# GREEN SKILLS FOR CITIES

## General concepts on urban areas and NbS

The Green Innovation Challenge
September 25/29 2023

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**ONE**

# General Concepts

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# General concepts

## Climate Change

- **Climate change is the most significant challenge** to achieve sustainable development. World leaders and environmental activists declare that we need to take action to face it. The EU has set targets for reducing greenhouse gas emissions up to 2050.
- We should connect long-term with short-term (**Mitigation and Adaptation) strategies**, change our behavior, and invest in **green infrastructure** to manage climate change in the long run.

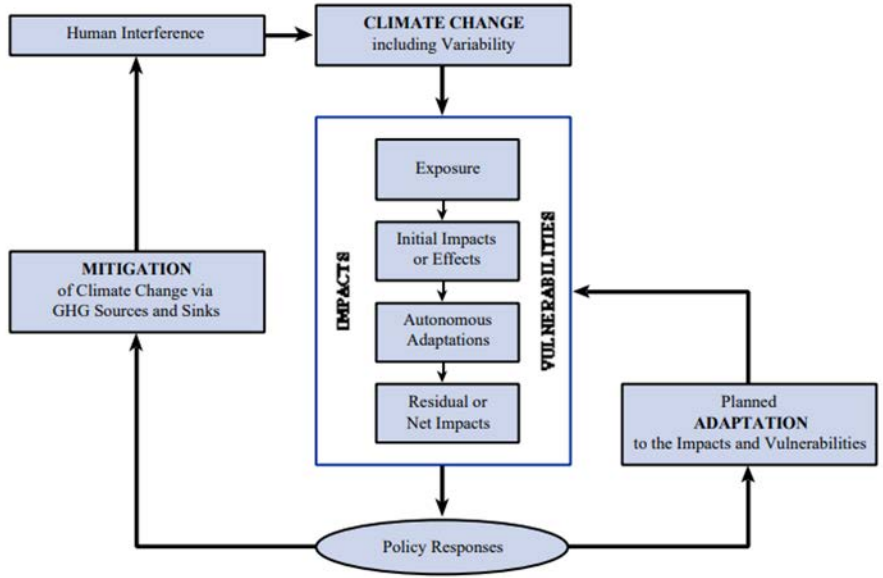



**Figure 1-2**: Places of adapatation in the climate change issue (Smit *et al*., 1999).

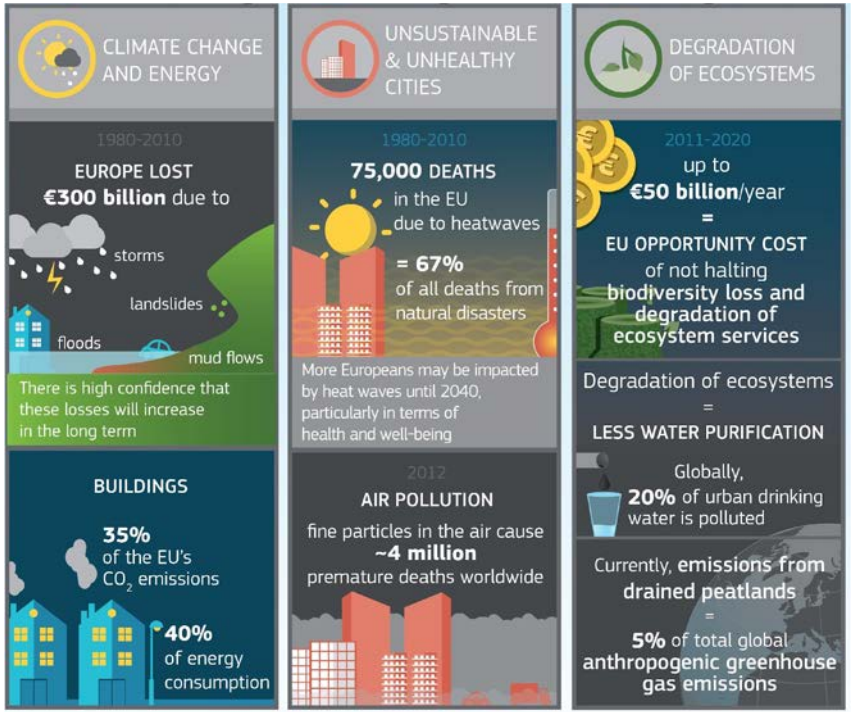
https://www.ipcc.ch/site/assets/uploads/2018/03/wg2TARchap1.pdf

SECTION **ONE**

# General concepts

## Challenges

- From 1980 to 2010 **EU lost €300 billion** due to storms, landslides, mod flows.
- **Buildings** account for **35% of the EU's $CO_2$ emissions** and **40% of energy consumption**.
- From 1980 to 2010 **EU had 75 000 deaths** due to heat waves
- In 2012 the **fine particles** in the air caused **4 millions of premature deaths** worldwide.
- From 2011 to 2020 degradation of ecosystems cost up to €50 billion/year.
- **20% of urban drinking water is polluted** and emissions from drained peatlands represent 5% of global anthropogenic CO2 emissions.




Infographic EU Commission

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SECTION **ONE**

# General concepts

The 17 Sustainable Development Goals (SDGs) were set by the United Nations in 2015 to take action to end poverty, protect the planet, and ensure that by 2030 all people enjoy peace and prosperity. The SDGs recognize that action in one area will affect outcomes in others.


UN SDGs

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SECTION **ONE**

# General concepts

## Sustainable Development Goals

- **Goal 11** aims at creating econimic opportunities, affordable housingand **resilient societies,** bringing investment in **public transport**, **green public spaces**, and **urban** participatory and inclusive **planning** and management.
- **Goal 13** aims to address the needs of developing countries to both **adapt to climate change** and **invest in low-carbon development**.
- **Goal 15** addresses **the loss of natural habitats** and **biodiversity** and supports **global food and water security**.




UN SDGs

SECTION **ONE**

# General concepts

## Biodiversity

Key international regulations to support, restore and manage biodiversity:

- CBD - Convention on Biological Diversity (1992 – Rio de Janeiro)
- COUNCIL DIRECTIVE 92/43/EEC (21 May 1992) on the conservation of natural habitats and of wild fauna and flora
- WSSD - World Summit on Sustainable Development (2002 – Johannesburg)
- The European Green Deal (2019)
- EU Biodiversity Strategy for 2030 (2020)

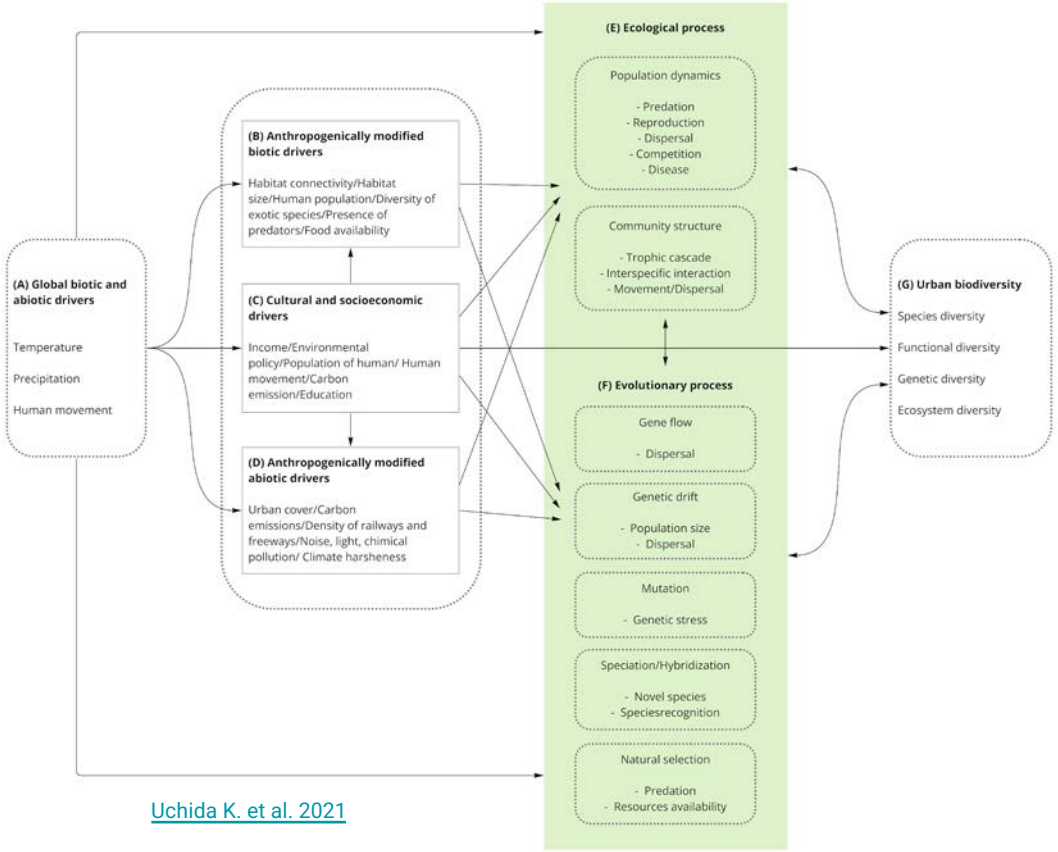
SECTION **ONE**

# General concepts

**Urban ecology** studies the interactions and relationships at the urban scale.

Cities are human-dominated ecosystems where natural and artificial elements coexist.

**New relationships** are established between components of urban ecosystems (plants, animals, microbiota, human and human artifacts).




Uchida K. et al. 2021

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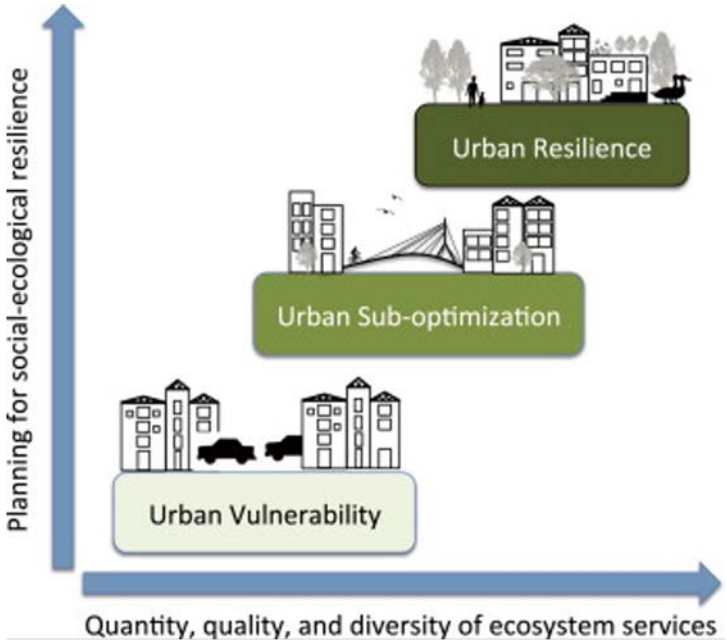
# General concepts

## Urban ecology

The introduction of natural elements in urban environments allows the establishment of **multitrophic interactions**, with:

- ➔ The restoration of ecological processes and functions.
- ➔ The increase of biodiversity in terms of quantity and quality (native species).
- ➔ Biological community in equilibrium, adapted to the environmental context and able to self-perpetuating over time.

**The result is resilient and sustainable cities.**




McPherson et al. 2015

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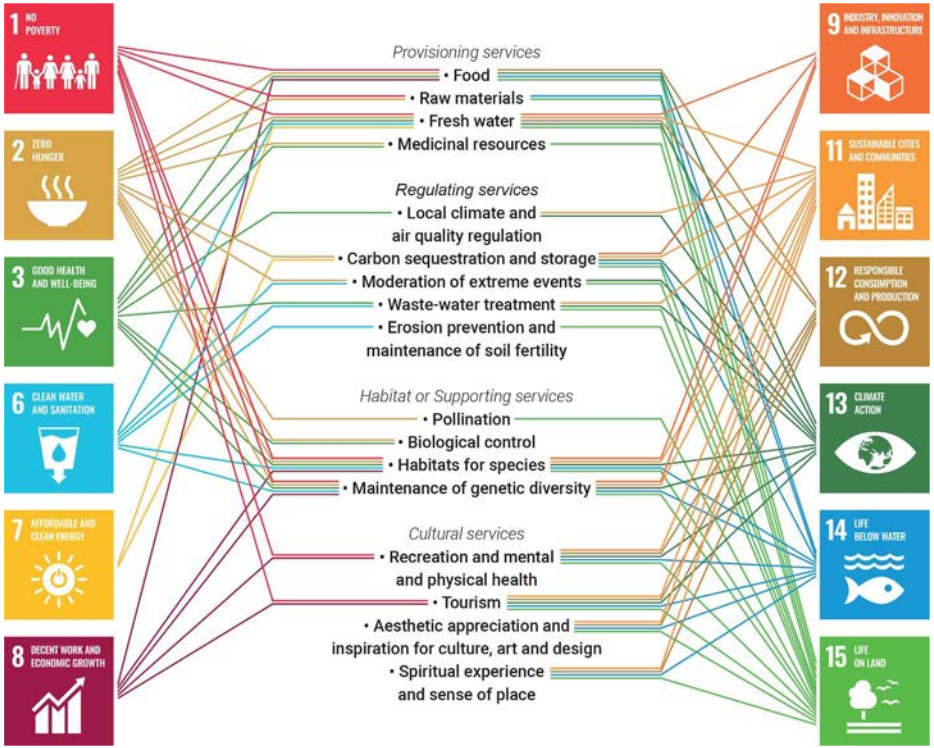
SECTION **ONE**

# General concepts

***Ecosystem services*** *play a relevant role in achieving the* ***UN Sustainable Development Goals***.




In Perini, 2022

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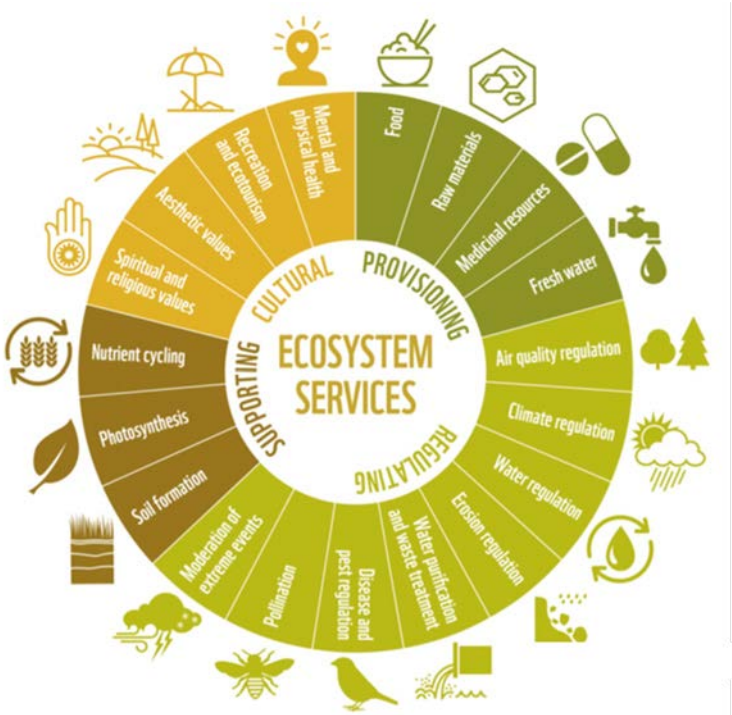
SECTION **ONE**

# General concepts

All the **ecosystem services** - like the provision of food, clean air, water, and resources like wood or medicine – **can only be provided by healthy ecosystems** and play a crucial role in **supporting local livelihoods**.




Range of ecosystem services provided by nature to humans

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SECTION **ONE**

# General concepts

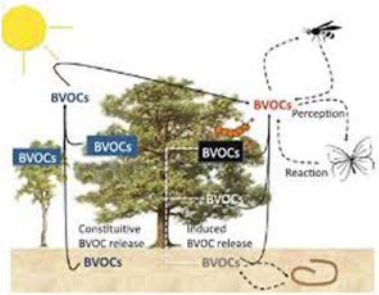

https://youtu.be/r7UCAsBT5Yg

SECTION **ONE**

# General concepts

## Ecosystems disservices

- **Invasive alien species occurrence**
- **Infrastructure damage (e.g., root damage on streets and buildings)**
- **Allergies, poisoning, hurting** by plants (e.g., rhinitis, accidental ingestion, thorny species)
- Biogenic **volatile organic compounds (VOCs)** emission (and related O3 formation)
- Unpleasant **odors** (e.g., wrong selection of plant individuals)
- **Traffic obstruction** by trees or limited access to public areas.




Tian et al., 2020

Von Döhren and Haase, 2019

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SECTION
**TWO**

# Introduction to NbS

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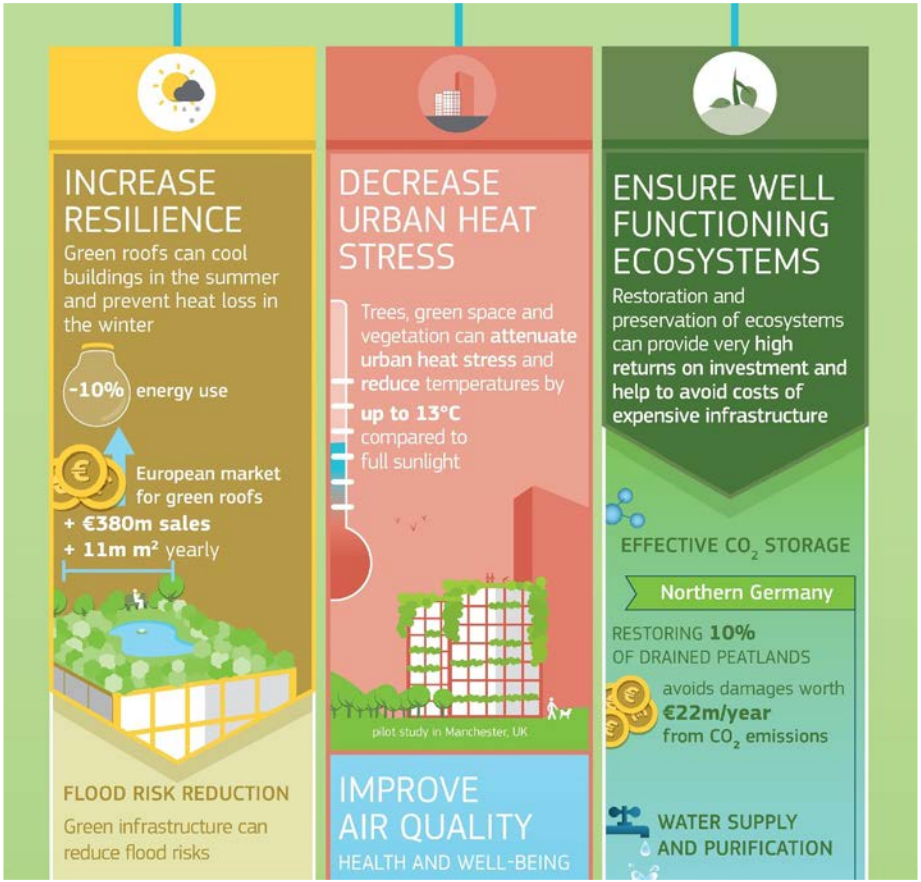
SECTION **TWO**

# Introduction to NbS

**Nature-based solutions** support the delivery of a range of **ecosystem services and major EU policy priorities, including EU Green Deal.**




(European Commission, 2022)

SECTION **TWO**

# Introducion to NbS

## Nature-based Solutions

NbS contribute to:

- ➔ Protection or restoration of natural ecosystems.
- ➔ Ecosystems services' provision (e.g. climate change adaptation, disaster risk reduction).
- ➔ Benefits to the environment (e.g. connect natural and artificial green areas, support biogeochemical cycles).
- ➔ Creation or restoration of multitrophic networks (e.g. plant-insect-bird interactions).
- ➔ Key solutions to connect natural and artificial ecosystems.


NbS as an umbrella term for ecosystem-related approaches Cohen-Shacham et al. 2016

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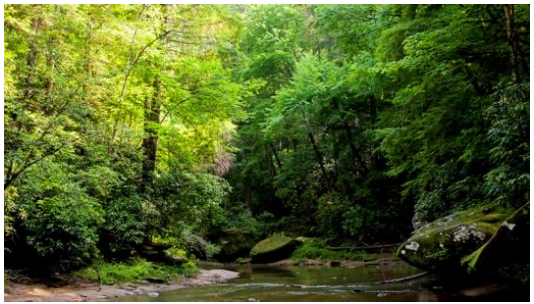
# Introducion to NbS

## Beneficial aspects for citizens

- **Protection or restoration of natural - Source of Food and Medicines, Cultural significance**
  Nature is the main source of food
  and plants are used as medicines and for spiritual and cultural pourposes too (ethnobotanical uses).
- **Recreation and Tourism**
  Nature is an important element for tourism and sport activities (like trekking, hiking, biking, and more).
  Urban forestry improves mental health too.
- **Water Quality improvement**
  Plants can act like a filter, by removing pollutants from soil and water.



# Introducion to NbS

## Beneficial aspects for citizens

- **Wildlife and Fishes Habitat**
  Green areas enhance biodiversity, by hosting plant species, mushrooms, insects, birds and mammals.
- **Flood Mitigation**
  Green areas, implemented with proper plants like trees and bushes, are important to mitigate floods. Crowns are able to reduce heavy rain impact on soil, while roots till the soil, helping to prevent its accompaniment.
- **Aesthetic Value**
  More pleasant aspect to urban environments, they break the static nature of buildings, a function of biological calendar as the seasons change.

# Introducion to NbS

## Beneficial aspects for citizens

- **Erosion reduction**
  Plants are a key element to reduce soil erosion: the roots hold the ground, the crowns reduce the impact of rain and winds.
- **Climate Change Mitigation**
  Plants are a key element in the carbon storage process. Urban green also helps to reduce the temperature by enhancing shadow and humidity levels.
- **Groundwater Recharge and Discharge**
  Woodland soils and tree roots increase water storage and reduce run-off. Tree roots take up water and water-borne compounds, stabilize soils, prevent Sedimentation and protect riverbanks. (from: Forestry Commission – GOV.UK)

# Introduction to NbS

## Role of plants in urban design and planning in response to climate change and city resilience

Plants in urban design play two important functions:

- **Aestethic value**: plants can make an environment more comfortable and pleasant.
- **Environmental function**: plants are a key element to mitigate pollution and climate change effects.

To reach these objectives it's fundamental to choose the right allocation (e.g. space suitable for tree growth), the proper species (e.g. keep in mind growth times and avoid invasive, poisonous, allergenic species) and to apply the right maintenance (e.g. proper pruning, irrigations...).

# Introduction to NbS

## Role of plants in urban design and planning in response to climate change and city resilience

Urban Green Areas are also important to enhance and protect biodiversity.

- ➔ Feeding plants for pollinators (e.g. bees, beetles, butterflies, flies);
- ➔ Feeding plants for birds and little mammals;
- ➔ Use of native plants to protect plants biodiversity.

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# Introduction to NbS

## Role of plants in urban design and planning in response to climate change and city resilience

Plants can be also useful to:

- **Reduce CO2**: Forests are department stores where carbon naturally accumulates and increasingly private companies plant a certain number of trees, especially in urban and peri-urban environments, to offset the emissions deriving from some of their activities (eg. poplars, maples).
- **Reduce PMx and acoustic pollution** thanks to the crowns and through the deposition on the leaf surface (eg. oaks, maples, elms).

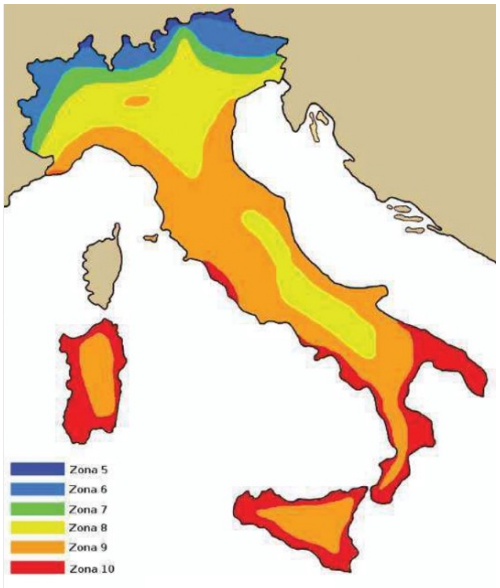
# Introduction to NbS

## Ecological characteristics and distribution of the plant species in the different terrestrial environments

Plants distribution is influenced by **primary factors** (light, temperature, water, chemical elements in soil, activity of organisms, natural events) and **secondary factors** (climate, physiography, mother rock and soil).

**Hardiness zone**: defined geographical area where a certain category of plants can grow and withstand the minimum temperatures of the area; each zone is defined by climatic conditions.

- ➔ Example: a plant described as "hardy to zone 10" means that the plant can bear a minimum temperature of -1 ° C (30.2 ° F) to 3.9 ° C (39.0 ° F).




(The United States Department of Agriculture)

SECTION **TWO**

# Introduction to NbS

## Nature-based Solutions

Potential components of a **Green Infrastructure**:

**Core areas** of high biodiversity value

**Core areas outside protected areas** containing large healthy functioning ecosystems

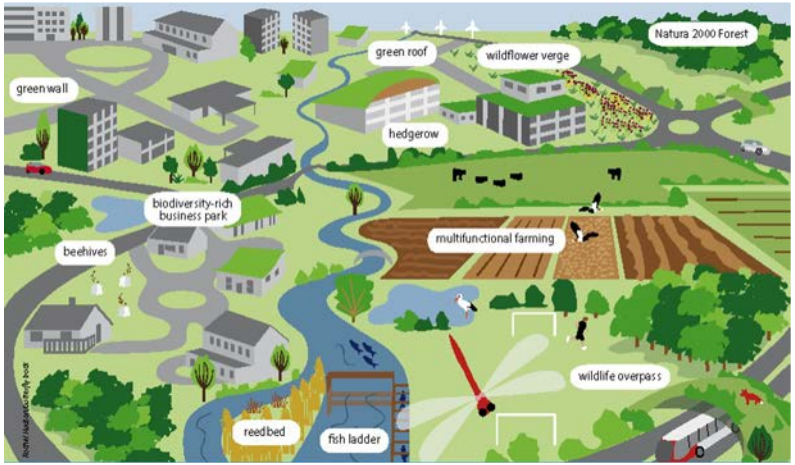
**Restored habitats** reconnecting or enhancing existing natural areas

**Natural features** acting as **wildlife corridors** or **stepping stones**

**Artificial features** enhancing ecosystem services or assisting wildlife movement

Sustainably managed **buffer zones** improving overall ecological quality and permeability of biodiversity

**Multi-functional zones** with compatible land uses creating land management combinations




Potential components of a green infrastructure

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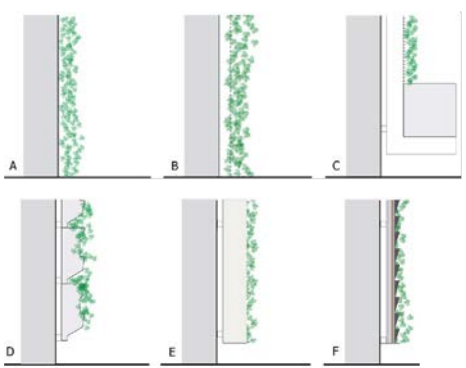
# Introduction to NbS

## NbS: built strategies

- **Green roofs** (fig. 1)**:** living vegetation on building roofs to provide visual benefit, ecological value, enhanced building performance, reduced surface runoff. They are divided in **extensive roofs** and **intensive roofs**. (Woods Ballard et al. 2015, page 233).
- **Green façades** (fig. A,B,C): application of **climbing or hanging plants** along the wall. (Manson, Joao-Castro, 2015).
- **Living wall systems (LWS)** (fig. D,E,F): classified as continuous or modular (Manson, Joao-Castro, 2015).

Delft University Library photo credit: Nol Aders CBY-SA 3.0




Green façade and living wall schemes: K. Perini, The huge green façade of the Palace Hotel in Victoria by Green Roof Consultancy (photo A. Magliocco)

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# Nature-based Solutions

## NbS: land media

- **Tree groups** (fig. 1): they absorb $CO_2$, retain fine dust, form **large shady areas** by modifying the **microclimatic characteristics** and **increase biodiversity** (Ordóñez, C.,2019).
- **Meadows** (fig. 2): **free natural areas** hosting **insects and birds, absorbing rainwater** and **improving biodiversity** (Babì Almenar et al., 2021).
- **Orchards** (fig. 3): category of trees able to absorb $CO_2$ and to be a **powerful engine for increasing biodiversity. (NbS Initiative).**


Tree Library Park in Milan, photo: Luca Bruno


Wildflowers meadow, photo: Chris Gomersall


www.naturebasedsolutionsinitiative.org

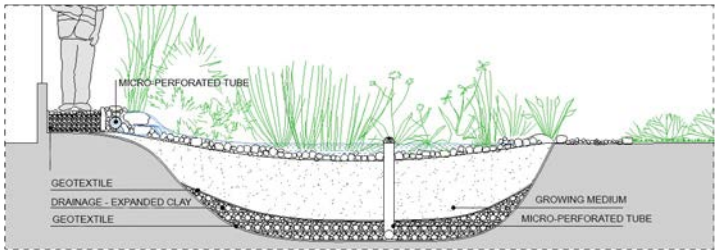
# Nature-based Solutions

## NbS: water media

- **Draining pavements** (fig. 1): pavement suitable for pedestrian and/or vehicular traffic, while allowing rainwater to infiltrate through the surface. (Woods Ballard et al. 2015, page 387).
- **Rain garden** (fig. 3): landscaped area that collects, absorbs, and filters stormwater runoff from waterproof surfaces, sized to accommodate temporary ponding after it rains. (Rain Garden Handbook, page 3).
- **Infiltration basins** (fig. 2): flat-bottomed, shallow landscape depressions that store runoff before infiltration into the subsurface soils (Woods Ballard et al. 2015, page 258).

1. Draining pavement (photo: K. Perini)

2. Infiltration basin (photo: K. Perini)




3. Section drawing of a Rain Garden (drawing: Paola Sabbion)

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SECTION
**THREE**

# Characteristics and performances of NbS

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SECTION **THREE**

# Characteristics and performances of NbS

When choosing the the plant species to use in a project, there are **some aspects to consider**:

- rate of growth
- roots develop
- habit and size of the species at the adult stage
- persistence of leaves, flowering and fruiting characteristics and any unwanted elements (e.g. thorns, resins)
- robustness of the wood and the propensity to break (both of the branches and of the entire plant),
- resistance to pollutants
- resistance to pathogens and parasites
- any toxic and / or allergenic species
- frequency of maintenance (e.g. species with particular needs)

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SECTION **THREE**

# Characteristics and performances of NbS

To **maximize carbon fixation**, the following species should be favored:

- fast-growing and long-living species;
- species that reach large dimensions when ripe;
- species that are resistant to disease and to stress factors related to pollution;
- Species capable of reproducing and economically renewing the established formation
- Fast-growing pioneer species in areas of anthrosols rich in detritus or in any case of thin soils;
- Mixed species with the same management needs (irrigation, pruning, fertilization, etc)

In addition to this, the disturbance to the roots shall be reduced in order to **preserve the carbon sequestered by the soil,** which is higher than that stored by vegetation.

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SECTION **THREE**

# Characteristics and performances of NbS

**Some species to be used <u>to maximize the CO2 sequestration (1/2):</u>**

- ➔ Poplars (the indigenous ones are Populus alba, P. nigra, P. canescens), has a rapid growth but it's potentially allergenic and requires a large amount of water;
- ➔ White willow (Salix alba): fast-growing, suitable for planting near waterways, but it can cause allergies;
- ➔ Lime trees (Tilia cordata, T. platyphyllos, T. x vulgaris): large and long-lived species;
- ➔ Maples (Acer campestre, Acer monspessulanus and A. platanoides, A. pseudoplatanus): speed of growth. A. campestre and A. monspessulanus are more rustic and adapted for interventions in pioneer and degraded conditions.

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SECTION **THREE**

# Characteristics and performances of NbS

**Some species to be used <u>to maximize the CO2 fixation (2/2):</u>**

- Turkey oak (Quercus cerris): long-lived and fast-growing;
- Lawson's cypress (Chamaecyparis lawsoniana), widely used for experimental forestation, tolerant to pollution and suitable for retaining dust;
- Hawthorn (Crataegus monogyna), rapid growth, resistant, it requires little maintenance. However, it must be taken into account that it is a shrub with thorns. Also it can be vehicle for the propagation of fire blight (caused by Erwinia amylovora), a bacterium that affects Rosaceae: its use should therefore be limited if near orchards (in some northern regions it is forbidden to plant new individuals).

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SECTION **THREE**

# Characteristics and performances of NbS

To **mitigate acoustic and atmospheric pollution** it's necessary:

- ➔ prefer native species (that are adapted to the climate and environment in question);
- ➔ favor tree species with large and tall foliage and low maintenance requirements;
- ➔ favor long-lived, evergreen species, better if resistant to stress;
- ➔ prefer species with leaves with trichomes, waxes, resins and with rough;
- ➔ prefer leafs with irregularly shaped surfaces;
- ➔ favor low VOCs emitting species such as maple, hawthorn and lime trees;
- ➔ species less subject to collapses;
- ➔ assess the direction and intensity of the prevailing winds;
- ➔ check that the individuals are appropriately placed.


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SECTION **THREE**

# Characteristics and performances of NbS

Some species to be used **to mitigate athomspheric and acoustic pollution (1/2):**

- ➔ Maples (Acer campestre and A. platanoides): resistant to atmospheric pollutants, as well as being efficient for the construction of sound-absorbing barriers;
- ➔ Oaks (Quercus cerris, Q. ilex, Q. robur, Q. frainetto, Q. pubescens): long-lived, large and with dense foliage, suitable for different environments and climates.
- ➔ Elms (Ulmus minor and U. montana): long-lived, tall and with dense and wide foliage, suitable for mitigating noise and atmospheric pollution.
- ➔ Lime trees (Tilia cordata, T. platyphyllos, T. x vulgaris): large and long-lived, they have dense foliage, suitable for both the mitigation of atmospheric and acoustic pollution.

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# Characteristics and performances of NbS

**Some species to be used <u>to mitigate athomspheric and acoustic pollution (2/2):</u>**

- **Hackberry** (*Celtis australis*): long-lived, very widespread thanks to its adaptability and resistance to pollution and its thick and large foliage that generates shade;
- **Tree heather** (*Erica arborea*) and **Viburnum** (*Viburnum tinus*), evergreen, are appropriate both for the sound-absorbing function and for the abatement of airborne pollutants.

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SECTION **THREE**

# Characteristics and performances of NbS

**To promote biodiversity it's suggested to favor**:

- a mixture of species and of various sizes to create a more varied habitat. The stratification of natural forests can be reproduced by using suitable shrub species (e.g. Cytisus sp., Crataegus sp., Ligustrum vulgare).
- a variety of planting layouts: planting new individuals in various ways allows you to create a habitat closer to natural conditions;
- native species, to contribute to increasing plant biodiversity as well;
- species with flowers and fruits to increase pollinators, insectivorous and frugivorous species.

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SECTION **THREE**

# Characteristics and performances of NbS

**Some species that can be used to increase animal biodiversity are (1/2)** :

- ➔ Hackberry (Celtis australis), which in addition to having a large crown, produces small edible fruits, with a sweetish taste, a trophic resource for various birds;
- ➔ Laurel (Laurus nobilis): evergreen that can be found both in the arboreal and shrubby state. It can be used as a refuge from fauna, and for the mitigation of noise and atmospheric pollution;
- ➔ various Rosaceae, both shrubs and fruit trees, suitable for providing trophic resources and shelter for fauna.
- ➔ Wild olive (Olea europeae), a spontaneous form of the olive tree, long-lived and rustic species, suitable for thermophilic and heliophilic conditions.

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SECTION **THREE**

# Characteristics and performances of NbS

**Some other species that can be used to increase biodiversity are (2/2)**:

- ➔ Poplars: they host a rich entomofauna (Häne & Kaennel Dobbertin, 2006);
- ➔ Shrubby Fabaceae (Spartium junceum, Cytisus spp.) and woody labiates (Teucrium fruticans) are favorable to food supply by Apoidea and other arthropods;
- ➔ Aromatic species (lavender, thyme, rosemary, mint, chamomille...), especially to build hedges ornamental or delimitation (e.g. green areas, dog areas...).

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# Characteristics and performances of NbS

## Urban green design

**Preliminary phase**

- Data collection (cartography from cadastral maps, regional technical maps...);
- Systematic survey and analysis of the site (topography, mapping of non-vegetal elements and the plants, reporting of animal species, identification of points of view and panoramas, survey of elements such as roads and buildings, verification of any regulatory constraints , verification of any easements such as transit areas, chemical-physical analysis of the soil, climate, perceptual analysis of the place discovering the relationships with the surrounding landscape);
- Investigation of the characteristics of the local landscape tradition (agricultural uses, residential use of the landscape, landscape traditions, particular outdoor furnishings e.g. dry stone walls, plant furnishings, traditions linked to collective spaces, traditions linked to green spaces and gardens);
- Verification of the client's needs (through meetings or interviews, with questionnaire).

SECTION **THREE**

# Characteristics and performances of NbS

## Urban green design

**Phase of drafting of preliminary and subsequent projects**

The drafting must respect **simplicity and gradualness**, have a dominant motif to give a precise imprint to the green area, **respect the proportions** between green space and free space, **evaluate the harmony** of the materials used, **correctly combine colors-shapes-volumes**, it must also comply with the quality standards of systemic disservices.

Unibocconi.it

SECTION **THREE**

# Characteristics and performances of NbS

## Urban green design

The **growth rate** can be referred to the **vertical or the diameter increase** (DBH, Diameter at Breast High) **at 1.3 m**.

It is influenced by many variables, such as soil, drainage, water and nutrient availability, light, exposure, plant age, etc.

Callipers, Forest measurement from Wikipedia, G. Elsner CC BY-SA 3.0

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SECTION **THREE**

# Characteristics and performances of NbS

## Urban green design

Plants growth it's classified into:

- ➔ Slow
- ➔ Medium
- ➔ Quick
- ➔ Very fast

Examples of **fast growing trees** :

- ➔ Mimosa (Acacia dealbata) 20 m
- ➔ Curly maple (Acer platanoides) 25 m
- ➔ Paulownia (Paulownia tomentosa) 12 m
- ➔ Red oak (Quercus rubra) 30 m
- ➔ Linden (Tilia platyphyllos, T. cordata, T. americana) 30-40 m

**Specie - meter per year**

*Paulownia tomentosa*: 5 m
*Salix matsudana x alba*: 4 m
*Populus nigra 'italica'*: 3 m
*Populus deltoides*: 3 m
*Salix babylonica*: 3 m
*Eucalyptus cinerea*: 3 m
*Platanus occidentalis*: 2 m
*Liriodendron tulipifera*: 2 m
*Populus tremuloides*: 2 m
*Fraxinus americana*: 2 m
*Acer rubrum*: 2 m
*Thuya standishii × plicata*: 2 m
*Pyrus calleryana*: 1 m
*Cupressocyparis x leylandii*: 1 m
*Metasequoia glyptostroboides*: 1 m
*Cupressus sempervirens*: 1 m
*Cryptomeria japonica*: 1 m
*Betula alba*: 1 m

# Characteristics and performances of NbS

## Urban green design

**Distances of planting hedges from the border line (not considered if there is a wall)**

- ➔ Hedges that grow to max 2.5m: minimum distance of 0.50m
- ➔ Hedges that grow over 2.5 m (e.g. hornbeam): minimum distance of 2 m

**Legal distances of trees**

- ➔ Tall trunk: at least 3 m away from the boundary line
- ➔ Not tall: at least 1.5 m away from the boundary line

**Quality of the chosen plants**

A correct selection of the plants is advantageous because they have a good post transplant root, they grow quickly, the chances of crashes and breakages due to adverse weather conditions are reduced, they have greater longevity.

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# Materials and case studies

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# Materials and case studies

VIDEO 1

**“Power-sharing for Nature-based solutions to climate change ”**

Fiona Nunan

TEDxWarwick

**17 min**

VIDEO 2

**“Nature-based solutions in the fight against climate change”**

Thomas Crowther

TEDxLausanne

**17 min**

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# Materials and case studies


1) Lausen, E.D., Jensen, M.B. and Randall, M.T., 2022. Into the air: a freestanding vertical greenery system (VGS) for evapotranspiration (ET) of roof runoff. Blue-Green Systems, 4(2), pp.326-339.
2) Perini, K., Calise, C., Castellari, P. and Roccotiello, E., 2022. Microclimatic and Environmental Improvement in a Mediterranean City through the Regeneration of an Area with Nature-Based Solutions: A Case Study. Sustainability, 14(10), p.5847.
3) Shwartz, A., Tzunz, M., Gafter, L. and Colléony, A., 2023. One size does not fit all: the complex relationship between biodiversity and psychological well-being. arXiv preprint arXiv:2306.07043.
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SECTION **FOUR**

# Materials and case studies

## Case studies: UNaLab

Evaluation of **NbS ecosystem services in a new urban park** (former military barrack).

**Key performance Indicators** evaluated:

- ➔ Biodiversity (plants and birdlife)
- ➔ Pollinator insects
- ➔ Evapotranspiration rate
- ➔ Carbon sequestration by plant
- ➔ Citizen wellbeing with environmental conditions

To obtain the benefits derived from a complex network of NbS.

www.unalab.eu

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# Materials and case studies

## Case studies: INPS Green Façade

INPS Green Façade is a pilot project built in the city of Genoa (Italy) in 2014 on the south wall of a four stories office building built early in the last century and renovated in the 1980s, owned by INPS (National Institute of Social Insurance).
The research results deriving from the monitoring activities are used to quantify the environmental impact for the entire life of the green facade to the obtainable environmental and microclimatic benefits, through a life cycle assessment and economic sustainability, thanks to a cost-benefit analysis.

Photo A. Positano

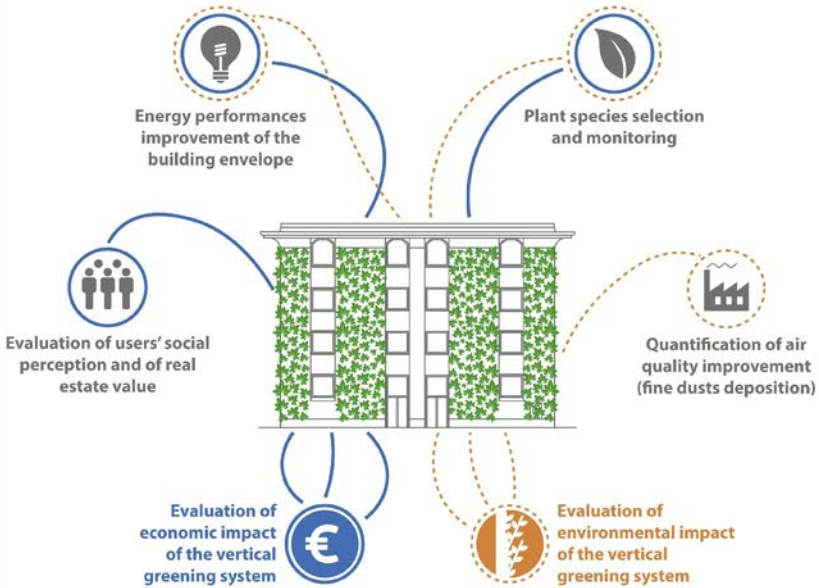
# Materials and case studies

## Case studies: INPS Green Façade

**Video**: [Facciata Verde INPS Short]

**Research papers abstracts**:

- Perini Katia, Ottelé Marc, Giulini Saverio, Magliocco Adriano, Roccotiello Enrica (2017). Quantification of fine dust deposition on different plants in a vertical greening system. ECOLOGICAL ENGINEERING 100 (2017) 268–276. doi:10.1016/j.ecoleng.2016.12.032
- Katia, Magrassi Fabio, Giachetta Andrea, Moreschi Luca, Gallo Michela, Del Borghi Adriana, 2021.




Monitoring activities scheme (Rosasco and Perini 2018)

# Materials and case studies

## Case studies: MosSkin

A low cost and lightweight moss envelope system for buildings has been developed to address the problem of the lack of greening in densely urbanized areas.
Several moss species have been sampled in the wild, selected, based on their ability to tolerate the abiotic stresses of urban environments and a modular multi-layer panel, with a built-in irrigation system, has been developed, designed and tested.
MosSkin is a **low-cost low maintenance, versatile and lightweight system**, with interesting performances in terms of water management and surface temperature reduction (up to 14°C).

Perini et al. 2020

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# Glossary

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# Glossary

- **ADAPTATION:** the process of adjustment to actual or expected climate and its effects. In human systems, adaptation seeks to moderate or avoid harm or exploit beneficial opportunities. In some natural systems, human intervention may facilitate adjustment to expected climate and its effects. Adaptation is place- and context-specific, with no single approach for reducing risks appropriate across all settings (Field et al., 2014).
- **ANTHROPOCENE:** geological epoch dating from the commencement of significant human impact on Earth's geology and ecosystems, including, but not limited to, anthropogenic climate change (Crutzen, 2006).
- **ANTHROPOCENTRISM:** Anthropocentrism refers to a human-centered, or "anthropocentric," point of view. Anthropocentric value systems thus see nature in terms of its value to humans (www.oxfordbibliographies.com).
- **BIODIVERSITY**: the variability of living beings of all origins including, among others, aquatic ecosystems and the ecological complexes they are a part of; this includes diversity within species and the diversity of ecosystems (UN 1992 Convention on Biological Diversity ).
- **BIOPHILIA:** theory assuming that humans possess an innate tendency to seek connections with nature and other forms of life (O. Wilson, 1984).

SECTION **FIVE**

# Glossary

- **BIOSPHERE**: that part of the Earth and atmosphere capable of supporting living organisms (EEA, 2004).
- **CLIMATE EXTREME EVENTS**: rare event at a particular place and time of year - a pattern of extreme weather that persists for some time, such as a season (IPCC, 2012).
- **CONSERVATION**: conservation is a common concern of humankind and represents the act of protecting Earth's natural resources for current and future generations (Convention on Biological Diversity,1992).
- **ECOLOGICAL FUNCTIONS:** a species interaction or ecological role whereby a species or group of species prevent extinction or endangerment, maintain a biogeochemical flux or pool, or support ecosystem productivity (Brodie et al, 2018).
  More simply,a set of ecological roles performed by e ach species in its ecosystem (Marcot et al, 2001).
- **ENVIRONMENT:** the air, water, and land in or on which people, animals, and plants live (Cambridge Dictionary, online).
- **GREEN INFRASTRUCTURE** (GI) includes natural, semi-natural, and artificial networks of multifunctional ecological systems within, around, and between urban areas: waterways, wetlands, woodlands, wildlife habitats, greenways, parks, and other natural areas (European Commission, 2010; Sandstrom, 2002; Tzoulas et al., 2007).

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# Glossary

- **GREENWASH**: when a company hides the true effects of its products or actions on the environment, by making it seem as though the company is very concern about the environment» (Longman 2009).
- **INFILTRATION** is defined as the flow of water from aboveground into the subsurface (Ferré and Warrick, 2005).
- **INVASIVE ALIEN SPECIES:** species accidentally or intentionally introduced, outside of their natural geographic range and that become problematic. They are often introduced as a result of the globalisation of economies through the movement of people and goods, or the transport of ornamental plants to new areas (IUCN, 2002).
- **MITIGATION:** human intervention to reduce the sources or enhancement of greenhouse gases, together with adaptation to climate change, contributes to the objective expressed in Article 2 of the United Nations Framework Convention on Climate Change (Edenhofer *et al*., 2014).
- **MULTISTAKEHOLDERS APPROACH**: a new integrated ecosystem approach to architecture that focus equally on humans, plants, animals and associated organisms such as microbiota (ECOLOPES project, 2021).
- **MULTITROPHIC NETWORKS**: the set of multiple interactions between species of different trophic levels of the food web that affects the distribuition and the aboundance of organisms (de Ruiter, 2005).

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# Glossary

- **NATURAL CAPITAL**: available stocks of renewable and non-renewable (e. g. plants, animals, air, water, soil, minerals) natural resources which support human life (WWF Living Planet Report, 2016).
- **NATURE-BASED SOLUTIONS (NbS):** solutions that are inspired and supported by nature, which are cost-effective, simultaneously provide environmental, social and economic benefits and help build resilience. Such solutions bring more, and more diverse, nature and natural features and processes into cities, landscapes and seascapes, through locally adapted, resource-efficient and systemic interventions (European Commission, 2015).
- **REGULATING SERVICES:** regulating services include pollination, flood control, water purification, and processes reducing threats of disease and harm from climate (Pielke, 2013).
- **RESILIENCE**: the capacity of a system for adsorbing changes to mantain foundam ental control on function and structure (Chapin et al., 2009).
- **SUSTAINABLE DEVELOPMENT**: development that meets the needs of the present without compromising the ability of future generations to meet their own needs (Keeble,1987).
- **STORMWATER RUNOFF** is generated from rain and snowmelt that flows over land or impervious surfaces, such as paved streets, parking lots, and building rooftops, and does not soak into the ground (United States Environmental Protection Agency, EPA).

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# Glossary

- **STORMWATER MANAGEMENT:** the effort to reduce runoff of rainwater or melted snow into streets, lawns and other sites and the improvement of water quality (United States Environmental Protection Agency, EPA).
- **URBAN RESILIENCE** can be defined as the ability of an urban system to adapt (maintain or rapidly return to previous functions) when facing a disturbance. According to academic and policy interests, it is crucial to improve urban resilience to cope especially with climate imbalances and related issues (Meerow et al., 2016)
- **VOC (VOLATILE ORGANIC COMPOUNDS):** any organic chemical compound of carbon, that under normal conditions are gaseous and enter the atmosphere taking part to the atmospheric photochemical reactions (EEA , 2004).

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