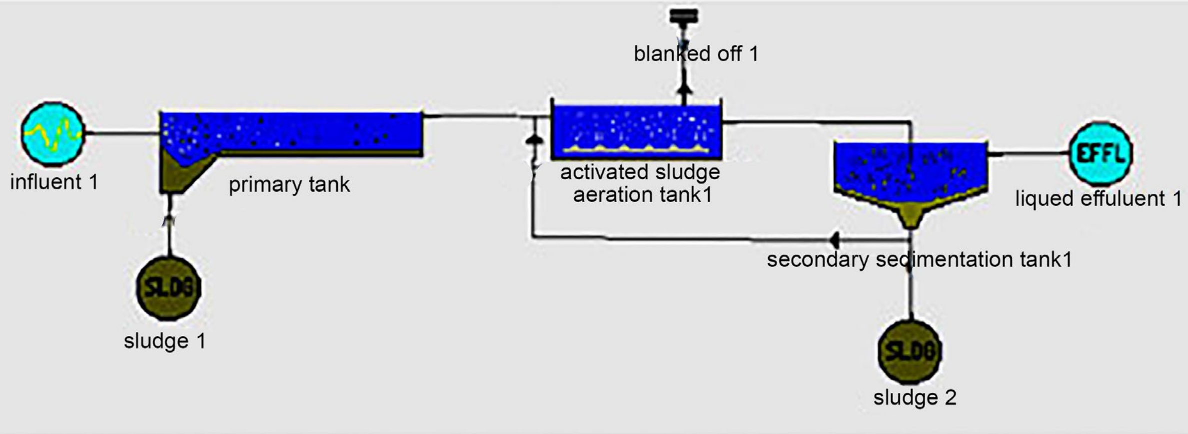
Biological Waste Water Treatment

Definition

Wastewater, which is basically used water, is also a valuable resource, especially with recurring droughts and water shortages in many areas of the world. Thus, the importance of wastewater treatment is: to restore the water supply and to protect from toxins.



Measure responding to	Adaptation ☐		Mitigation ☒	
Scale of application	City ☒	Neighbourhood ☒	Building ☒	
Expected efficacy of the measure	Immediate (< 1 yr) ☒	Medium term (10 yr) ☐	Long term (50 yr) ☐	
Lifespan of the measure (durability)	Short term (< 1 yr) ☐	Medium term (10 yr) ☒	Long term (50 yr) ☒	
Related primary SDG, if any	SDG 06	Specific associated targets	6. 3,4,6,7	
Related secondary SDG, if any	SDG 13	Specific associated targets	13. 1,2,3,5	
Addressed themes	Accessibility ☐	Energy ☒	Environment ☒	People ☐
Main strategy addressed	water management – efficient usage of wastewater			
Dimensional data	Primary tank volume: 2500 m³ diameter: 35m / Aerobic tanks volume: 32400 m³ Secondary sedimentation tank volume : 8105 m³ diameter: 60m			
Space usage	Monofunctional ☒		Multifunctional ☐	
Construction costs	Variable (depend on the size. it can be a basic system that could be constructed for building or city scale with high costs.)			
Maintenance / management costs	Frequent maintenance needed			
Quantification / metrics	Plant modelled according to ASM1 model. Biochemical oxygen demand (BOD) - Chemical oxygen demand (COD)			

Detailed description

Activated Sludge Process is a system to biologically treat industrial or sewage water waste to oxidizing carbonaceous and nitrogenous matter, removing phosphate, driving off entrained gases carbon dioxide, ammonia, nitrogen, etc., generating a biological floc that is easy to settle and generating a liquor low in dissolved or suspended material

In principle all Activated Sludge Process consist of three main components: a primary tank to resolve big components before the aeration tank, which serves as bio reactor; a settling tank ("final clarifier") for separation of solids and treated waste water; a return activated sludge equipment to transfer settled activated sludge from the clarifier to the influent of the aeration tank.

The term "activated" comes from the fact that the particles are actively teeming with beneficial, sewage digesting bacteria, and protozoa.

Best practices

Wastewater treatment plant of south of Isfahan

Iran is facing a big problem in terms of water resources and expected drought in future. As to fight back, they developed new environmental policies and inventions to secure the countries future. In big cities, with governments support, big plants created to reuse of water. one? of them is; The Isfahan city, has three large wastewater treatment plants in North, South and East with a capacity to treat 63 m³ per day. According to statistics, Iran's water recycling in agriculture is below 50%. Almost 90% of the scarce water resources are consumed by the agriculture sector. To solve the situation treated water resources started to use in agriculture and other sectors.

In Isfahan Wastewater Treatment plant; produced sludge is treated by aerobic digestion to have optimum outcome. After achieving an exemplary result; Environmental Health Laboratory of Isfahan conducted a search to use data in other plantations in Iran. In this study, in the first section the characteristics of influent and effluent wastewater were measured over a period of 68 days. In the second part, mathematical modeling was done by the STOAT modeling software. Finally, the measured output values were compared with the values predicted by the model. As a conclusion; Model's values were 10% better than the predictions to show a success on the plants efficiency.

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Rainwater Storage Beneath Sport Fields

Definition

Water storage facilities is storing in underground crates that is an interesting form of multiple uses of single spaces

Measure responding to	Adaptation x	Mitigation x		
Scale of application	City ☐	Neighbourhood x	Building ☐	
Expected efficacy of the measure	Immediate (< 1 yr) x	Medium term (10 yr) ☐	Long term (50 yr) ☐	
Lifespan of the measure (durability)	Short term (< 1 yr) x	Medium term (10 yr) ☐	Long term (50 yr) ☒	
Related primary SDG, if any	SDG 6	Specific associated targets	6.A	
Related secondary SDG, if any	SDG 12	Specific associated targets	12.2	
Addressed themes	Accessibility ☐	Energy ☐	Environment x	People ☐
Main strategy addressed	strategy for more efficient water management			
Dimensional data				
Space usage	Monofunctional ☐	Multifunctional x		

Construction costs	Average to high
Maintenance / management costs	Average
Quantification / metrics	Underground tanks ranging in size from a 4,000 gallon polyethylene OcTank system to the largest standard individual fiberglass vessel at 75,000 gallons.

Detailed description

One option for creating additional water storage facilities is storing in underground crates. This is a hidden technology that fits the criteria of sustainable urban planning, which is why it is discussed here. An interesting form of multiple uses of single spaces is realising water storage beneath sports fields. The technical aspects are simple to achieve using storage boxes/bulbs or Aquaflow. The Physical Planning Department of the City of Amsterdam summarised the various options for Amsterdam's Bijlmerpark.

Sports fields can be integrated into water systems in one of two ways:
- The water storage facility is connected directly to surface water. In this scenario, the water level below the sports fields rises according to the surface water level.
- The water storage facility is not connected directly to surface water. In this scenario, the water that needs storing is fed in from elsewhere, stored and drained at a delayed pace.

Best Practices

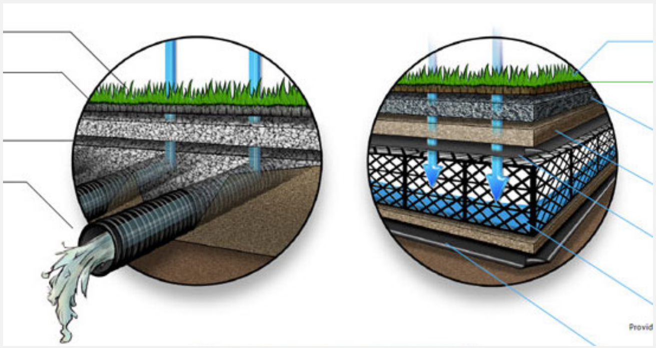
1-Drainage Filtration and Water Storage at World Cup Stadium

The huge Maracana sports stadium in Rio was the focal point for the 2014 World Cup, and will also be the main venue during the 2016 Olympic Games. With an all seated capacity of 85,000 the stadium will be the largest in South America.

The sports stadium has recently undergone extensive renovation, part of which is the installation of a rainwater harvesting system to supply the toilet facilities and to irrigate the pitch. The system was designed and supplied by Brazilian Wisy partner Aquastock.

WISY Vortex Filters

A total of 18 WISY WFF300 Vortex filters were used to harvest the rainwater from the vast 50,000 square metre roof area. The Wisy vortex filter was chosen for this project due to its low maintenance features, high filter efficiency, vehicle load bearing and oxygen enriching capabilities.



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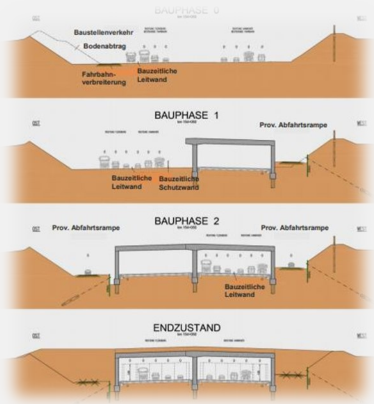
Interventions in Transport Linear Infrastructures

Green Roof Canopy

Definition

It aims to reduce negative environmental effects of high capacity transportation systems like noise and air pollution.



Measure responding to	Adaptation ☐		Mitigation ☒	
Scale of application	City ☒	Neighbourhood ☐	Building ☐	
Expected efficacy of the measure	Immediate (< 1 yr) ☐	Medium term (10 yr) ☒	Long term (50 yr) ☐	
Lifespan of the measure (durability)	Short term (< 1 yr) ☐	Medium term (10 yr) ☐	Long term (50 yr) ☒	
Related primary SDG	SDG 11	Specific associated targets	11.2, 11.6, 11.7,	
Related secondary SDG	SDG 9	Specific associated targets	9.4	
Addressed themes	Accessibility ☒	Energy ☒	Environment ☒	People ☒
Main strategy addressed	Urban air quality and Noise protection			
Dimensional data				
Space usage	Monofunctional ☒		Multifunctional ☒	

Construction costs	approximately 28,000,000€ per acre
Maintenance / management costs	approximately 150,000,000€ per acre
Quantification / metrics	1,20mt thick layer of rooting soil above tunneling construction (information from A7 tunnel in Altona)

Detailed description

The motorways generally create a high volume of noise, a physical barrier between areas and because it contains heavy truck traffic, it lowers the surrounding air quality. The green roof canopy system can help to reduce air pollution, restore vital space to nature, help with storm water management and flash flooding and all the other benefits that green roofs provide. It is also important to realize the social benefits. Giving people back the space over city roads increases social cohesion and gives back a sense of community. The structure of the system starting from tunneling motorway using steel or concrete systems and greening the roof of the construction with meadows, woods, bike paths, community gardens, and tree-lined squares etc.

Best practices

1) Green Roof Covering: A7 tunnel construction in Altona / Hamburg

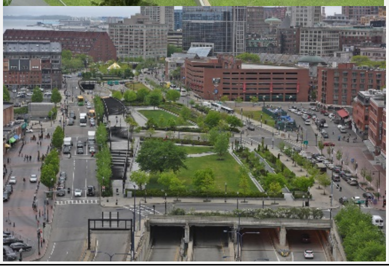
Existing highway A7 had divided two neighborhoods from each other and had a negative environmental effect like noise and air pollution. Tunneling the highway and creating a recreational park on the top of tunnel was a solution to solve the existence problem.

The tunnel has approximately 3,5mt length, 42mt width and 5mt height. Creation of new parks along covered motorway includes green areas like open meadows, woods, bike paths, community gardens, and tree-lined squares. For this purpose, the tunnel is covered with a 1.20-Mt-thick layer of rooting soil.

- For the first stage of tunneling which has 560 Mt length
- 34 Mt width and 4.90 Mt clear height, it will be used 33,000 m³ of concrete and 5,000 tons of steel to build the structure.

2) The Green Way / Boston

It is a part of one of the largest and complex projects in USA called "Central Artery Tunnel Project" (Big Dig) that relocating the elevated highway to the underground. Removing elevated highway gave a chance to create green space along tunneled highway around 17 acres with parks, gardens and many facilities while providing re-connectivity to the neighborhoods that were cut off by the old highway.



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Green Noise Barriers

Definition

Green noise barriers include all noise abatement/mitigation structures that form a part of a road system, including vertical, cantilevered/curved barriers and noise enclosure including in the design vegetation adapting to the surrounding environment, at grade or on elevated structures.

Measure responding to	Adaptation ☒	Mitigation ☒

Scale of application	City ☒	Neighbourhood ☐	Building ☐
Expected efficacy of the measure	Immediate (< 1 yr) ☐	Medium term (10 yr) ☒	Long term (50 yr) ☐
Lifespan of the measure (durability)	Short term (< 1 yr) ☐	Medium term (10 yr) ☒	Long term (50 yr) ☐
Related primary SDG, if any	SDG 11	Specific associated targets	11.2, 11.6
Related secondary SDG, if any	SDG 13	Specific associated targets	13.1, 13.2

Addressed themes	Accessibility ☐	Energy ☐	Environment ☒	People ☒

Main strategy addressed	Improve outdoor urban environmental quality - Urban Air Quality – ENV22
Dimensional data	600 x 600 x 90 mm (DURAGREEN module dimensions). Weight: 90 kg/m2 (water saturated weight)

Space usage	Monofunctional ☒	Multifunctional ☐

Construction costs	190 euros per square meter (Acoustic 120 economy green barrier)
Maintenance / management costs	
Quantification / metrics	Noise reduction: 7 Db (research report Peutz A2137-1-RA)

Detailed description

Noise barriers and noise embankments are often relatively large and conspicuous structures which may not fit in with the surrounding environment. When a noise barrier has been erected, it represents a considerable economic investment and can be expected to remain standing for several decades.
Different types of green noise barriers adapted to the surrounding environment are used. Because of their size and conspicuousness noise barriers and noise embankments often set their mark on the environment in which they are placed. Therefore it is important to focus on aesthetically and visually satisfactory solutions both with regard to the urban environment "behind" the barrier and as seen from the road "in front" of it.

Best practices

Green noise barrier A348 near Velp in the province of Gelderland

DuraGreen developed an ingenious and sustainable system for extensive vertical vegetation. The modular DuraGreen® Extensive system can be mounted quickly and easily, and is low in maintenance because of the integrated irrigation system.
The green noise barrier along the A348, The Provincial Executive defends the plantings because it absorbs particulate matter, dampens noise and offers a beautiful appearance. Moreover, the planting does not have to be pruned and watering is not necessary.
The project costs almost 190,000 euros, but calculated per square meter this solution is about 150 euros cheaper than a regular screen.

Source: *DURAGREEN website*

Source: *De Gelderland website*

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Interventions in Natural Areas and Management of Rural Land

Carbon sink

Definition

A carbon sink is anything that absorbs more carbon than it releases as carbon dioxide.

Measure responding to	Adaptation ☐		Mitigation ☒	
Scale of application	City ☒	Neighbourhood ☒	Building ☒	
Expected efficacy of the measure	Immediate (< 1 yr) ☒	Medium term (10 yr) ☒	Long term (50 yr) ☒	
Lifespan of the measure (durability)	Short term (< 1 yr) ☐	Medium term (10 yr) ☐	Long term (50 yr) ☒	
Related primary SDG, if any	SDG 15	Specific associated targets	15.2, 15.3	
Related secondary SDG, if any	N/A	Specific associated targets	N/A	
Addressed themes	Accessibility ☐	Energy ☐	Environment ☒	People ☐
Main strategy addressed	Improve environmental outdoor quality			
Dimensional data	From a single tree to a wide forest of hundreds of hectares			
Space usage	Monofunctional ☐		Multifunctional ☒	

Construction costs	4$ to plant a new root
Maintenance / management costs	N/A
Quantification / metrics	Average of 7,2kg of CO_2 captured by tree of 80 years old

Detailed description

The main natural carbon sinks are plants, the ocean and soil. Plants grab carbon dioxide from the atmosphere to use in photosynthesis; some of this carbon is transferred to soil as plants die and decompose. The oceans are a major carbon storage system for carbon dioxide. Marine animals also take up the gas for photosynthesis, while some carbon dioxide simply dissolves in the seawater.

But these sinks, critical in the effort to soak up some of our greenhouse gas emissions, may be stopping up, thanks to deforestation, and human-induced weather changes that are causing the oceanic carbon dioxide “sponge” to weaken. Scientists are looking for ways to help nature along by devising ways to artificially sequester, or store, carbon dioxide underground.

Best practices

The amount of carbon capture might reach a load between 600kg and 6 tons per hectare depending on the fact this is a reforested area or a new forest and according to the variety. The highest value of potential absorption of CO2 is the one of the fir tree.

More related to the city and that still exercises a carbon sink effect, urban forest might be mentioned. Urban forest capture CO2 but not only. They also provide shadow, might contribute to the reduction of air conditioning. 50 million of tree planted in the Californian cities could capture 4.5 million tons of CO2, a proportion of 90kg/tree/year.

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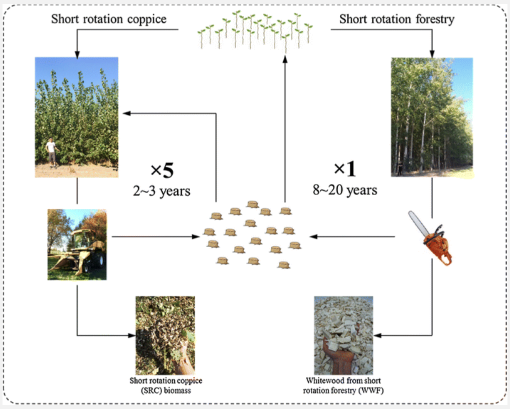
Short Rotation Forestry for biomass production

Definition

Short-rotation forestry refers to high-density, sustainable plantations of fast-growing tree species that produce woody biomass on agricultural land or on fertile but degraded forest land.



Measure responding to	Adaptation ☒		Mitigation ☐	
Scale of application	City ☒	Neighbourhood ☐	Building ☐	
Expected efficacy of the measure	Immediate (< 1 yr) ☐	Medium term (10 yr) ☒	Long term (50 yr) ☐	
Lifespan of the measure (durability)	Short term (< 1 yr) ☐	Medium term (10 yr) ☒	Long term (50 yr) ☐	
Related primary SDG, if any	SDG 07	Specific associated targets	7.2	
Related secondary SDG, if any		Specific associated targets		
Addressed themes	Accessibility ☐	Energy ☒	Environment ☐	People ☐
Main strategy addressed	Producing energy from biomass and biogas. ENE 3_Short Rotation Forestry for b production			
Dimensional data	SRFs have a rotation cycle from 3 to 20 years. Fast growing tree species planted up to 10,000 trees per ha. Around 1-2 ha of SRF can cover energetic needs of a single household, but to be profitable at least 50 ha of SRP is needed.			
Space usage	Monofunctional ☐		Multifunctional ☒	
Construction costs	The cost of producing willow wood chips, including transport, amounts to about 235 EUR/ha excluding land rental costs.			
Maintenance / management costs	After 20-30 years the field needs re-plantation.			
Quantification / metrics	The annual yield of biomass produced reaches to 20 tons (Mg) of dry matter per ha per year. Energetic value of dried biomass reaches to 274 GJ per ha for one year plantation to 1,262 GJ per ha for a 3 years rotation cycle.			

Detailed description

The biomass produced is used for construction, pulp and paper, fodder and energy. Wood from short-rotation forestry may replace wood from tropical forests and from protected forest areas and thus help conserve valuable natural forests for future generations. The full growth potential of a tree species is realized by creating optimal water and nutrient conditions, eliminating competition by herbaceous plants and other tree species, and preventing biotic and abiotic damage.
Land that can be used for this type of plantation includes agricultural land that is no longer needed for agriculture because of overproduction; clear-cut forest land in tropical and temperate areas; and degraded land, especially in many developing countries.
The methods used should be accepted from environmental, economic and aesthetic points of view. Production from short-rotation forestry facilitates protection of valuable natural forests by meeting needs for wood resources.

Best practices

Enköping municipality Plant in Sweden
The power plant uses a mixture of wood chips from energy forest and wood waste from the forest industry in a combined heat and power generation. The plant provides close to 50% of all electricity consumed in the town (about 40,000 inhabitants) and all heating needed through district heating.

Short Rotation Forestry in Sicily, Italy
Is a potential area (not irrigated land) that produces about 1.3 MT of biomass that could be transformed into wood pellets. The experimental field of Mussomeli is located near a municipal waste water treatment plant, which was used for irrigation. No fertilizer was applied.

Monitoring and control system for wastewater irrigated energy plantations Project in Poland (WACOSYS 6 FP UE)

Effluents from wastewater treatment plants (WWTPs) were effectively used for irrigation of energy forest plantations. It has been estimated that from 7 to 20 Euro could be save per kilo of nitrogen by using natural instead of mineral fertilizers.

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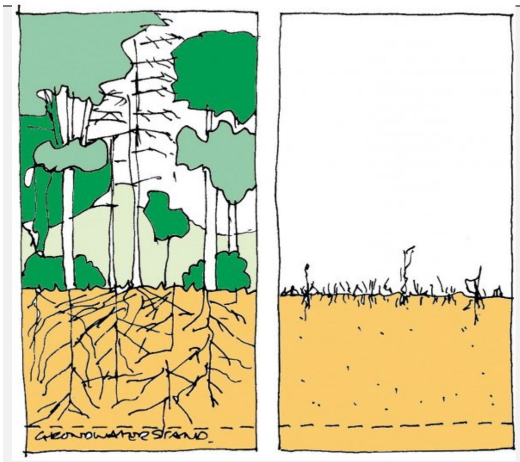
Hedge Biotopes

Definition

[Natural hedges is made up of different types of shrubs and/or trees and preferably is not pruned too neatly.]



Measure responding to	Adaptation ☒		Mitigation ☐	
Scale of application	City ☐	Neighbourhood ☒	Building ☐	
Expected efficacy of the measure	Immediate (< 1 yr) ☒	Medium term (10 yr) ☒	Long term (50 yr) ☐	
Lifespan of the measure (durability)	Short term (< 1 yr) ☒	Medium term (10 yr) ☒	Long term (50 yr) ☒	
Related primary SDG, if any	SDG 15	Specific associated targets	15.A	
Related secondary SDG, if any		Specific associated targets		
Addressed themes	Accessibility ☐	Energy ☐	Environment ☒	People ☐
Main strategy addressed	[Ecological corridor and Green coverage]			
Dimensional data				
Space usage	Monofunctional ☐		Multifunctional ☒	
Construction costs	20-80€ per square meter（depending on the price of plants）			
Maintenance / management costs	0-20 € per square meter per year			
Quantification / metrics				

Detailed description

[Hedges play an important function for many animals. Most favourable is a hedge that is made up of different types of shrubs and/or trees and preferably is not pruned too eatly. Such a hedge is comparable to the edge of a forest. These hedges can be realised in parks but also as the property demarcation between private gardens. Berry- and fruit-bearing, nectar-producing species help insects and birds to survive in the city.
When planting hedges, species should be considered that fit physically in the location once they have finished growing; that saves much pruning. Of course, colour, flowering and location determine the choice of species.

Best practices

[The 'Zeeuwse haag' (Zealand hedge) is a hedge that consists of 60% hawthorn, 20% sledge and 20% field maple. In addition, the hedge is filled with rabid, egelantier, elder and cowboy. In the past, these gardens were planted as security.

The hedge provides a place for birds; not only by the protruding bushes, but also because the hedge provides good shelter for birds of prey and suitable nesting. A subsidy can be obtained in the Netherlands for the construction of a Zeeland hedge.]

Flowering hedge: https://nl.wikipedia.org/wiki/Zeeuwse_haag

[Benjes Hedges: Habitat for Wild Animals and Plants
During 2003-2004, The project Benjes hedges was established on the edge of the meadows and pastures. Over 1000 young trees were planted along the hedges. Since then, the wind and the birds have provided the hedges with seeds. Now all kinds of wild plants are growing in there. During the first year, the hedges have already filled in with wonderful high perrenials.

Over 20 various blooming plants can be found there. All kinds of insects can be seen on the plants and blossoms.]

http://www.heimatfuertiere.de/english/projects/benjes-hedges.shtml

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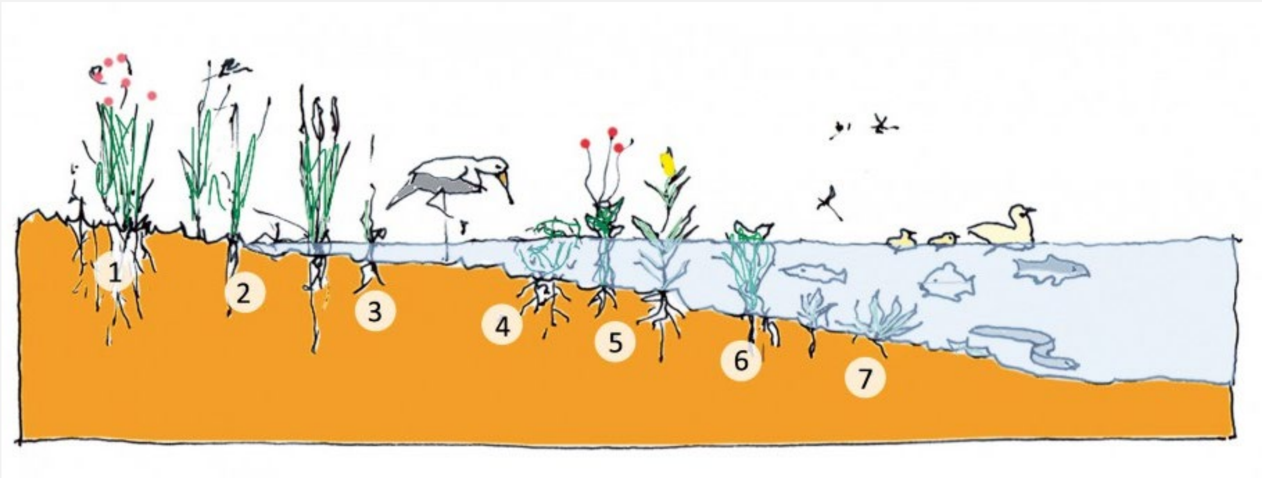
https://kiwidutch.wordpress.com/tag/hedge/
http://www.heimatfuertiere.de/english/projects/benjes-hedges.shtml]

Wet biotopes

Definition

Green riparian zones form a gradual transition from shore to water. It has a positive impact upon water quality. Reeds and rushes absorb nutrients and floating particles settle on them, as a result of which the clarity of the water improve .



Measure responding to	Adaptation ☒		Mitigation ☐	
Scale of application	City ☒	Neighbourhood ☒	Building ☐	
Expected efficacy of the measure	Immediate (< 1 yr) ☐	Medium term (10 yr) ☒	Long term (50 yr) ☐	
Lifespan of the measure (durability)	Short term (< 1 yr) ☐	Medium term (10 yr) ☐	Long term (50 yr) ☒	
Related primary SDG, if any	LIFE AND LAND	Specific associated targets		
Related secondary SDG, if any		Specific associated targets		
Addressed themes	Accessibility ☐	Energy ☐	Environment ☒	People ☒
Main strategy addressed	water management: By 2020, ensure the conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems and their services			
Dimensional data				
Space usage	Monofunctional ☒		Multifunctional ☐	
Construction costs				
Maintenance / management costs				
Quantification / metrics				

Detailed description

On the dry shore, land and shore vegetation can establish itself, in the shallow water marsh vegetation and in deeper water there is place for various water plants. Nature-friendly shores with an ecologically sound structure form excellent living areas for many plants, birds, insects, amphibians, fish and mammals. It is desirable to partly plant the shore vegetation and to create as much variation as possible in order to prevent reeds/rushes to develop over the entire shore length, which would cause a monoculture.

By shaping shores in a nature-friendly or ecological manner, living areas are created for different plants and animals. This can be done in various ways, for the sake of different groups of animals or plant communities. When nature-friendly riparian zones are desired, it is important to establish first what can be expected and what is desired and what is not.

Best practices

Brasserhout, Den Haag, The Netherland

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Community Compost Hub

Definition

Composting is nature's recycling system. It is the product of decomposed organic matter involving beneficial microorganism such as bacteria, fungi and creatures such as worms which produces a nutrient-rich soil. A Compost Hub is a medium or large scale system used to process composts or vermi-composts.

Figure 01. Compost Hubs

Figure 02. Worm Farm Hub

(Source: www.cultivatingcommunity.org.au/wp-content/uploads/2015/04/Food-Know-How-Metro-Fund-Final-Report_Cultivating-Community-and-City-of-Yarra-July-2014.pdf)

Measure responding to	Adaptation ☒	Mitigation ☒

Scale of application	City ☒	Neighbourhood ☒	Building ☐
Expected efficacy of the measure	Immediate (< 1 yr) ☒	Medium term (10 yr) ☐	Long term (50 yr) ☐
Lifespan of the measure (durability)	Short term (< 1 yr) ☐	Medium term (10 yr) ☐	Long term (50 yr) ☒
Related primary SDG, if any	SDG 12	Sustainable consumption and production patterns	12.3, 12.5
Related secondary SDG, if any	SDG 13	Combat climate change and its impacts	13.2.1

Addressed themes	Accessibility ☐	Energy ☐	Environment ☒	People ☐

Main strategy addressed	Efficient Waste Management (ENV 26: Composting)
Dimensional data	*(Case Study)* 6 community compost hubs with a total of 554 households, 32 cafes and 3 offices as participants.

Space usage	Monofunctional ☒	Multifunctional ☐

Construction costs	*(Case Study)* 475,941AUD over 18 months
Maintenance / management costs	
Quantification / metrics	*(Case Study)* Ave. Landfill diversion rate of 2.8 tons per week of household food waste and Greenhouse gas emission reduction of approximately 4.5 tCO2-e per week10

Detailed description

Food waste in EU is estimated at 20% of the total food production. Within the total 47 million tons of food waste, more than half of this comes from local households. Food waste in landfills rots slowly creating methane producing greenhouse gas that is 25 times more potent than carbon dioxide. Composting is a natural process based on the progressive degradation of biological material with the help of aerobic bacteria.

Best practices

Food Waste Reduction Program (Food Know How Project)

A joint development between non-profit organization and local government: Cultivating Community and City of Yarra in Australia. It aims to reduce the amount of food waste going to landfill. It covers from workshops and training about reducing food waste (menu and meal planning) to composting.

These are the easy ways to save money, reduce landfill, lessen wastage of resources and produce valuable fertilizer for the garden/community.

It was implemented over an 11 month period (June 2013-May 2014) (with the total of 18 month-budget including project design and evaluation periods).

Outcomes and findings of the project are the following:

- An **average landfill diversion rate of 2.8 tons per week** of food waste from households, offices and cafes at end of program.
- Diversion capacity of 3.8 t per week of food waste from households, offices and cafes at end of program.
- Total cafe diversion of 37 t of food waste, with a final average diversion of 1.2 t per week.
- Total potential household food waste diversion of 82.5 t per year.
- Development, trial and evaluation of six compost hubs using a range of systems.
- Final **greenhouse gas emissions reduction** of approximately 4.5 tCO2-e per week.
- Creation of **approximately 100m3 compost**, provided as free, high-quality fertilizer to community groups.

It was able to integrate community composting into high-rise public housing enabling a step forward to developing organic waste recycling solutions for Melbourne's multi-unit housing sector. It also earned continuous positive response from the participants.

The program won the United Nations Association of Australia World Environment Day Award 2014 for Sustainability Education.

Figure 03. Worm farm management demostration

Figure 04. Food waste collection from participating cafes

Figure 05. Aerobin Hub demonstration

(Source: www.cultivatingcommunity.org.au/wp-content/uploads/2015/04/Food-Know-How-Metro-Fund-Final-Report_Cultivating-Community-and-City-of-Yarra-July-2014.pdf)

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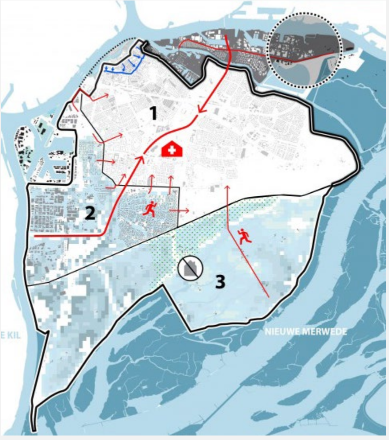
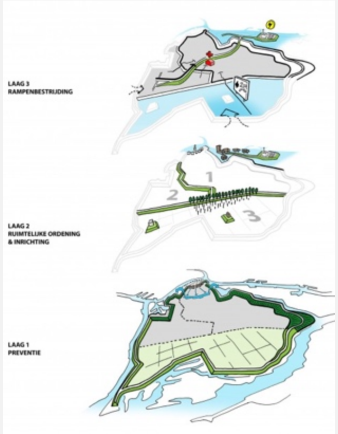
COMPARTMENTALISATION ON AN URBAN SCALE

Definition

Dividing a large dike ring into a number of smaller compartments, even within urban areas, can limit the consequences of flooding to a smaller area.

Measure responding to	Adaptation ☒		Mitigation ☐	
Scale of application	City ☒	Neighbourhood ☐	Building ☐	
Expected efficacy of the measure	Immediate (< 1 yr) ☒	Medium term (10 yr) ☐	Long term (50 yr) ☐	
Lifespan of the measure (durability)	Short term (< 1 yr) ☐	Medium term (10 yr) ☐	Long term (50 yr) ☒	
Related primary SDG, if any	SDG 11	Specific associated targets	11.3, 11.5, 11.5,	
Related secondary SDG, if any	SDG 13	Specific associated targets	13.1	
Addressed themes	Accessibility ☐	Energy ☐	Environment ☒	People ☒
Main strategy addressed	Strategies for a more efficient water management			
Dimensional data	The concept is divided into 3 Layers (case of Dordrecht). In each Layer length (km) and height (m) are the main dimensions.			
Space usage	Monofunctional ☐		Multifunctional ☒	

Construction costs	[insert numeric data and ranges if available here (costs/unit)]
Maintenance / management costs	1)*By unit*: 500 mil.eu. per dike 2)*By population*: N/e Euro/capita
Quantification / metrics	MLS = L_1 u $L_{2/1}$ u $L_{3/1}$ (Failure of the multi-layered safety system. L_1 – failure of the Layer1, $L_{2/1}$ – of the Layer1 and 2, $L_{3/1}$ – Layers 1-3).

Detailed description

Multi-layered safety is an integrated flood risk management concept based not only on flood probability reduction through prevention (layer 1) but also on consequences' minimization in the case of a flood through spatial solutions (layer 2) and crisis management (layer 3).

A comprehensive flood risk reduction plan reduces the frequency of floods, and it would also minimize the consequences once a flood occurs. So, the dike should be divided into a number of smaller compartments, composed in the order to keep the most crucial infrastructure and people more protected and moreover, spatial organized according to crisis management (safe emergence of people during the crisis).

Best practices

Island of Dordrecht, the Netherlands (pic 1,2)

In the pilot study, attention was given to the three layers of the multi-layered water safety strategy.

Layer 1 is the prevention of floods;

layer 2 is sustainable spatial planning;

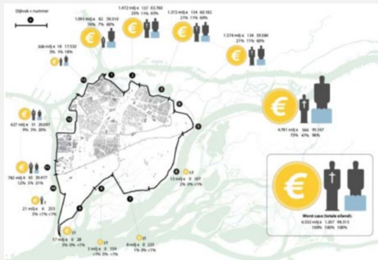
Layer 3 is disaster control.

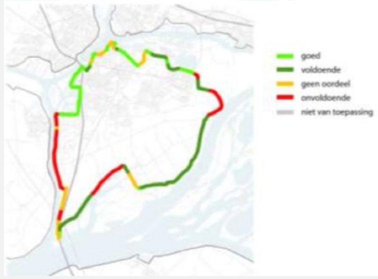
The multi-layered water safety strategy is depicted in terms of an area-specific risk approach for the Island of Dordrecht. Layer 1 shows a differentiated primary defense system, with the construction of a delta dike and a custom-made solution for the Voorstraat. Layer 2 shows the use of available compartimentalisation dikes, adaptive construction outside compartment 1 and the protection of vital infrastructure. Layer 3 shows possible evacuation routes, a life-line, shelters and how to guarantee the continued functioning of vital infrastructure.

Waterproof Amsterdam, the Netherlands (pic 3,4)

The city is influenced by the sea, the rivers, the Ijsselmeer and a refined system of regional canals. All possible flooding consequences were accumulated into one map and divided them into national, regional and local scale. On all levels spatial measurements can be taken adding up to a compete flood proof strategy for the city.

Special attention has been given to the banks of the IJ and the deep polders on the Southeast of Amsterdam. Here is a spectrum of possibilities for flood proofing on a local scale. They vary from guiding floods in public spaces to securing open inundation polders and from selective climate dikes to flood proof building developments.





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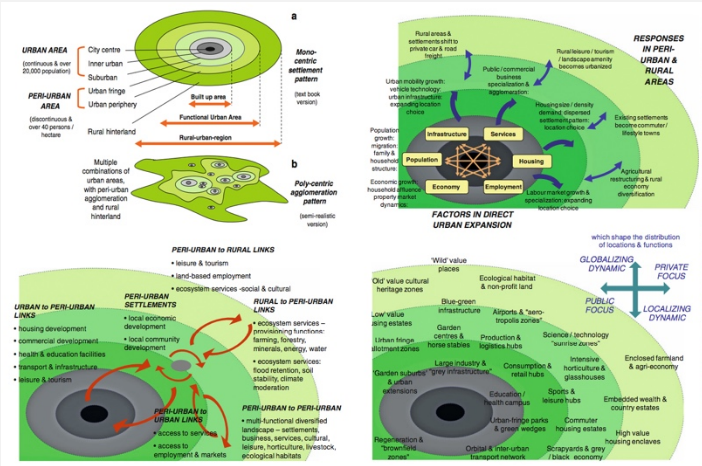
Peri-Urban Park

Definition

Periurban parks are the areas of ecological, landscape and cultural interest located on the outskirts of or near urban settlements, but inherently interwoven with the urban environment, where environmental protection, recreational, cultural, educational, economic and development related functions can coexist, with the support of public policies, plans and actions and with full citizen involvement.



Measure responding to	Adaptation ☒		Mitigation ☒	
Scale of application	City ☒	Neighbourhood ☐	Building ☐	
Expected efficacy of the measure	Immediate (< 1 yr) ☐	Medium term (10 yr) ☒	Long term (50 yr) ☒	
Lifespan of the measure (durability)	Short term (< 1 yr) ☐	Medium term (10 yr) ☐	Long term (50 yr) ☒	
Related primary SDG, if any	SDG 13	Specific associated targets	13.2, 13.2.1	
Related secondary SDG, if any	SDG 8,7	Specific associated targets	8.9, 7.1	
Addressed themes	Accessibility ☐	Energy ☒	Environment ☒	People ☒
Main strategy addressed	impact positively on the environment and on halting biodiversity loss through focus on policy to manage solution to mitigate pressures on biodiversity and creation of parks in natural suburban areas, in line with European environment policy and redevelopment in suburban areas.			
Dimensional data	1.10 €/m²			
Space usage	Monofunctional ☐	Multifunctional ☒		
Construction costs				
Maintenance / management costs				
Quantification / metrics				

Detailed description

Peri-urban parks They refresh city temperatures; absorb air pollutants and decrease traffic noise. They look after our physical and mental health. They are outdoors gym, nature-schools and a green place to meet with family and friends. In some areas, Peri-urban parks are also places where one can grow and buy fresh and organic vegetables.

Besides, peri-urban parks are essential components of green infrastructure– a new way to provide landscape connectivity and to preserve the territory and its ecosystem services. Peri-urban parks can adopt very different forms: they can be forests, rivers, green rings, agro-ecological spaces and re-naturalized landscapes. All located at the city doors
Peri-urban receive a lot of pressure: visitors overflow, unwanted city equipment, exotic species and vandalism. These are threats that managers must deal with, while trying to protect biodiversity. Today, with over 80% of the European population living in urban and suburban areas, the conservation of this natural non-urbanized areas on the outskirts of cities urges to be addressed.

Best practices

The Periurban Park of the city of Mantua is a green path for pedestrians and cyclists. Several stretches run along the shores of the three lakes formed by the Mincio River around the city.
The stretch along Lago di Mezzo (middle lake) is a loop connecting the two city bridges: from Ponte dei Mulini to Porta Giulia, in Citadel, the path crosses a green area where the remains of one of the city's fortifications are to be found; the path leads then to Ponte San Giorgio near the stronghold of through an underground passage called “Eco tunnel of ecological network”. The Park is an "open-air science museum, where numerous devices lead visitors to discover science in their everyday life: battery, echo tube, kaleidoscope, pulleys, rotating disks, anti-gravity mirror. The path also includes levers, a Newton disc, a wireless telephone, Pan's pipes and a gyroscope.

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Recycling Organic waste by local communities

Definition

Recycling human waste as a natural and infinite symbiotic process, between the city and its surrounding biological agricultural land.

Measure responding to	Adaptation ☒		Mitigation ☒	
Scale of application	City ☒	Neighbourhood ☒	Building ☒	
Expected efficacy of the measure	Immediate (< 1 yr) ☒	Medium term (10 yr) ☒	Long term (50 yr) ☒	
Lifespan of the measure (durability)	Short term (< 1 yr) ☐	Medium term (10 yr) ☒	Long term (50 yr) ☒	
Related primary SDG, if any	SDG 11	Specific associated targets	11.6	
Related secondary SDG, if any	SDG 15	Specific associated targets	15.1	
Addressed themes	Accessibility ☐	Energy ☐	Environment ☒	People ☒
Main strategy addressed	Improve environmental outdoor quality, ENV 26 composting, ENV 9 Filtration and natural drainage management, ENV 22 Urban air quality strategies to improve outdoor urban environmental quality			
Space usage	Monofunctional ☒ the terrain where compost is produced		Multifunctional ☒ less erosion and run-off and carbon sequestration where compost is applied	

Detailed description

This is actually an important step to reach a circular economy. Modern agriculture is facing a lot of problems such as erosion and the depletion of organic material in the soil. Chemical fertilizers increase harvest quantities but it does not make the soil richer. Biological organic material in the soil is a great way to ensure a stable food supply in the future because soil gets richer by the year.
At the moment enormous amounts of food gets wasted after the consumer buys the produce but also before the harvest of the yields because of economical speculation. This is not how a circular economy works and one way to reach one step closer is composting locally.
Organic waste can be burnt to produce heating and energy. But there is a lot of energy in this natural material that gets wasted in the process. With composting locally and re-using it locally, a symbiosis between food produce and food waste arises. In this way the urban metabolism mimics the life-supporting ecosystems on which all life on Earth depends, thus restoring—rather than depleting.

Best practice

Biocomp Nepal

The goal of the private company is to produce high quality compost (eco-certified), out of a local abundant resource: organic waste from vegetable markets and private companies based in Kathmandu and its region. The common objective is to create a sustainable and profitable business in the Kathmandu Valley.

The project is based on a “win-win” idea, aiming to improve the quality of life of the farmers but also of the urban population. It proposes a solution for the management and upgrading of the urban organic waste while developing agribusiness in the Kathmandu region and allowing farmers to produce with an added value.

Process organic waste into compost, reducing methane emissions otherwise caused in traditional landfills (methane recovery).

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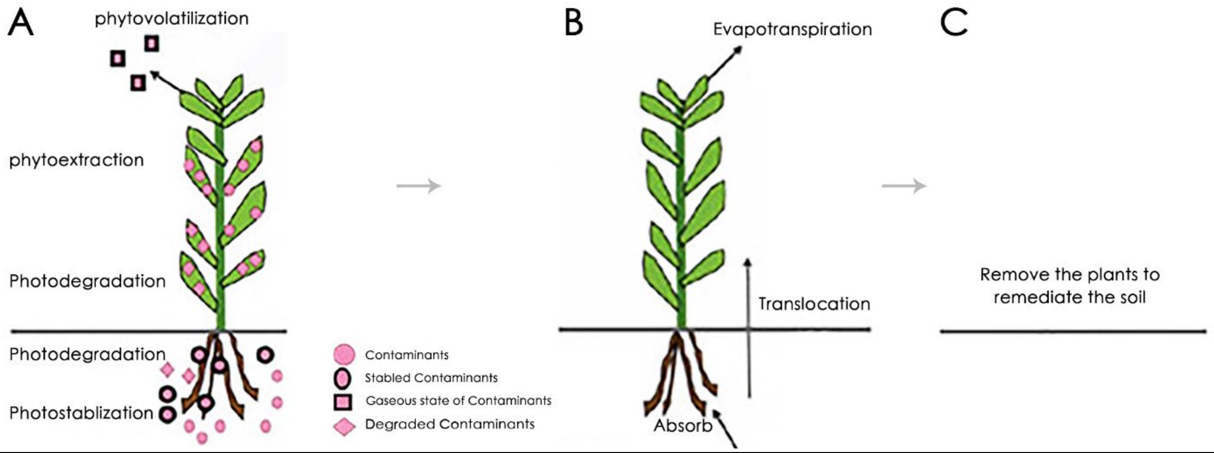
Soil Phyto-Remediation

Definition

means plants use the sun's energy to cleanse (stabilize, degradate, extract, or gasify) contaminants (especially heavy metal ion) in soil so that the brownfields could be reused/ recycled. This method can be used in peri-urban or rural areas where factories just moved and waiting for redesign.



Measure responding to	Adaptation ☐		Mitigation ☒	
Scale of application	City ☒	Neighbourhood ☒	Building ☐	
Expected efficacy of the measure	Immediate (< 1 yr) ☐	Medium term (10 yr) ☒	Long term (50 yr) ☐	
Lifespan of the measure (durability)	Short term (< 1 yr) ☒	Medium term (10 yr) ☒	Long term (50 yr) ☐	
Related primary SDG, if any	SDG 12	Specific associated targets	12.2, 12.4	
Related secondary SDG, if any	SDG 03	Specific associated targets	03.9	
Addressed themes	Accessibility ☐	Energy ☐	Environment ☒	People ☐
Main strategy addressed	soil management and improvement; reuse of brownfields			
Dimensional data	depends on kind of plants and area of lands			
Space usage	Monofunctional ☐		Multifunctional ☒	

Construction costs	5000 -- 125000 US$ / hectare (site preparation, planting, and harvesting of plant material)
Maintenance / management costs	vary from different plants/ weathers
Quantification / metrics	depends on kind of plants

Detailed description

many urban areas and many rural ones have large quantities of toxic materials in the ground. If people live where a gasoline station used to be, people might have things in the soil that harm the health. These areas can be abandoned but actually some of them are near the centre as the city is outspreading all the time, and it is a waste of land resource for leaving contaminated area unused.

Certain plants have a particular gift for sucking up specific chemicals, either as a quirk of their biology or as a way to make themselves poisonous and avoid being eaten. When these plants are sown on contaminated ground, they absorb the contaminants into their tissues, gradually reducing the amount in the soil.

The basic method of Soil Phyto-remediation is straightforward: find out what toxins lurk in the ground, and use a regimen of plants appropriate for the climate that hyper-accumulate those particular toxins. The petroleum-based poison would become sugar water. For Metals, some plants can absorb the metal and metabolise it into some kind of molecule, making it less easy to be absorbed by the human body and thus safer to be around. After the plants are harvested with the metals concentrated in their tissues.

The most appealing aspect of this new field is its scale, that the work to clean up toxic-waste sites could be done with no massive government project or corporate funding, with no bulldozers or construction equipment, without advanced and delicate technology beyond that to measure the toxin levels. certain limitations still exists like the plants have to be able to grow in that climate, and should not be an invasive species that will take over the landscape.

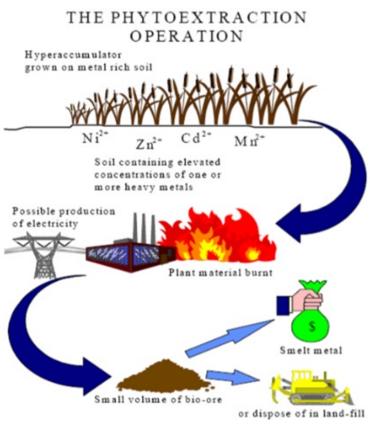
Best practices

1.Brazil: Phytoremediation of Mercury-Contaminated Mine Wastes

Abandoned gold mines in Brazil are leaking mercury and other heavy metals into the soil and water. Mercury is one of the most toxic of heavy metals, and once in the soil it is soaked up by grass, which is eaten by cows, will get into human body. Farmers are now growing maize and canola plants in the area, though, which soak up heavy metals quite nicely – gold as well as mercury. Scientists overseeing the project estimated farmers could get a kilogram of gold per hectare from doing this, which would help pay for the clean-up.

2. Other practices

--Mustard greens were used to remove 45% of the excess lead from a yard in Boston to ensure the safety of children who play there.
--Pumpkin vines were used to clean up an old Magic Marker factory site in Trenton, New Jersey
--Alpine pennycress helped clean up abandoned mines in Britain.
--Hydroponically grown sunflowers were used to absorb radioactive metals near the Chernobyl nuclear site in the Ukraine as well as a uranium plant in Ohio.



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