REGREEN
NATURE-BASED SOLUTIONS

Fostering nature-based solutions for smart, green and healthy urban transitions in Europe and China

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WP N°6 The Governance and Planning of Urban Nature-Based Solutions

GUIDELINES FOR URBAN AND TERRITORIAL PLANNING: INCORPORATING NBS IN URBAN LAND USE PLANNING

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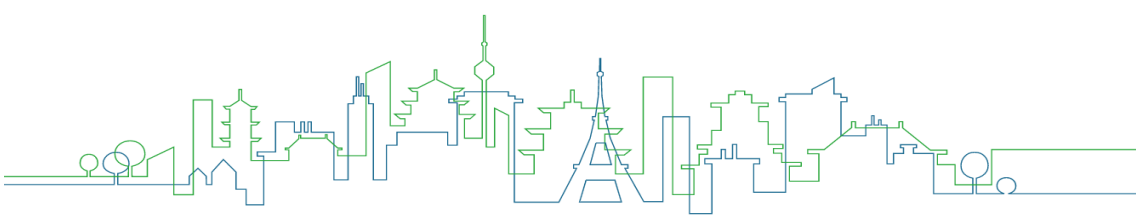

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EXECUTIVE SUMMARY

This deliverable investigates approaches to reduce urban land take and to integrate NBS in planning systems. It is targeted at elected representatives, municipal technicians from all departments (green spaces, urban planning, roads, etc.) and city stakeholders.

This document analyses the “No Net Land Take” objective from the European Commission, the current urban land take situation in three European Union countries, how they are addressing the EC’s objective and gives guidelines on how to reduce urban land take. In the second part, the deliverable provides guidelines for better integrating NBS into urban planning documents and includes several case studies.

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1 INTRODUCTION

On a global scale, changes in land use are mainly driven by the intensification and extension of agricultural land (contributing to the homogenisation and simplification of landscapes), but also by urbanisation. According to the IPBES, urban areas around the world have more than doubled since 1992. Soils are limited natural resources and are fundamental for biodiversity and ecosystems functions: for storing carbon, for filtering contaminants, for recycling water, etc. However, urbanisation plays a major role in soil artificialisation. In ecology, soil artificialisation is defined as any process that permanently affects all or part of the ecological functions of soil, in particular its biological, hydric and climatic functions, as well as its agronomic potential. By transforming land use, urbanisation accelerates climate change (carbon release) and threatens biodiversity, caused by the destruction and fragmentation of habitats. The alteration of urban soils, which are often paved, also amplifies the effects of climate change (runoff, flooding, urban heat islands, etc.). While nature-based solutions (NBS) can be integrated at the building scale (e.g. green roofs), most of them rely on functional soils and ground level vegetation. Therefore, protecting and restoring urban soil is an essential prerequisite of NBS strategies in cities. In this context, slowing urban growth, preserving soil integrity, and improving soil quality through NBS have become key strategies to enhance cities' resilience to global change. This deliverable carried out by the REGREEN project investigates approaches to reduce urban land take and to integrating NBS in planning systems.

REGREEN is a European Horizon 2020 project on nature-based solutions in urban environments. It aims to improve the knowledge and tools supporting creation of NBS in urban settings. REGREEN works through three Urban Living Labs (ULLs) in Europe Aarhus (DK), Ile-de-France (F) and Velika Gorica (HR). And three in China: Beijing, Shanghai and Ningbo.

Nature-based solutions refers to initiatives aimed at the conservation, management and restoration of ecosystems. Their aim is to attenuate climate change (e.g. via carbon capture and storage) and to facilitate adaptation to climate change (e.g. via protection against flooding, heat waves). These solutions can complement or replace the grey infrastructure traditionally used in cities' development. Nature-based solutions are also multi-functional whereas grey solutions only solve one problem at a time. As well as benefiting climate and biodiversity, they improve the living environment and health of city-dwellers at lower cost to local authorities.


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2 LAND TAKE IN ULLS AND CURRENT POLICIES

Land take is the transformation of agricultural, natural and semi-natural spaces into urban and other artificial uses. Despite a slowdown in the last decade, land take in EU-28 still amounted to 539km²/year between 2012-2018 [1]. Since the mid-1950s, the total surface area of cities in the EU has increased by 78% while the population has grown by just 33% [2]. Built-up areas are expanding more quickly than populations are growing. Urban sprawl often continues even where populations are decreasing. This phenomenon is now foremost among the drivers of rapid climate change and the erosion of biodiversity. The loss of soil functions and ecosystem services is one of the major environmental challenges Europe is facing.

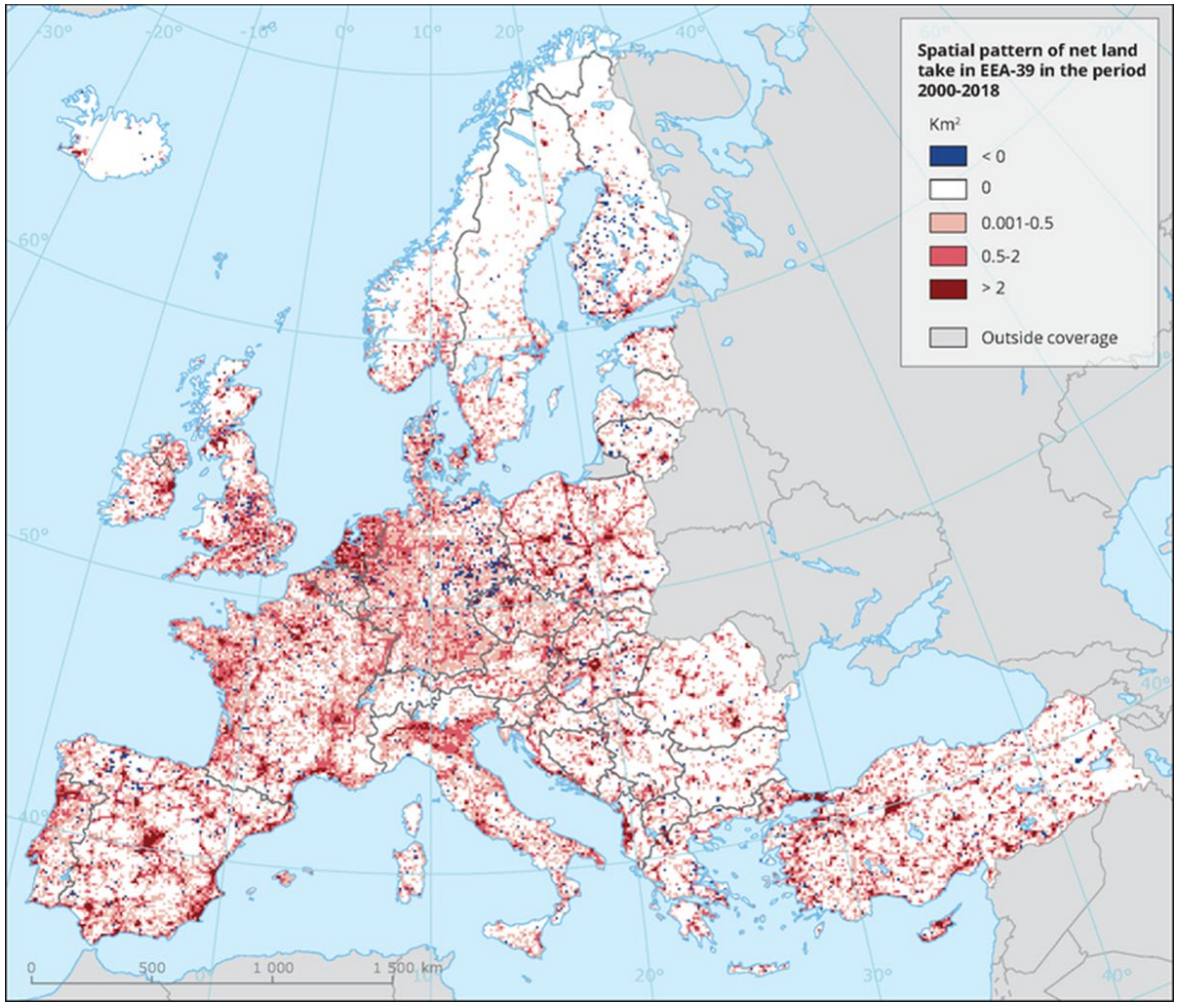


Figure 1: Net land take measured from the Copernicus Corine Land Cover dataset between 2000-2018 ©European Environment Agency

- **Strongest drivers of land take are: expansion of industry and commercial sites, low-density or dispersed urban development, constructions.**
- **Land take increased during 2000-2018 but the rate of increase slowed down.**
- **Strongest drop in land take was seen after 2012, in expansion of construction sites and of industrial and commercial sites.**
- **Development of green urban areas and dense urban expansion are the lowest portions of land take.**
- **Most land take impacted arable land and permanent crops as well as pastures and mosaic farmlands.**

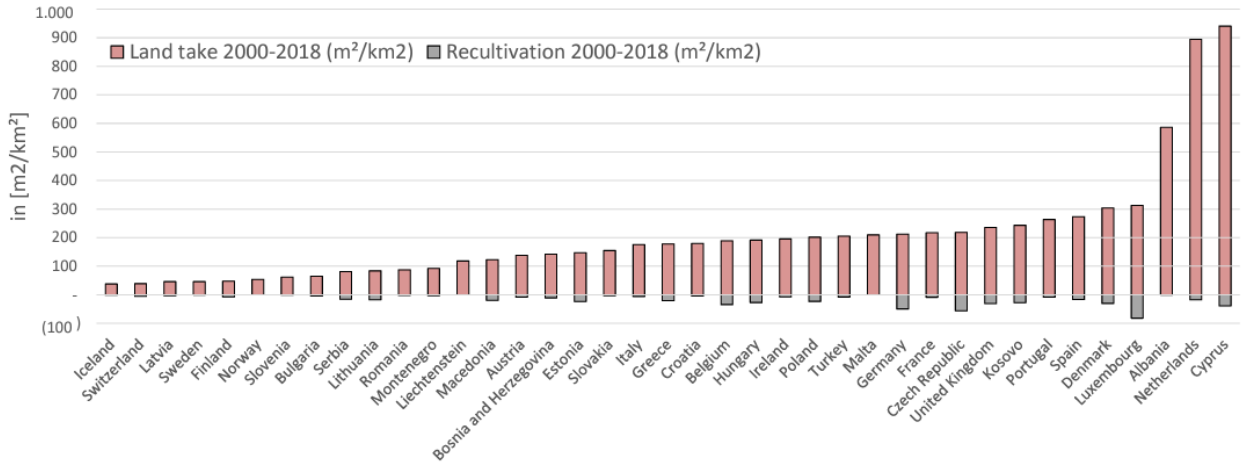


Figure 2: Yearly land take and land recultivation in the period 2000-2018 (in proportion of country area) ©European Environment Agency [3]

The drivers leading to soil artificialisation are numerous and complex. A meta study (Colsaet et al., 2018) analyzed 193 scientific articles and summarized the causal relationships between land take and different explanatory factors (Figure 2). Among them, population and income growth, as well as the development of transport infrastructure and increased use of cars, are widely studied drivers that are most often found to increase land take. Political and institutional factors are extensively mentioned in the literature, suggesting that urban sprawl is not a mere result of "market forces" but is also shaped though public policies. Weak or inadequate planning, subsidies for land consumption and car transportation are said to increase urban sprawl, while infrastructure pricing and subsidies for urban renewal would have the opposite effect. The institutional setting, especially administrative fragmentation, reliance on local taxes, and competition between local jurisdictions, is suspected to be a major determinant of land take as described in the graph below.

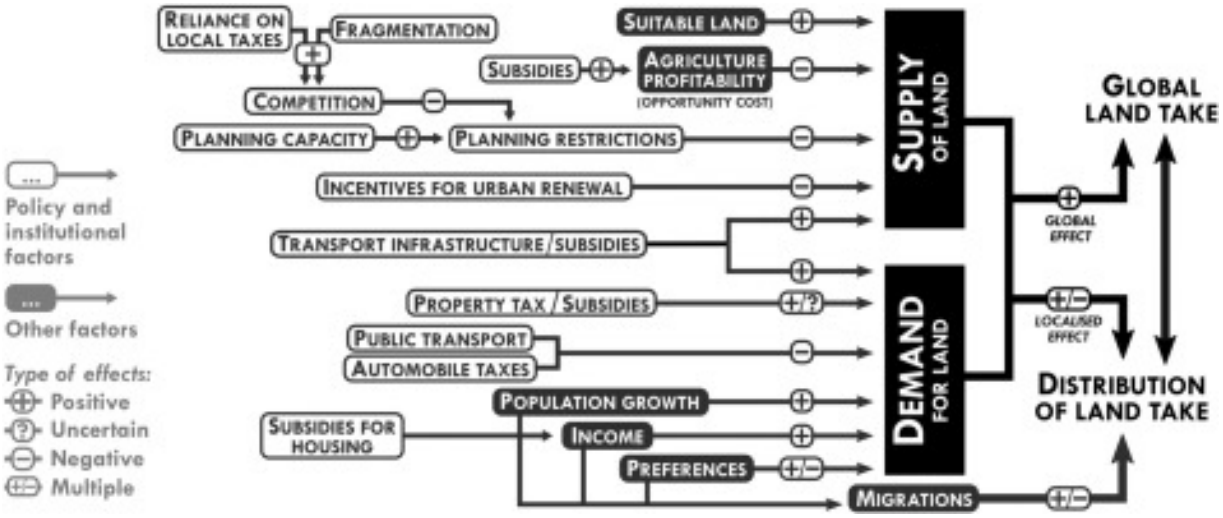


Figure 3. Graphical abstract of main land take and urban land expansion drivers ©Colsaet et al., 2018

To address the global issue of land take, the European Commission has proposed in the EU Environment Action Program to 2020 (7th EAP) to achieve "No Net Land Take" by 2050 and calls for a paradigmatic shift in urban development. Sealing agricultural land and open spaces should be avoided as far as possible and the focus should be on building on land that has already been sealed. It marks a turning point in strategies designed to slow urban sprawl as it places the emphasis on urban renewal and densification. It also introduces a renaturing goal that involves "giving back to nature" an amount of land equivalent to that consumed by urban growth. For example, unused land could be returned to cultivation or renaturalised so that it can once again provide the ecosystem services of unsealed soils. Achieving the No Net Land Take Objective presents a number of challenges, in particular measuring and defining the extent of artificial development, finding sites that have already been developed to avoid the consumption of new land, and finding sites for renaturation. The implementation of the No Net Land Take goal, however necessary it may be, may also result in even greater urban densification in cities that are already suffering from climate change and dwindling biodiversity.

> *"By 2020, EU policies take into account their direct and indirect impact on land use in the EU and globally, and the rate of land take is on track with an aim to achieve no net land take by 2050; soil erosion is reduced, and the soil organic matter increased, with remedial work on contaminated sites well underway."*

Table 1. Policies to reduce land take in the EU and selected countries. The EU target is non-binding, and very few EEA Member States have quantitative policy targets to reduce land take: 17 EEA Member States monitor land take on a regular basis ©European Environment Agency [4]

Region	Land take target
EU	Achieve no net land take by 2050
Austria	Reduce net land take to 2.5 ha/day in 20230 currently 12 ha/day
Belgium	To decrease land take gradually: - 2016: daily land take 6 ha/day (baseline) - 2025: interim target 3 ha/day - 2040: final target 0 ha/day "land take neutral"
Germany	To reduce land take for settlements and traffic routes to less than 30 ha/day by 2030 (currently: about 60 ha/day)
Luxembourg	To reduce land consumption from 1.3 ha/day (average 2000-2006) to 1 ha by 2020, and 0 ha by 2050
Slovakia	30% of agricultural soils are protected from land take and bound to a fee if land take cannot be avoided, ranging from 0.5 and 20€/m² for agricultural and up to 100€/m² for vineyards.

Soils, biodiversity, and ecosystem services

More than 40% of living organisms in terrestrial ecosystems are directly associated with soils during their life cycle (Decaëns, 2006; Decaëns et al., 2010). 25% of described species are soil-dependent (FAO, 2021), yet little is known about soil biodiversity, despite the recent upsurge in scientific interest. Through their trophic and non-trophic interactions, these organisms play an essential role in the functioning of ecosystems, and their loss reduces the capacity of soils to be functional. The majority of animal and plant species reside in the top 15-20 cm of soil, where organic matter and roots are most abundant. The development of nature-based solutions must focus on protecting good quality soils and restoring degraded soils.

A review carried out in 2019 by Ademe [4], analysing more than 200 articles relating to the multifunctional quality of agricultural, forestry and urban soils, identifies seven interacting functions to describe how soils function:

- Habitats for soil organisms and regulation of soil biodiversity.
- Retention and supply of nutrients for soil organisms and plants.
- Storage, recycling, and transformation of organic matter: storage, decomposition, and transformation of endogenous and exogenous organic matter.
- Water retention, circulation, and infiltration: retention, circulation, and infiltration of water in the soil (useful reserves, leaching, runoff, percolation, etc.).
- Filtering, buffering and degradation of pollutants: filtration, retention, and degradation of all types of organic and inorganic pollutants.
- Stable physical support for plants: anchoring and root growth.
- Control of the chemical composition of the atmosphere and contribution to climatic processes: gas and energy exchanges between the soil and the atmosphere, thereby affecting climatic processes.

2.1 Land take in REGREEN ULLs (Aarhus, Velika Gorica and the Paris Region)

As part of the REGREEN project, UFZ[3] compared the space covered by urbanisation processes in the three European ULLs and three Chinese ULLs in 2020 (*Banzhaf and al., 2021*). Chinese cities have experienced dramatic urban expansion over the past 20 years. Specifically, the built-up area of the three cities has grown from 4,077 km² to 7,508 km². In the two-decades between 2000 and 2020, the built-up space increased by 84%. In Beijing and Shanghai 1,950 km² and 1,920 km² of cropland in each city had been lost for urbanisation. As coastal cities, Shanghai and Ningbo have respectively converted 25.8 km² and 100.5 km² of water bodies into built-up surfaces due to human land reclamation.

The built-up area of the three European ULLs has been rather stable over the last two decades, with the total area slightly increasing from 1,780 km² in 2000 to 1,986 km² in 2020, an increase of 11.6%.

2.1.1 France and the Paris Region

In France between 2006 and 2016, urban growth consumed about 20,000 hectares of land every year, at a rate 4 times faster than population growth [5]. In addition, 40% of urban sprawl takes place where vacant buildings are rising sharply, and 20% in municipalities where the population is declining [6].

For many years, The Paris Region has led several schemes to control land take. In 1960, the Plan d'aménagement et d'organisation générale (Padog) focused on the need to avoid the uncontrolled spread of the city. In 2013, the Schéma directeur de la région Île-de-France (Sdrif) provided a regulatory framework for the potential urbanisation of the region's communes (for a total potential area of 29,000 hectares by 2030, an average of 1,315 ha/year). Despite a slowdown for a period (2012-2017), land consumption still accounts for 710 ha per year on average, mainly on agricultural land (Adam and al., 2022). The Paris Region Masterplan (SDRIF) is still largely dominated by the planning of "grey infrastructures" to support urban development (construction, power lines, sewage plants and above all roads and railways). Currently, this master plan is being updated and No Net Land Take is a unique opportunity to build a new paradigm and give more space for nature in the future.

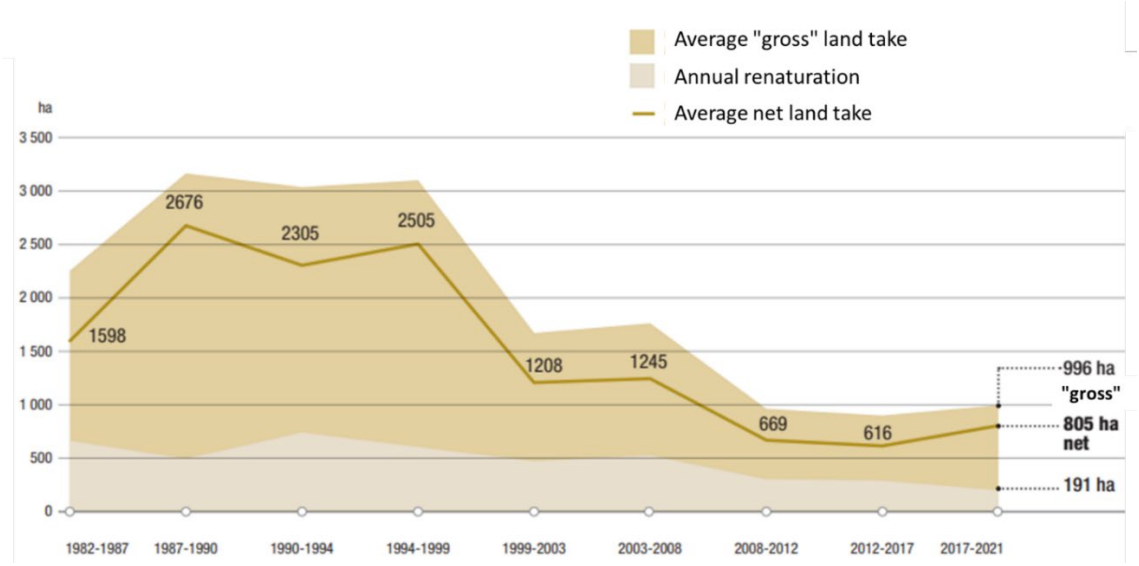


Figure 4: Urbanisation of natural, agricultural and forest areas in Île-de-France. Note for the reader: average annual net land take is equal to average annual gross land take excluding annual renaturation [7] ©Institut Paris Region

[3] Helmholtz Centre for Environmental Research GmbH – UFZ

2.1.2 Aarhus Municipality

According to the European soil Data Center, artificial soils account for 6.9 % of the national surface area. In Aarhus Municipality a total area of 12,980 hectares is built up in 2023. Between 2013 and 2022, urban growth consumed approximately 1,375 hectares of land, which equals an average land consumption of 62.5 ha /year. In the same period the population has increased with 43,299 inhabitants. Thereby the growth rate for built up areas are about 11%., which is slightly slower than the population growth rate on 12%. In 2023 1,600 hectares of non-built land are still designated to city development during the coming planning periods.

The new political document "Strategy for municipal planning 2023" is based on an approximate population growth of around 4,000 inhabitants/year and at this pace it is estimated that the city and its surroundings need to provide 2,000 new homes every year. As a consequence of the rapid population growth and the increased demand for new space to accommodate people and businesses in Aarhus Municipality, coupled with a wider societal demand for space for green areas nature and climate adaptation, the local policy that supports the need for more housing areas has changed throughout the years. In 2009 the city had a strategy of densification, which means that city development for some years was concentrated in the existing city, which relieved some of the pressure on the open land. Around 2020 more and more people criticised the way the densification was carried out, and the politicians started to slow down the densification and instead they focused on city development outside the city. For example, in 2022 the city council adopted a new plan that ensured 300 hectares of agricultural land would be converted into housing areas (source: Aarhus Municipality).

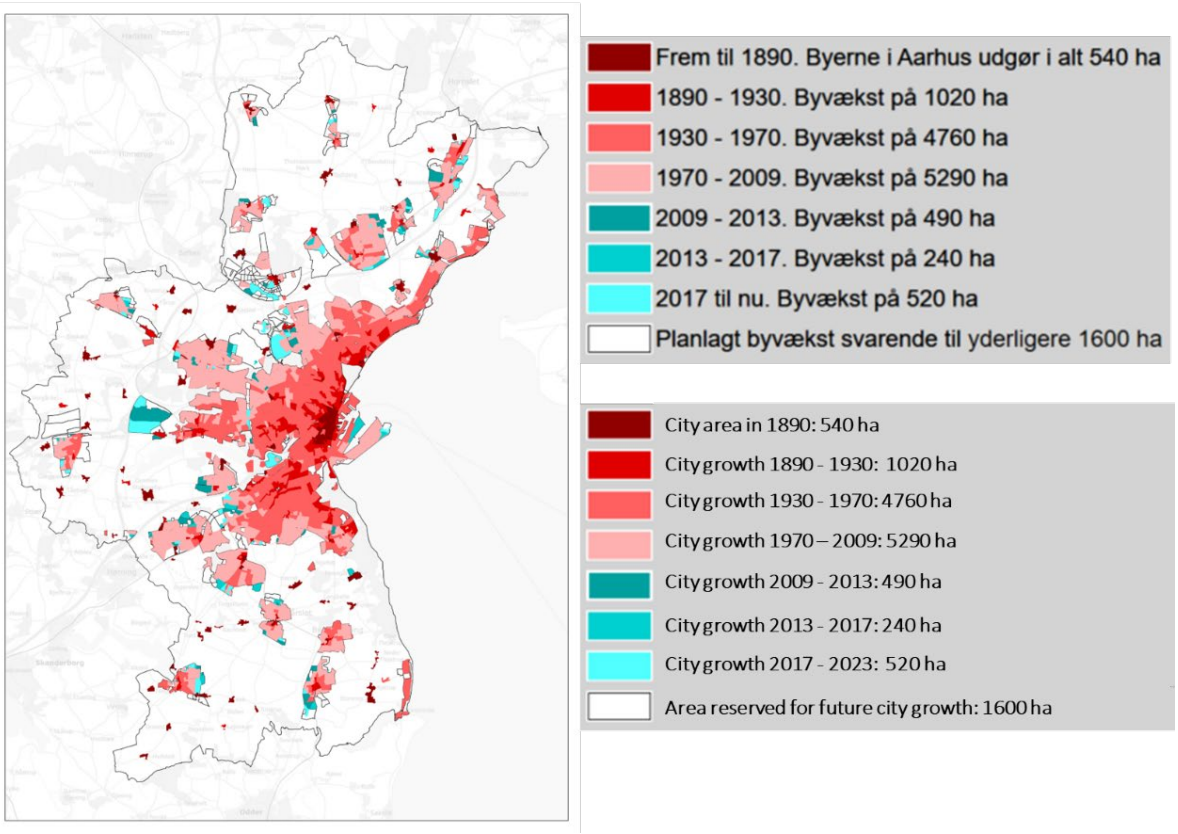


Figure 5. Map of the impact by area of city development in Aarhus from 1890 to 2023 ©The city of Aarhus

In Denmark the national planning authorities are safeguarding that municipalities do not designate too large areas for city development. In relation to a newly adopted city development plan in Aarhus from

2021, that included agricultural land for future city development, the national authorities stated that Aarhus Municipality has enough space for future city development and the authorities objected to the plan (*source: Aarhus Municipality*). Therefore, it is a goal for the municipal administration to make clear for the politicians, that right now it will not be possible to include more open field areas for city development unless corresponding areas will be excluded from the municipal plan.

2.1.3 The city of Velika Gorica

Based on a report on the state of the space in the City of Velika Gorica for the period from 2014 to 2018 in the city of Velika Gorica, the construction zone and recreational spaces account for 5,260 hectares, or 16% of the city's total area of 32,866 hectares. Built structures outside these zones take up 1,210 hectares, making up 3.7% of the overall land. Agricultural land spans 13,774 hectares, constituting 42% of the total area, while forests cover 12,048 hectares, or 36.7%. Combined, agricultural and forested areas make up 78.6% of the city's total land. Water bodies occupy 573 hectares, which is 1.7% of the city's entire area. The city is still developing and spreading to the outside rural parts (data from 2014-2018)[4]. In 2022, as part of the REGREEN Project, a refined Land Cover Classification was produced with a 10 m ground resolution (Wu and al., 2021). The total area of built-up area is 2,985 hectares, with 902 hectares of dense built-up area and 2,083 hectares of dispersed built-up area.

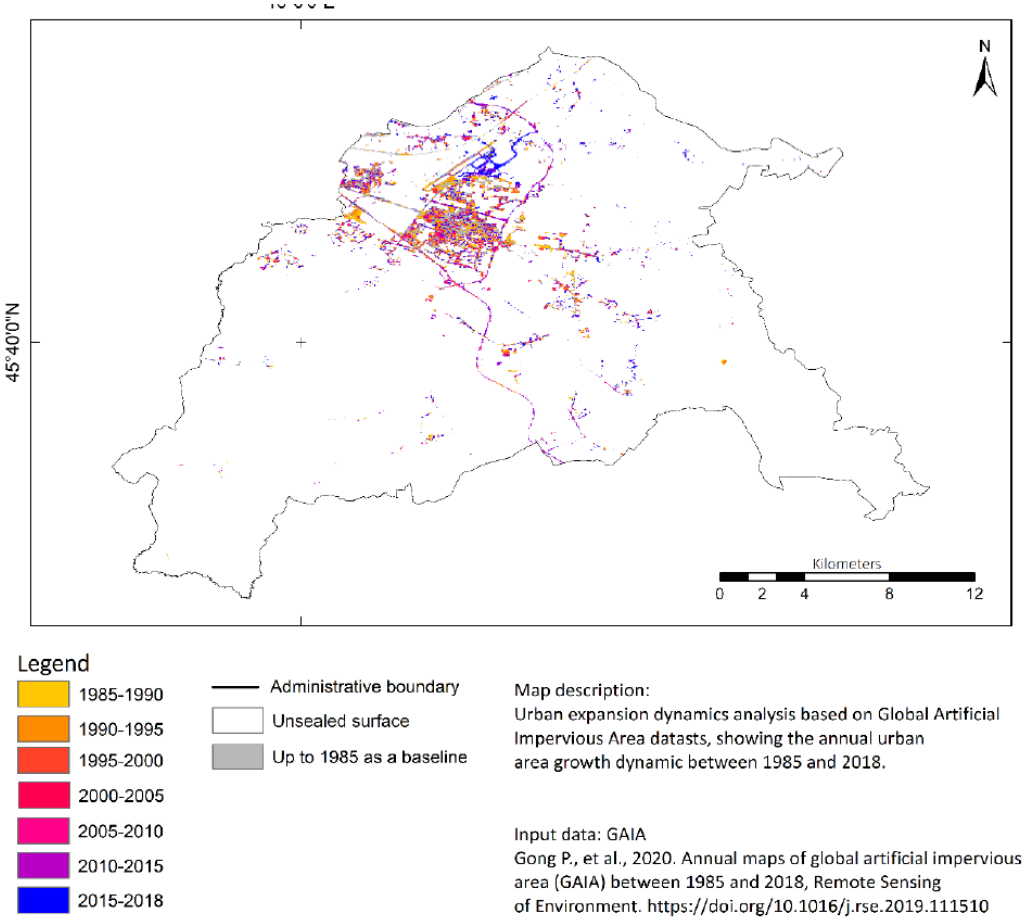


Figure 6. Urban expansion dynamics of Velika Gorica between 1985-2018

[4] Sources from Velika Gorica Municipality

2.2 How ULLs are addressing the No Net Land Take Challenge?

2.2.1 France and the Paris Region

In 2018, the French government decided to transpose the No Net Land Take (known in French as le *Zero Artificialisation nette* or Net Zero Land Take). This principle has been included into the Climate and Resilience Act (Loi Climat et Résilience, August 2021) and it states that there must be a goal for reducing land take by 50% in 2031 and that Net Zero Land Take must be achieved by 2050. This goal must then be integrated into regional planning documents before being applied to smaller administrative areas (communes and groups of communes: i.e. towns and villages). The implementation of the Net Zero Land Take goal requires a complex strategy that involves reducing urban sprawl by encouraging urban renewal and densification and using renaturing initiatives to restore land consumed by urban growth. Although achieving "net" zero land take implies a degree of flexibility, many authors stress that renaturing remains a significant technical and financial challenge and that the priority must be to avoid new land take by making do with what already exists [8].

The Paris Region is currently reviewing its Master Plan (SDRIF) approved 25 years ago. A first version has been drawn up and voted on in July 2023. A Public inquiry has been launched before the introduction of the new Master Plan in summer 2024. Objectives related to the Net Zero Land Take include:

- decrease the previous suggested area to be used for urbanisation by a third regarding the old Master Plan (SDRIF 2013)
- reducing urbanization by 20% every 10 years
- protecting nature (116,000ha) and agricultural land (38,000ha)
- extending or creating 145 green spaces to give every resident access to a nature area within 10 minutes.
- reaching 30% of "pleine terre", which may be translated approximately as "open ground" or "natural soil", in densely populated cities.

The actors involved in the process of writing the Paris Region Masterplan are the Paris Region Institute in coordination with many stakeholders: the state, cities, the CESER (representatives of civil society), Chambers of Agriculture, commerce and industry, Paris airport, public establishments of new towns… And for the first time, citizens were consulted through public meetings and a participatory web platform.

What is the Paris Region Master Plan (SDRIF)? The master plan for the Paris Region is a planning document that aims to control urbanization, land use, the preservation of rural and natural areas, and the location of major transport infrastructures. Once definitively adopted, the SDRIF is the reference document for the development and planning of the Paris Region.

2.2.2 Denmark and Aarhus Municipality

In Denmark, administrative power related to spatial planning and land use planning is shared between the central government and municipalities. From 2007, the Ministry of Environment establishes the general framework for the regional spatial development plans and municipal plans through a national planning report, overview of national interests in municipal planning, national planning directives, consultation, and other forms. The Minister holds veto to match municipal plans with overall national interest[5]. Guidelines are an important part of national planning. They are issued regularly to interpret legislation such as guidelines on municipal planning, rural zone administration, local planning and environment impact assessment, etc. Other guidelines inspire local planning, incorporating environmental considerations, managing landscape protections or strategies for municipal planning [9]. In 2014, the "Green Urban Denmark" [10] highlights how Copenhagen, Aarhus and Sonderborg have developed and implemented green urbanization. The green initiatives range from extensive retrofitting of buildings, reorganisation of energy supply, radical changes in transport patterns to environmental and climate change awareness campaigns.

Although Aarhus Municipality has no current policy on land take, some steps are taken towards reducing the amount of land for city development. One of the main political objectives in Aarhus is to support city growth and business development to ensure that the city stays attractive for people to live and work in, and for companies to settle within the municipality. One of the main focuses in the municipal planning framework is therefore to reserve areas that secure space for new housing and businesses.

Aarhus Municipality aims at supporting the city growth, also in the coming years. This means, that the municipal planning framework still makes it possible to include non-built agricultural land for city development. Thus, the municipal planning framework has no overall quantitative goals for the size of new housing and business areas. However, the Municipality of Aarhus have decided a number of qualitative goals for location, content and quality of new housing areas in the newly adopted Planning Strategy 2023. Some of the qualitative goals point to an awareness of not including excess bare land for city development, and instead to use already appointed areas:

- prioritize development on already designated city development areas and only designate new areas, if special conditions require that,
- prioritize new housing areas close to public transport,
- more focus on city development in the suburbs and less focus on densification in the dense city,
- focus on strong and sustainable development of local communities,
- more focus on health and quality of life and support of the mixed city,
- explore development of new types of housing that demand less space.

To balance the focus on city growth and to support the sustainability of city, the Planning Strategy also focuses on climate adaptation, climate mitigation, protection of drinking water and nature protection. However, none of the policies have objectives that reduce net land take. Politicians and administration have recently been working on a decision on confirming the EU goals for net zero land take in 2050. However, the decision is not yet adopted by the city council.

[5] Overview of spatial planning and territorial development in Asian and European countries, by the National Spatial Planning and Regional policy Bureau, Ministry of Land, Infrastructure, Transport and Tourism (MLIT), of Japan: https://www.mlit.go.jp/kokudokeikaku/international/spw/general/denmark/index_e.html#:~:text=Minister%20of%20Environment%20must%20veto,plan%20with%20a%20specified%20content.

2.2.3 Croatia and Velika Gorica[6]

On a national scale, Croatia is comparatively less developed in relation to more advanced EU member states. Currently, Land Take is viewed as a policy that could potentially hinder development. However, the Ministry of Construction is proactively adopting EU best practices and implementing complementary measures to enhance the quality of built environments. To do so the ministry has built a program for green infrastructure targeting the following:

- Ensure quality planning and development management green infrastructures in urban areas.
- Providing advanced, expanded and easily available green infrastructure in urban areas.
- Achieving high level of knowledge and social awareness of sustainable development of urban areas through development of green infrastructure.
- Development of the circular economy system for public spaces and buildings.
- Enabling circular building renovation[7] of unused spaces and buildings.
- Building capacity for high level of knowledge and social awareness on circular space management of buildings (sustainable and circular re-use of spaces and buildings).

The program is focused on municipalities to enhance current state of urban areas by:

- Municipalities are encouraged to adopt a strategic approach to spatial planning through the development of Green Urban Renewal Strategies.
- Additional points are awarded in national funding schemes to municipalities that employ participative approaches, involving citizens in planning and project execution.
- Incentives are also provided for the reuse of existing spaces, such as brownfields, in the form of extra points for national funding.
- A comprehensive manual has been developed at the national level, offering best-case examples for the development of Green Urban Renewal Strategies.
- Municipalities are encouraged to explore blended financing options for green projects.
- This dual-level approach—both at the city and national levels—aims to balance development needs with sustainability goals, thereby shaping a more resilient and inclusive urban future.
- Providing funding for pilot projects that show the benefits of NBS.

In Velika Gorica, it is projected that shifts in land use are on the horizon, with a particular emphasis on the expansion of built-up areas. These developments are expected to be shaped predominantly by demographic and economic factors. While the city currently lacks a formal policy on Land Take, it has undertaken a series of initiatives over the past four years to mitigate urban land consumption and address the urban heat island effect:

- The local building code mandates that at least 35% of newly developed areas should be allocated for Nature-Based Solutions (NBS).
- Velika Gorica is actively aligning with ministry guidelines to secure funding and serve as a pilot area for NBS projects.
- The city is forging partnerships with private companies to secure additional funding for mature NBS projects.
- Active engagement is ongoing with the Green Fund, which provides grants specifically for NBS initiatives.

[6] Sources: Velika Gorica Municipality

[7] Circular renovation uses economy principles in building's renovation, which means keeping materials and products in use as long as possible and efficiently reusing or recycling all waste.

2.3 Guidelines for implementing the No Net Land Take objective.

The factors contributing to land artificialisation are complex, numerous and interwoven in the different European countries, making the fight against land artificialisation complex and specific to each organisational system. In their thesis, Colsaet et al (2018) identified several relatively formalised instruments through which actors (public or private) impose, negotiate, or express commitments to limit or control soil artificialisation (Colsaet et al., 2018). A distinction can be made between the production and management of standards (hard law) and regulation in the form of incentives (soft law), and between standards that apply to an area (land law and planning at various levels) and standards that apply directly to projects (environmental requirements linked to authorisation procedures). Taxes and subsidies are other forms of incentives and differ from the point of view of internal management: taxes are generally automatic and non-negotiable, whereas subsidies require an application to be made and then a dialogue to obtain them. Lastly, other incentives are linked to the operational side and include actions on the ground that have a direct impact on limiting artificialisation: either actions to protect land, or actions to improve the "ecological content" of projects. In this document we suggest some general guidelines for implementing the No Net Land Take related to the REGREEN project and applicable to the different EU countries.

The principle of “avoiding” land take must be essential in Europe.

The objective of zero net artificialisation means avoiding as far as possible any further development of agricultural and natural land. As it is impossible to imagine a complete halt to development demand, even in the long term, the term "net" here means that new areas will have to be compensated for by ecological restoration of land that has already been developed. This prospect, although attractive on paper, will encounter difficulties in implementation on the ground, as is already the case with offsetting measures. Although the hope of "net" soil artificialisation is attractive, finding enough sites for recultivation or renaturation each year may be difficult or even unfeasible in some regions. In addition, the “stock” of depaving and renaturing sites is finite. Once all the feasible sites have been renatured, it will no longer be possible to balance the land take equation. It will then be necessary to move towards the “avoidance of land take” by giving up on some projects.

The "no net land take" objective is therefore inseparable from a path of frugality. In his latest book, geographer Guillaume Faburel wants to “put an end to big cities and metropolisation” [11] and suggests moving away from the metropolises and reinvesting in the countryside. While pressure on land use is high in major cities, in some countries more drastic decisions have been taken to limit urban sprawl and encourage densification of the existing fabric. This is the case in the municipality of Alsterdorf, in the suburbs of Hamburg in Germany, where to limit urban sprawl, the mayor has banned the construction of detached houses. As a result, only blocks of flats are permitted on the nine plots of land still available for building in the district of Hamburg-Nord. This measure, which has been adopted in several other cities, has sparked a lively debate in Germany, but also raises the question of the regulatory tools available to control land use.

Avoidance may simply consist of abandoning projects deemed unnecessary or too devastating for biodiversity, but this is a matter for political decision and societal debate. Technically, avoidance can also mean making greater use of vacant buildings to create new housing, a figure that is rising in many European countries. Cities should also encourage the renovation of dilapidated buildings and infrastructure and do their utmost to develop in areas that have already been artificialised. Many towns and cities are therefore committed to urban densification, sometimes to the detriment of the

last remaining urban green spaces. For this reason, any densification policy must also ensure that green areas are preserved and must impose the necessary measures to achieve this.

The Mitigation hierarchy is a widely used tool that guides users towards limiting as far as possible the negative impacts on biodiversity from development projects. The objective of this tool is to achieve no overall negative impact on biodiversity also referred to as no net loss. It is based on a series of essential, sequential – but iterative – steps taken throughout the project's life cycle. The sequential steps of the mitigation hierarchy is: avoidance, minimization and offset.

Increased protection of natural areas and agricultural land.

Priority should be given by states and cities to protect natural areas, agricultural lands, and forest, whatever the quality of the soil or its state of conservation. A wide range of legal and contractual tools can be used to protect these ecosystems. Under no circumstances should renaturing operations justify the destruction of existing nature areas which, in addition to being important for biodiversity, also fulfil other essential functions.

Changing funding policies and financial incentives.

Building on agricultural land is often the most economically competitive option due to its relatively low market value. In some countries, the price differential between agricultural land and land suitable for urban development serves as a compelling incentive for the expansion of urban areas onto agricultural land. It is imperative to assess funding policies and financial incentives with a view to reducing those subsidies that act as drivers for unsustainable land take and soil sealing. Such subsidies might encompass support for private housing and other construction projects on undeveloped land and green areas, incentives for commuters that indirectly promote urban expansion and necessitate expanded transportation infrastructure, and municipal budgets heavily depending on urbanization fees, which create a financial incentive for increased soil sealing by local authorities.

Soil must be considered as a common good.

Urban sprawl stands as a clear illustration of the tragedy of the commons, as outlined by Jaeger and Schwick in 2014. These two authors point out that the advantages of land utilization accrue to an individual citizen or commercial entity, while the adverse consequences are borne collectively by society. The initial objective should be to increase awareness regarding the shared value of land ecosystem services and the enduring economic repercussions of its depletion. Jaeger and Schwick (2014) propose that restraining urban sprawl necessitates social initiatives, such as the implementation of targets and restrictions aimed at managing the use of landscapes as a communal resource. Analogous to water and air resources, if all potential users acknowledge the enduring worth of land and the lasting impacts of unregulated land consumption, users may voluntarily opt for collective measures.

States and cities should avoid compensation measures wherever possible.

Over the last 20 years, European countries have to different degrees introduced off-site and out-of-kind compensation (Wende et al., 2005). Several European countries have introduced, or consider introducing mitigation banking (Droste and al., 2022), including Germany, France, Spain, and the UK : the authorities make the destruction of protected areas or species conditional on the submission of a file in which the developer, after showing how they have avoided unnecessary consumption, reduce their footprint as far as possible and propose designated land, now of degraded ecological quality, in order to restore it and thus attempt to "compensate" for what they have destroyed or damaged. Today, these cases are few and far between. In France, for example, the Avoid, Reduce and Compensate (ERC) sequence is generally applied to "major projects", particularly large infrastructure projects (major road projects, shopping centres, stations, etc.). After several decades, the application of the ERC sequence still has many weaknesses and, in many cases, does not meet its objective of no net loss of biodiversity. While the problem of the sustainability of compensatory measures is a major reason for this, the choice of compensation sites - mainly in areas with a low capacity for ecological gain (areas that are already semi-natural) to the detriment of heavily artificial areas whose renaturation would bring real benefits - is another. In fact, the waterproofed areas created by a project are generally not compensated for. What's more, many buildings are still exempt from this obligation. In numerical terms, artificialisation is first and foremost the result of the nibbling away of land by individual housing ("detached houses") and business parks. It is also the result of a myriad of small-scale projects - starting with houses built by private individuals on a 'piecemeal' basis.

It is necessary to monitor land take.

In order to implement the No Net Land Take, it is essential to ensure accurate monitoring of urban development at local, national, and European level, as well as monitoring the rate of urban renewal, density, and renatured areas. It can be achieved through a wide variety of data sources: indicators produced by the European Environment Agency [12], Urban Atlas [13], the Land Use/Cover Area frame Survey, known as LUCAS [14], or the imperviousness layers produced by Copernicus [15]. But given the limitations of European data sources [16], the evaluation in each Member State of the above processes is often based on national data sources, generally more detailed than those available at the European level. It would therefore be more effective that this detailed monitoring will be carried out at regional and national level.

Implement land recycling and land densification.

Land recycling addresses the reuse of abandoned, vacant or underused land for redevelopment. Land densification is defined as the land development that takes place within the urban area, making maximum use of the existing infrastructure instead of building on arable land, permanent crop land or semi-natural areas. It is a key planning instrument for achieving the goal of no net land take by 2050. There are many ways to make the city build “on itself”:

- Considering unused resources at local level like empty buildings or unoccupied houses*.
- Sharing and intensifying the use of buildings. Intensification can be achieved over time, by adding extra uses during periods when buildings are not in use. For example, a gymnasium could be used as a covered market, a school as a venue for associations in the evenings and at weekends, or a canteen could be shared between a school and a retirement home*.

***The first two guidelines have the advantage of ensuring economies, reducing the need to build, and the need for building materials. They are therefore more environmentally friendly solutions. The life cycle of materials has many negative effects on ecosystems and biodiversity, starting with the way raw materials are produced. The processing, transport and end-of-life treatment stages also emit pollution that impacts natural environments (chemicals, waste, greenhouse gases).**

- Changing buildings to accommodate a new function when the activities they house become obsolete. This may involve offices, business premises, storage facilities, industrial sites, public buildings, etc. The conversion of buildings improves the carbon footprint of new housing production by preserving a large part of the structural work, unlike demolition-reconstruction operations.
- Soft densification by extending the height of existing buildings by a few storeys or by subdividing housing (creating different flats in detached houses).

Densifying cities while preserving natural areas.

Densification must not be to the loss of urban green spaces, as they contribute directly to quality of life, biodiversity, and climate change adaptation. Green space must be protected in urban planning documents. The implementation of the No Net Land Take objective should encourage cities to think about a density that is acceptable not only to residents but also to all living things. For example, a Polish study recommends a minimum of 45% ground-level vegetation cover or aquatic environments (Szulczewska and al., 2014) in residential areas to ensure adequate air cooling, rainwater permeability and evapotranspiration during heat waves. Another study suggests that a minimum of 30% of areas covered by vegetation or water within 250m of dwellings improves the health of residents (Cox and al. 2017). In a study of 75 cities, researchers have shown that to support biodiversity adapted to the urban environment, the minimum size of a habitat is 4.4ha. Where more sensitive species that usually stay away from cities are concerned (so-called “urban avoiders”), this rises to 53.3ha (Beninde et al., 2015). This data can be used to develop strategies for densification that are consistent with ecological, climatic, and social issues.

Brownfields and urban densification: finding the balance.

Brownfield sites are very often cited as the ideal solution (see box below) for implementing the No Net Land Take challenge. While some brownfield sites, such as those that have been heavily sealed and built-up, are ideal for densification, others have over time become nature areas and support biodiversity in cities. Finally, other brownfield sites represent the last hope of recreating natural spaces in heavily urbanised areas. Still too easily regarded as "spaces waiting to be developed", recognition of their status as nature areas should be considered as part of an ambitious ecological policy.

Several scientists have shown that brownfield sites have real potential for the conservation of urban biodiversity (Bonthoux et al, 2014). In the Paris Region, the diversity of plants, birds and butterflies in brownfield sites is higher than in any other "natural" urban areas (parks, gardens, cemeteries, and so on) (Baude et al, 2011). They do not harbour the same species as managed areas; they act as a refuge for so-called "urban avoiders". Finally, brownfield sites also contribute to the ecological continuity of local areas by allowing species to travel across the urban matrix (Muratet et al, 2019).

Implement ambitious, planned renaturing strategies.

Today, compensating for artificialisation through renaturation strategies means finding one of the scarcest and most coveted resources in regions where urbanisation is progressing: free land (or "land reserves"). Renaturing means "giving back to nature" an amount of land equivalent to that consumed by urban growth. These might be oversized car parks, school playgrounds, the courtyards of buildings, riverbanks lined with concrete, residual unused public space that has been needlessly asphalted over, factories, occupied or disused business parks or shopping centres, dilapidated buildings, etc., where renaturing would be of significant ecological benefit.

Identifying areas suitable for renaturing is essential for implementing a No Net Land Take strategy[8]. It helps to determine if it is possible to compensate an urban extension project. In addition, it makes it possible to develop relevant renaturing strategies to strengthen ecological networks, to increase the number and surface area of ecological interest and to allow the deployment of NBS.

Renaturing focuses on restoring soil functions and presupposes a return to an open ground. This excludes above-ground solutions like green roofs, raised beds, planted slabs, modular living walls, etc.

Renaturing is sometimes confused with desealing, which merely entails restoring permeability to the upper layer of the soil, often by using porous ground covering materials that facilitate drainage. Desealing is a necessary but not sufficient condition for the restoration of the soil's ecological functions.

Create an economic model for renaturing.

The cost of recultivation / renaturing actions depends on the historical conditions of the site and the techniques used. According to France Stratégie (Fosse et al, 2019), the average cost of soil restoration is between 95 and 390€/m². These are significant costs, but it can be offset by savings made thanks to rainwater management and the direct and indirect benefits that a new natural area provides. It is important to consider all benefits in a cost-benefit analysis. For example, in the town of Douai (in the Nord département in northern France), where 25% of public space is managed using alternative techniques, it is estimated that a saving of 1 million €/year is made (30-40%) compared to traditional methods. Even if renaturation brings many benefits, it has a cost. The question is: who should bear the

[8] As part of the REGREEN project, a method has been developed to help cities identify priority areas for renaturing, see Case study 9.

costs of renaturation? The developers? Local authorities? Residents? While it is not easy to answer this question, one answer would be to change the economic models to promote urban regeneration rather than urban sprawl, but also to make renaturing operations possible. An ambitious renaturation strategy requires an economic model. It is possible to modulate or modify tax rules at national, regional, or even more local levels, or to mobilise discounts or exemptions to encourage renaturing operations as part of the No Net Land Take (Cocquière, 2020).


©Gwendoline Grandin

3 NBS IN PLANNING SYSTEMS

3.1 Current situation

NBS include options for every form of ecosystem and for various scales of action, whether aimed at mitigation or adaptation. Urban planning is concerned with shaping cities, towns, and regions by managing development, infrastructure, and services (Bush and Doyon, 2019). In this section, we will focus on the urban environment and on the three scales of NBS interventions allowing to take into consideration the practice of urban planning: city, neighbourhood, and buildings [17]. Mechanisms and approaches for mainstreaming NBS into planning documents are highly context-specific, making it difficult to propose specific recommendations. Nevertheless, it is possible to formulate general guidelines that can then be taken up and integrated into the planning context of each city.

Planning has long recognized the importance of the green spaces for city dwellers (Buxton and al., 2016; Hagan, 2014; Wheeler, 2013), but when it comes to NBS, Mc Phearson and al. (2015) highlighted the need for planners and managers to make new relationships and partnerships (Coaffee, 2013) and to include urban ecologists, horticulturalists and landscape planners in this partnership (Parris et al., 2018; Scott et al., 2016).

To date, limited attention has been given to the integration of NBS within urban policies and planning. Kauark-Fontes et al. 2023 (CONEXUS H2020 project) show that NBS integration in urban policy and planning is novel in all the seven CONEXUS cities but advancing considerably with initial dialogues among the public sector, academia, and local actors of various provenances. They carried out a study of integration of NBS in local policy and planning from Barcelona, Lisbon, and Turin. A total of 41 official documents that integrate NBS to some extent were identified: 10 in Barcelona, 17 in Lisbon, and 14 in Turin. The data collected revealed that NBS were integrated into different policy levels, from municipal to national: 23 were municipal, 3 metropolitan, 7 regional, and 10 national (Table 3), with most of them indicating or referencing a connection with international agendas. The document's analysis also showed a predominance of framework plans and strategies (46%), equally followed by master and action plans (Table 4).

Table 2. NBS policies found per city and governance level

	Barcelona	Lisbon	Turin	Total
Municipality	5	13	5	23
Metropolitan	1	1	1	3
Regional/provincial	4	2	4	10
Total	10	17	14	41

Source: Kauark-Fontes et al. (2023)

Table 3. Types of NBS policies found

Municipality	Frameworks and strategies	Master plans	Action plans
Barcelona	50%	20%	30%
Lisbon	47%	24%	29%
Turin	43%	36%	21%
Total	46%	27%	27%

Source: Kauark-Fontes et al. (2023)

This study reveals a possible move toward a less fragmented NBS urban governance and a more integrated approach to NBS development, i.e., a step forward for the uptake of NBS in urban settings (Sarabi et al. 2020). The results from Kauark-Fontes et al. 2023 demonstrate an increase in the inclusion of NBS in urban policies in the last 7 years and increased dialogue between said policies toward NBS development. However, although some NBS integration in policy and planning documents can be found, the results revealed that there are still gaps in their integration. The concept is still mainly assimilated in the environmental and planning policies, with its integration in other types of policies being an exception rather than the rule. NBS still struggle to be integrated with other sectors like education, health, and communication plans and strategies, thus highlighting the importance of dissemination and local understanding of the concept so that it can be accessible to all (Sowińska-Świerkosz and García 2022). In a study, Marušić et al. (2023), gave recommendations for bridging the policy-implementation gaps to bring NBS closer to urban planning. According to the authors, one challenge is associated with how to upgrade planning documents with the representation of NBS-related information and characteristics, in both the text-based and graphical components, to align with the existing urban planning language rather than being a separate appendix that merely provides examples that might not be fully considered for the area or location of interest.

3.2 Ensuring the ecological quality of NBS

NBS refer to a large range of actions from protecting, restoring or even creating new ecosystems. For local stakeholders, this broad concept can be vague and lead to very different understanding and applications. In urban areas, NBS are often confused with traditional landscape design with the assumption that NBS will automatically support biodiversity conservation goals by virtue of being green (Connop et al., 2015). Many so-called NBS projects refer to urban “greenery” and focus on a few aspects (aesthetics, stormwater management) rather than an integrated approach based on science in ecology. More research is needed to clarify the links between biodiversity and NBS design. NBS approaches should move towards biodiversity-led approaches by considering the potential for improving species and ecosystem functioning. Some researchers have warned policymakers and practitioners that NBS should be explicitly designed to provide measurable benefits for biodiversity (Seddon et al., 2021). More co-construction between urban ecology scientists and landscape planners could help avoid what (Connop et al., 2018) call blandscaping, in other words landscaping that uses the same designs, and often the same species, across different urban regions nationally and globally.

A bunch of “green” solutions have been standardized in cities, for instance beehives to the detriment of habitats for wild pollinators, “ready-to-use” vegetation systems for green roofs or façades, bioswales designed for water infiltration and not as habitats for wildlife, urban micro-forests with attractive marketing instead of wild urban forest protection. For example, the recently proclaimed largest green wall in Europe on the Kö-Bogen II commercial building in Düsseldorf consists of 8 km of hornbeam hedges in metal planters with automatic irrigation and fertilization as well as regular pruning to maintain geometric shape and size (Kraft 2020). Urban greening that has already reached the intended size when planted undermines fundamental ecological processes such as plant growth. In general, biogeochemical cycles that sustain ecosystem services are often neglected (i.e. carbon sequestration in soils), and plantings with low diversity of functional traits provide limited support for urban biodiversity (Brunbjerg et al., 2018; O’Riordan et al., 2021; Parris et al., 2018; Ziter, 2016). More effort should be made to design NBS with diverse types of habitats, more variation in vegetation strata and structures, that support native biodiversity, use local resources, and aim to increase connectivity between patches. In the future, local guidelines designed by urban ecologists and landscape architects can help cities to integrate these urban ecology principles in NBS design and management.

MacIvor and Knapp (2023) argue that there is, however, no one-size-fits-all solution of NBS to support biodiversity. Context in terms of climate, biogeographic region, and local knowledge as well as socio-economic conditions impact not only the benefits provided by NBS, but also how NBS should be

constructed in terms of biodiversity. Biodiversity aspects such as species richness or traits which are well studied and manageable should be part of a selection process by practitioners. Often, local knowledge already provides important expertise to support species selection and maintenance decisions for resilient and sustainable long-term NBS. NBS are also about how we manage urban green areas. The intensity of management by mowing, pruning of trees and shrubs, removal of dead wood and mulching can lead to simplification of habitats and reduction of biodiversity (Aronson et al., 2017).

Renaturing built-up or sealed areas can take extremely varied forms. However, it is often confused with greening, whose primary aim is to create a green I that makes the city more attractive. Greening takes place with no connection to the climatic or geographical context and tends to use ill-adapted horticultural species and requires numerous inputs (topsoil, 28rogramme28, irrigation, etc.), which means that these areas are not self-sufficient and are reliant on intensive management. Conversely, renaturing is based on ecological engineering. It relies on knowledge of the living world and takes each level of biodiversity (genetic, specific, and ecological) into account. It is to maintain ecological functionalities by targeting relevant flora and fauna, by taking soil quality into consideration and by using minimum resources (Deboeuf De Los Rios et al., 2022).

3.3 Guidelines to integrate NBS in urban planning systems.

3.3.1 Environmental assessment and knowledge

To properly incorporate the challenges of biodiversity and NBS into regional planning, local councils can deepen their understanding by conducting nature surveys and running ecological diagnostics. Ecological assessments include inventories of fauna, flora, habitats, local climate, hydrology, and other studies carried out by ecologists, naturalists, or environmental protection associations. The diagnosis identifies existing ecosystems that are essential for adaptation and mitigation, with a view to protecting them in urban planning documents and mapping areas that are vulnerable to the effects of climate change: urban heat islands, flood risk, lack of green spaces, etc. In France, there is an initiative called the “Biodiversity Atlas” (Atlas de la Biodiversité Communale), which helps local authorities to understand and preserve nature. This process takes place over 3 years, with fauna, flora and habitats inventoried throughout the town. It also involves a range of stakeholders (elected representatives, residents, associations, businesses, etc.) by offering a plethora of activities: presentation of the initiative and the results, participation in the inventories, press and social networks communication, events, nature fieldtrips, etc. Biodiversity Atlas produces 3 types of reports: naturalist field inventories (species and habitats); maps showing the issues at stake, which can be incorporated into town planning documents; recommendations for preserving and restoring ecosystems.

High-resolution mapping is a valuable tool to get information about vegetation cover in cities. Knopp et al., have provided a detailed land use and land cover map for the municipality of Aarhus with a spatial resolution of 20cm. This study has found that utilizing both multitemporal orthophotos and elevation data can enhance the land cover mapping of urban landscapes. Their results provide an addition to existing municipal cadastral data and serves as a basis for urban planning (Knopp et al., 2023). The land use map is potentially useful for urban planners, especially if it is combined with ecological information on the parcels, such as inventories of fauna, flora and habitats, ecological status, etc.

French Capital of Biodiversity competition

Many of the case studies in this document come from the "French Capital of Biodiversity" competition [18]. Launched in 2010 as part of a European programme, the French Capital of Biodiversity competition now unites numerous partners at national and regional levels.

The participation is open to every French city and inter-community. With a different theme every year, they are asked to present 3 exemplary actions they have taken in their locality, either by themselves or with local partners.

The actions taken are assessed through peer review by the competition's Scientific & Technical Committee. The best applications receive a site visit, documented in a report, and the communities considered the best examples for that year's theme may see themselves receiving an award, such as the French Capital of Biodiversity. Each year, the best actions are then published in a book (the competition's yearbook).

Ten years after its launch: 55 municipalities have been awarded, around a hundred workshops have been organised across France, 90 field trips, over 500 exemplary actions have been published, available on the competition website.

Case study 1

Naturalist knowledge helps the city of Morne-à-l'eau to act for nature (France, Guadeloupe)

The city of Morne-à-l'Eau has worked hard to understand biodiversity, by funding surveys, monitoring and academic research projects. This solid knowledge base has been built through the local officials and departments, via sustainable partnerships with the State, the Guadeloupe National Park, the Coastline Preservation Authority, universities, and voluntary groups. The various assessment tools have been used to inform the city's management practices and environmental restoration work in equal measure. It has helped to identify priority projects, such as the ecological restoration of a former landfill site and the renaturation of Babin beach. Restoration of the beach has enabled mangrove trees to be planted to combat erosion and create buffer zones against flooding. To go further, in 2019 the town has launched its "Atlas of Communal Biodiversity", with a focus on the role of trees in biodiversity conservation, and as a buffer against flooding. The atlas will identify actions to protect and restore nature, which will then be incorporated into the local town planning scheme [19].

Planting of mangrove trees to combat erosion and recreate buffer zones against flooding ©Gilles Lecuir

Case study 2

Participatory inventory of wetlands in Saumur Val-de-Loire (France, Pays de la Loire)

The *communauté d'agglomération* (area council) of Saumur Val-de-Loire carried out an inventory of wetlands in all 24 of its cities. The objectives were to locate wetlands and to assess their ecological status. Each city set up teams to carry out the inventories. They were made up of elected representatives, hikers, farmers, members of nature conservation associations and representatives of public institutions such as the French Biodiversity Office. Each group was trained in wetland recognition and the inventory process. This approach helps to raise awareness, provide training, and improve knowledge of wetlands. This is an essential step for ensuring their protection in urban planning documents.

A sedge meadow inventoried as part of the wetlands inventory ©CASVL

Case study 3

A "Biodiversity Atlas" to guide the future planning document of Cormelles le Royal (France, Normandie)

From 2019 to 2021, the city of Cormelles le Royal worked with several naturalist NGOs to conduct a "Biodiversity Atlas". Over 3 years, the city organized more than 80 events: field trips, workshops, exhibitions, photographic competitions, conferences, etc. These events were aimed at local inhabitants, schools, elected representatives, municipal staff, retirement homes, enterprises, and farmers. Fauna and flora monitoring revealed the presence of 65 tree species and 363 animal species. A map of Ecological habitats has been produced at the scale of the city. The Biodiversity Atlas has enabled an action plan to be drawn up to promote nature in the city and improve the state of biodiversity conservation. Several projects have already been launched, including the creation of a pond, improving the quality of green spaces and their management (transition from traditional management to ecological management). The results of the Atlas will soon be used to draw up the new town planning document and will help the municipality to preserve nature and to deploy NBS.

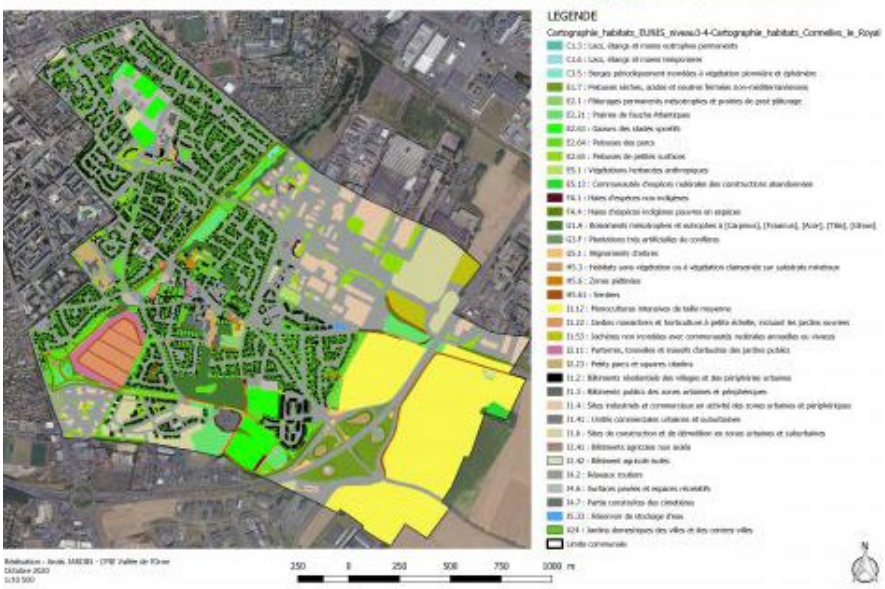


Figure 7: Mapping of ecological habitats in the city ©Cormelles le Royal

3.3.2 Mainstreaming ecological corridors in planning documents

The importance of ecological connectivity has been demonstrated in several studies (Shanahan et a.l, 2011): making it easier for species to move around increases genetic mixing between populations and maintains dynamic, adaptable, and resilient ecosystems. In 1995, members of the Council of Europe signed a biodiversity and landscape strategy with the aim of formalising a pan-European ecological network. Very quickly, countries such as Poland proposed national maps of biodiversity reserves (especially large national parks) and large corridors to be protected (especially riparian forests). On a smaller scale, in urban areas, green infrastructure can have many forms (green spaces, parks and gardens, temporary wilderness, trees and rows of trees, etc.), and each one can serve as a small reservoir for biodiversity or a biological passageway or corridor.

The modelling of ecological connectivity or landscape networks is currently an important issue for researchers in ecology and practitioners of landscape management alike. However, most of the official documents concerning the green and blue grid are produced on a global scale (region or county) and are not very suitable for the urban scale. It is necessary to rely on more local documents when they are available from the municipality, or to carry out specific studies of potential reservoirs and corridors at the scale of the town or neighbourhood. At present, the various corridors are often limited to a landscape “pencil stroke” resulting from an anthropocentric representation, with no real link to the biology of the species and their modes of movement. Target species can be identified by ecologists to design ecological corridors that are functional from a biodiversity point of view.

Graph-based modelling has been shown to be a powerful way of representing and analysing landscape networks (Foltête et al., 2012). One of the most popular approaches is a graph-theoretic method promoted in ecology and known as habitat networks or landscape graphs. Landscape graphs have given rise to several software applications, including mainly Conefor Sensinode and Graphab. They are used to model the movement of species based on land-use and biological data (movement capacity of the species in question, habitat preferences, landscape features that are unfavourable to movement, etc.). Software applications provide users with a basis for visualizing ecological networks and characterizing their functional properties by means of connectivity metrics. The primary contributions that graph-based modelling may make from a land planning perspective are in: (1) identifying the most vulnerable areas of an ecological network in which to prioritize conservation measures, (2) locating the areas in which to implement field actions (e.g. landscaping) so as to improve overall connectivity, and (3) assessing and mapping the impact on species of a change in land cover (Foltête et al., 2014).

Case study 4

In Val d’Ille-Aubigné, analysis drives action (France, Grand-Est)

The combined district council at Val d’Ille-Aubigné has been actively protecting biodiversity since 2013, weaving it into its local green and blue corridor plan. In 2019, they have launched a major study across its 19 districts to draw up its new corridor plan. A map of the green and blue corridors, a diagnosis of the ecological functioning of the Val d’Ille-Aubigné and an action plan were produced and integrated into the new planning document. Since then, the district council has carried out several initiatives to restore ecological connectivity and is participating in the deployment of the NBS: creation of a pond in a business park, the rehabilitation of former sewage lagoons, the planting of mixed species hedges, building animal corridors underneath roads, the building of educational pathways, etc.

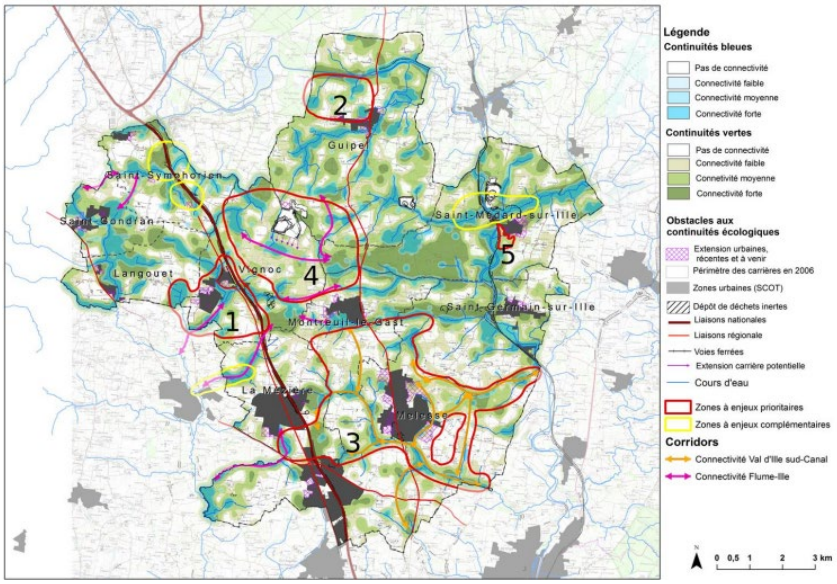
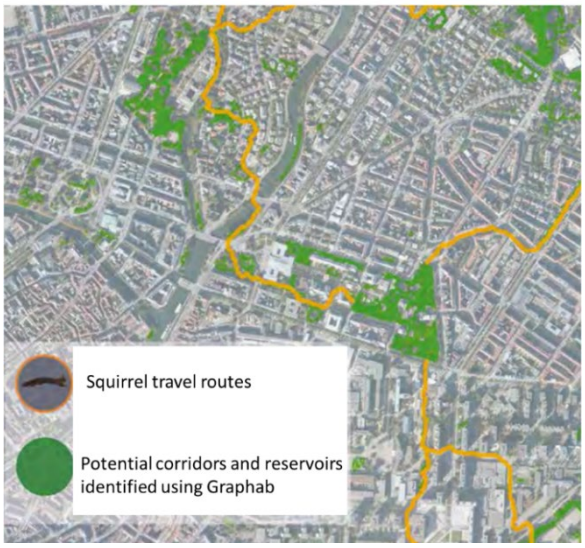


Figure 8: Map of sectors with "green and blue grid" issues ©Val d'Ille-Aubigné [20]

Case study 5

Modelling ecological corridors in the city of Strasbourg thanks to the red squirrel and bats (France, Grand-Est)

The city of Strasbourg launched a pilot project to identify the green network in its urban area. It has been modelled thanks to the Graphab software. This work was carried out with the red squirrel (*Sciurus vulgaris*) as the target species and, more recently, two species of bats, the lesser noctule and the common noctule: *Nyctalus leisleri, Nyctalus leisleri* (*Hector et al, 2017*). The green network is made up of natural urban spaces such as parks, green spaces, rows of trees, private gardens, etc. This approach is used as a tool to diagnose opportunities and threats to better assess the importance of natural spaces in planning and management processes (demineralization and greening of pavements, façades, planting of shrubs, etc.).



Identifying the green network for the red squirrel
©Strasbourg Eurométropole

Case study 6

Integration of the Green and Blue Network in the Eurometropolis of Strasbourg in urban planning documents (France, Grand-Est)

The Eurometropolis of Strasbourg brings together 33 municipalities, which comprises one third urban area, one third agricultural area and one third natural areas. Since its identification, the Green and Blue Network has been integrated into the Local Urban Development Plan of the Eurometropolis. The green and blue network *Planning and Programming Guidelines* (Orientation d'aménagement

33rogramme) sets out the principles to be observed and the objectives to be achieved to strengthen the position of ecological continuity. This is a qualitative and quantitative approach to enhance and improve nature, thanks to written regulations and graphs regulating land occupation and urbanization:

- planted areas must consist of at least 2 plant strata (tree, shrub, herbaceous) and use local species.
- development projects must maintain the existing vegetation as far as possible.
- written regulations limit the amount of soil that can be sealed, imposing an “open-ground” ratios for construction projects (varying from 5 to 30% depending on the district). In addition, areas of spontaneous vegetation have to be maintained.
- Fences are regulated and must allow the movement of (small) fauna, the document points out that planting hedges of local species is to be preferred.
- New buildings must have green roofs and/or façades planted with climbing plants.
- Building projects are only allowed if they do not disturb ecological connectivity for the European hamster (*Cricetus cricetus*) – an endangered species in the Eurometropolis area.
- For any construction near the dispersal zone of the European green toad (*Bufotes viridis*), green spaces must include habitats that meet the vital needs of the green toad and allow it to disperse.
- A planning policy preserve 10,0000ha of natural areas, forests and agricultural land from urban sprawl.

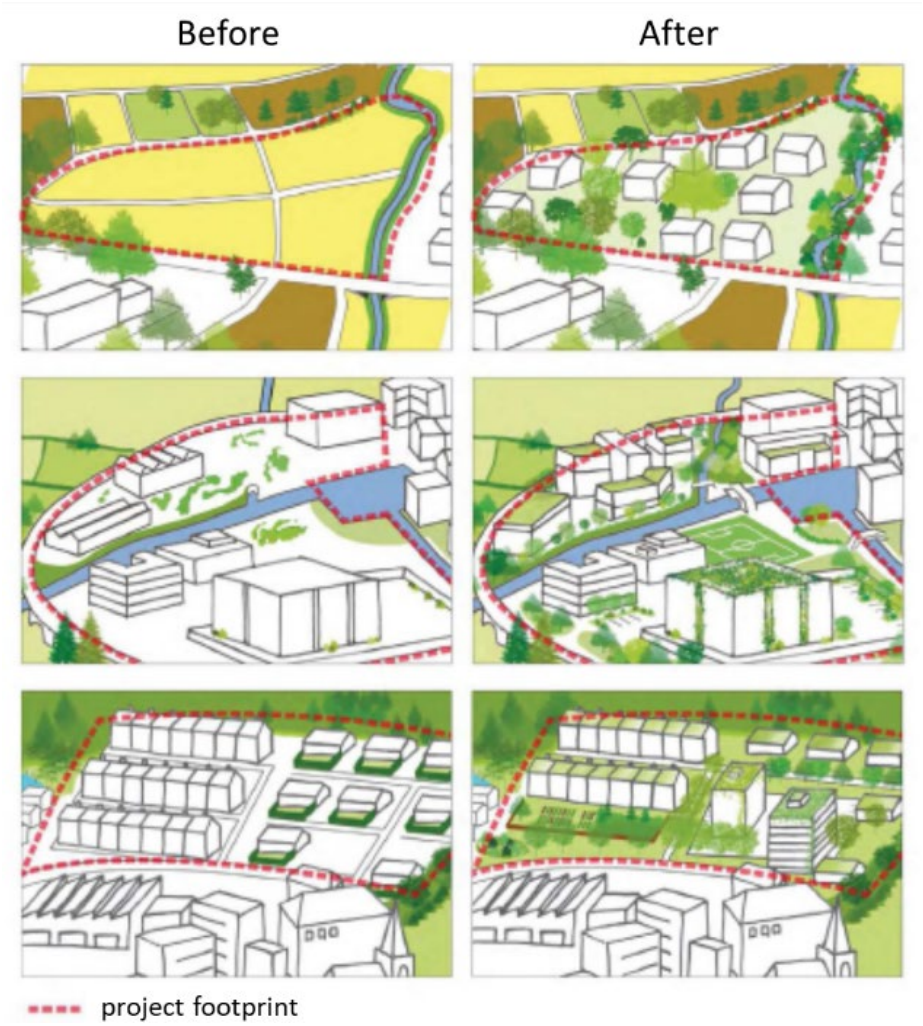


Figure 9: An extract from the Planning and Programming Guidelines requiring new construction projects to increase the amount of green space ©ADEUS

3.3.3 Modelling and mapping ecosystem services to improve NBS planning.

NBS integration into planning documents often comes up against 2 challenges: (1) identifying spatially where to maintain and develop NBS, and (2) identifying priorities in planning documents. A planned strategy for NBS would greatly contribute to making NBS more efficient and making local projects more coherent with one another. Flooding data could e.g. be used to identify potential sectors in which wetlands should be protected or restored. Mapping and modelling tools are essential for spatialising issues and providing a working basis for urban planners. This may involve precise mapping of land use, but also monitoring land use over time (artificialisation, disappearance of natural environments or landscape features). Models can be used to project objectives: restoring ecosystems and developing NBS in areas of high interest, restoring the green grid and ecological continuity, planting hedges in agricultural areas, etc. Regarding the need for cooling cities, data on urban heat island effects could help to identify sectors that could largely benefit from NBS targeting air cooling, such as peri-urban forests or enhanced tree cover in dense urban areas, even if greening is probably insufficient to limit health impacts of extreme heat (Pascal et al., 2021). NBS could also target the recovery of wildlife corridors, which will be important for the adaptation of species to climate change. In many cities, urban rivers could be re-opened as well as riverbanks and riverine forests restored. These data could usefully be used for the implementation of NBS into the planning process, whether it is in the zoning system (protection of land, restoration efforts) or in guidelines associated with planning schemes (green and blue framework, principles for biodiverse design and management). For instance, a recent study has assessed the quantity of ecosystem services in cites of China and Europe under 3 land cover scenarios (business-as-usual, a market-liberal scenario, and an ecological protection scenario). The researchers stressed that the proposed framework, as well as the results, may provide important guidance for urban planning (Wu and al., 2022).

Case study 7

Mapping and modelling ecosystem services thanks to the City Explorer Toolkit

The City Explorer Toolkit is designed as a flexible system to allow city authorities to conduct several assessments for their city. These include the following features (explained in more detail in the sections below):

- Mapping the pressures (heat, air pollution, noise, etc.) and current green and blue space and socio-economic status from census data.
- Ecosystem service models to calculate how current green and blue space provides different services.
- Creating opportunity maps to see which areas give the best location for new or improved green and blue space.
- Creating scenarios to test locations and calculate the additional benefits from new green and blue space.

The toolkit differs from other decision support systems because it can live-calculate new estimates of the benefits based on user-created scenarios, and these calculations rely on internal models which are sensitive to local context rather than simple look-up tables. The toolkit also incorporates socio-economic and demographic factors into the assessment, meaning that users can tailor their decision-making to focus on benefits to particular sectors of the community (e.g., the young, the elderly, or those living in more deprived areas in the city). The tool allows a range of visualisation options for the modelling outcomes, including tables of summary data, graphics, and maps.

Mapping pressures focuses primarily on environmental pressures such as hot-day temperatures (either land surface temperature, or air temperature, depending on the data available), air pollution levels (with a current focus on particulate matter PM2.5, but can be updated for other pollutants),

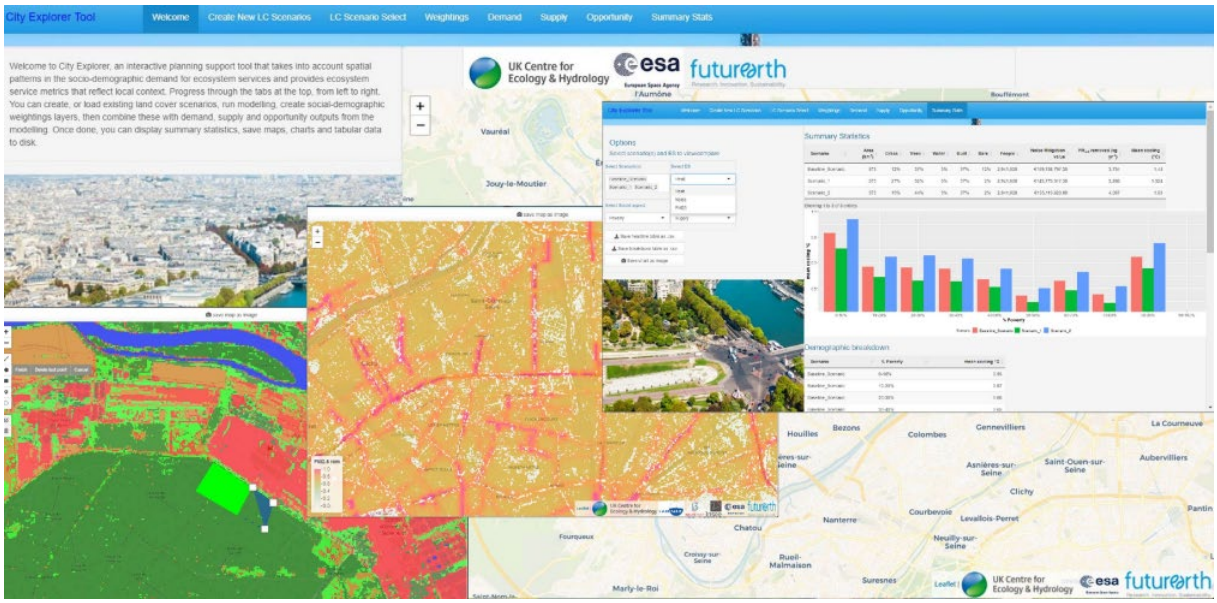
noise levels from road or rail sources, and could also incorporate flooding risk. The data on current landcover categories classifies this into simpler categories for the purpose of modelling (deciduous trees, coniferous trees, shrubs, grass, rivers, static water bodies like ponds and lakes, buildings, other sealed surfaces), but incorporates finer-scale classifications where this is useful for individual ecosystem services models. Socio-economic and demographic data include population broken down where possible by age band, and indices of wealth/deprivation.

Ecosystem service models currently supported in the toolkit include: air pollution removal (PM2.5) by trees; hot-day cooling by urban green and blue space; noise mitigation by trees; surface water run-off reduction (by green and blue space).

Other planned models for incorporation include: water quality improvements by riparian trees, and trees in the wider urban catchment; aquatic biodiversity improvements due to tree cover; carbon sequestration.

Opportunity maps allow users to assess the best locations to implement new NBS for each pressure/service, and these can be adjusted according to the needs of a particular demographic if required. Separate opportunity maps for each service can be combined to give an overall indication of the best locations to address multiple urban challenges.

Scenarios can be created by users within the tool or can be uploaded as a separate input layer. The models can then be run on these new scenarios and results of different stored scenarios can be compared to see how the ecosystem service outcomes differ. This can be used to test different locations for new NBS in the city, or different types of NBS in the same location, for example.



City Explorer Tool overview ©UK Centre for Ecology and Hydrology

Case study 8

IDEFESE: ecosystem services mapping to inform urban and regional planning policies.

IDEFESE is a 30-month project concerned with ecosystem services mapping to inform urban and regional planning policies [21]. The case study involves the Ile-de-France region, the city of Shenzhen in China and the Twin Cities in the USA (although the approach is applicable to other cities and regions). The approach relies on open-source tools, within the InVEST (Integrated Valuation of Ecosystem Services and Tradeoffs) software, that compute biophysical and socio-economic metrics relevant to a variety of decisions in data-rich or data-scarce contexts (Hamel et al., 2021). In Île-de-France, evaluation of ecosystem services involved more than 50 stakeholders from 27 institutions, including government agencies, and NGOs. The project examined the distribution of ecosystem services to provide recommendations for future master plans of Île-de-France. As well as mapping ecosystem services, different types of scenarios were studied: agricultural transformation, urban sprawl/densification, and renaturing project implementation. 27 scenarios were modelled, showing that: (i) renaturing policies are not ambitious enough to date and have a strong impact when developed in urban centers, (ii) scenarios involving changes in agricultural practices have a very significant influence on the provision of ecosystem services and (iii) urbanisation policies show contrasting trends depending on the densification or sprawl choices made, with densification also potentially leading to the loss of services provided by nature for populations that already have limited access to them. IDEFESE findings suggest that such maps and scenarios provide a valuable decision-making tool to improve the cost-effectiveness of incentive-based conservation instruments and better inform land use decision planning (Claron et al., 2022).

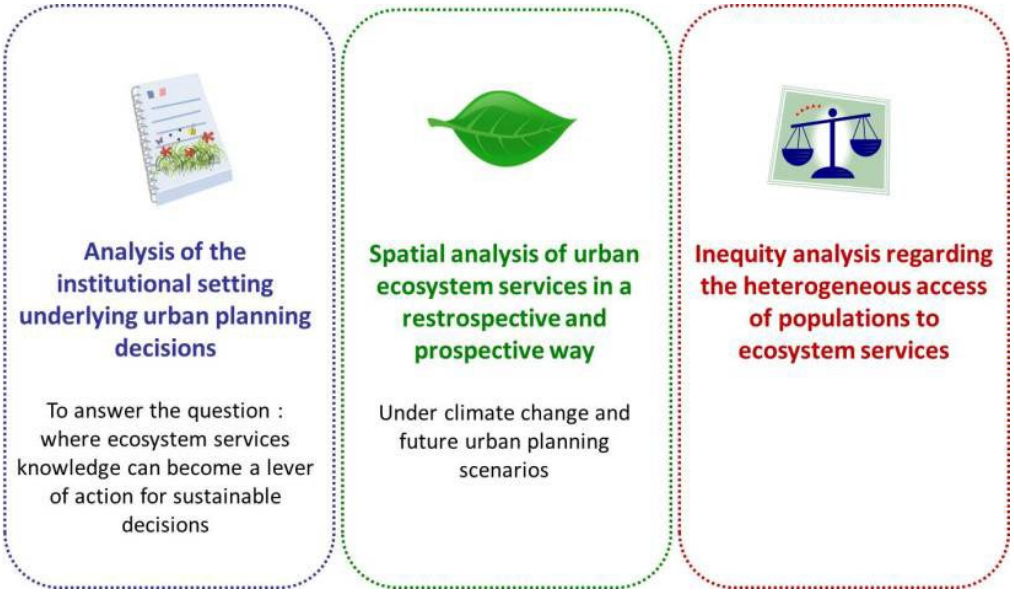


Figure 10: IDEFESE addresses 3 main objectives by leveraging academic knowledge (ecology, economics, climate sciences), and involving a broad range of stakeholders (urban planners, non-profits, water agencies, Chamber of Agriculture, etc.)

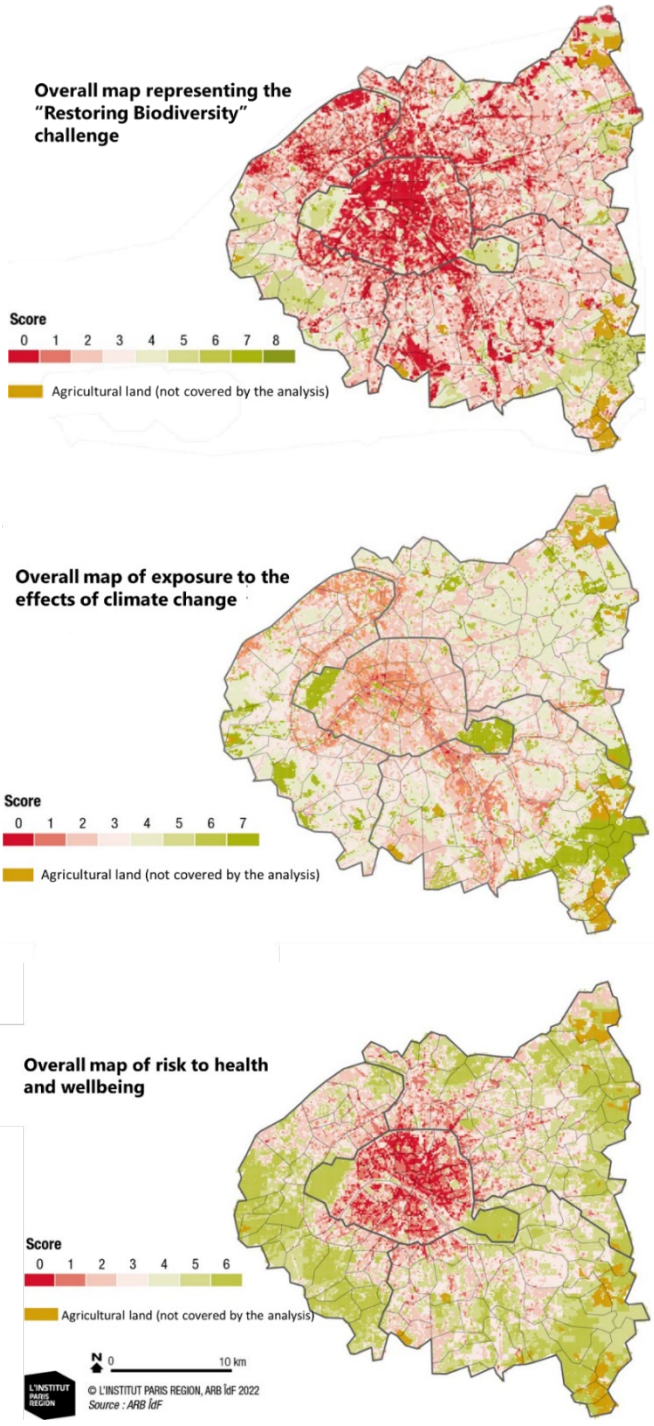
Case study 9

A mapping method for identifying areas with high renaturing potential.

As part of REGREEN, the Biodiversity Agency of Paris region (department of Institut Paris Region) developed a method for identifying urban areas with high renaturing potential [22]. One of the objectives was to help cities to develop a renaturing strategy and incorporate this into their planning documents. The identification of urban areas to be renatured as a priority was based on 3 main issues: restoring biodiversity, adapting to climate change, and improving health. Each challenge was studied using criteria selected from the scientific literature and according to the availability of data at the Ile-de-France level.

- Restoring biodiversity in targets areas that are deficient in terms of biodiversity, by studying the size of green spaces; the type of plant cover; and the presence of rare habitats.
- Adapting to climate change in targets areas exposed to climate risk: river flooding, runoff, and urban heat islands.
- Improving health and the living environment in targets areas that are vulnerable because of lack of green spaces, air pollution and health problems relating to urban heat islands.

This methodology was carried out using a GIS approach. The Paris Region was divided into 125 m x 125 m cells. Thanks to the datasets available at regional level, the status of each cell is analysed and converted into a score (Figure 3). For example, a cell exposed more or less significantly to air pollution is given a score that reflects this. A score is thus attributed to each criterion, and then an overall score is given to each challenge. In this way, it is possible to pinpoint the urban areas where renaturing work (or NBS) should be carried out as a priority, depending on biodiversity, climate change or health.



Map results of the study of the three issues for Paris and the inner suburbs. The higher the level of renaturation required, the lower the score (red) ©Institut Paris Region

3.3.4 Protect and restore ecosystems.

Better integration of NBS into planning documents means protecting existing ecosystems. They already play a role as NBS, for conserving biodiversity or adapting to climate change. All ecosystems must be protected, even those of poor ecological status. A degraded ecosystem has a better chance of seeing its functions restored than one that has been destroyed. The increase in knowledge about ecological restoration, the construction of buildings that are more respectful of living organisms, etc. should under no circumstances justify the destruction of existing ecosystems. For example, older trees in urban areas are more effective at providing shade and cooling than younger trees. For the first few years after planting, the survival of young trees depends on water resources. With climate change, mortality rates are increasing. Finally, even if young trees manage to survive, it will take years before they reach the size and cooling efficiency of older trees. For this reason, urban planning documents should first and foremost seek to protect existing trees. In terms of protection, particular attention should be paid to wetlands. Wetlands are among the most vulnerable types of environments in terms of climate change, incurring damage and losing ground faster than any other kind of ecosystem (*IPBES, 2019*). And yet, in both urban and rural areas, wetlands carry out essential natural functions including flood prevention, water purification and carbon storage. The main challenge is preserving existing wetlands and related flood-prone areas (wetland meadows, riparian forests) of all sizes (especially ponds and marshy forests). Local authorities have several tools at their disposal that can be easily deployed to protect ecosystems, nature areas in urban environments, often referred to as "ordinary nature" or more specific areas of nature, such as a square, a pond or a tree. The most common forms of protection are:

- Land acquisition, which involves acquiring land to protect it. It is often used in areas threatened by urbanisation.
- Laws or regulatory requirements, which provide a framework for or prohibit human activities that could harm fauna, flora and ecosystems (e.g. biotope protection orders, biological reserves, classified sites, PLU regulations).
- Contractual protection, which involves delegating the management of an area to a third party for a specific period (management of a natural area e.g. Natura 2000).

When conservation is no longer enough, restoration becomes necessary. Each city has high potential for natural development, provided they can transform impervious surfaces (concrete and asphalt) on a broad scale. This would constitute a significant asset in terms of carbon capture and storage, restoring water cycles, reducing urban heat islands and increasing green surface area as a whole. Renaturing sealed areas makes it possible to adapt cities to climate change and to make them more permeable to wildlife by developing nature-based solutions. Such approaches have already been adopted by municipalities. For instance, the Wallon government in 2021 launched a call for projects for the creation of urban parks. Projects in seventeen towns were earmarked and will share a budget of 12.1 million euros to create 45 hectares of new green spaces after desealing. In Flanders, the government financed some twenty “experimental desealing gardens” as part of a call for projects in 2019. The funding (5 million euros) was set aside for the removal of concrete, asphalt and certain buildings and the landscaping of the freed-up space. More recently, the Île-de-France region has made renaturation a fully-fledged objective of its climate change adaptation plan. In 2022, the region set up a new agency (*Île-de-France Nature*) to achieve its objectives: depaving 5,000 ha by 2030 and financing renaturing projects in 145 cities identified as a priority using the method developed in the REGREEN project (Case study 9).

Urban planning documents can be powerful tools for the widespread deployment of this type of NBS, by setting quantitative targets as well as by targeting specific areas thanks to governmental zoning,

private easements, and restrictive covenants. In terms of adaptation to climate change, renaturing can target several trajectories depending on the area concerned to respond to one or more types of vulnerability that have been identified. Several types of recommendations can be formulated, for example:

- Restoring and remeandering urban rivers and renaturing riverbanks.
- Restoring floodplains and other buffer zones to cope with overflow (wetland meadows, networks of ponds, lakes, alluvial woodland).
- Increasing the number of alternative rainwater management systems in previously sealed areas (floodable gardens and parks, networks of ponds, lakes, rain gardens, planted swales, etc.).
- Increasing the density of tree and plant cover in paved streets, in popular public squares and along roads.
- Create a canopy capable of providing shade and promoting evapotranspiration to reduce the UHI effect.
- Use species able to fix atmospheric pollutants to improve air quality.
- Extending a biodiversity reservoir, a patch or an area of ecological interest whose size is considered insufficient.
- Re-establishing connections between existing biodiversity patches and reservoirs.
- (Re)creating a habitat or ecological niche for fragile species in urban environments or a community of target species.

Case study 10

The city of Bonnelles protects its wetlands (France, Île-de-France)

In the 1990s, a 22-hectare wetland was threatened by an urban project. To protect this environment, the city of Bonnelles had the site classified as a regional nature reserve with the help of its regional natural park (Parc Naturel Régional de la Haute Valée de Chevreuse). This French protection tool, which is also used in other European countries, corresponds to wilderness areas (IUCN category Ib). It is one of the highest categories of protected area. Between 1990 and 2007, the city and the regional natural park carried out several ecological restoration projects. The city is continuing its policy of preserving the site: wet meadows have been purchased and incorporated into the existing Nature Reserve. This extension will further diversify existing habitats, plants, and animals. The city of Bonnelle is also running a range of projects to raise awareness among the local population of the importance of preserving these ecosystems in order to mitigate and adapt to climate change.

Access to the Bonnelles regional nature reserve, and actions to maintain the habitats and species living there, are governed by a management plan which is overseen by an official from the regional natural park ©Jonathan Flandin

Case study 11

Muttersholtz, where dialogue and law support nature (France, Grand-Est)

The local development plan for the village of Muttersholtz was very closely aligned with the regional green and blue corridor. Zoning and regulation have used every tool available to make the area more accessible to nature: a total ban on building in biodiversity reservoirs, no backfilling in any agricultural or nature areas, a 6m margin between all water courses and construction within the village, classification of riverside woodlands as wooded areas, and the creation of special plots to extend ecological corridors, particularly in cereal-growing areas. This regulatory protection derives from a concerted dialogue and direct interaction with landowners and farmers.

A grassland corridor in the cereal plain protected in the Muttersholtz local urban development plan ©Ville de Muttersholtz

Case study 12

The protection of the forests around the city of Strasbourg (France, Grand-Est)

In 2020, the city of Strasbourg has redefined its priorities into its planning document in terms of protecting and restoring nature in order to meet the challenges of adapting to climate change and the social demand for more nature (increased following Covid-19). The new priorities are:

- Protecting and transforming the green belt into a climate buffer.
- Increasing the number of projects of depaving and renaturing public spaces, particularly school yards.
- Increasing the number of green spaces and developing NBS in deprived neighbourhoods.
- Continuing the canopy plan. Its first objective is to protect the existing tree heritage, then to increase the number of trees by planting 10,000 trees by 2030, and to improve the ecological management of trees.

To date, the city of Strasbourg has succeeded in protecting nearly 3,000 ha of natural areas and has 3 national nature reserves (wilderness areas, IUCN category Ib):

1. The reserve of Rohrschollen Island (protected in 1997). Its protection aims to preserve one of the last alluvial forests, a rare and declining habitat throughout Europe. The City of Strasbourg is participating in a project to restore Rhine alluvial habitats on Rohrschollen Island, which is funded as part of the LIFE+ Nature program.

2. The reserve of Neuhof-Illkirch Forest (protected in 2012). The forest covers 945 ha and forms a green belt around the city. Its proximity to the city makes it a preferred recreational space for its residents, with 200,000 visitors each year. Faced with this high usage, a consultation process with residents was initiated in 2019 to revise the traffic plan within the reserve and enhance the preservation of these alluvial forests. The new traffic plan includes measures such as depaving and the renaturing of 8.5 kilometers of trails now closed to the public. This project allows to create 55,000 square meters for wildlife (a 20% increase).

3. The reserve of Robertsau and Wantzenau forest (protected in 2020). This is a 493-ha forest located to the north of the city. In 2011, the City of Strasbourg purchased approximately 34 ha of land on the edge of the forest that were being used for monoculture of corn. 3 hectares have been restored as wetland areas, and 30 hectares are now grazed or mowed.

Restoration of habitat dynamics at the of Rohrschollen Island reserve ©Gwendoline Grandin

Case study 13

Fight against urban heat islands (France, Auvergne Rhône-Alpes)

The Metropolis of Lyon has a long history of associating its climate initiatives with the role of trees and nature across its cityscape. In its "*Climate Plan*" and in its major urban planning document, the Metropolis has set ambitious targets for protecting existing trees and increasing the amount of public and private space shaded by trees. This is one way to meet the urban heat islands challenge. Trees will be planted on a massive scale thanks to the efforts of more than 120 public, private and voluntary organisations working together under the "*Tree Charter*". By 2030, an additional 300,000 trees should increase the proportion of the city covered by shade from 27% to 30%. But trees have another essential quality to reduce temperature: evapotranspiration. Evapotranspiration cools the ambient air, provided that the plants have water reserves in the soil. The Metropolis is also working to depave urban spaces and to store rainwater. It is also carrying out cutting-edge research to measure and qualify the capacity of trees to provide cooling service to citizens. The current climate is characterised by a high degree of uncertainty as to how trees will react to rapid changes in temperature, rainfall and the range of animal and plant species with which they interact. This is why the Metropolis is betting on diversity by broadening and varying the species of trees planted.

Redevelopment of rue Garibaldi includes monitoring to gauge the capacity of trees to offset heat islands via evapotranspiration © Laura Albaric

Case study 14

Stream restoration in the "Ruhr Metropolitan Area" (Germany, North Rhine-Westphalia)

The Emscher restoration is a large-scale restoration project in the "Ruhr Metropolitan Area" in the federal state of North Rhine-Westphalia, Western Germany. This area is one of the densest urban agglomerations in Europe. In a 30-year project that started in 1990, the Emscher River and its tributaries are re-converted from highly modified open wastewater channels with concrete beds into near natural stream systems. For this, an underground sewer network of 423 km length is constructed to separate waste and river water. Subsequently, the concrete shells are removed, the channelization reversed, stream profiles widened, and secondary floodplains created.

The restoration process aimed to deal with the impacts of climate change by harnessing ecosystem services to offer buffers against floods and dry periods. The project enhanced both the quality of life in the Ruhr metropolitan area and the resilience of the area to climate change impacts (Gerner et al., 2018).

Comparison between an unrestored (left) and a restored section (right) ©Dortmund Aplerbeck, source: Emschergenossenschaft).

Case study 15

A gradual restoration of a 60-hectare floodplain to help manage flooding in Agglopolys (France, Centre Val-De-Loire).

In keeping with its flood risk prevention plan, for almost seventeen years Agglopolys, the *communauté d'agglomération* (area council) of Blois, has been recreating a floodplain for the River Loire in a district called La Bouillie. Located on the south bank of the Loire, the 60-hectare district is being gradually de-urbanised. A *zone d'aménagement différé* (gradual development zone) has been designated, giving Agglopolys the opportunity to purchase buildings and houses on sale before demolishing them so that the sites can be restored.

Since 2004, 132 buildings have been purchased and demolished out of 143 that have been identified. Various surveys carried out on the area's history, landscape, ecology, hydrology, etc. have made it possible to plan La Bouillie's future use. As well as managing river flooding, the project aims to restore functional natural areas (shrubland, meadows, hedgerows, wetlands) and agricultural areas (farms, public or non-profit orchards, allotments). The new area will also be an attractive place to walk, reconnecting residents with the River Loire, the River Cosson and the forest of Russy. Far from being set in stone, this programme forms the basis for debates and discussions to which all local stakeholders can contribute. Workshops and public consultations were held in 2021 to improve participation and encourage ownership by the local community.

The La Bouillie district to be de-urbanised in order to restore a floodplain. © Agglopolys

3.3.5 Requiring construction projects to incorporate NBS

ECO-SPATIAL INDICES

A number of eco-spatial indices have been developed in several cities (Hirst et al., 2008). First introduced in Berlin in 1994, the green factor is now one of the most widely adopted policy tools for urban greening and has been implemented in Seattle, Hamburg, Southampton and Stockholm. Most of them express a ratio between the surface area covered by greenery, open water, permeable paving, rainwater infiltration facilities, etc. and the total surface area of the site. These tools encourage the maintenance of a percentage of vegetation in the project and can vary from one urban area to another, depending on the issues identified in the planning documents and the political will.

Cities adapt the green factor system to give different values to specific types of green space, for example by giving a higher value to ponds and rainwater run-off areas in poorly drained neighborhoods (Figure 6). In France, many towns and cities are now applying this type of tool in their “Plan local d’Urbanisme” (local urban development plan) to encourage the retention of green spaces, particularly in peri-urban areas. From the point of view of maintaining open land, these tools are not all equally effective. While some encourage the conservation of open spaces as a priority (such as the RBVA), others are more flexible, allowing open spaces to be replaced by eco-developable areas on the building or on the slab, or both, depending on the location of the project.

Like all urban planning tools, they are highly dependent on political will and trade-offs. The level of ambition given to these indices is sometimes based on arbitrary decisions taken by planners. In a study of 18 residential neighbourhoods in Poland (Szulczewska et al, 2014), researchers suggest that a minimum of 45% of areas covered by open vegetation is necessary to ensure environmental stability on this scale (RBVA index). An American study (Cox and al. 2017) specifies that a minimum of 30% of areas covered by vegetation or water, within a radius of 250m of dwellings, makes it possible to improve the health of residents and limit the decline in biodiversity. These indices, which should be taken as indicative, can nevertheless be used as a framework for integrating nature into developments, and can be applied by means of a full-ground coefficient to encourage developers to voluntarily maintain a ratio of built to unbuilt space that is favourable to nature areas. While green roofs and façades are useful and beneficial in many respects, they can never replace open spaces.

1. A bird box for every apartment
2. A biotope for specified insects in the courtyard (water striders and other aquatic insects in the pond).
3. Bat boxes in the courtyard.
4. No surfaces in the courtyard are sealed, and all surfaces are permeable to water.
5. All non-paved surfaces within the courtyard have sufficient soil depth and quality for growing vegetables.
6. The courtyard includes a rustic garden with different sections.
7. All walls, where possible, are covered with climbing plants.
8. There is 1 m² of pond area for every 5 m² of hard-surface area in the courtyard.
9. The vegetation in the courtyard is selected to be nectar rich and provide a variety of food for butterflies (a so-called 'butterfly restaurant').
10. No more than five trees or shrubs of the same species.
11. The biotopes within the courtyard are all designed to be moist.
12. The biotopes within the courtyard are all designed to be dry.
13. The biotopes within the courtyard are all designed to be semi-natural.
14. All stormwater flows for at least 10 m on the surface of the ground before it is diverted into pipes.
15. The courtyard is green, but there are no mown lawns.
16. All rainwater from buildings and hard surfaces in the courtyard is collected and used for irrigation.
17. All plants have some household use.
18. There are frog habitats within the courtyard as well as space for frogs to hibernate.
19. In the courtyard, there is at least 5 m² of conservatory or greenhouse for each apartment.
20. There is food for birds throughout the year within the courtyard.
21. There are at least two different old-crop varieties of fruits and berries for every 100 m² of courtyard.
22. The façades of the buildings have swallow nesting facilities.
23. The whole courtyard is used for the cultivation of vegetables, fruit and berries.
24. The developers liaise with ecological experts.
25. Greywater is treated in the courtyard and re-used.
26. All biodegradable household and garden waste is composted.
27. Only recycled construction materials are used in the courtyard.
28. Each apartment has at least 2 m² of built-in growing plots or flower boxes on the balcony.
29. At least half the courtyard area consists of water.
30. The courtyard has a certain colour (and texture) as the theme.
31. All the trees and bushes in the courtyard bear fruit and berries.
32. The courtyard has trimmed and shaped plants as its theme.
33. A section of the courtyard is left for natural succession (that is, to naturally grow and regenerate).
34. There are at least 50 flowering Swedish wild herbs within the courtyard.
35. All the buildings have green roofs.

Figure 11: Factors currently used by cities that have been listed by the GRaBS project co-financed by the European Union European Regional Development Fund and INTERREG IVC Programme ©Figure adapted from GRaBs project [23]

Case study 16

The Malmö Green Factor (Sweden, Scania)

The city of Malmö, Sweden, is often cited as an example of a city where green planning tools have been successfully used in new developments, in particular the Malmö Green Factor (an innovative way of calculating green space requirements for new developments) and the Green Point System (a checklist of green and blue infrastructure options that developers can use to achieve a minimum level of green/blue space), implemented in the Västra Hamnen district of Malmö. From the outset, each building was required to meet a green space factor, in line with the city's policy requiring each development to set aside a proportion of its footprint as green space, and initially awarding biodiversity bonus points for everything from large fruit trees and potted plants by the roadside, to bird boxes and ponds. In this part of Malmö, there are no fences around homes or parks, allowing small wildlife to circulate.

Canal-side flats in the Västra Hamnen district of Malmö, Sweden, where town planners have required all apartment blocks to comply with a "green space factor" © Marc Barra

DESIGNING GREEN ROOFS AND GREEN WALLS AS NBS

Green roofs and walls are becoming increasingly popular; they allow cities to reduce the effects of urban heat islands, to improve rainwater management, as well as creating new habitats and natural environments for biodiversity. Eco-spatial indices in planning documents are powerful tools for their deployment. However, to ensure they engender positive effects for climate and biodiversity, green roofs, and walls must be specifically designed.

In France and Europe, most green roofs are made from thin pozzolan (no greater than 15 cm, generally between 5 and 8 cm) with Sedum species. These types of roofs have become popular because they are lightweight, easy to install, inexpensive and low-maintenance.

The prevalence of “ready-to-use” extensive green roofs has been criticised by landscape designers and ecologists alike, who saw this standardisation as leading to a lack of coherence with respect to the local context, an erosion of expertise (which was nonetheless highly diversified in this area) and an insufficient use of ecological skills (in botany, urban ecology and soil ecology) required in the framework of any urban nature policy. Moreover, their benefits for biodiversity have not been proven, just as for the other benefits often cited, such as rainwater retention water retention, air quality, CO_2 capture, quality of life.

Between 2017 and 2019, the GROOVES study (Green ROOfs Verified Ecosystem Services) studied 36 green roofs in the Paris Region to assess the benefits of these new urban ecosystems [24]. The objective was to provide new scientific insights as well as guidelines on the design and management of green roofs. Four categories of green roofs have been studied: extensive roofs (0 - 15 cm soil depth), semi-intensive roofs (15 - 30 cm), intensive roofs (over 30 cm) and "wildroofs". This fourth type denotes non-planted roofs on which plants grow spontaneously. The study assessed several parameters including flora, fauna, fungi, soil bacteria and other ecological functions.

Some planting systems decay and can leave traces behind. Avoiding the use of plastics is more essential than ever in the design of green roofs. © Marc Barra, ARB îdF

What can we learn from the study? How can green roofs be improved? Clearly, we cannot expect green roofs to provide the whole range of ecosystem services at the same time, be it in terms of biodiversity, rainwater management, urban cooling, or pollination. It is, however, possible to design and manage them in such a way as to optimise some of their functions, depending on their location and the goals set by local authorities.

The observations made during the project also showed that some design approaches rely on a lot of man-made components (plastic geotextile planters, non-biodegradable membranes or felt, plastic netting, built-in watering systems, etc.) whose usefulness is questionable. Of the 36 roofs studied, 13 do not include man-made components, which confirms that it is possible to restrict the use of potentially energy-guzzling manufactured materials that can leave lasting traces: significant amount of plastic debris has been observed left behind when systems deteriorate, sometimes on very recent roofs. This aspect must not be neglected, especially as these man-made components add to the cost of green roofs. The way plants are packaged also involves industrial processes that tend to standardise products for sale (e.g. plants packed in pot trays or sold as regrown rolls). New design approaches inspired by landscaping techniques and ecological engineering could be applied: creating dry grassland, meadows, or sandy environments, choosing local species adapted to climate conditions, planting wild seeds collected nearby, etc. Finally, "wild roofs" require no planting at all: plants grow on them spontaneously from seed carried by the wind or by animals [25].

As is often the case in ecology, there is no "perfect recipe", but recommendations vary according to the group of species under consideration, the criteria under analysis, the geographical location, and so on. Where substrate depth is concerned, we see that plant diversity stops increasing when the soil is about 30 cm deep, while pollinator diversity continues to increase beyond that threshold. "Mixed" or "agricultural" substrate about 30 cm deep containing at least 10% clay and 60% sand will be more likely to support varied flora and more able to retain rainwater [21].

Results and recommendations from the GROOVES study [21; 22]

1. When soil depth exceeds 25 cm floristic diversity no longer increases whereas pollinator diversity continues to rise.
2. Roofs made up of “agricultural” and “mixed” substrates can store more water than roofs with “mineral” substrates.
3. Observations show that, on a single roof, evapotranspiration can be 6 times greater with more abundant vegetation.
4. While roofs can help with cooling, their efficiency will be very limited during heatwaves with very low rainfall.
5. I suggest that for high water retention capacity the threshold substrate depth is about 30 cm, and between 10 and 30 cm for average water retention.
6. It is possible to plant nothing and allow spontaneous vegetation to establish itself (wildroofs).
7. To reduce the ecological footprint created by materials, it is necessary to adopt a low-tech approach at the design stage to limit the number of artificial components (geotextile membranes, plastic trays, etc.).
8. Items can be placed on the roof to create extra habitats for species: piles of rocks, dead wood, a pond, etc.
9. For planted roofs, opt for local plant varieties from trusted suppliers, it is also possible to collect wild seeds from neighbouring environments.
10. It is advisable to vary substrate depth on a roof to create different conditions for living organisms. By the same token, the diversification of plant strata (moss layer, herbaceous layer, shrubs or even trees) is a sign of quality.
11. Plan for maintenance in the design: over-frequent maintenance can adversely affect biodiversity (through cutting, mowing, trampling, etc.). One or two simple annual checks are usually enough (to get rid of undesirable woody plants and rubbish). If the roof is accessible to the public, include footpaths and “keep off” areas.
12. Avoid the use of pre-grown systems (trays, rolls, etc.). Instead, plant plugs or sow seeds and define your own floristic composition.
13. Avoid using imported agricultural soil. Opt for a substrate comprising recycled materials (crushed brick, compost, excavated soils).
14. If the roof is uncultivated, it is not necessary to include a watering system (even if the roof changes with the seasons!).
15. Green roofs are dynamic ecosystems whose vegetation is likely to change over time. This is an inevitable natural process that forms part of the life of the roof. It is not necessary to seek to maintain the initial palette of plants.
16. On the scale of a town or city, it is preferable to have a varied range of green roof designs. Climbing plants can be used to connect the green roof with the ground.

Figure 12: Results and recommendations from the GROOVES study [21; 22]

Case study 17

Ecological engineering used for greening a roof in Boulogne Billancourt (France, Île-de-France)

Built in 2014 and designed by architects Chartier-Dalix, the Ecole des Sciences et de la Biodiversité in Boulogne-Billancourt is one of the most successful examples of green architecture in the Paris Region. Its single tiered façade and its living roof are the result of a partnership between the architects and the ecologist Aurélien Huguet. The depth of the roof substrate varies between 30 cm and 1 m, making it possible to create a range of habitats from a meadow to an urban "micro-forest". In 2020 the architects decided to renovate the meadow to increase its potential for biodiversity using ecological engineering techniques. The main aim was to increase the diversity of perennial flowering local species typical of old meadows. The project team identified areas of dry grassland in the park of Marly-le-Roi. With the agreement of the park authorities, a plot was identified as an "ideal donor" due to its exceptional floristic diversity and compatibility with conditions on the roof in Boulogne. In June and July, seeds were collected by hand from the earliest flowering species (meadow sage, erect brome, quaking grass) before the area was entirely hand mown. The harvested seeds and hay were spread out on the rooftop. The operation was monitored to evaluate its success and to fine-tune practices where necessary. One year later, floristic evolution indices showed the appearance of eleven flower species from the donor meadow, as well as several new insect species.

The Ecole de Sciences et de la Biodiversity in Boulogne-Billancourt. ©GROOVES Study

Like roofs, walls and façades represent additional surfaces for urban vegetation. Here again, the ecological quality will depend on the choice of plants and the design. Green walls are becoming increasingly common in cities but are raising questions among ecologists. While they provide aesthetic advantages, some of them are complex installations which require multiple supports (metal cladding, integrated irrigation system, artificial substrate) and large quantities of resources (water, inputs, plant renewal). In most cases, it's preferable (and often much cheaper) to use climbing plants [26].

As well as being easy to install, climbing plants create a microclimate near walls that regulates temperature and relative humidity, helping to reduce the heat island effect in summer. They are a refuge and source of food for many wild pollinators. They are often mistakenly thought to damage walls, when in fact they prevent ultraviolet rays, rain and atmospheric pollutants from reaching the wall directly, thus protecting the materials from physical and chemical erosion. Installation is relatively simple:

- Provide areas of open ground at the foot of the buildings where the vegetation will be planted;
- Choose plant species suited to the local climate (avoid irrigation outside the plant installation period);
- It is possible to create a ground-to-roof continuum with cables or wires stretched along the walls, between the ground and the roof.

Climbing plants (right), are hardier and less expensive to maintain than artificial walls ©left, Marc Marra ©right, Aurore Micand, Plante&Cité

Case study 18

The "greening walls" initiative of the city of Lille (France, Hauts-de-France)

The "greening walls" initiative was launched in 2003 by the city of Lille. It enables residents to plant their walls free of charge. The city takes care of the administrative formalities required to obtain the necessary permits and pays for the digging of the pit in the pavement at the foot of the façades. In some cases, the city of Lille authority will supply the seeds or climbing plants. Public buildings are also taking part in the "Greening Walls" initiative. In 2019, 400 pavement pits to green the walls were completed.

Examples of green façades in Lille (Exemples de façades végétalisées à Lille) ©Gilles Lecuir

Many cities have produced guides for greening façades, roofs, wall footings, pavements, and tree roots. These guides include lists of suitable local plants, examples and advice (e.g. choice of materials for support structures, how to plant).

- Greening guides for façades, roofs, wall footings, pavements and tree roots - Eurométropole Strasbourg (67): https://www.nature-en-ville.com/ressources/guide-de-vegetalisation-facades-toitures-pieds-de-murs-trottoirs-et-pieds-darbres
- Guide to greening the foot of façades - city of Lille: https://www.adu-lille-metropole.org/wp-content/uploads/2021/05/cahier5verdissement.pdf
- Guides to greening roofs and walls - City of Paris: https://www.paris.fr/pages/la-vegetalisation-du-bati-21439

RAINWATER MANAGEMENT AND SUSTAINABLE URBAN DRAINAGE SYSTEMS (SUDS)

Soil and surfaces in urban areas are often highly mineralised, preventing the natural flow of water cycles. Channelling and management of water also leads to vast infrastructure costs for local councils. Natural soils and vegetation help limit the harmful effects caused by extreme phenomena such as flooding; by intercepting water on the surface of the leaves, plants reduce the quantities of water that reach the soil. More and more local councils are opting for solutions that limit soil compacting and the use of impervious ground surfaces. Conventional rainwater management techniques (grey infrastructure) are gradually being replaced by so-called alternative techniques inspired by natural systems to encourage infiltration and water purification on the plot. Most of the sustainable urban drainage systems can be described as NBS.

These alternative techniques can be applied on all scales: green spaces, parks and gardens, woodland, but also all wetlands and water sources: ponds and rain gardens, urban rivers and associated environments (riparian vegetation, flood expansion zones). This also includes planted ditches along roadsides and buildings. Several studies have shown that SUDS have the potential to provide habitat for biodiversity (Barra, 2020). However, specialists have also pointed out the need to improve the design and the management of rainwater systems (improving structural diversity and irregularities on riverbanks, lighter mowing, etc.) so that they have a positive impact on biodiversity (Oertli et al., 2019) and water management. For example, over-intensive management of rainwater systems has a negative effect on biodiversity. Researchers (Vermonden, 2010) suggest drastically reducing management interventions (mowing in particular) to allow the flora to express itself. This also seems to be the case for ditches, which are often intensively managed. In addition, root density and the quantity of biomass are a factor in the effectiveness of water penetration into the soil.

On the left, an intensively managed ditch; on the right, on the right, an example of ecological management
©Marc Barra

Particular attention needs to be paid to the soil when designing the site. It is important to preserve or restore the quality of the soil to ensure good water infiltration and the development of vegetation. During the construction period, it is important to limit soil compaction by avoiding the storage of equipment or moving machinery in the areas provided for rainwater management structures.

Example of a non-functional ditch whose soil was compacted during the development work in the neighbourhood. EcoQuartier Hoche, Nanterre *©Marc Barra*

Drainage pavements or permeable asphalt, which are genuinely useful on certain surfaces to improve stormwater management, can't be described as NBS. Their design approaches rely on a lot of man-made components (plastic, non-biodegradable membranes, concrete slabs, etc.). The same criticisms can be made to grey drainage systems as high-tech green façades, requiring large quantities of resources, industrial processes that tend to standardise products, etc. Their use should be limited to roadways, paths and parking areas whose use is incompatible with permanent planting. Their ability to manage rainwater better than waterproof surfaces should under no circumstances justify their massive development, to the detriment of open-ground areas.

Drainage pavements or permeable asphalt are made of man-made components and can't be considered as NBS ©Commune de Narbonne

Case study 19

Water management: from grey to NBS in the département of Seine-Saint-Denis (France, Île-de-France)

The Seine Saint Denis département has gradually developed alternative rainwater management techniques to replace grey infrastructure. SUDS are integrated right from the design stage of development projects. Storage areas are designed as multifunctional spaces, and water becomes a central element of the development project. For example, green spaces accessible to residents can become a water storage area during a temporary heavy rainfall event. These are floodable gardens. The water level is limited to 50cm for public safety reasons. This technique has been implemented in Stains, as part of the Three Rivers development area.

As well as reducing the risk of flooding, these projects also bring water back to the heart of the city. The Conseil Général de la Seine-Saint-Denis is also carrying out a project to reopen the Vieille Mer river, with the aim of reintegrating the watercourse into the urban environment. The project involves reopening several stretches of the river. Seine-Saint-Denis has also included a rainwater zoning plan in its urban planning documents, defining the areas where SUDS can be developed depending on the characteristics of the soil and subsoil [27].

One of the rainwater management areas in the Trois Rivières district of Stains ©Atelier de l'Île

Case study 20

Diverse types of SUDs to manage rainwater in the Haute Deûle district of Lille (France, Hauts-de-France)

The city of Lille uses planning documents to deploy NBS and improve stormwater management. For example, its Local Urban Development Plan sets out several guidelines and objectives for the development of an "eco-district" (*écoquartier de la Haute Deûle*):

- Creating a new district considering ecological connectivity issues and restoring biodiversity by targeting specific species.
- Creating a district adapted to climate challenges (water management and urban heat islands)
- Improving the quality of the water in the Deûle (river).

The Haute Deûle eco-district includes several types of SUDS, including: an 8,500m² water garden designed with diverse types of habitats for biodiversity and a network of vegetated ditches, designed with a range of wetland vegetation to support entomofauna (sedges, purple loosestrife, meadowsweet, willows, alders, etc.). SUDs were designed by ecologists to make them effective for biodiversity. At the same time, waterproofed surfaces are reduced as much as possible. The pedestrian walkways are made of unjointed cobblestones. The project has preserved an existing woodland to maximise rainwater infiltration. A raised wooden path has been installed in the woodland to allow residents to walk around without damaging the ground and plants. Various sensors have been installed at different points on the site (ditches, rain gardens, near trees and mineral areas) to measure climatic data, water quality in the vegetated rafts, and the passage of certain species (chiropterans, orthopterans, soon avifauna). These sensors will be used to assess the effectiveness of the SUDS with a view to improving their design and management.

One of the ditch networks designed with wetland plants ©Atelier de paysages Bruel Delmar

3.3.6 Raising awareness and community engagement

Planning in sectoral silos is a well-known problem, negatively impacting any possible confluence of actions toward NBS integration and implementation. However, a constellation of national and international plans including NBS, combined with the development of cross-cutting policies and plans, and an increasing interest from the municipalities and citizens, offers a potential enabling environment for NBS integration in urban policies. In addtion, NBS are a challenge to plan and implement in cities due to their systemic nature. They require the inclusion of multiple actors' perspectives, knowledge, and expertise, as well as acceptance by various groups (Frantzeskaki et al. 2020). A way forward to a more inclusive governance of NBS across all identified considerations (cross-sectoral, multi-species, epistemic, spatial and inter/intragenerational) is to take an intersectional approach to identify, engage, co-design, and co-create as well as empower communities to connect with NBS when in place (Frantzeskaki et al. 2023). In addition, there needs to be better transdisciplinary links between research scientists and urban planning and design and other professionals to ensure that NBS are prioritised in urban planning and design (Heymans et al., 2019).

Enhancing NBS in cities also requires major changes in vision and approaches to traditional urban planning. Training stakeholders in novel ecological practices is thus a crucial step in the process of mainstreaming NBSs. It is a good opportunity to redefine the concept as it remains open to different interpretations. The aim is to enable participants to understand the complexities of nature-based solutions, identify how they can be applied in different settings and the various approaches it encompasses. During the REGREEN project, two training workshops were carried out in the city of Aarhus and Velika Gorica. Feedback from the participants highlighted the importance in such training to share a common language about nature-based solutions, to convince people about their benefits, and to constitute a team to improve their implementation. Training workshops are an opportunity to share scientific arguments to convince reluctant people about the benefits and interest of NBS. Training helps to reduce fears and receive ideas currently related to the idea of bringing back nature to the city or giving it more space [28].

However, NBS implementation also depends on the governance framework - that is, the contextual pre-conditions, policy processes and institutions that proved helpful or even essential for the initiation, planning, design and implementation of NBS (Martin et al., 2020). Drawing from 3 case studies in Nocera Inferiore (Italy), Munich (Germany) and Wolong (China), some researchers have identified key governance enablers of successful NBS (Martin et al., 2020). The results show that the most critical enablers involving governance innovation are: polycentric governance (novel arrangements in the public administration that involved multiple institutional scales and/or sectors), NBS co-design (innovative participatory processes) and financial incentives.

A piece of work carried out as part of the REGREEN (Petersen et al. 2023) project has found similar results by evaluating innovative policy for NBS from the 3 European ULLs (Île-de-France / France, the city of Aarhus / Denmark, and the city of Velika Gorica / Croatia). The researchers highlighted several conditions for successful NBS implementation:

- openness to transversal and collaborative working with stakeholders especially with those who are likely to use and maintain the green / blue spaces.
- exposure to examples of NBS implementation and innovation elsewhere.
- the existence of a policy champion / entrepreneur (e.g. within local government) with the ability to influence policy and / or implementation.
- the involvement of boundary actors with expertise and ability to play a coordination and advisory role.
- the existence of an external policy driver having tangible effects locally combined with public awareness around this – either gradual (climate heat effects) or sudden (e.g. flooding event) – as is likely to accelerate and release funding for NBS.

- willingness to engage with / appeal strategically with regard to external policy drivers e.g. climate adaptation; health.
- coherence of NBS initiative with existing / planned government strategy - especially as this tends to be linked to availability of funding.
- adequate enforcement of targets and regulations for green space to combat the pressure of urban development.
- availability of funding (preferably strategic and long-term).

Case study 21

Improve the dialogue in municipalities between politicians, urban planners and citizens thanks to interactive walkable floor maps

The dynamic of interactive walkable floor maps approach is part of the REGREEN project [29]. The floor maps consist of very large aerial photos or very high-resolution satellite images (with a ground resolution of 20 to 30 cm per pixel; which corresponds to a scale of approximately 1:1500 to 1:2000), printed onto a flexible and durable background (either fixed to the floor or rollable for easy storage). These were produced with most recent remote sensing data and show individual features such as houses, streets and trees. The maps present a static view of a study area at a certain point in time. However, these maps can be made dynamic through the use of overlays. These may be QR codes linking to information on a website, transparencies of planning processes, photos, drawings and sketches and other ways of illustrating information (e.g., sticky notes; photo elicitation) that tell stories about present and planned activities relating to NBS.
The joint idea of floor maps is to improve transversal and collaborative working, provide a new tool for democratic and experiential governance, as well as for education and awareness raising among participants, and scaffolding transitions towards adoption of NBS in cities [30].

Participants interacting with the walkable floor map in Velika Gorica, Croatia, September 2022 ©Carolyn Petersen

During the REGREEN project, walkable floor map Policy Workshops were developed among the 3 EU ULLs as a way of engaging policy makers in policy learning towards NBS innovation in their local context. Participants were asked to:

- describe and critique the current situation of NBS implementation, including barriers and governance aspects;

- imagine what their preferred future NBS implementation could look like without the current constraints;
- explore the obstacles and constraints involved as well as ways of getting to that situation.

The data about the workshop processes demonstrates the value of providing opportunities for dialogue and social interaction (involving experts, stakeholders and local citizens) in which all three types of policy learning may occur, but especially where the dialogue involves potential futures and thinking outside of current limitations (e.g., talking about future visions). Implementation of Policy Workshops using walkable floor maps facilitated policy learning and reflections on institutional practices through group discussion and experience sharing amongst the participating policy makers. The walkable floor maps were found to add greater spatial contextualisation and locally grounded policy learning. The futures workshop elements facilitated discussions of future opportunities and barriers. These methods together led to the questioning of common approaches and assumptions and 'thinking outside of the box' and produced both comparative and nuanced results.

Case study 22

Saint-Paul: restoring nature to build resilience (France, Réunion)

With its diverse natural habitats and native species, Saint-Paul on Réunion island is on the front line when it comes to climate change. Coastal erosion and the risk of coastal flooding, pollution of the lagoon, coral dieback... That's why the city included the project to protect and restore Hermitage beach (the island's busiest seaside resort) in its local urban development plan and its *Air Energy Climate Plan*. Protecting the beach and restoring its ecological functions should help to protect the coast from the risk of marine submersion, exacerbated by climate change. Another objective is to preserve the reef, which has been greatly weakened by warmer water (coral bleaching). The city council worked with tourism professionals to rethink the natural infrastructure to balance leisure activities with ecological functioning. A public consultation was launched to respond to the expectations of the population. Surveys were also carried out on the beach to inform residents and raise their awareness of the project. The traffic and parking pattern has been modified to reduce the impact. Motorised traffic has been greatly reduced and parking spaces have been moved further away from the beach. Paths have been created to channel user traffic and reduce the impact of human activities on the environment. In addition, an experimental mangrove was established to act as a buffer in the event of storm surges coinciding with heavy rain, which could lead to significant runoff. The city has also carried out work to restore the backshore: planting shrubs and diversifying the mono specific Filaos woodland to limit the spread of diseases that attack Filaos.

Discovery walks: a group of users walked along the Hermitage beach to find out about the effects of erosion and ask questions about the project to restore and enhance the beach. ©L'Hermitage Nout plage i refé

Case study 23

Raising awareness in the urban community of Marne et Gondoire (France, Île-de-France)

The urban community of Marne et Gondoire is busy awareness raising and encouraging resident participation. As a prime example, in 2013 it produced an educational kit on farming for schools. This helped teachers educate pupils aged 6 – 11 about growing food. More widely, within the framework of its regional climate-air-energy Plan, the community formed a citizen's body to jointly devise its strategy and plan of action. This "climate club" has brought together over 150 volunteers who work within a framework of regular workshops, particularly in connection with biodiversity and nature-based solutions.

Workshop "The Climate Fresco" with the Municipal Council of Children of Bussy-Saint-Georges (Animation « La fresque du Climat » avec le Conseil Municipal des Enfants de Bussy-Saint-Georges). ©CA de Marne et Gondoire

Case study 24

A Climathon organized by the Metropolis of Lille to define pilot projects to improve resilience (France, Hauts-de-France)

In 2019, the Lille European Metropolis (MEL) drew up its *Climate Air Energy Plan* with an extensive public consultation between 2018-2019. Over 1,000 contributions were collected thanks to: an online platform (questionnaire and free contributions); workshops with local authorities and enterprises; 10 workshops with citizens; and a climathon on NBS.

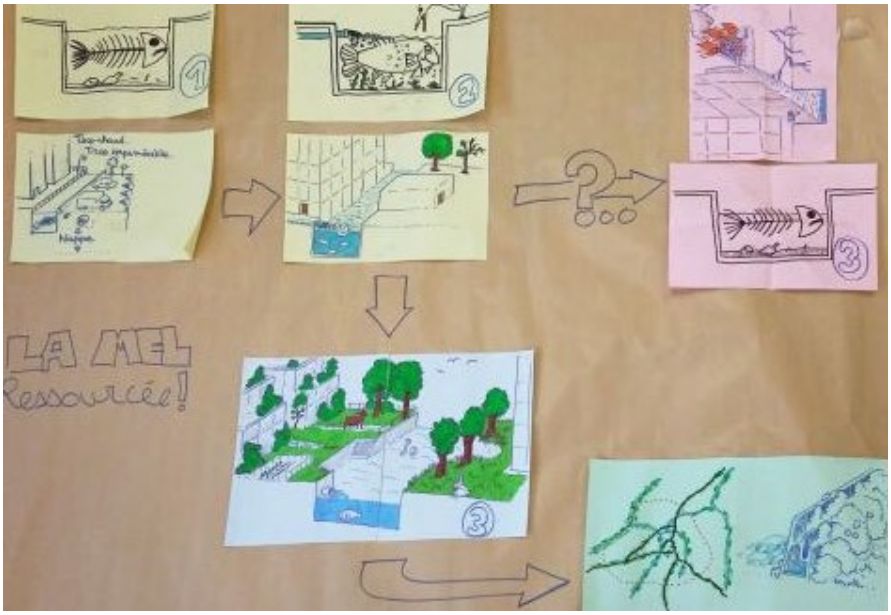
The Climathon: in order to produce the planning document, the Metropolis organised a Climathon bringing together around 60 participants, students, researchers and experts. For a whole day, volunteers were divided into 9 groups to identify concrete solutions to the following question: How can we significantly develop NBS in cities and adapt to climate change? Each group participated in ideation/brainstorming and then prepared a pitch and visual supports to present their ideas. The projects put forward by Climathon participants include ideas for greening streets and buildings, rainwater harvesting, depaving soil, reopening a river and creating a new urban agriculture site.

This Climathon was an opportunity to build a network of experts on nature and water in the city and training participants in NBS. Lastly, the Climathon created materials to feed into the Climate Plan and identified 9 concrete projects to address climate adaptation in the Metropolis [31].

A new governance: The Climate Plan aims to engage stakeholders thanks to a new governance. The Metropolis has therefore set up a *Metropolitan High Council* for Climate (*Haut Conseil métropolitain pour le Climat*), made up of various audit boards representing the main stakeholders:

- Audit board of local authorities, key partners in the implementation of the Climate Plan.
- Audit board of socio-economic stakeholders, whose actions have a decisive impact on the region's greenhouse gas emissions.
- Audit board of experts and scientists, they will develop guidelines and research projects linked to the metropolitan policies on climate-air-energy issues.
- A citizens' audit board.

Together, these audit boards will support the Metropolis in steering and monitoring both the strategy and the action programme of the Climate Plan [32].



Poster of the winner of the Climathon, which proposes to renew the link between the city and water ©Metropolis of Lille

Case study 25

Training of municipal actors in a new form of governance in Besançon (France, Bourogne-Franche-Comté)

The city of Besançon has long been involved in protecting nature. In 2010, Besançon received an award in the French Capital of Biodiversity competition. Since then, the city has amplified its action for nature, with strong political support and the involvement of all of the city's departments. In 2016, the city hired an ecologist as director of the "Green Spaces Department". From then on, a real cultural change took place: the city moved from a traditional approach to protecting and managing green spaces to an ecological approach. All of the Green Spaces Department is trained in ecology and attend naturalist courses. The city's other departments are aware of biodiversity issues and work closely with the Green Spaces Department. In addition, Besançon's actions are based on solid scientific knowledge, close partnerships with the research community and regular biodiversity monitoring. In 2018, the city won the French Award of Biodiversity [33]. Since then, the Green Spaces Department has been renamed the Biodiversity and Green Spaces Department. This change of name clearly demonstrates the cultural shift around nature and biodiversity issues.

In terms of engaging and involving citizens in nature-related issues, the city has set up several initiatives, including participatory nature observatories, participatory budgets, and nature education programmes. One of its key initiatives is the Forest Council, a new form of governance. The City of Besançon owns more than 2,000 hectares of communal forest. In 2017, the city council initiated workshops with residents and forest managers (entitled "Besançon naturellement forestière"). The aim was to share ideas and objectives on the future of the forest. Between 40 and 95 people attended each workshop[34]. At the end of 2018, the workshops led to the drafting of an objectives document and

the creation of the Forest Council. This council is made up of around 30 members and is renewed every 2 years: elected representatives, hunters, timber industry professionals, former foresters, local residents, ecologists, associations, etc. The council has to consider ways of improving forest management (e.g., increasing the number of senescence islands and dead wood on the ground) and to share knowledge with local residents [35].

Consultation with residents - Forest Council ©Besançon Plus Grand

Case study 26

Nature For City LIFE: improve and implement NBS in the Metropolis of Nice Côte d'Azur (France, Provence-Alpes-Côte-d'Azur)

The Nature for city LIFE project aims to strengthen the adaptation of cities to climate change through NBS. The project is supported by the European Union's LIFE programme [36]. The two main objectives of this project are to raise awareness and train the various stakeholders in NBS.

The Metropolis of Nice Côte d'Azure has trained city designers, elected representatives and technicians from the cities of the metropolitan area, as well as developers. Several workshops were held in Nice, Carros and Cagnes-sur-Mer in March 2019. The workshops in Carros and Cagnes-sur-Mer were fieldtrips that addressed the following themes: preserving biodiversity, management and design of green spaces, acceptance of ecological management, stormwater management, etc. The field visits were followed by an indoor workshop to list barriers and opportunities to implement NBS.

Residents were made aware of NBS thanks to workshops organised in March and April 2019. In addition, the Metropolis has created urban walking trails on the theme of "Nature in the city and the climate" and organised events (storytelling walks, exhibitions, etc.) on NBS.

Workshop and field trips for elected representatives and technicians ©Métropole Nice Côtes d'Azur

4 CONCLUSIONS

Urban sprawl is one of the main factors of biodiversity erosion, with the urbanization of agricultural or "natural" land at the forefront. The link between urban sprawl and the destruction of habitats, plants and animals was highlighted again recently by the IPBES [37]. The No Net Land take objective is to come up with new development models that are more respectful of the soil and biodiversity. The implementation of this objective is based on 3 essential conditions: the protection of natural, agricultural and forest areas, the renewal and densification of cities. However, urban densification must not be achieved at the expense of urban green spaces, as they contribute directly to quality of life, biodiversity, and the adaptation of cities to climate change.

The No Net Land take objective raises questions about our ability to be economical with land and materials. In their Manifesto for Happy and Creative Frugality in Architecture and Planning [38], Dominique Gauzin-Müller (architect), Philippe Madec (architect and city planner) and Alain Bornarel (engineer) call for a "low-tech" approach to construction and planning, giving priority to "relevant, appropriate techniques that do not pollute or waste". The 3 authors encourage building and planning professionals to question their practices to limit the effects on the environment, biodiversity, and landscapes. Moreover, ecological issues will only be considered if ecologists are more widely present in local authority and in training courses for engineers, landscape architects and architects.

The frugal approach must therefore remain the watchword in No Net Land take objective but needs to be combined with strong measures to restore artificial areas. Deconstruction and depaving operations, coupled with renaturing initiatives, appear to be priorities for "giving back to nature" the equivalent of the areas consumed. However, renaturing needs to be planned at all scales to strengthen ecological continuity, increase the number and surface area of habitats for biodiversity, and enable the deployment of NBS.

Despite a growth in interest in applying an ecological approach to urban planning and design, particularly over the past thirty years, this has not become mainstream in practice and the negative impacts of urbanisation continue (Heyman et al., 2019). Numbers of local initiatives show a change in attitude towards urban planning by considering biodiversity and climate change issues through NBS. Over the last few years, more municipalities across Europe are slowly transitioning from traditional engineering to a nature-based approach to planning. They rely on NBS to adapt cities to heat and flooding, improve the health of inhabitants or reduce green spaces deprivation. Progressively, green assets are replacing gray infrastructures, wetlands and flood expansion areas are restored for flood management, forests and urban woodlands projects are imagined fighting against summer heat, concrete banks are renatured and finally, there is a growing interest in depaving urban sealed areas. However, these local actions must multiply and be embraced by municipalities. The deployment of NBS is largely driven by opportunity, whereas cities should build a clear roadmap with more regulations and incentives if they want to deploy NBS on a large scale. A recent bibliometric and a content analysis [39] have identified different barriers and enablers to NBS integration into planning documents. Lack of financing models, private land ownership, lack of social acceptance, lack of knowledge, awareness of technical levels and benefits, lack of cooperation between sectors, perceived costs, social inequalities, institutional fragmentation, and inadequate regulations have been regarded as the main barriers. Contrarily, recognized enablers include easy access to policies, good communication, stakeholder engagement, supportive regulations, inclusion of NBS in plans, guidelines and strategies, pilot projects, awareness marketing, involvement of different institutions, financial incentives, and monitoring and evaluation. Other studies [40; 41] have also shown that policy drivers, such as financial incentives, collaboration and communication are major NBS enablers.

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