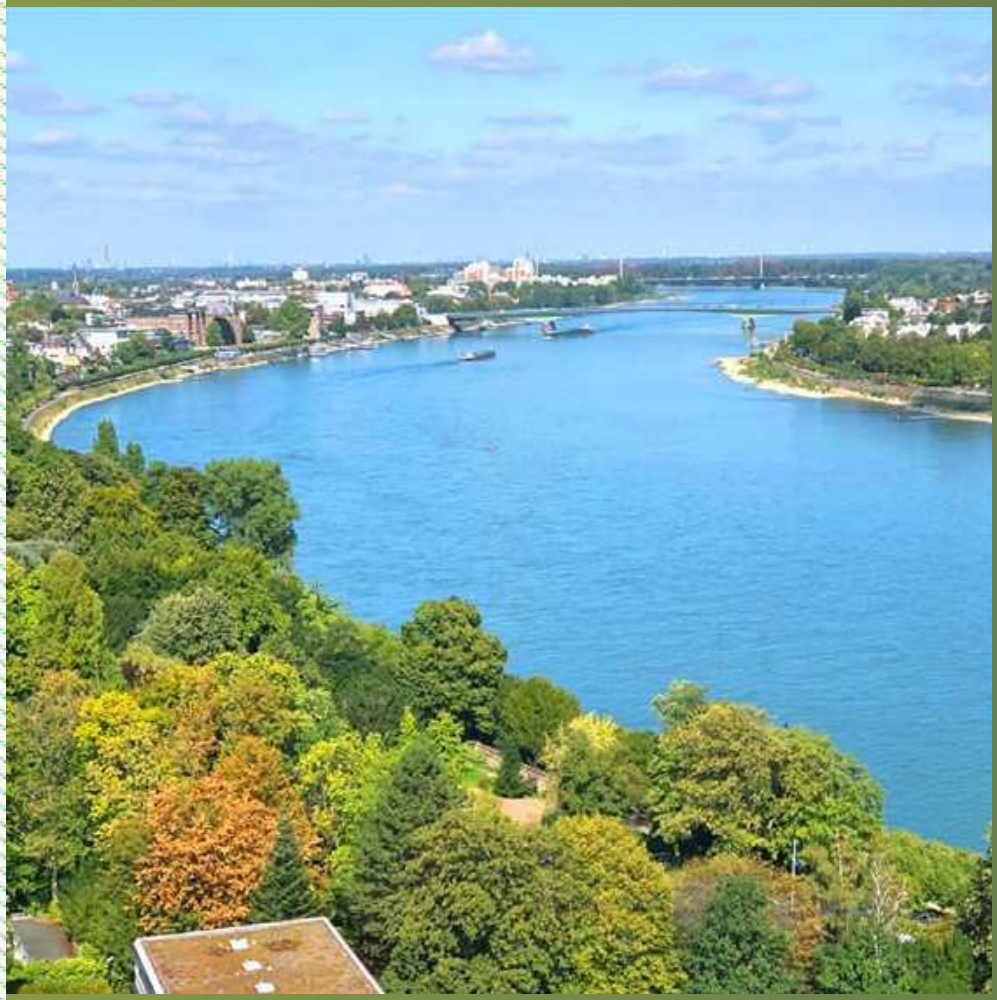
GUIDELINES
FOR URBAN FORESTS AS NATURE-BASED SOLUTIONS



CLEARINGHOUSE
中欧城市森林应对方案

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GUIDELINES FOR URBAN FORESTS AS NATURE-BASED SOLUTIONS (UF-NBS)

SERIES EDITORS
Clive Davies and Rik De Vreese

SECTION EDITORS
Clive Davies, Magdalena Biernacka, Jerylee Wilkes-Allemann, Ivana Zivojinovic

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KEY DEFINITIONS AS USED IN THESE GUIDELINES

Bioremediation: removal of contaminants in the soil and water environment. This process uses living organisms (mainly microorganisms, among them bacteria) that catalyse purification processes, destroying or transforming various pollutants into less harmful forms.

Ecosystem Services (ES): all the benefits people derive from nature. According to the Common International Classification of Ecosystem Services (CICES), they include three groups: provisioning (e.g. genetic materials, wild plants and animals), regulating and maintenance (e.g. climate regulation, mediation of noise, filtration), and cultural (e.g. aesthetic, entertainment, physical use of land) (Haines-Young and Potschin, 2018). The European Commission, Directorate-General for Environment (2015) refer to four services: supporting, regulating, provisioning and cultural.

Green space governance: refers to the management and decision-making processes related to the development, use, and conservation of public and private green spaces, such as gardens, parks, urban forests, and other natural areas. It involves the coordination and collaboration of various stakeholders, including government agencies, non-governmental organisations, community groups, and individuals.

Nature-based Solutions (also written as NbS): Nature-based Solutions (NBS) are defined as "*actions to protect, conserve, restore, sustainably use and manage natural or modified terrestrial, freshwater, coastal and marine ecosystems which address social, economic and environmental challenges effectively and adaptively, while simultaneously providing human well-being, ecosystem services, resilience and biodiversity benefits*" – (UNEP/EA.5/Res.5)

Participation: redistribution of power that enables citizens to be deliberately included in the future.

Rehabilitation: improving natural habitats and functioning of relatively lightly degraded ecosystems.

Remediation: removing pollutants in extremely degraded ecosystems.

Restoration: for strongly degraded ecosystems, biotic and abiotic conditions can be improved by restoration activities in the direction of the natural reference state. It can be part of rehabilitation and is also known as renaturalisation or renaturing.

UF-NBS (also written as UF-NbS): Activities to protect, sustainably manage, and restore natural or modified ecosystems found in urban and peri-urban forests, forested parks, small forests and trees in urban areas. Activities should respond to societal needs, ensuring human well-being and biodiversity.

Urban forestry: the practice of planning and managing urban forests to ensure their health, longevity, and ability to provide ecosystem services now and in the future.

Urban forests (UF): tree-based urban ecosystems that address societal challenges, providing ecosystem services for human well-being and biodiversity benefits. Urban forests include peri-urban and urban forests, forested parks, small woods in urban areas, trees in public and private spaces and associated green spaces.

Urban tree(s): usually long-living woody organisms, including woody shrubs, usually single-stemmed, with the potential to grow at a site in an urban or peri-urban area. This includes roadside trees, trees in squares, parking areas, or parks and private gardens. Urban trees appear as individual trees or as groups of trees.

Introduction

These guidelines on Urban Forests as Nature-Based Solutions (UF-NBS) have been written to assist individuals and organisations that have senior policy and practice responsibility for trees in various urban settings, to manage these as a resource to support cost-effective restoration of the urban and peri-urban environment, including ecological connectivity, human well-being, public health, social inclusion and nature recovery.

The guidelines bring together research and practice findings from Europe and China investigated through the Sino-European CLEARING HOUSE project. This project ran from 2019 to 2024 and received funding from the European Union's Horizon 2020 Research and Innovation Programme under Grant Agreement 821242 and the National Key R&D Programme of China under grant No. 2021YFE0193200.

Four guidelines and nine case studies are brought together in this document. Each guideline covers a key topic in the creation and management of UF-NBS. The first guideline is on planning, policy and delivery which are critical aspects of delivering urban forests at the city or regional level. Core to this is the need for appropriate strategy and planning processes that can help set the objectives and secure the resources for the long-term management of the urban forest as a nature-based resource. The second guideline is on cost-effective, restoration and rehabilitation which is focused on accessible and attractive urban forests adapted to the needs of different users and in which multifunctionality and a holistic approach emerge as key recommendations. The third guideline focuses on the importance of integrating public stakeholders and citizens in managing and planning UF-NBS. Simple tools on how stakeholders can be identified and integrated in the process are presented to help local actors proceed with this. The fourth guideline is on change management and institutional reform. Implementing management and institutional changes in the domain of social-environmental-economic policy and practice is complex and resource demanding. To effectively govern UF-NBS, several critical factors must be considered of which collaboration and partnerships stand as the foundation. The case studies presented here are exemplars of good practice and are intended to inform and inspire the reader.

It is important to appreciate that through their very existence, urban forests, meaning the combination of all woody vegetation within and close to the urban area are already acting as a nature-based solution. However, existing management practice can be suboptimal when it comes to maximising the nature-based benefits that the urban forest can provide. To overcome this, there is a thread weaved through the guidelines. That is that the planning, policy and delivery of the urban forest should take a whole ecosystem-based approach (EbA) with delivery based on the established concept of ecosystem services (ES). For some readers, this represents the continuation of an existing journey, but for others, it will represent a new way of thinking.

There is no preordained order in which to access the guidelines, but many will find it helpful to start with the guideline on planning, policy and delivery and especially the need to take a strategic approach.

Clive DAVIES and Rik DE VREESE
Series Editors

31st JULY 2024



Figure 1: The urban forest of Krakow, Poland: Source: Clive Davies

GUIDELINE 1

PLANNING, POLICY AND DELIVERY FOR URBAN FORESTS AS A NATURE-BASED SOLUTION

Clive Davies, Astrid Hamm, Manuel Wolff, Sebastian Scheuer, Ivana Živojinović

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Summary

Planning, policy and delivery are critical aspects of delivering urban forestry at the city or regional level. Core to this is the need for appropriate strategy and planning processes that can help set the objectives and secure the resources for the long-term management of the urban forest as a nature-based solution. Many cities and regions already have urban forest-related plans and strategies but frequently these have not encompassed the potential for the urban forest to deliver a wide range of ecosystem services. This guideline seeks to rectify this by providing advice to policy makers and planners to help them update current practice or establish new practice in that direction. In addition to this, guidance is provided on how urban forests can be a factor in sustainable development and human well-being, how to maximise the role of the macro- and microbiome in the urban forest, why mature trees are a key focus for nature-based solutions and how brownfield sites are a key strategic resource for urban forestry.

A new strategic approach

A question for decision makers to ask is ... '*what is different about realising the nature-based benefits of the urban forest and how is this different from current practice*'? The answer is that planning, policy, and delivery should focus foremost on an 'ecosystem-based approach' (Figure 2).

Current urban forest practice may undervalue the role of trees to meet urban challenges, being overly focused on risk management, frequently reactive in nature and lacking the right knowledge in the right place at the right time. These characteristics can stand in the way of realising the potential ecosystem services that trees individually and in combination can provide. Nevertheless, current practice is already delivering ecosystem services, but this can be more by chance rather than by design and may lead to suboptimal outcomes. Take as an example the case of the aesthetic beauty of trees. This is a key reason why trees exist and are planted in urban areas. It is clearly a much-valued cultural ecosystem service. However, the regulating and supporting services of the same trees may not be considered, such as their important role in pollination or nutrient cycling.

Prioritising **ecosystem services in urban forest management** can result in very different outcomes to the management of urban trees, woodlands and forests. Take for instance, the valuable microhabitats created by the tree's ageing process. Consider also how managing the soil around trees can lead to beneficial outcomes in terms of the valuable soil microbiome.



Figure 2: The answer to the question what is different about, realising the nature-based benefits of the urban forest, and how this is different from current practice, lies in prioritising an ecosystem-based approach in urban forest/tree strategy. Source: European Commission, Directorate-General for Environment (2015)

Types of Urban Forest

The United Nations Food and Agriculture Organisation (FAO) has produced guidelines on urban and peri-urban forestry. They define Urban Forests as "networks or systems comprising all woodlands, groups of trees, and individual trees located in urban and peri-urban areas including forests, street trees, trees in parks and gardens, and trees in derelict corners. Urban forests are the backbone of the green infrastructure, bridging rural and urban areas and ameliorating a city's environmental footprint". These guidelines on urban forests as nature-based solutions (UF-NBS) adhere to this FAO definition. It is important to note that the balance of types of urban forests varies significantly between different urban areas. For example, the urban forest in some cities will be dominated by street trees and in others by recognisable forest stands. Almost all urban areas will, however, include most types. The importance of this is that locality and context matters, hence an urban forest strategy and management plan for one cannot be simply copied from one urban area to urban area.

There are however many overlapping issues and one of these is that whatever the local and contextual issues may be, an ecosystem approach is the underlying and unifying principle to be followed if an urban forest is to achieve its full potential as a nature-based solution.

What is an ecosystem approach?

The ecosystem approach is described in the Convention on Biological Diversity (CBD) (2023) as a strategy for the integrated management of land, water and living resources that promotes conservation and sustainable use in an equitable way and is the primary framework for action under the convention. It recognises that humans, with their cultural diversity, are an integral component of ecosystems. The ecosystem approach has been adopted in these guidelines as a framework for the development of planning policy and delivery to ensure that the urban forest is considered first and foremost as a nature-based asset. This can be regarded as a first step from current practice in most, but not all situations. The main point arising is that developing the urban forest strategy and management plan based on an ecosystem-based approach can lead to better outcomes than is currently attained. Indeed, considering the wider status of urban forests globally, which remains under threat through urbanisation, development and environmental degradation this approach can help elevate urban forests to a more important position in decision making. Figure 3 is an infographic designed to help urban forest managers and those developing strategy to consider the requirements of an NBS compliant urban forest strategy and can be used as a checklist.

The urban forest strategy and accompanying management plan

The urban forest strategy is the key element of planning and managing trees in urban settings and crucial in achieving the potential of trees as nature-based solutions. This plan should include a demands assessment, identification of potential conflicts between different users, the setting of long-term management objectives and determining how the urban forests solutions provide nature-based solutions. The urban forest strategy is also the basis for the definition of long-term operational goals and measures including how the canopy cover can be increased in a cost-effective way. Figure 3 provides guidance on how to prepare an ecosystem service-based urban forest strategy with an accompanying text below. Note that the urban forest strategy should be accompanied by a urban forest management plan which details how the long-term operational goals are to be delivered.

EXPERTISE: A group of experts from multiple departments rather than individual departments should lead the process of strategy preparation, in consultation with stakeholders and local communities. It is necessary to ensure that this group of experts (which might typically include foresters, landscape architects, arborists, planners etc.) should include people familiar with and committed to the delivery of ecosystem services.

CLEAR RESPONSIBILITY: Responsibility for urban trees and urban forests generally lies with one or more public authorities. The authority(ies) should decide the spatial extent of the urban forest strategy. For practical reasons this may be constrained by socio-political or administrative boundaries, but it should be recognised that the urban forest for any given area generally extends beyond these boundaries and hence collaboration with other authorities is a necessity.

INVENTORY: It is necessary to have a tree inventory as a basis for good planning. This can present the urban forest numerically as well as conditions and local significance. When linked to a geographical information system (GIS) the inventory

reveals networks, opportunities and threats. The CLEARING HOUSE project partners developed a Spatial Impact Assessment and Classification tool (SIAC)[1] which models tree cover, assesses street tree density, and evaluates spatial relationships with streets or buildings. A presentation of SIAC can be found here. An urban forest inventory should include ownership data and information on location, forest type, tree species composition, dimensions and tree health condition. Photographs are also highly beneficial and provide a future reference point. There are tools available to model ecosystem service provisioning (including economic valuations for selected ecosystem services), based on the inventory (e.g. iTree).

HISTORY: An urban forest strategy that is ecosystem services compliant is built upon historic foundations even if it is leading in a new direction. Existing documents (e.g. forest or park management plans, spatial plans, decrees, land use plans, and legal documents) must be considered when preparing a strategy. Basic data on the strategic area is scoped from existing data sources.

STAKEHOLDERS: The main target groups/stakeholders that the strategy address should be determined and will typically include local inhabitants, visitors, educational institutions, forest owners etc. It is beneficial to define and describe the target groups with the help of an analysis. These various groups and stakeholders can be considered as the beneficiaries of the ecosystem services. This element of the strategy will help avoid criticism at a later stage.

MAPPING ECOSYSTEM SERVICES: Since ecosystem services are the basis for the nature-based solutions, this is a critical step. For each ecosystem service, there should be a short explanation in text explaining why it is relevant and why its importance is recognised. For example, if the ecosystem service is to protect an important groundwater resource against pollution, the extent of benefit should be mapped, and the reasoning described. It is not necessary to prioritise all ecosystem services only those that are most important due to high public interests or because it can tackle a recognised local challenge.

SPATIAL DEVELOPMENT: The spatial development concept addresses the future distribution of the urban forest including location, ecological connectivity and plans for future growth. The spatial development concept should reflect where ecosystem management objectives are most needed, where strategic urban forestry investment are needed, etc. Zoning could include where and how to provide woodland-based recreation, where less disturbed nature-areas are be located, where forest school projects could be focused and how tree planting can improve the 'street scene' or meet the 3:30:300 rule (Konijnedijk, 2023).

STRATEGIC PRIORITES are listed in an urban forest strategy where the overall objectives in priority order. This will include what are the main priorities (i.e., long-term strategic objectives) and how these are linked to the intended ecosystem service outcome. Ideally strategic priorities should be accompanied by a short explanation for each priority. This section of the urban forest strategy should give an overview of other important ecosystem services (linked to the spatial development concept) such as the association with other habitats such as riverbanks or species rich grassland, the recognised conflicts, the challenges in forest management and the legal and planning frameworks.

MANAGEMENT OBJECTIVES are listed in an **URBAN FOREST MANAGEMENT PLAN** and are linked to the strategic priorities. The management plan should also answer operational questions for instance (i) who is responsible for the management, (ii) who needs to be involved – collaborators or other partners, (iii) what are the ecosystem services and are there potential disservices to be considered, (iv) what is the legal ground for the work and have all permissions been received, (v) how will management works be supported by financial instruments. The management plan can be an annex to the main urban forest strategy. The typical time horizon for an urban forest strategy and its associated management plan may be 10 – 25 years with long term targets up to 100 years or more. Management plans generally must work within the financial cycle of the lead organisations and key stakeholders; however, these should always reflect the long-term objectives.

[1] https://zenodo.org/records/10695583

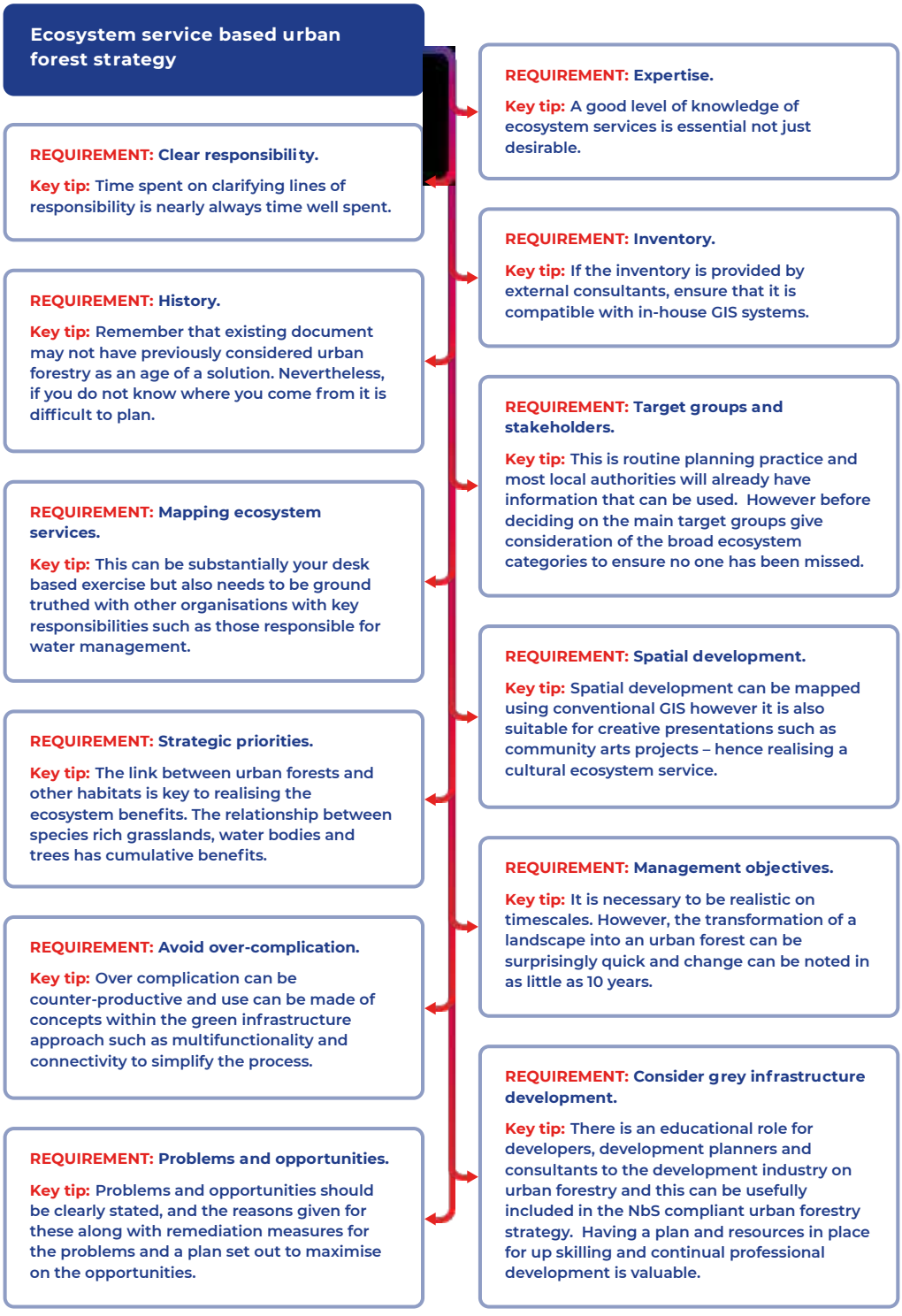


Figure 3: Guidance for producing a NBS compliant urban forest strategy, source Clive Davies/CLEARING HOUSE project

OVER-COMPLICATION should be avoided as it may be counter-productive not least by delaying the policy making process. To avoid conflicts ideally one key ecosystem service should be prioritised as the most important and others identified as secondary, tertiary etc. However, based on the Green Infrastructure approach[2], it is still necessary to stress that the urban forest is multifunctional and that identifying an ecosystem service priority is not intended to make the urban forest less multi-functional but to provide a focus for management and resources.

GREY INFRASTRUCTURE impacts on the urban forest and the relationship between the urban forest and grey infrastructure should be considered in both the strategy and management plan. The issues that will be encountered are multi-various including underground services, elevated cables (electric, telecoms etc.), new urban design, built form and not least the impact of urban development (housing, commercial, industrial etc.). Remember that development is an opportunity as well as a threat and one that can provide financial leverage. Note that the loss of a mature tree is not easily offset by planting a new one, indeed the loss of ecosystem services demands both significant new planting and finance. Clearly set out guidance for developers is a necessity and this should be robust and ambitious. Encourage developers and their agents to seek the right advice and when possible, offer access to continual professional development to those involved in grey infrastructure industries about nature-based solutions.

PROBLEMS AND OPPORTUNITES: The path towards sustainable urban forest management cannot be entirely foreseen, hence problems and opportunities will inevitably appear. Some problems may be intractable and require long term sensitive handling whereas others may be short term and more easily addressed. Tried approaches involve dialogue, use of independent external experts and if the problem is technical in nature, professional advice that are not available 'in house'. Opportunities should normally be seized even if not the top priority although care should be taken that an opportunity doesn't become a problem later if not properly evaluated at the outset.

How can urban forests contribute to better health and well-being in cities?

Nature's positive influence on human health and wellbeing has been proven and implemented for a long time. For example, hospitals and health institutions have often had extensive parks featuring large trees to offer sick people the opportunity to interact with nature. This has been especially important for the recovery of people suffering from psychological illnesses. Recently, walks in a forest or landscape park, consciously 'diving' into and opening oneself to the nature experience has become popular under the Japanese term of 'forest bathing'. Recognition of the importance of our close connectivity to nature, has become more prominent in the health and well-being discourse. As was witnessed at the height of the COVID-19 pandemic many people living in cities do not have access to gardens or personal green space and rely heavily on public green spaces such as wooded parks. The negative impacts of climate change such as heat waves is increasing demand for urban shade to provide refuges for people during these episodes. Valuable knowledge from the past must be combined with innovative new ideas to create a liveable environment for people within nature, as well as a respectful interaction with nature as our own, as well as many other living organism's habitats we live in. Ultimately maintaining high living standards will only be possible if we cooperate with nature on a grass-root level. Trees can provide many of the benefits needed for human health and well-being, including shade and space for recreation and recovery. Figure 4 shows how and why urban forest managers and policy makers can help deliver sustainable development and human well-being within a framework of their planning and policymaking.

[2] https://environment.ec.europa.eu/topics/nature-and-biodiversity/green-infrastructure_en

Mature trees are key elements of Urban Forests as Nature-Based Solutions

The negative effects of climate change, increasing urban development and intensive land management have taken their toll on mature trees. Mature trees play a significant role in cultural and historical landscapes as contemporary witnesses from a far past. They also generate an emotional link to the development of landscapes and human history in a framework of time and space. Their role as a nature-based solution is immense as they provide shade, water management, play a major role as significant biotopes for many hundreds of different animals, plants and fungi and are key providers of cultural ecosystem services. The bigger and older a tree gets, the more ecosystem services it provides (see Figure 5).

Mature trees are still felled for the reason of human 'inconvenience', such as leaf drop that is considered as a nuisance by some people. They can be regarded as 'dangerous', since they might show structural or biological weakness due to their age, often, sadly, caused by inappropriate human activities. There is a generalised suspicion that the oldest trees are 'dangerous' and, therefore, a health & safety issue for humans. That is why it is the more important to protect and maintain mature trees in a professional way to ensure they can further provide well known advantages to human health and to biodiversity. The cumulative impacts of climate change such as drought combined with increasingly negative effects caused by the densification of cities makes the professional management of mature trees even more important. For the most part mature trees, with their aged biomass, form and functions are almost an ideal NBS, especially if they have a well-established micro-biome. Indeed, being too manicured works against their NBS performance. Planning and policy actions to promote the value of mature trees as a key element of urban forests as nature-based solutions are shown in Figure 6.

To conserve and enhance mature trees, consider the following:

ROBUST LEGAL INSTRUMENTS: laws, bylaws, and other legal instruments are essential to protect mature trees. Such instruments are a deterrent for inappropriate tree felling. Notwithstanding the need for care when it comes to public safety, mature trees should be given the highest level of legal protection. Drawing these up for the first time can draw on their equivalence to other heritage features. Generally mature trees should not be removed before wide stakeholder engagement unless it is an emergency. Senior leaders should draw an equivalence with highway management – regular inspections and with adequate annual maintenance budgets.

QUALIFIED PROFESSIONAL CARE: the management of trees is highly skilled work. Arborists are skilled in tree care and proper management techniques. Foresters are skilled in the management of tree stands as forest habitats. Local authorities should possess both these services in-house, supplementing their work with contractors as necessary working under their guidance.

MANAGING CHANGED CIRCUMSTANCES: trees can live for a long time when properly cared for. However, urban areas are dynamic places and during the lifetime of an individual tree or stands of trees their immediate environs may change significantly. When change is anticipated or observed plans should be put in place to mitigate the impact. New development can present mature trees with a sudden change to their growing conditions; water logging or drought over longer periods of time are quite typical of this. These conditions require to be diagnosed properly and remediated carefully to enable the tree to adapt to new growing conditions and restore its vitality appropriate for its age and environment. Cutting and pruning of mature trees is sometimes necessary but is generally best

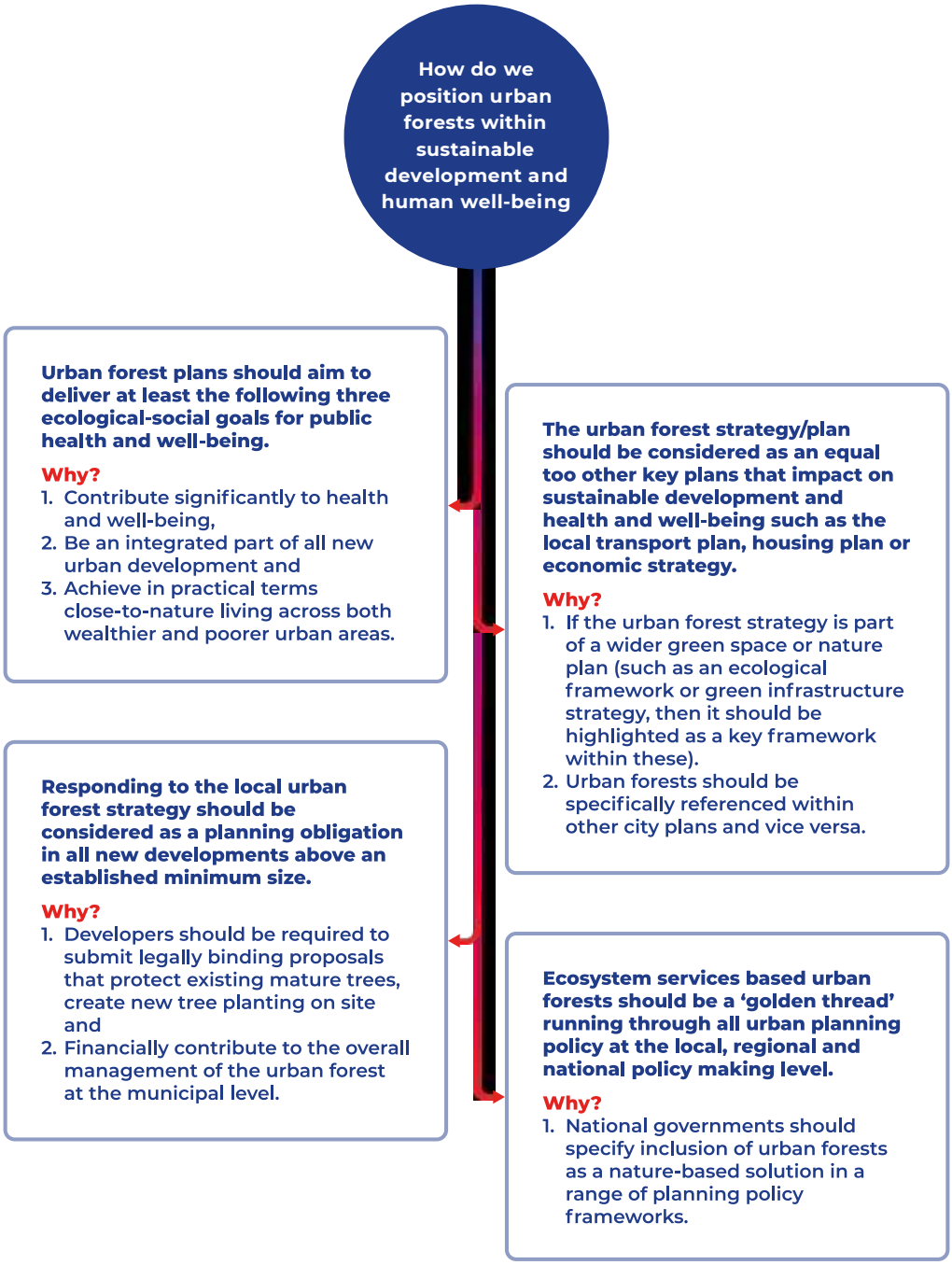


Figure 4: How do we make urban forestry in sustainable development and human well-being. Source: Clive Davies/CLEARING HOUSE project.

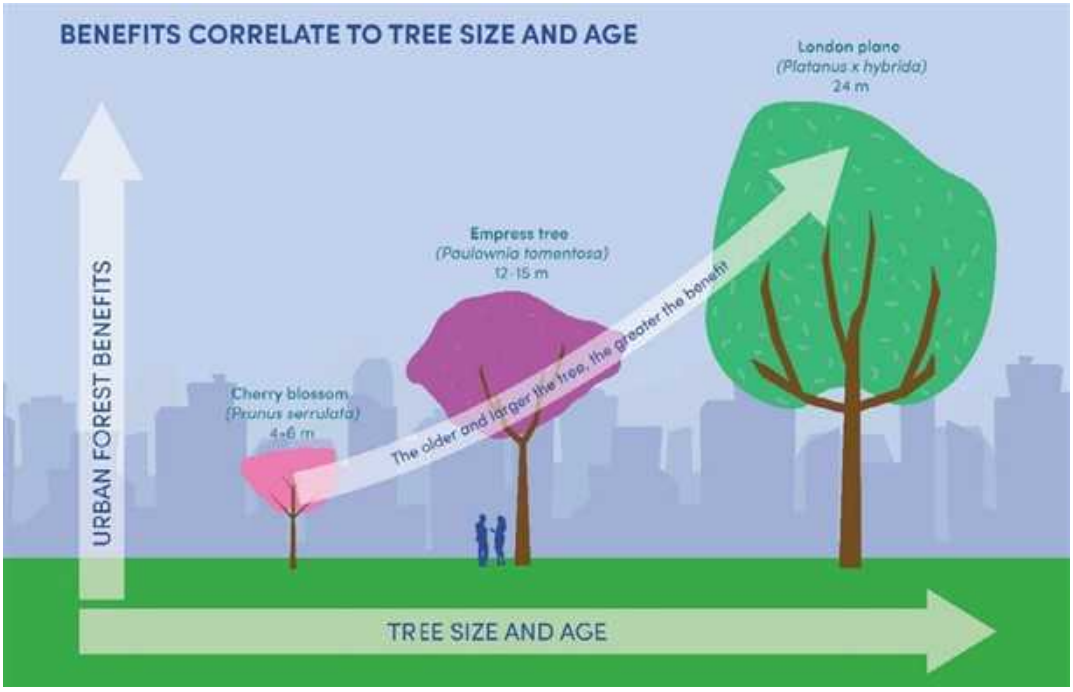


Fig. 5. The benefits a tree provides correlate to its size and age (source: European Forest Institute)

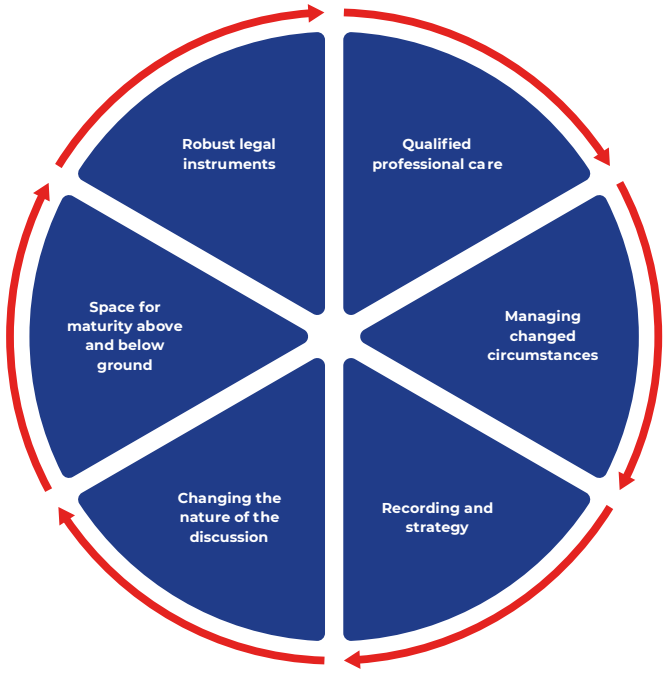


Figure 6: Planning and policy actions to promote the value of mature trees as a key element of urban forests as nature-based solutions. Source: Clive Davies/CLEARING HOUSE project

avoided since the cutting of large branches can create large wounds which take much longer to recover.

RECORDING AND STRATEGY: It is imperative to know what mature trees any given area has. This information is the starting point for proactive management of them. Tree surveys and inventories are a necessity but should go beyond the limited recording of location and species. An inventory should include information that can be used for long-term management.

CHANGING THE NATURE OF DISCUSSION: It is necessary to change the nature of the discussion around mature trees. Public education is key to overcoming fears about them and to explaining how their ecosystem services strongly outweigh any disservices. Programmes of education from the very young to the very old are highly recommended along with positive messaging in all forms of media. Local authorities and where appropriate private real estate owners should manage the removal of leaf litter from roads and pavements where they are a slip hazard, but these should be composted and reused as a soil conditioner. It is normally not necessary to remove leaf litter from grass surfaces as the microbiome will do this work anyway. Direct citizen engagement is positive and can help defuse conflict within a community if problems arise.

SPACE FOR MATURITY ABOVE AND BELOW GROUND: To capture the nature-based benefits of mature trees, they must grow to a certain size to provide tangible ecosystem services such as clean air, shade, water filtration and retention. Most of all they need space to grow both beneath and above ground and a reliable supply of ground water and nutrients. Mature trees like the human body face various changes during their lifetime, so does the tree as a biological entity. It is very important to care for the different species of mature trees in a different and appropriate way, as they have very different needs to young trees.



Figure 7: **Positioning of individual trees near buildings needs care and refection on future growth, however the benefits should not be underestimated, trees can reduce energy consumption in winter by providing a windbreak and in summer shade. Varaždin Croatia. Source: Clive Davies.**



Figure 8: **The trees in this picture have suffered from poor ground works and are unlikely to survive, specialist Tree Officers have a role in directing street works around trees. Zagreb, Croatia. Source Clive Davies.**

The importance of the macro- and microbiome for urban forests as a nature-based solution

Trees are a habitat to a vast variety of animals, plants, and fungi. The macrobiome (larger organisms) and microbiome (smaller organisms) occur in tree-based habitats above and below ground. It is well known that old trees are a living habitat to a huge diversity of animals and plants, as well as various other organisms like fungi, lichen and bacteria. A single tree provides millions of calories in form of carbohydrates, sugar, cellulose, lignin, and various other carbohydrates. Above all, they have important symbiotic relationships with various fungi, lichen, and insects. There is invisible 'connections' below and above ground between trees and their 'partners', along with other organisms.

Trees are most likely the only organisms with such a wide variety of beneficial functions to various other organisms. Hence the role of trees provides many potential nature-based benefits and are to a significant extent self-regulating even in highly artificial urban environments; biodiversity, energy, bio-communication, symbiosis, soil conditioning, nutrient cycling and even self-defence are in the 'toolkit' of trees and harnessing these to address societal challenges can be likened to engineering with nature. The urban forest strategy should include policies and in the case of the management plan actions for maximising the role of macro- and microbiome in urban forests; figure 9 proposes actions to achieve this.

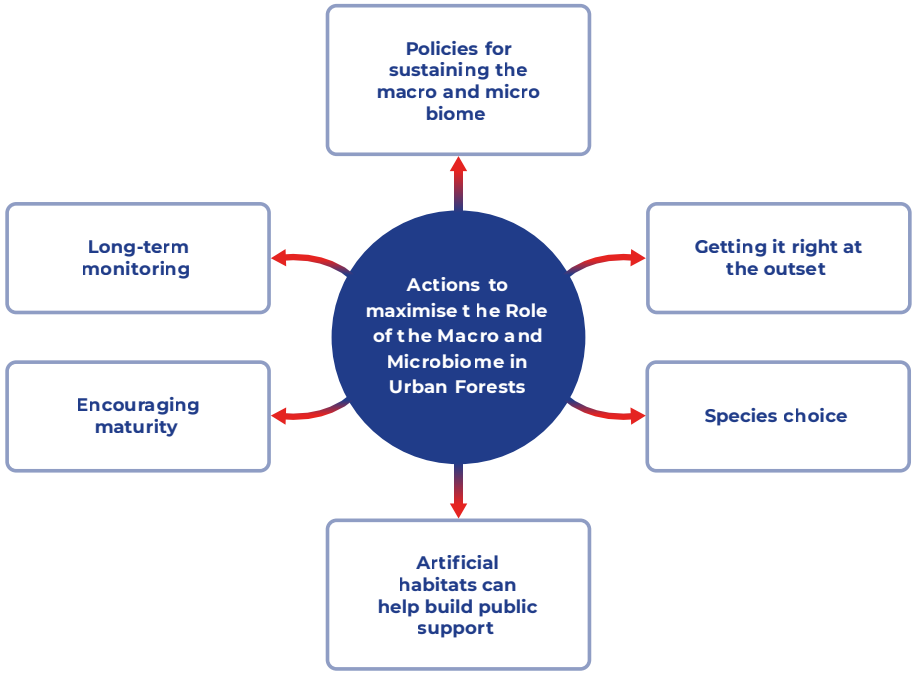


Figure 9: The macro- and microbiome play a key role in delivering the nature-based benefits of urban forests. Source: Clive Davies/CLEARING HOUSE project

To manage and enhance the macro- and microbiome consider the following:

GET IT RIGHT AT THE OUTSET: In the case of new tree planting initial soil condition should be considered at the outset. Soil constraints (compaction, nutrient availability, waterlogging) will lead to long term underperformance of the tree, hence amelioration of the soil (such as decompaction) before planting is beneficial. In the case of mature trees soil conditioning through direct intervention can provide a major boost to overall tree health and improve the microbiome.

SPECIES CHOICE: This is important to the long-term evolution of the macro- and microbiome hence the choice of species most suited to the location when it comes to new planting is crucial. Species that are genetically adjusted to the locality will contribute the most. However, in the face of global change notably through climate (heatwaves, drought, flooding etc.) species selection should also consider future patterns and provide an ability for the macro- and microbiome to adjust with time.

ARTIFICIAL HABITATS CAN HELP BUILD PUBLIC SUPPORT: The creation of artificial habitats such as nest boxes for birds and bats is an opportunity for community engagement in urban nature and build public support for nature-based solutions.

ENCOURAGING MATURITY: The creation and sustenance of microhabitats especially on mature trees is to be encouraged as whilst these may ultimately lead to structural failure, they have a contributory role to the microbiome and through the food chain to the macrobiome.

LONG-TERM MONITORING: Long-term monitoring and regular evaluations of the macro- and microbiome is needed. In the absence of in-house services, it may be necessary to purchase such services from consulting firms and/or academic research institutions. In addition, there is a notable opportunity for citizen science in respect of monitoring and evaluation which has the dual benefit of community education and engagement.

Urban Brownfields as a strategic resource

In densifying cities, brownfields are a valuable and non-renewable land resource, and their revitalisation is high in the agenda at many policy levels (Urban Agenda for the EU, 2018). Brownfields are defined as land available for development which has previously been built on or used for purposes that have altered the condition of the soil, generally associated with land contamination (EESC, 2023). Cities frequently aim for structural densification as well as the maintenance, further development, and qualification of urban greenery with brownfields being the key for this twin strategy. Against this background, the key role of brownfield revitalisation is:

- providing ecosystem services beneficial for human well-being with high quality greenery,
- helping to limit land consumption and preventing urban sprawl (e.g. at the fringe of cities),
- promoting social inclusion and addressing societal challenges with valuable public green spaces in deprived neighbourhoods,
- ensure ecological connectivity and biodiversity benefits,
- supporting economic redevelopment.

Brownfield revitalisation brings about trade-offs. On the one hand, the renaturation of brownfields brings more and diverse natural features into the urban setting, providing many ecosystem services and biodiversity benefits. On the other hand, redensification of brownfields can support cities in limiting greenfield consumption and prevent urban sprawl. However, the construction and soil-sealing on former brownfields makes important natural niches and biodiversity stepping-stones disappear. The growing competition for the use of brownfields requires a forward-looking, interdisciplinary strategy focused



Figure 10: **Suggested decision-making steps on how to make brownfield sites strategic resource for urban forests. Source: adapted from Manuel Wolff et al. (2023)**

on the concept of multifunctionality. When dealing with these areas urban forests can help.

The revitalisation of brownfields to green end uses such as urban forests has proved to have a value for creating functional corridors for species movement within dense built-up structures (Wolff et al., 2023) – more on other types of informal green spaces in Guideline 2, pp. 38–39. At the same time, urban forests can contribute to improved environmental justice in the city by providing recreational functions for residents living in less affluent neighbourhoods. A four-step decision making approach is suggested in the context of urban forests (Figure 10).

To manage and enhance the opportunity presented by brownfields for UF-NBS consider the following:

SCREENING: In the first step, decision-makers should carefully screen their strategic pool of brownfields and urban forests and select those brownfields that can play a role in structural redensification of the urban forest network. Normally such brownfields play a very small role for the functional urban forest/green infrastructure connectivity of the city but have potential to contribute to a better-connected network.

POTENTIAL AS STEPPING-STONES: In the second step, brownfields that potential can serve as stepping-stone when the area is renatured are prioritised for renaturing. Brownfield sites which would either strengthen existing or create new networks should be renatured in the first place. In contrast, brownfield patches with no or a very low contribution to connectivity when renatured could serve as potential candidates for redevelopment.

PRESERVING CONNECTIVITY: In the third step, planners are asked to preserve connectivity by maintaining and protecting the relevant nodes of the urban tree canopy network. Several brownfields with a high relevance as stepping-stones are connected to a comparably low number of links to major corridors which could quickly vanish due to densification. Consequently, planning is asked not just to preserve the brownfield sites, but also their connections to other surrounding canopy patches — otherwise the functional connectivity could decrease with limited options for animals to move.

CONSERVING EXISTING NATURE: Long established brownfields are already very diverse ecologically and may have established a significant vegetation cover, one that exhibits cultural significance from its former land use. Natural regeneration of trees especially colonising species may already be well developed too. These mature sites are especially valuable and working with the natural regeneration provides significant opportunities for the development of the site's ecosystem services.

Support tools for UF-NBS

There are many tools available to assist in the planning of the urban forests however, not all of these are focused on trees and urban forest as nature-based solutions. Recognising this, the Sino-European, CLEARING HOUSE project commissioned a Spatial Impact Assessment and Classification tool—referred to as SIAC.

This is an application that seeks to support researchers and practitioners in gaining insights into urban forests at the local level. SIAC allows a modelling of tree cover, thereby supporting the identification of local trends in tree-based vegetation cover based on trait-based principles outlined in the CLEARING HOUSE projects typology of urban forests as nature-based solutions (Scheuer, S., et al. 2022).

SIAC further supports a classification of tree-based entities and a data-driven assessment of spatial relationships. Various indicators such as street tree density or an approximation of the 3 and 30 components (3 trees visible from every home and 30 percent tree canopy cover in every neighbourhood of the 3-30-300 rule (Konijnendijk, C. 2022) are subsequently derived by SIAC.

Adapting a graphical approach, SIAC also enables modelling of tree cover connectivity, that is important for biodiversity. In so-doing, SIAC may help to identify tree-based entities important for maintaining connectivity, or to identify locations where the planting of new trees may help to improve connectivity.

Finally, as a function of modelled tree cover, benefits of urban forests as nature-based solutions for climate change mitigation, e.g. carbon storage and sequestration—and for the promotion of human health and well-being of citizens, e.g. by mitigating urban heat island effects or by regulating air quality may be approximated. SIAC relies on comparatively basic data, thus promoting transferability. The tool is made available open source as a plugin for the QGIS software.

Research in support of UF-NBS

For successful UF-NBS implementation research is needed and the analysis of results can provide valuable information about the distribution and connectivity of urban forest resources:

- Habitat network maps can be used to identify areas of high ecological value, such as habitat corridors that connect isolated patches of forest in a form of green infrastructure. By mapping these corridors and identifying areas where new planting or restoration efforts are needed, cities can create more resilient urban forest ecosystems that are better able to withstand the impacts of climate change and other stressors.

- Strategic path networks can also be an important tool for promoting connectivity and accessibility. By mapping and analysing the distribution of pedestrian and bicycle paths, cities can identify opportunities to improve connections between urban forest patches and create safe and convenient routes for people to access and enjoy these resources.

- Canopy cover mapping and urban heat island analysis, can provide important information about the distribution and impacts of the urban forest on the surrounding environment. This information can be used to inform decisions about where to plant new trees or prioritise other management efforts, such as increasing canopy cover in areas with high temperatures or poor air quality.

Key messages on planning, policy and delivery for urban forests as nature-based solutions

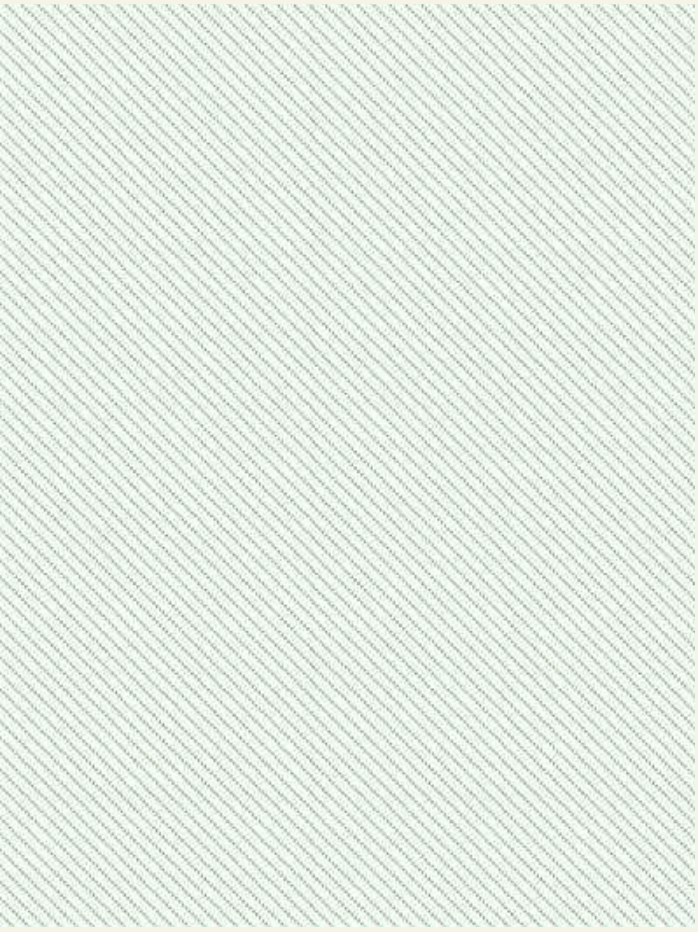
1	Take a strategic approach to the management of your urban forest and prioritise the delivery of ecosystem services in its management. This may involve a notable transition away from risk management to ecological management.
2	The urban forest strategy should be accompanied by a management plan, which includes the demands assessment, identification of potential conflicts between different users, and the setting of long-term management objectives.
3	Consider how the strategy and management of the urban forest can best contribute to the better health and well-being of your city or urban area. Trees provide many benefits, ranging from urban cooling to recreation space and the benefits of being close to nature.
4	Mature trees matter a lot as they possess many years of accumulated ecosystem services. Human inconvenience is rarely an excuse to remove a tree, but they do need conservation and enhancement within a legal framework and professional care.
5	The macro- and microbiome of the urban forest is critical to the delivery of nature-based solutions since trees are a habitat to a vast variety of organisms. It is important to choose the right species, manage the soil and monitor the long-term impacts of development in the vicinity on biodiversity.
6	Urban Brownfields are a strategic resource for urban forest as a nature-based solution, and their potential as stepping stones, and the preservation of ecological connectivity should be highly valued.
7	There are support tools that can be used to help manage the urban forest. The CLEARING HOUSE project developed SIAC, which is a plug-in to the QGIS software.
8	For successful implementation research is needed, including habitat network maps, strategic path networks and canopy cover mapping. Such services are available from consultants and many universities.

Case study links (see case studies section)

Fu Forest Trail, Shenzhen Urban Forest, Beijing Plain Area Afforestation Programme (BPAP), Kamp Beverlo, Ruhr Metropolitan Region (Industrial Forest Project), Drwinka River Park, Metropolitan Area of Barcelona (Llobregat&Co).

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Figure 1: **The 120 hectare Boscoincittà in Milan comprises urban woods, meadows, streams, wetlands and around two hundred vegetable gardens. It is cultivated and cared for the Italia Nostra Centre for Urban Forestry. Source: Clive Davies.**

GUIDELINE 2

COST-EFFECTIVE RESTORATION AND REHABILITATION MANAGEMENT FOR URBAN FORESTS AS NATURE-BASED SOLUTIONS

Magdalena Biernacka, Jakub Kronenberg, Tomasz Bergier, Clive Davies, Barbara Darr, Łukasz Mielczarek, Przemysław Szwałko

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Summary

The role of restoration in ecosystem health was recognised by the United Nations, which declared 2021–2030 the Decade of Ecosystem Restoration. In the face of numerous crises, including climate change and the COVID-19 pandemic, it is necessary to provide accessible and attractive urban forests adapted to the needs of different users, including the most vulnerable groups (e.g. people with disabilities, children and seniors). When creating urban forests, the key is their multifunctionality, including providing space for different social groups, biodiversity (finding space not only for people but also for different species of plants and animals), continuity (urban forests should be connected to each other to serve as a natural ecological corridor), as well as providing local plant species. Such a holistic approach makes it possible to provide urban forests that welcome all living beings in the city. Urban Forests can also be created on post-industrial, abandoned land (brownfields), which, through rehabilitation, renaturalisation and the use of nature-based solutions, can be a crucial part of the ecosystem of any city.

Climate change and ecosystem restoration

Climate change has a significant impact on the functioning of ecosystems, including urban forests. For example, in temperate regions, there has been a clear tendency to shorten the period of snow cover and an increase in the average temperature and storms in winter. Moreover, heat waves and accompanying rainless periods are more common, as exemplified in Europe and parts of China, leading to increased tree decay. The frequency and intensity of torrential rains and extreme wind phenomena are increasing worldwide. These factors have a significant impact, and it is therefore necessary to take these into account while planning and implementing green space management, especially the protection and restoration of urban forests. The negative impacts of climate change are particularly harmful in urban areas, most notably because of the poor quality of ecosystems. This is due to the high fragmentation of urban forests in urban areas (e.g. due to pollution and development pressures), reduction of biodiversity through improper maintenance, unfavourable management of these areas (e.g. too frequent mowing of grasses, raking of leaves, cutting of old trees, selection of inappropriate plant species or species monocultures).

Ecological restoration is the process of assisting the recovery of a degraded, damaged, or destroyed ecosystem in the direction of a historic reference state. Restoring natural ecosystems is essential to ensure resilience to climate change and nature recovery, especially in urban areas. The following actions can be taken for this purpose:

- planting new trees using appropriate species adapted to the local climate and soil,
- encouraging natural regeneration and thus the conditions for germination and growth of young trees,
- increasing functional diversity traits (e.g. species competitiveness, co-occurrence patterns); selecting tree species in such a way that they have a positive impact on each other, do not take up valuable sunlight or space, do not compete for habitats, while maintaining the highest possible biodiversity.

The above activities can be implemented using the following tools:

- establishment of tools for financing biodiversity and green infrastructure (including increasing the ecological awareness of citizens to support this as an investment, not a cost),
- introduction of realistic and measurable key performance indicators for the restoration and rehabilitation of urban forests,
- regulations for conservation of mature trees,
- development of lists of recommended species for the city, dependent on the location, soil, prioritised ES in the location,
- development of inspiration book with NBS for specific situations,
- manual for natural regeneration and tree care for young trees,
- involvement of citizens in watering (young) trees and small maintenance.

To ensure nature's ability to regenerate, it is necessary to preserve the natural elements in the city. Moreover, they should be connected by natural corridors so that animals and plants can move freely. Such corridors support human health benefits and physical activity, most notably promoting active travel. Within such corridors, people can move freely from one green space (e.g. a park, woodland or, forest) to another without being exposed to harmful external factors (such as noise and air pollution). Creating such social-ecological corridors provides an important example of larger-scale urban ecosystem restoration that provides broader benefits spanning climate adaptation and mitigation (new urban forests, mature trees[1], increased ecological quality, reduced need for motorised mobility in cities).

In the face of climate change and accompanying negative phenomena, it is necessary to ensure resilience for cities through appropriate design and implementation of urban green infrastructure. The key is to provide ecologically robust infrastructure

[1] See guideline on planning policy and delivery for more information on mature trees.

that not only intercepts and stores rainwater and lowers the air temperature but also ensures synergy between nature and social and cultural objectives (Tubridy, 2020).

Hence, nature provides us with insurance since investing in restoration strengthens ecosystems and translates into greater resilience throughout the city. In turn, this translates into a better quality of life and health of urban inhabitants. Moreover, urban forests encourage spending time together and support inclusivity and justice in relation to various socio-economic groups e.g. using community gardens (Gray et al., 2022). Planners and decision makers face many challenges related to the design of urban forests. However, their multifunctionality and renaturalisation can help mitigate climate change and positively affect the perception of a given space. New and existing urban forests have a key role in increasing urban resilience and offer many ecosystem services, however, for them to continue to perform their role as important components of urban green infrastructure, they will need protection and restoration and management.

Restoration and rehabilitation challenges

Restoration and rehabilitation of urban forests requires funding, the consent of owners, appropriate planning decisions, and compliance with the law. Hence this process is based on different institutional conditions for each country. In some countries, institutions (e.g. state government, and municipal officials) may favour environmental protection and the restoration and rehabilitation process. In contrast, in others, these issues may be disregarded and "pushed to the margin". Perhaps the most essential prerequisite for ecosystem restoration and rehabilitation is awareness of environmental problems, as it warrants the cooperation of various actors and the provision of funding (Table 1).

Table 1. Challenges related with restoration and rehabilitation processes and possible solutions.

Challenge	Solutions
High costs, lack of funds	▸ Financial support from the private sector. ▸ Obtaining additional public funding. ▸ Investigating and implementing the potential of new methods such as crowdfunding.
Reluctance on the part of public institutions	▸ Raising awareness among officials (e.g. meetings with experts and politicians, workshops, information campaigns). ▸ Cooperation between individual units, offices, sharing information and available documents, dialogue. ▸ Cooperation with researchers and NGOs.
Reluctance on the part of private owners	▸ Subsidies and tax reliefs for urban forests owners and users. ▸ Raising awareness among urban forests owners (e.g. workshops, training and meetings with experts, transect guided walks etc). ▸ Guidelines and requirements regarding the management of urban forests by private owners (e.g. local zoning provisions, guidance documents). ▸ Land purchase.
Lack of environmental awareness and knowledge among citizens	▸ Raising awareness among citizens[2] (e.g. workshops, lectures, information campaigns in the media). ▸ Environmental education in schools and kindergartens (e.g. through the City of Trees education package). ▸ Promoting civil society (green participatory budget, citizen juries, participatory GIS as the My Dynamic Forest application). ▸ Innovating with new technologies such as applications (Apps) that expand ecological knowledge through, for example, citizen science.
Legal regulations	▸ Legal regulations are not easy to change, but strong social opposition to the existing, harmful law can lead to its improvement.

[2] See guideline on mechanisms for public and stakeholder engagement

Restoration and rehabilitation methods and perspectives

For strongly degraded ecosystems, biotic (e.g. number of plant and animal species) and abiotic (e.g. soil, water, air quality) conditions can be improved by restoration activities in the direction of the reference state (for example the historical vegetation at this location), but most often without completely reaching it. In turn, rehabilitation serves to improve natural habitats and strengthen the functioning of ecosystems. It is not about returning to a historical state of a given ecosystem but about its proper functioning and go even further than reference state. We can also use remediation, which consists of removing pollutants in significantly degraded ecosystems (Klaus and Kiehl, 2021). Table 2 introduces some methods for ecosystem restoration and ecosystem rehabilitation.

Table 2. Methods related with restoration and rehabilitation processes and their description

Method	Description/instructions
New plantings (young trees, other plants, e.g. perennials, grasses – in the ground)	When planting new trees and other plants, follow these main guidelines: ▸ The width and depth of the pit must comply with the habitat conditions of a given plant species. ▸ The soil surface around planted trees protected with mulch. ▸ Plants should be stabilised in the ground. ▸ Plant handling must be undertaken with extreme care and training provided. It is crucial to promote native plant species that can increase local biodiversity.
Soil reclamation	▸ Soil reclamation concerns mainly areas damaged by industry or, for example, the extraction of raw materials. Reclamation methods can be divided into two types: I. Technical reclamation mainly consists of shaping the soil-forming terrain. Technical reclamation involves many activities, but the most important are shaping the relief, removing contaminated soil and covering areas with a layer of fresh soil, and strengthening escarpments. II. In turn, biological reclamation consists of shaping the soil through rational fertilisation and using agents that increase the formation of humus. Reclamation also involves selecting plants that fertilise the soil and improve its structure. We can also use bioremediation – removal of contaminants by living micro-organisms.
Maintenance of dead organic matter	▸ Dead organic matter is the dead remains of organisms in varying degrees of fragmentation. In the soil, it is a crucial renewable source of nutrients and serves as a means of improving soil structure and minimising soil erosion. ▸ The key is to keep such matter in the urban forest unless it is causing a hazard, e.g. by not raking leaves in the autumn, not removing dead wood (in addition, for many fungi, plants and animals, it provides habitat, especially in the case of insects it is the place of reproduction, feeding base and provides shelter). What is more, these activities bring a real reduction in the costs associated with maintaining the urban forest.

Method	Description/instructions
Restoration of the natural course of the river, adding buffer vegetation and creation floating islands on the water reservoirs	▸ Riverbeds and watercourses are often located in urban forests, and preserving their natural state is particularly important and recommended (e.g. by creating natural river parks). ▸ If not excessively degraded, the river may be left to naturally restore its course simply by abandoning its regulation and other activities in the channel and designating a sufficiently wide strip of land for rivers so that they can regain their proper balance (creation of near-natural riverbed) ▸ It is also important to properly manage the vicinity of the river to ensure the proper condition of riparian habitats. Riverside plantations can stabilise the riverbed. In turn, shrubs and riverside herbaceous plants can reduce siltation and cyanobacterial blooms and thus reduce the costs of maintenance works in the riverbed. ▸ Restoration of the belt of reed vegetation and the growth of shrubs and trees along the watercourses will contribute to restoring the natural character of rivers, increasing the shading of the water table and lowering its temperature, and strengthening shore slopes through root systems and increasing diversity of habitats in the coastal zone. Such transition zones may be important for many groups of flora and fauna. ▸ Green filtration islands (plants planted on buoyancy structures floating on water) will prove themselves in water reservoirs (e.g. ponds) with steep banks or a small area where it is impossible to create a coastal zone of swamp plants. They can be moored to the shore, anchored in the middle of the water reservoir, or allowed to float freely.

In urbanised areas, we can find both remnants of historical ecosystems (e.g. forest, which is a remnant of primeval or semi-natural forest or wetlands), but also hybrid ecosystems that are partly developed and altered by humans or are the remnants of human activity (e.g. former industrial areas and brownfields). The restoration process requires selecting appropriate methods for the type of ecosystem and the possibility of interfering with it and its transformation. Limiting the maintenance of these spaces, introducing native species, and thus enhancing biodiversity and the natural character of these places is highly beneficial. It is also beneficial to change the approach to the management process, or even to reduce it, e.g. a reduction of river bank management contributes to the emergence of native plant species and the occurrence of natural processes that are limited with intensive management. It is also worth considering nature sensitive grass moving schemes in the context of urban brownfields, as reduced mowing reduces costs but also contributes to biodiversity e.g. wild pollinators (Figure 2).

Greening post-industrial areas (brownfields)[3] can be a good strategy to increase the amount of greenery in cities and the flow of ecosystem services (Chowdhury et al., 2023). However, scenario analysis related to such sites in Shanghai has shown that a significant proportion of brownfield greening projects preferably by carried out in more populated and economically dynamic areas. Such efforts should improve biodiversity, provide recreational areas, and be part of the green-blue network in the city (Zhong et al., 2020). Bioremediation can be used to restore such areas, i.e., through the introduction of microorganisms that naturally remove hazardous substances from the soil. Bioremediation processes are affected by many factors (e.g. temperature, soil pH). Therefore, these processes will differ in each place and sometimes require more time, so that the soil can be cleansed and adapted to the introduction of new plantings.

[3] See guideline on planning, policy and delivery.

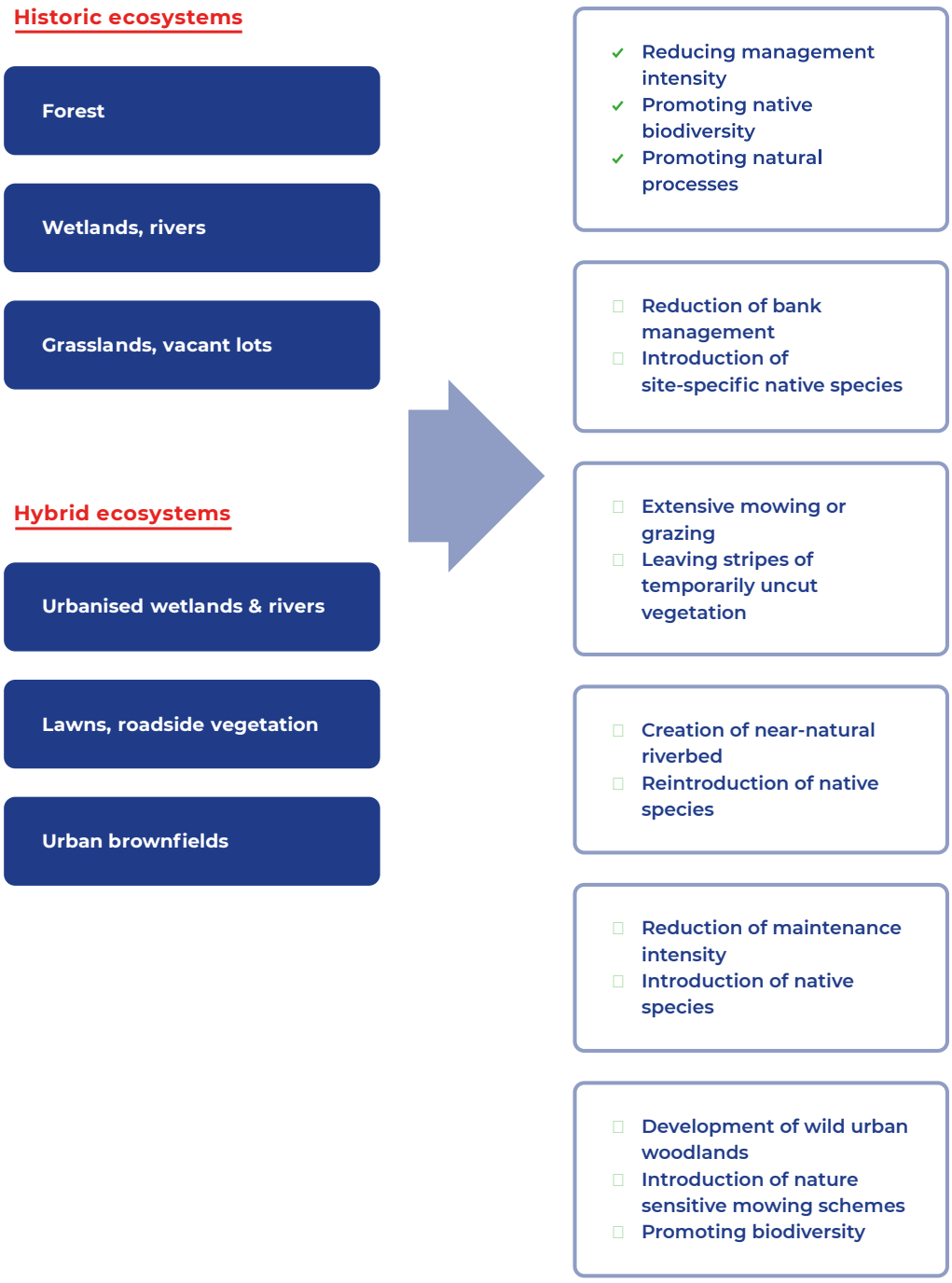


Figure 2: Types of ecosystems in urban areas and examples of restoration activities, adapted from Klaus and Kiehl, 2021.

Multifunctionality of urban forests through integrated management

Green spaces in the city can be divided into formal green spaces (e.g. parks, woodlands, allotment gardens) and informal green spaces (e.g. fields, meadows, brownfields) (Figure 3) – more on brownfields in Guideline 1, pp. 25–26. Depending on the level of formalisation of green spaces, there are often different entities responsible for their management. Frequently, formal green spaces are controlled by local authorities (e.g. Urban Greenery Board), planners (e.g. Municipal Planning Office) or units dealing with municipal matters in the urban area (e.g. Department of Municipal Management). Therefore, the management of green spaces is entrusted to specific units that take care of plants, maintain order, provide equipment (e.g. benches, playground equipment, fields), and ensure the safety of users of a given green space (Biernacka and Kronenberg, 2018). Formal green spaces are usually better protected than informal green spaces (e.g. through appropriate provisions in local zoning plans). However, with the current promotion of a compact city and densification of urban areas (limiting suburbanisation), informal green spaces may be at risk (especially smaller patches of greenery, green squares or street greenery). On the other hand, informal green spaces are often unprotected, do not have an official manager, or their legal status is unknown. Such areas (especially peripheral ones) are treated as a spare place for new investments and are often taken over by developers. In turn, the protection of these spaces is particularly recommended because they often host a large diversity of plants and animals (high biodiversity) that do not even live in formal green spaces (e.g. parks) (Sikorski et al., 2021).

One of the significant challenges of managing urban forests is to plan and design a given area in such a way that it meets the expectations of a diverse group of urban residents, including the most vulnerable groups (children, the elderly, people with disabilities – both physical, intellectual, and those related to the perception of stimuli, such as neurodivergent persons). Adapting the green space to meet the needs of so many groups is a huge challenge and requires consultation with various organisations, experts, and professionals who will share their expertise. Of course, it is also very important to maintain the urban forest itself, which involves maintenance treatments, care for cleanliness, and the renovation of damaged or worn-out equipment. Such activities require constant supervision of the green space and regular checks on the condition of equipment and infrastructure (Figure 4).



Figure 3: Types of formal and informal green spaces in the city.

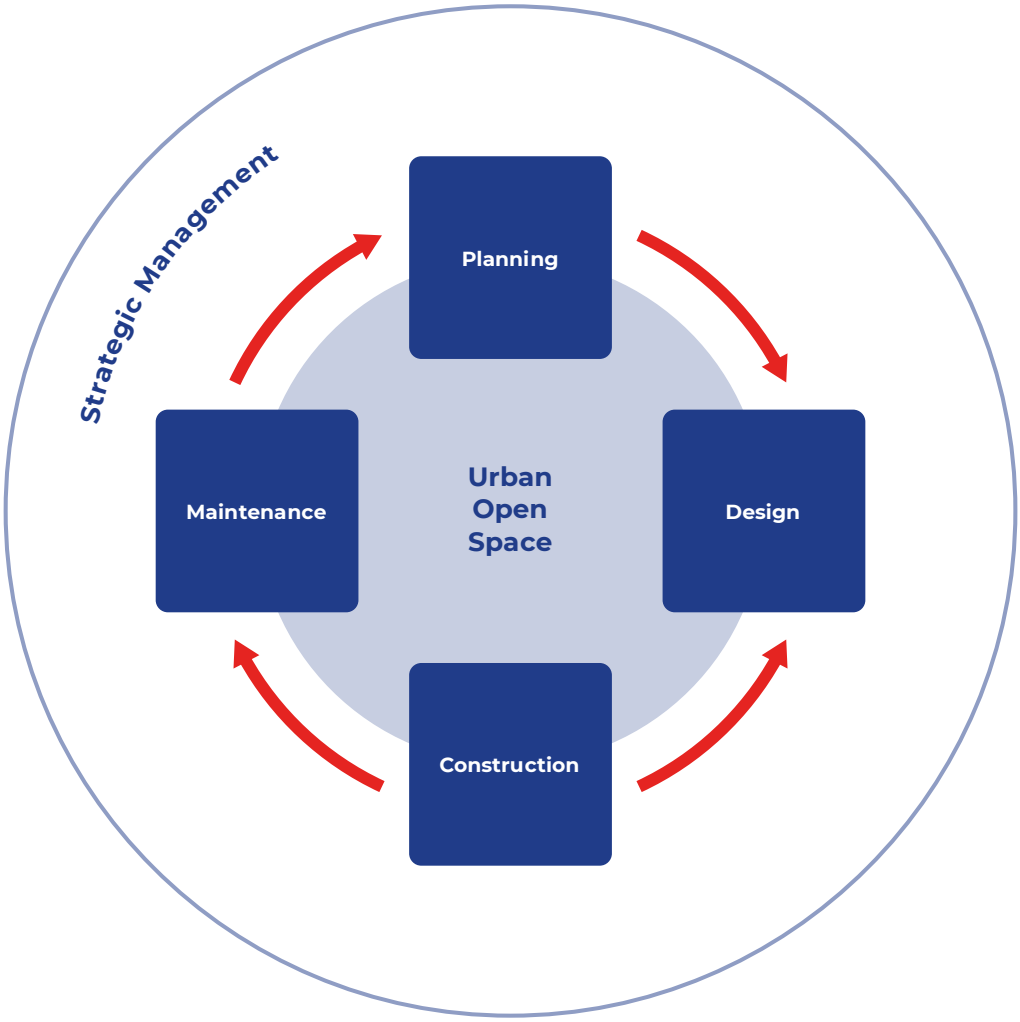


Figure 4: Cycle of strategic management of urban forests, adapted from Randrup et al., 2021.

Taking care of the needs of diverse users, it is necessary to ensure the multifunctionality of urban forests, which will be adapted to the needs of children (e.g. safe playgrounds, sports fields, educational paths), the elderly (e.g. plenty of benches, shaded gazebos, drinking water faucets), people with mobility disabilities (e.g. wide and paved paths, recreational equipment and toilets adapted to their needs), blind people (e.g. use of typography, clear composition of paths, reduction of dangerous crossings and pavement) or people on the autism spectrum (e.g. places where one can calm down, isolated from the crowd and noise; sensory gardens). Only by designing a multifunctional and diverse space with different elements and zones can the needs of various groups be met. It is particularly important to pay attention to people with special needs, e.g. elderly people, disabled people or pregnant women, for whom the availability of public spaces (including urban forests) may be significantly limited (mobility restrictions, poorly constructed infrastructure, lack of places to relax in the form of benches and shaded gazebos) (Figure 5). The key is to increase the number of users of urban forests so that residents with special needs can also use them, which directly affects the quality of their life and health.

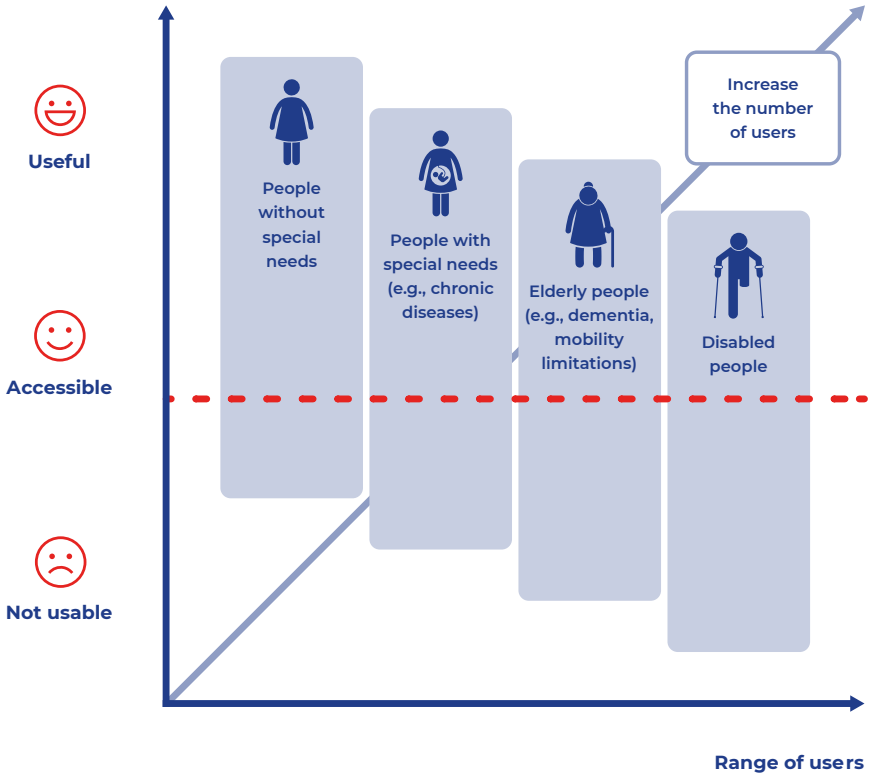


Figure 5: Basic tenets of universal design. Adapted from: Universal Design Guidelines for Outdoor Spaces, Plan and Design for Choice, 2009.

Monetary benefits from restoring urban ecosystem services

To measure the value of benefits (ecosystem services) associated with urban forests, a whole catalogue of methods for valuing non-market goods has emerged, which include indirect valuation methods and direct valuation methods. With these methods, we can count how much the benefits associated with, for example, the restoration of a given ecosystem translate measurably into financial aspects. Many studies conducted in various cities worldwide have shown that restoring ecosystems and planting new trees translates into financial benefits that outweigh the costs associated with tree planting and maintenance. The benefits range from reduced health care expenses (e.g. thanks to the physical activity that takes place in urban forests or the absorption of pollutants, particulate matter, and noise suppression). Moreover, urban forests affect climate regulation, which translates into reduced expenses associated with cooling houses during the summer period (particularly as climate change is causing average temperatures to rise in many places, with heat waves and the occurrence of so-called tropical nights becoming more frequent).

City residents are often willing to pay for the use of ecosystem services and access to urban forests. The results of the research show that residents are willing to pay (in the form of a tax) to increase the number of trees on streets where there are no such trees. In addition, research related to hedonic pricing (involves determining how the presence of an asset, e.g. a park contributes to the value of a chosen asset, e.g. a property) shows that people are willing to pay more when buying an apartment or house when the property is located close to urban forests, especially the larger and more attractive (well-equipped) ones (Giergiczny and Kronenberg, 2012; Czembrowski and Kronenberg, 2016; Łaszkiewicz et al., 2019). The existence of these spaces not only translates into the quality of life of the residents and building their resilience but also affects the perception and image of the urban area and can greatly enhance the attractiveness of a given space, thus attracting tourists and new investors.

Based on a study of strategies related to the maintenance, protection, and use of UF-NBS in Australia, two most important lessons were drawn (Ordóñez, 2021):

- Innovative regulation and incentives for trees on private urban land (e.g. tax credits for backyard tree care – a paradigm shift from "deterrence" to encouragement).
- Prioritising the multifunctionality of urban forests (urban forests are not only providing shade and air purification function, but also habitat for many plant and animal species and cultural and historical heritage).

Cost-effectiveness of UF-NBS

Notwithstanding the monetary benefits from restoring urban ecosystem services, decision makers generally require an assessment of the benefits and costs. The World Bank Group has produced a guideline for project developers to help make the case for investment in nature-based solutions and report that the net benefits of NBS for climate resilience are significant, however, they note that a lack of knowledge at the project level is a key barrier. They propose an actionable methodology for project level assessment. This has been adapted for UF-NBS.

Set objectives for the cost-effectiveness assessment.

- Ask pre-concept/strategic level questions (i.e. how this fits with the urban forest strategy and management plan).

- Undertake an economic and financial analysis (collect relevant data e.g. costs, timescale, inflationary pressures etc).
- At the design phase undertake cost management when required.
- Monitor impact and compare with initial analysis and apply to future assessments (i.e reflective practice).

Methods

- Least effort: Use rapid assessment methods that rely on comparative data sets that are openly available.
- More effort: As above, but also involve stakeholder engagement to provide more precise, quantitative and context specific results.
- Most effort: Data derived locally through a combination of research methods likely involving research institutes/universities and/or consultants as well as stakeholder engagement.

Fostering NBS for smart, green and healthy urban transitions in Europe and China has also been investigated by the REGREEN project, and a report by Panduro et al. (2021) provides more details on cost estimates for de-pavement projects, street trees, green roofs and green walls. The report argues that stepwise ranking of policy objectives in a cost-effectiveness analysis is a viable approach that will enable policymakers to make an informed choice over competing solutions.

Key messages on cost-effective restoration and rehabilitation management for urban forests as nature-based solutions

1	Ensuring urban resilience, ecological continuity and healthy ecosystems reduces the negative impacts of climate change and provides a better quality of life for residents.
2	Ensure resilience whenever possible, e.g. by using nature-based solutions, choosing plants adapted to local climate and soil, increasing the genetic and species diversity and counteracting fragmentation of ecosystems.
3	Restoration and rehabilitation processes involve numerous challenges which can be overcome through financial support (from the private sector, national or international funds), increased awareness among officials and managers of the urban forest and the use of new technologies.
4	Methods related to restoration and rehabilitation include new plantings, soil reclamation, maintenance of dead organic matter (e.g. by preserving deadwood), restoring the natural course of streams and restoration of indigenous vegetation.
5	Divide green spaces into formal (e.g. parks, forests, cemeteries, allotment gardens) and informal (wastelands, grasslands). The former category is managed and (usually) protected, while the latter are not normally protected, hence new developments threaten their existence. Risk reduction policies are necessary here.
6	In the provision of urban forests, the key is their multifunctionality (responding to the needs of multiple user groups) and universality (providing access to urban forests also to the least privileged groups in the urban area – people with disabilities, the elderly, children, people with chronic diseases), i.e., designing spaces following the guidelines of universal design.
7	For the valuation of ecosystem services, non-market valuation methods can be used. Research based on these methods shows that ecosystem services have a very high value (e.g. translating into reduced health care expenses). In addition, residents often want access to urban forests and may pay extra for them (in the form of taxes or higher property prices).

Case study links (see case studies section)

Shenzhen Urban Forest, Beijing Plain Area Afforestation Programme (BPAP), Kamp Beverlo, Ruhr Metropolitan Region (Industrial Forest Project), Drwinka River Park, Metropolitan Area of Barcelona (Llobregat&Co).

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Figure 1: **Participatory planning and management in the City of St. Gallen, Switzerland. Source: J. Wilkes-Allemann**

GUIDELINE 3

MECHANISMS FOR PUBLIC AND STAKEHOLDER ENGAGEMENT FOR URBAN FORESTS AS NATURE-BASED SOLUTIONS

Jerylee Wilkes-Allemann, Clive Davies, Jiali Emily Jin, Florim Sabani, Eugènia Vidal Casanovas

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Summary

The importance of integrating public and private stakeholders, as well as citizens in managing and planning UF-NBS is essential. Here we present simple tools on how public and private stakeholders can be identified and integrated in the process of planning and managing urban forests as nature-based solutions to help local actors proceed with this. This guideline shows that participation is very important and that it is only successful if relevant stakeholders are actively involved in the process and concludes that participatory solutions require a certain openness to the objectives and goals on the part of those commissioning them.

Why is it necessary to engage public stakeholders and citizens in planning and managing UF-NBS

It is important to integrate public and private stakeholders, as well as citizens in planning and managing UF-NBS as it legitimises the process and enables identifying the needs of citizens (van Ham and Klimmek, 2017). Additionally, through participation it is possible to avoid potential conflicts, as well as providing opportunities for citizens to play an important role in monitoring UF-NBS.

In the context of this guideline stakeholders are defined as an institution, a person or a group that uses, is influenced or has interest in the planning and management of UF-NBS. Examples of public stakeholders include public agencies and other relevant departments. Private stakeholders are private persons, private land owners, as well as private companies. Citizens (e.g. residents) are considered as separate even though they could be also interpreted as being part of the private stakeholders.

The question of "how to decide" is a core question of governance and one with long history. Participation in the context of governance plays a crucial role (Arnstein, 1969). The International Association for Public Participation[1] defines public participation as *the process by which an organisation consults with interested or affected individuals, organisations and government entities before making a decision.*

Public participation is seen as a two-way communication and a collaborative problem-solving process with the goal of achieving better and more acceptable decisions. In the context of UF-NBS, participation can be understood as the *redistribution of power that enables citizens to be deliberately included in the future*, by taking power and transforming their cities and neighbourhoods into sustainable, healthier and greener places that specifically address local problems and needs (MUEC, 2015). Arnstein (1969) identified eight levels of Citizen Participation. Cowling et al. (2014) and Amereller (2020) simplified these into five levels which are shown and described in Figure 2.

> "The idea of citizen participation is a little like eating spinach: no one is against it in principle because it is good for you." (Arnstein, 1969)

Information and consultation can be seen as a pre-participation step. In information the decision-making power and control of the organisation or leading party steering the UF-NBS is at its highest. However, the higher the level of participation, the lower the decision-making power and control by the leading party. On the contrary, the less level of participation, the less influence citizens or stakeholders have on the UF-NBS proposed. This can impact on the acceptability of a nature-based solution as viewed by local communities and other stakeholders and can reduce local commitment to the long-term management of it. In collaboration, joint decision-making and empowerment of stakeholders in decision-making is the true step of participation. It can be said that the highest level of participation (e.g. empowerment) is at the same time the highest level of democratisation.

[1] www.iap2.org



Figure 2: Levels of participation as simplified by Cowling et al. (2014) and Amereller (2020). Source: Adapted from Cowling et al. (2014)

Information

Informing citizens of their rights, responsibilities, and options is the first step toward legitimate public stakeholder and citizen participation. However, information is frequently performed one sided, e.g. from public stakeholder or the municipality to citizens or relevant stakeholders with no channel provided for feedback and no power for negotiation. Under these circumstances, citizens do not have the possibility to influence an UF-NBS being designed "for their benefit."

The tools most frequently used in such a one-way communication are newspapers, social media, posters, and expositions. For example, the City of Zurich used an exposition called "Trees in Cities" (Figure 3) to explain to citizens the importance of trees in the city, the challenges they are confronted with, and which trees will be relevant in the future and that will play a crucial role in the context of climate change. Visitors had the possibility to give some feedback at the end of the visit.

Workshops and meetings are sometimes used to inform stakeholders using a one-way communication, thus providing superficial information, discouraging questions, or giving irrelevant answers to stakeholders involved.



Figure 3: **Trees in Cities exposition in the City of Zurich, Switzerland, to explain about the importance of trees in the city and the challenges they are confronted with in the future. Source: Bianca Baerlocher.**

Consultation

Consultation can be understood as inviting concerned citizens to give their opinion on a topic as well as hearing their expectations and concerns about a certain UF-NBS project. As with information, consultation can be a legitimate step toward full participation. However, if consulting is not combined with other modes of participation, it loses legitimacy and can lead to frustration with the stakeholders (citizens and public stakeholders) involved. Frequently used methods for consultation are surveys, individual meetings, or consultation workshops. In consultation a specific stakeholder group could be invited to participate in a workshop to comment on certain aspects of a new UF-NBS projects such as the creation of a food forests. Their opinions are heard but at the end the lead of the projects takes the final decisions and the stakeholders involved are not able to decide anything.

Collaboration

Collaboration can be understood as joint activities with stakeholders engaged in problem solving and the development of proposals. In this mode of participation, a two-sided communication is used, meaning that stakeholders involved are allowed to provide feedback and give their opinion as well as propose new solutions to the issue being discussed. In this mode of participation multiple stakeholders stemming from different fields are brought together to implement an UF-NBS project and refine the proposed approach by e.g. the municipality. Even though participants are closely involved in finding a good solution to the problem, the key decision-making role still lies in one or a group of lead agencies.

Joint decision making

In joint decision making the involved parties have the same shared control of decision-making. It can be composed by a steering committee comprised of multi-stakeholders that provide oversight of a UF-NBS project and make joint decisions on it. An example is the co-creation process of a new food forest in an area owned by the community. In this process stakeholders involved have the same level of decision-making as the public stakeholders from the community

Empowerment

The highest level of participation is empowerment, where e.g. citizens are responsible for decision-making. In this case a specific stakeholder group could, for example, take responsibility for undertaking and leading certain parts of a UF-NBS project (e.g. developing and implementing an assessment approach) for a given period or the city gives citizens the right to use a parcel for a food forest, the citizens can fully decide on how to design it, species, management etc., and can call for logistical support from the city for specific management interventions. It should be recognised that empowerment can be a challenge to public funding accountability depending on the local or national context.

What is the added value of a participatory approach in UF-NBS

Integrating stakeholders in a participatory process is not only a basis of democracy but it also provides important benefits to UF-NBS planning and managing. Participatory approaches play a crucial role when designing neighbourhoods, as they provide undeniable advantages compared to conventional processes managed solely by professionals or public stakeholders. The main reason is that neighbourhoods are composed of citizens that spend every day in it, or employees who work there. Thus, they provide crucial observations and knowledge that is different from experts. Professionals or public stakeholders can then supplement with their knowledge the information provided by citizens. By integrating citizens' observations, concerns and aspirations from the start, and throughout the project, all participants can find solutions collectively that meet the community's true needs. More than just a simple consultation, participatory UF-NBS planning promotes open dialogue and interaction between users, experts and decision makers throughout the entire process resulting in a combined knowledge that tackles better local challenges as shown in Figure 4.

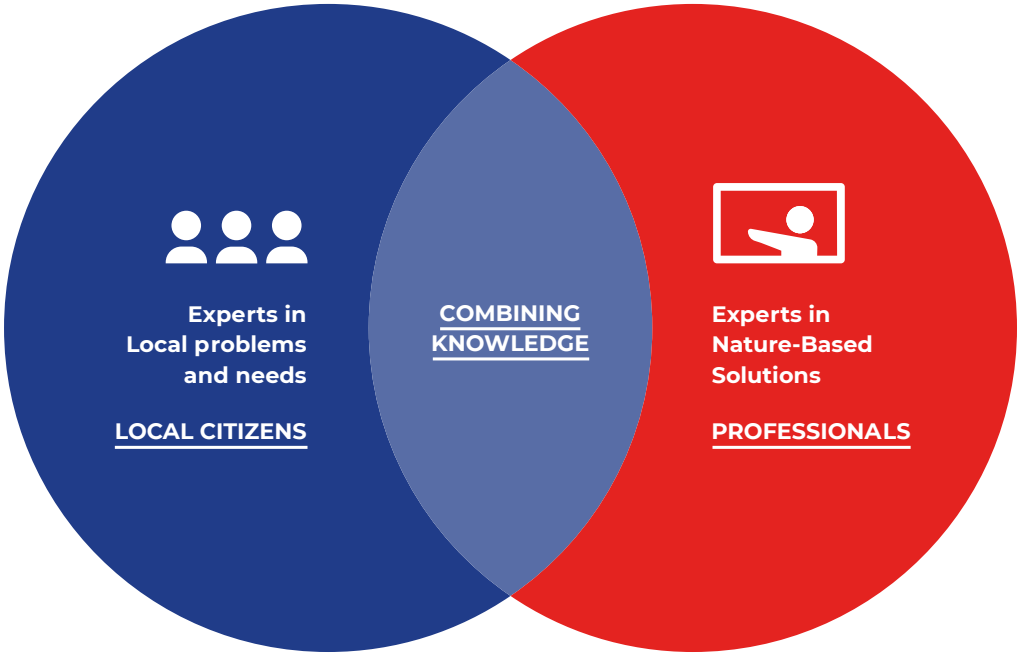


Figure 4: The added value of the participatory approach. Source: compiled by authors adapted from MUEC, 2015.

What are the benefits of public stakeholder engagement and citizen participation

UF-NBS projects in urban and peri-urban areas are framed by many interests that sometimes collide. Thus, integrating relevant stakeholder in UF-NBS projects from the beginning may reduce conflicting situations and at the same time legitimate the process, as well as integrate local knowledge. In this context and based on MUEC (2015) citizen participation can:

- supplement the technical knowledge of professionals by informing them about day-to-day use of an urban and peri-urban area,
- prioritize needs and target specific locations,
- improve analysis and proposals to ensure that results better reflect real needs,
- form alliances with community leaders,
- promote the social acceptability of a UF-NBS project and its adoption by the community,
- understand the time, budget and technical constraints of the various partners,
- promote democratic governance and support active citizenship,
- ensure the spirit of the UF-NBS project is maintained in the long term through the participation of active citizens and partnerships with local organizations.

Art as means for participatory engagement in UF-NBS

Art-based methods are defined as "*research in which the arts play a primary role in any or all the steps of the research method. Art forms [...] are essential to the research process itself and central in formulating the research question, generating data, analysing data, and presenting the research results.*" (Austin and Forinash, 2005, p. 458–459).

Art-based methods, such as photography, sculptures, and theatre have been in the last decade widely used in projects engaging communities (Colemans et al. 2015). In participatory processes these methods have the potential to explore a shared problem or issue from different perspectives. It also offers the possibility of creating knowledge by positioning dialogue and participation at the centre (Kunt 2020). Depending on the context conditions, the problem to be solved or issue to be discussed and the target community, art-based participation may be chosen.

Four steps to successful participation in UF-NBS planning and management

Step 1 – Identify all relevant stakeholders

In a first step all relevant stakeholders need to be identified. The following guiding questions may help:

- What is the goal of the participatory approach and project?
- Which persons or organisations are affected by or interested in the project, its development and its results/impacts?

Based on these questions it is possible to list all relevant stakeholders using the template in Figure 5. If possible, less than 30 stakeholders should be identified. Afterwards the identified stakeholders should be clustered to have groups of stakeholders and to ease the integration of these stakeholders in the process.

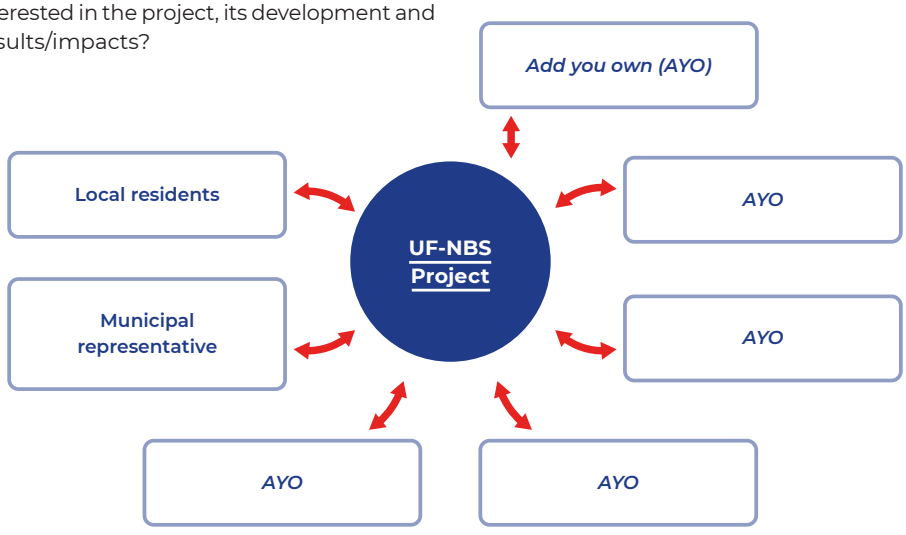


Figure 5: Who are relevant stakeholders for a given UF-NBS project? Source: Template compiled by authors.

Step 2 – Run a stakeholder analysis

In a second step a stakeholder analysis should be run. In this context the following questions should guide the analysis:

- How large are the interests in the project (preparation, objectives/impact, implementation)?
- How great is the influence (power) of the stakeholders in relation with the realisation of the objectives?
- What are their feelings towards the goals (positive/neutral/negative)?

Based on this question identified stakeholders should be rated based on the criteria: interest in the project (e.g. 1 to 4 whereby 4 means high interest in the project), influence in the project (e.g. 1 to 4 whereby 4 means high influence in the project) and attitude towards the project (e.g. +/-/n). Thereafter stakeholders should be classified in the four-field matrix as shown in Figure 6.

Stakeholders identified as **key players** are very important and need to be integrated in the participatory process. Additionally, it is key to actively cooperate with these stakeholders, as their influence in the process is very high, as well as their interest. Stakeholders identified as **stars** are important, as they have high influence and low interest. Thus, these types of stakeholders need to be satisfied during the process to be able to implement the project. **Experts** are less important, as their influence is low, however, their interest is high. Thus, experts need to be regularly informed about the project/process. Stakeholder defined as **others** need to be kept in mind in case, at some point, they need to be integrated. An integration may be necessary in case the interest or influence of the "other" stakeholders' changes during the process.

After the stakeholder analysis, the overall coherence (such as influence between the identified stakeholders) needs to be verified by discussing it with other persons (e.g. colleagues) who know about the contextual situation. It is important to reflect on the quantity of key stakeholders and the power relations that lie between them. This can be done based on local knowledge or bilateral exchange with some of the expert groups. Based on this information a strategy needs to be set to avoid one sided discussion.

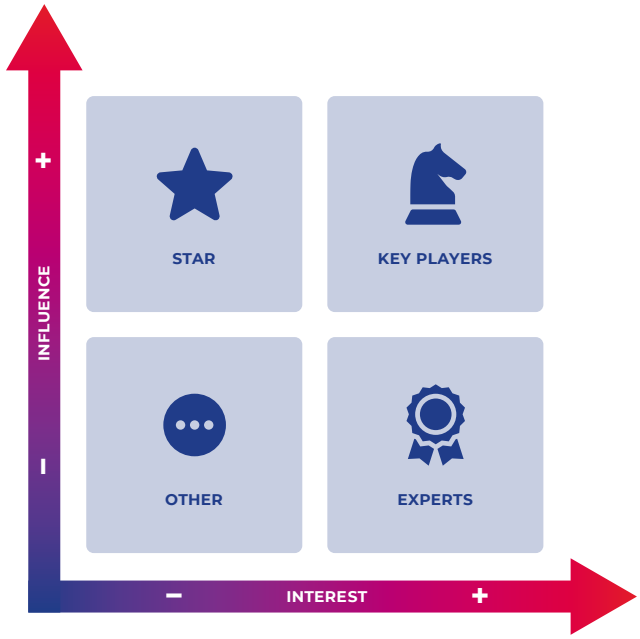


Figure 6: Four-Field matrix. Source: Compiled by authors.

Step 3 – Develop a strategy

In the third step a strategy to integrate stakeholders needs to be developed. It is important to remember that the main goal is not to influence the stakeholders but to have a mutual exchange on experiences and concerns. In this step it is also crucial to assess options for action and resources for dialogue. Furthermore, it is important to correctly assess the scope for action by the lead organisation, and the degree of power delegation to the stakeholders. It is crucial to keep in mind that it is practically impossible to win all stakeholders for the UF-NBS project in question or to address all concerns of stakeholders equally.

In this step an analysis of the stakeholders from the stakeholder matrix should be undertaken and somewhere between three to seven communication measures (e.g. emails and flyers informing about the project; workshops and discussions informing about the project, etc) determined which are appropriate for each specific stakeholder group.

Four questions need to be considered:

- Which stakeholders and stakeholder groups can be clustered to be integrated in the process?
- Which stakeholder sectors should be informed or involved, and which form of communication will be used?
- Which goals are aimed to be reached with the selected communication tools?
- Where do changes in interest/influence/power need to be made?

Step 4 – Prepare for dialogue

In step four the goal is to prepare for dialogue. This means that the concrete measures are defined that will be implemented, as well as the exact methods. The timeline for the implementation should also be concretised in this step. Furthermore, the responsible for doing it should also be defined. The crucial questions are:

- How should the measures in concrete terms be implemented?
- How (exact methods, use of resources)?
- When?
- Who and by whom?

In step four it is important to consciously define the level of citizen participation, as well as involve all identified stakeholders according to their role and the objectives of the project. Table 1 and Figure 7 can be used as a basis for this.

Table 1: Level of citizen participation. Source: Compiled by the authors.

Stakeholder	Category	Communication strategy and role
Local residents	Interest group	Direct involvement in the process
Municipality	Owner	Initiator of the process
Association or NGO	(Describe)	Information (or more)
Others etc.		

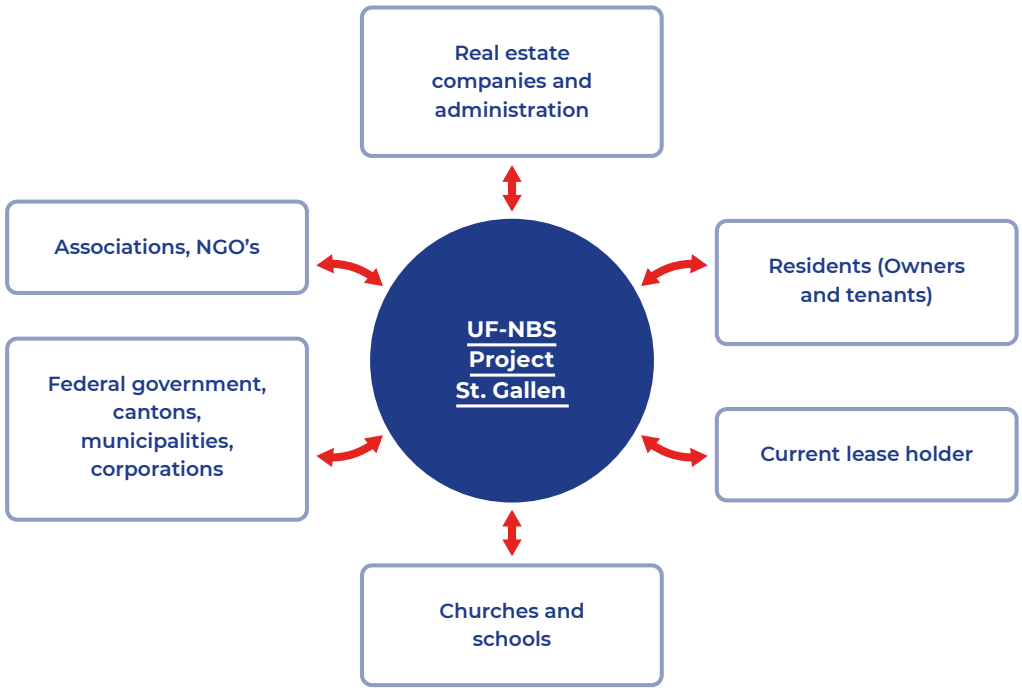


Figure 7: Example of stakeholder mapping based on an example in Switzerland. Clearly this needs to be adapted to the local situation. For St Gallen, Switzerland see case studies on urban forests as a nature-based solution (UF-NBS) at the end of this document. Source: Compiled by the authors.

Additionally, like any other project, a detailed description of which activities should be run, when and which stakeholders should be involved needs to be prepared as shown in the example below (Table 2).

Table 2: Description of activities. Compiled by the authors.

	Year 1				Year 2			
Milestone	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Co-creation workshops	X			X			X	
Field event		X	X			X		
Survey of participants				X				X
etc								

Challenges with participatory approaches in UF-NBS

Participatory approaches are full of challenges, these include amongst others:

- communicating the objective and the content of the participatory process in simple easily understandable language,
- being clear on the level of participation of the stakeholders and the level of power delegation,
- identifying the right stakeholder groups to be involved in the process,
- mobilising citizens/residents and other identified stakeholder groups,
- dealing with power relations of the stakeholders and opposition of some stakeholders to the project,
- diverging objectives during the participatory process and reconciling divergent positions,
- reflecting proposed ideas in the final decisions.

In the CLEARING HOUSE project one example is the Metropolitan Area of Barcelona (see case studies on urban forests as a nature-based solution (UF-NBS) at the end of this document). In this case three main challenges were identified. These include: technology, dissemination and data interpretation. The first one, technology, was a big challenge as the interface needed to be customised to make the most of the participatory GIS (using ArcGIS Platform by ESRI). The second one, dissemination of information, concerned making the tool known so that people who were not involved in workshops also contributed to the participation process. The third challenge, data interpretation, concerned the issue of how to handle it.

In the case of the City of St. Gallen in Switzerland two main challenges were encountered. First, there was a strong rejection of all new project outlines by a group of residents. Views were collected for the status quo and against new projects. For this reason, an "existing project variant" – i.e. a variant that does not envisage any fundamental changes in the perimeter – was included as an independent variant and submitted to the other participants for voting and evaluation. The "existing project variant" is now also one of the variants submitted to the City Council. These opposing residents were actively involved in the process, and an attempt was made to give the "loud" opinion of this group the appropriate weighting using suitable workshop methods. On the other hand, this open type of process design is a novelty in the locality and the systemic approach and processing is diametrically opposed to classical project management. This means that no standardised established tools can be used and new solutions must be sketched out – which, however, also illustrates the added value of this type of project development.

Conclusion

Participation is very important if the field of nature-based solutions and UF-NBS is no exception to this. Based on the examples presented it can be concluded that participation processes are only successful if those people affected are actively involved in the process. Additionally, participatory solutions require a certain openness to the objectives and goals on the part of those commissioning them. Furthermore, the identification and description of interest groups and the corresponding considerations on communication and the level of involvement are the first steps towards successful participation even though it will mean spending some time in identifying the stakeholders and deciding on the right level of participation. Furthermore, framework conditions and parameters that cannot be changed by the stakeholders must be communicated consistently and transparently at the beginning of the process (including the level of power delegation).

Key messages on mechanisms for public and stakeholder engagement for urban forests as nature-based solutions

1	Define clear, measurable, and realistic goals. Identify the desired results to develop appropriate activities. Agree on the rules and boundaries and make the process clear and transparent and be open about constraints. Avoid technical jargon by using plain language in communications, technical documents and during activities.
2	Adapt the process and avoid rigid models and vary the methods according to the target group and modify the process as you go along if needed. Ensure that you document the process, recording what is being said and take pictures making sure you get permission for this.
3	Provide the necessary time and financial resources to support the process based on the scale and significance of the project. Remember to involve groups with different interests and reach out to major stakeholders as soon as possible to avoid potential resistance.
4	Work at the human scale: Emphasize working in small groups and at the neighbourhood scale so that everyone is comfortable and heard. Call on experienced facilitators if these skills are not 'in-house' to ensure participation includes well-directed facilitation.
5	Illustrate ideas by using visual presentations to facilitate understanding of ideas and concepts. Go on-site to facilitate the understanding of concepts and develop well-adapted solutions by working at, or near, the project site.
6	Emphasize quality when preparing activities and use a few, well-planned activities to collect highly significant data. Learn from the experience of others too by getting ideas from what has been done elsewhere. Use networks such as EFUF (www.efuf.org) to stimulate ideas and learning.

Case study links (see case studies section)

Ruhr Metropolitan Region (Industrial Forest Project), Lochend Community Woodland, St Gallen Switzerland, Metropolitan Area of Barcelona (Llobregat&Co).

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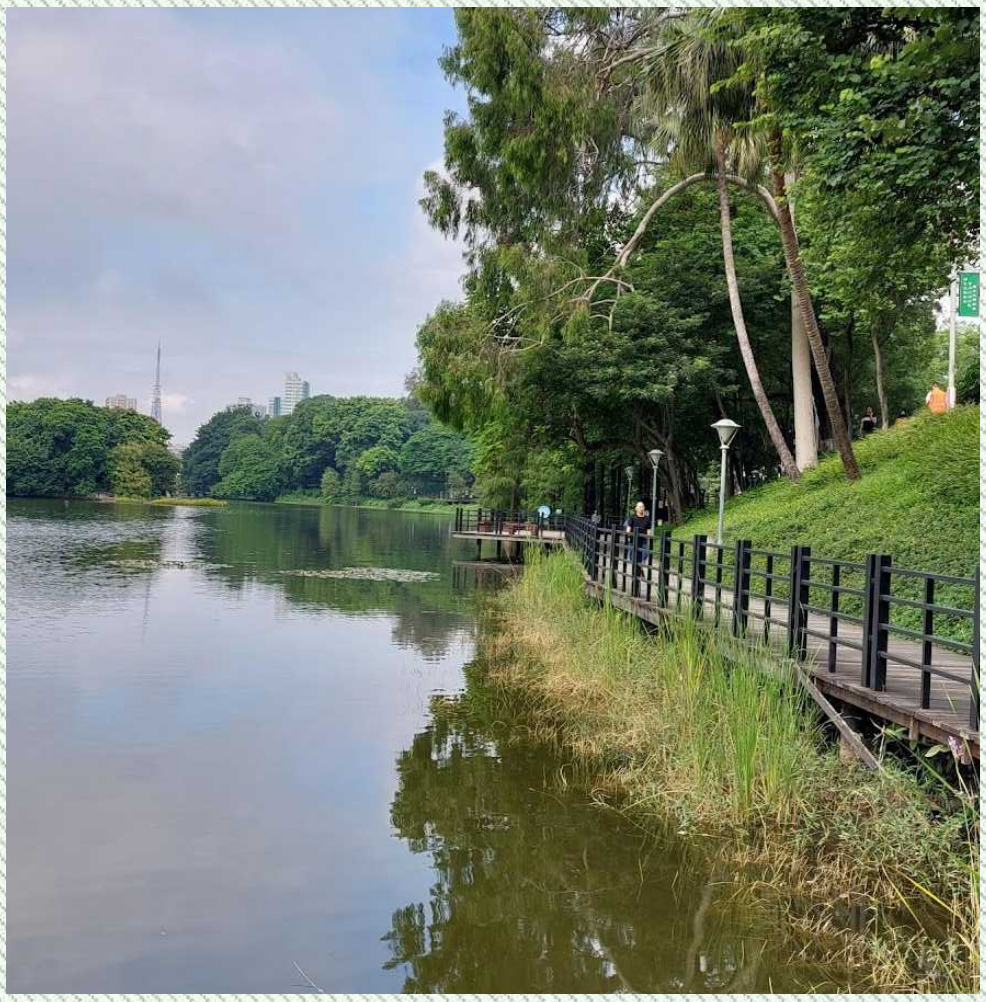


Figure 1: **The urban forest of Guangzhou, China; Photo credit: Ivana Zivojinovic**

GUIDELINE 4

CHANGE MANAGEMENT AND INSTITUTIONAL REFORM FOR URBAN FORESTS AS NATURE-BASED SOLUTIONS

Ivana Živojinović, Stojan Ivanović, Andreas Bernasconi, Clive Davies, Ian Whitehead, Dorsa Sheikholeslami, Jerylee Wilkes-Allemann, Barbara Darr, Jelena Tomićević Dubljević, Silvija Krajter Ostoić, Dijana Vuletić

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Summary

To effectively govern urban forests as nature-based solutions, several critical factors must be considered. Collaboration and partnerships stand as the foundation of effective UF-NBS management, involving government agencies, NGOs, and local communities as well as fostering regional cooperation. Robust planning and strategy development, such as Urban Forest plans, ensure that UF-NBS efforts align with integrated policies at different levels. Financial support, drawn from various sources, can fuel UF-NBS initiatives, enabling their growth and impact. Community engagement is of prime importance, involving residents, voluntary groups, and inclusive language to encourage participation. Capacity building through training and external expertise elevates the effectiveness of UF-NBS management.

Change management

Change management refers to the body of knowledge and practices that deals with how organisations can effectively plan for, implement, and manage changes in structure, processes, and systems. Kotter (2012) developed an eight-step process for managing organisational change (list adapted by the authors see Table 1).

Table 1: A process for managing change adapted by the authors (after Kotter), whilst generic they provide useful guidance to those developing urban forest strategies and management plans.

1.	Establish a sense of urgency: Organisations must create a compelling reason for change and communicate the urgency of the situation to employees.
2.	Form a powerful coalition: Organisations must assemble a team of other organisations/ people who have the necessary skills and influence to drive change.
3.	Create a vision for change: Organisations must create a clear and compelling vision for the future that can guide the change effort.
4.	Communicate the vision: Organisations must communicate the vision for change to all employees in the organization, using a variety of communication channels.
5.	Empower others to act on the vision: Organisations must remove barriers to change and give employees the tools and resources they need to implement the vision.
6.	Create short-term wins: Organisations must create opportunities for early successes that demonstrate the benefits of change and build momentum for the change effort.
7.	Consolidate gains and produce more change: Organisations must continue to build on the early successes and make further changes to achieve the vision.
8.	Anchor new approaches in the organisation's culture: Organisations must embed the new approaches and behaviours into the organisation's culture, so that the changes become sustainable over time.

There are drivers for change too; for example the Edinburgh Declaration on Biodiversity recognises the necessity of transformative changes across ecosystem management to achieve sustainability, highlighting the vital role of subnational governments, cities and urban local authorities and those involved with built development.

Change management in urban forests where nature-based solutions are a key objective is about pursuing better management, support and sustainability of them, but not in isolation from all relevant policy areas, such as urban planning, infrastructure, development and social equity. Key is to improve an organisation's ability to deliver enhanced ecosystem services and support nature recovery. Risk-based management which is often a key feature of urban forest practice in cities needs to be supplanted by an ecosystem service-led approach in most situations short of a serious danger to life. Change should first be achieved and implemented in organisations that manage and govern (directly and indirectly) the urban forest at various governmental levels and in various sectors. This can then be followed by changes in relations and interactions with other stakeholders who have an interest in urban forestry (Keesstra et al., 2018).

Understanding the institutional background of urban forests

Governance of urban forests refers to the policies, regulations, and practices that govern the management, protection, and development of trees and forests in urban areas. Urban forests are an essential component of the urban environment and are by their very nature effective nature-based solutions (NBS). Effective governance of urban forests requires the collaboration and coordination of stakeholders. The governance of UF-NBS can be steered at different levels. In some cities the key stakeholder is the national government, which owns the urban forests and provides regulations for their governance and management, while in others these are regional or local/city authorities, in others it is private forest and tree owners. This highlights the important role of a coordinating body and a multi-tiered approach to urban forest planning.

National government's role in UF-NBS

National governments can play an important role in promoting UF-NBS since cities and urban areas are one of the most important ecosystems regarding countries commitments in several environmental agreements. As an example, parties to the United Nations Convention on Biological Diversity (UN CBD) have agreed to significantly increase the surface area and quality of green spaces and enhance ecosystem connectivity in urban areas through the sustainable use of biodiversity as part of the Kunming-Montreal Global Biodiversity Framework (Target 12). Such targets and goals are unachievable without putting nature-based solutions and urban forests at the centre of the urban agenda. National governments can drive and support the development and implementation of urban forests and promote these as nature-based solutions (UF-NBS) by:

(i) developing specific national planning policies and legal regulations for establishing and protecting urban forests and creating incentives for 'tree' owners to contribute to and maintain these as nature-based solutions in pursuit of national targets and international agreements.

(ii) providing national 'ring fenced' funding, such as grants, loans, incentives and fiscal measures which can be used to plant and maintain urban trees, support research and develop education and social engagement programmes.

(iii) support social, scientific and cultural research on UF-NBS through their universities and research institutes.

(iv) promote the benefits of urban forests and increase public awareness about their importance by supporting national campaigns.

(v) influence national curricula for schools and further education organisations to raise awareness of the importance of the urban forest for city sustainability.

(vi) foster partnerships between national stakeholders which have 'trickle down' potential to the local level.

(vii) establish standards and guidelines ensuring that urban forests are managed in a consistent and effective manner across different regions.

Regional government role in UF-NBS

In some specific cases, authority over urban forests lies at the regional level (including urban regions or metropolitan areas). Regional governments can have similar roles to those described for national governments. Here specific focus can be made on creation of regional green infrastructure networks

between different cities and municipalities. While identifying and developing regional strategies for urban forests, it is imperative to consider spatial scale (Criterion 2 of the IUCN Global Standard on NBS [NBS is informed by scale]). This includes the linkage between cities, peri-urban areas and forests outside the city area. It is important for policymakers to consider how urban forests fit within the regional and national policy for forests and the forest-based sectors, taking into consideration co-benefits as well as internal and external risks and opportunities. As an example, the climate-related outcomes and benefits of urban forests should be compared with the co-benefits of promoting increased use of forest products in cities including timber constructions.

The local authority's role in UF-NBS

Frequently governance over the urban forest is at the city or urban local authority level. Creating specific regulations and policies, support for forest education, research and creating partnerships at city level are all important. Bylaws that regulate cutting single trees in gardens for example are usually a municipal competence. Local authorities can be active through direct finance, training and human resources in UF-NBS through for example street tree planting, public park planning and management of brownfields. Municipalities often manage irrigation systems and wetlands that are an integral part of the urban forest. Developing an ecosystem service based Urban Forest Strategy provides a spatial overview, detailed information, recommendations and resources relevant to the regional and local context to effectively and adaptively design, implement, manage and grow an urban tree canopy.

Local communities and private landowners' role in UF-NBS

Comprehensive and robust governance processes are imperative for obtaining successful outcomes. Components of inclusive governance of NBS include opportunities for involvement in the design, decision-making, monitoring and feedback processes for all stakeholders (IUCN, 2020). Local communities and private landowners have a latent role in promoting and maintaining UF-NBS not least since in many urban areas parts of the urban forest are under private ownership (e.g. companies, foundations, private individuals).

Local communities have an important role in advocating for UF-NBS at the neighbourhood level. Community leaders can work with local governments and in neighbourhoods to identify areas that would benefit from increased tree cover and advocate for tree planting and nature-based maintenance programmes. Residents can also participate directly in tree planting and maintenance activities and help to monitor the health of urban forests.

Private landowners can integrate trees and other vegetation into their properties while actively preserving the well-being of existing trees on their land. Collaboration with local governments and community organisations enables private landowners to identify areas that would benefit from increased tree cover allowing them to champion initiatives focused on tree planting and maintenance. In addition, they can have role in preserving and protecting existing urban forests on their property.

Education and awareness, raising awareness of NBS and empowering local communities and private landowners is essential to engagement with UF-NBS. Local authorities and Environmental NGOs have a key educational role.

Institutional change

Creating more resilient UF-NBS requires institutional change at multiple levels. Integrating UF-NBS into comprehensive city planning, coupled with increased funding, human resource allocation, and robust policies, can enhance the creation and maintenance of resilient green infrastructure.

Breaking down silos between departments through horizontal integration

Horizontal integration refers to the coordination and collaboration between different departments or units within one institution, and between various institutions and agencies involved in urban forestry and related sectors (tourism, health, nature protection, recreation, sports, etc.). This type of integration involves breaking down silos between departments and fostering communication and collaboration to achieve common goals related to urban forests and nature-based solutions. Demonstrating institutional-level horizontal integration for urban forest planning, design, management and monitoring involves implementing various strategies:

- Interdepartmental collaboration: involving multiple departments (e.g. parks and recreation, public works, planning and environmental protection) helps to ensure that the urban forest is planned and managed in a coordinated and effective manner. This should include regular communication between departments, shared staff resources, joint planning and decision-making. Establishing an interdepartmental task force for urban forests is very good practice in horizontal integration.

- Public-private partnerships: collaboration between the public and private sectors can help to leverage resources and expertise for urban forests. For example, private companies can provide funding for tree planting and maintenance programmes, while municipalities can provide access to public lands and resources.

- Collaboration with non-governmental organisations (NGOs) can play an important role in urban forest management by providing expertise, resources, and community engagement. Where volunteers are involved, this should not be regarded as a free or replacement service, and NGOs need reliable core funding to meet their overhead costs.

- Urban forest management should be integrated with neighbouring municipalities plans and policies, such as land use planning, transportation planning, and climate action planning. This can help to ensure that urban forests are incorporated into broader strategies for sustainable urban development.

- Collaboration among institutions can help to improve the collection, pooling and sharing of data and technological resources on urban forests, including data, software equipment and protocols for tree inventory, monitoring, socio-economic data, and public involvement.

- Collaborating across political boundaries at the regional level is essential to maximize the impact of green infrastructure and network benefits.

Mainstreaming UF-NBS through vertical integration

Vertical integration involves coordination and collaboration between different levels of government (from local to national and international) and companies from the local to the national level. Examples of vertical integration at the institutional level for urban forest management include:

- Determining commonly understandable definitions and concepts between various stakeholders is a strong start towards vertical integration of policy goals.
- Coordinated planning between different levels of government can help to ensure that urban forests are integrated into broader policies and strategies for sustainable (urban) development.
- A collaborative approach to resource sharing among government levels can improve funding and resources for urban forests. For instance, national or regional governments can offer financial support for extensive tree planting and maintenance initiatives, while local governments can contribute their specialised knowledge and expertise in the area.
- Capacity building at all levels of government can help to ensure that urban forests are managed effectively. This can include training and professional development opportunities for local urban forest managers and other actors.
- Collaboration between different levels of government can also help to advocate for nature-based solutions as a key component of sustainable development. This can include raising awareness of the benefits of urban forests, advocating for policy and funding support, and building alliances with stakeholders across different sectors.

Public private partnerships

Public private partnerships (PPPs) are an example of horizontal integration that involves collaboration between government agencies and private entities, such as businesses, non-profits, and community groups. In the context of urban forests, they take many forms, such as joint initiatives to plant and maintain urban green areas, public education and outreach campaigns, and partnerships to secure funding for tree planting and maintenance programmes. One key advantage of them is that they can leverage the resources and expertise of both public and private sectors to achieve common goals. For example, businesses may be able to provide funding or volunteer support for urban forest projects, while government agencies can provide technical expertise and regulatory support. However, PPPs must be carefully designed and managed to ensure that they are effective and equitable. This may involve developing clear governance structures, establishing transparent decision-making processes and ensuring that all stakeholders have a voice in planning and implementation.

Community partnerships

Community partnerships in UF-NBS describe activities that are co-produced with residents and various types of community groups, normally in collaboration with government agencies and other stakeholders. Such activities deepen community engagement and commitment to nature-based solutions. The list of community-based organisation types is very extensive and includes for example, community owned companies, community regeneration companies and cooperatives. Determining who and how such organisations can be involved has to be scoped locally.

Establishing evidence-based foundations through research partnerships

Establishing evidence-based foundations for urban forests involves conducting research to understand the benefits and challenges of urban forests and using this knowledge to inform policy and management decisions. Some steps that can be considered include conducting research through field studies, experiments, surveys and data analysis; data acquisition to inform decision-making which can help to reduce possible conflicts and improve communications; engagement of multiple stakeholders in action research to ensure knowledge is fully incorporated into the research design, methodology and analysis; interdisciplinarity to draw in a wide range of expertise and evaluation of outcomes to determine nature-based solution effectiveness and identify areas for improvement. Research bodies can sometime access funds unavailable to other sectors.

Innovations

Institutional innovations

Institutional innovation in urban forests involves the creation of new institutional arrangements and governance structures that support the sustainable management and conservation of the urban forest. This may involve the establishment of new partnerships between local governments, NGOs and private sector, as well as the development of new policy and legal frameworks that prioritise urban forest conservation and management. One example of institutional innovation is the creation of 'ring-fenced funds', which are dedicated financing mechanisms designed to support the long-term management and conservation of urban forests. These funds may be supported by public and private sector actors to provide resources for tree planting, maintenance, and ecosystem restoration initiatives. A good example is Biodiversity Net Gain (BNG), which has been introduced by the UK government as a way of creating and improving natural habitats and ensuring the development as a measurably positive impact.

Local governments can also enhance/improve urban forest management by establishing a dedicated urban forest department. In addition to planning and management, an urban forest department would coordinate stakeholder efforts, conduct public outreach and education. Advancements in institutional approaches to urban forest management may encompass the creation of innovative technological solutions, including the implementation of remote sensing and participatory GIS mapping. These technologies play a pivotal role in facilitating the monitoring and effective management of urban forests as nature-based solutions.

Social innovations

Social innovation involves the development of new approaches, practices, and partnerships that foster social cohesion, participation, and empowerment. This may involve engaging marginalised communities in the management and decision-making processes related to urban forests or creating new opportunities for social interaction and community-building in and around urban forests (Moulaert et al., 2013; Živojinović et al., 2019). One example of social innovation in urban forest management is the creation of community gardens or urban farms in urban forest areas. These spaces can provide opportunities for community members to connect with nature, engage in physical activity, and grow fresh produce, while also contributing to the conservation and management of urban forests. Social partnerships can help ensure that urban forest management decisions are informed by diverse perspectives and are responsive to the needs and interests of different members of society.

Market-driven innovations

Market-driven urban forest innovations refer to approaches that leverage market mechanisms to incentivise the adoption of nature-based solutions. This can take a variety of forms, including payment for ecosystem services (PES) schemes, carbon markets, and green infrastructure investments. Linking the urban forest to market-based mechanisms can help ensure that the benefits provided by trees and forests are properly valued, compensated and tailored to local contexts and needs (Pagiola et al., 2002). One example of a market-driven innovation is the use of PES schemes to incentivise the planting and maintenance of trees in urban areas. PES involves the payment of financial incentives to landowners who provide ecosystem services, such as carbon sequestration or stormwater management, using trees and forests (Wunder, 2015). In urban areas, PES schemes can provide a powerful incentive for property owners to plant and maintain trees.

- Crowdfunding platforms can be used to raise money for UF-NBS projects from many people. This approach can be particularly effective for smaller-scale projects that do not require large amounts of funding.

- Carbon offset programmes – urban forests absorb carbon dioxide from the atmosphere, making them a valuable tool for mitigating climate change. Carbon offset programmes allow companies and individuals to purchase carbon credits to offset their own carbon emissions. UF-NBS projects can be registered as carbon offset projects, providing a funding source for their maintenance and expansion.

- Environmental impact bonds (EIBs) are financial instruments that allow investors to fund environmental projects. Investors receive a return on their investment if the project achieves its environmental goals. EIBs can be used to fund UF-NBS projects, providing a way for investors to support environmentally beneficial projects while earning a financial return.

- Philanthropic grants – foundations and other philanthropic organisations can provide grants to fund UF-NBS projects. These grants can be used to fund research, education, and other initiatives related to urban forest management.

- Green bonds are fixed-income securities that are issued to fund environmental projects. UF-NBS projects can be financed through the issuance of green bonds, providing a way to raise funds for their development and maintenance.

Tools for change management

Co-creation and co-management

Co-creation involves the collaboration and participation of diverse stakeholders in the planning, design, implementation, and evaluation of UF-NBS projects. Related to this is co-management, which involve sharing management responsibilities between different stakeholders, such as local government, community groups, and businesses.

Placemaking and place-keeping

Placemaking and place-keeping are important considerations because they involve creating and maintaining a sense of place within the urban forest that is both functional and meaningful for the people who use it (Frantzeskaki et al., 2018; Colding and Barthel, 2013). Placemaking is the process of creating inviting, people-centred UF-NBS that are welcoming, accessible, and enjoyable for everyone and involves the collaborative planning, design, and management of the urban forest that reflects the unique identity and character of a community, and that promotes social interaction, creativity, and well-being. Place-keeping is the practice of preserving and protecting the cultural, social, and historical significance of a place. It involves maintaining the integrity and character of a place and ensuring that it remains a meaningful and valued part of the community over time. It is focused on sustainability and long-term stewardship, rather than short-term gains or development.

Entrepreneurship and innovation

Entrepreneurship and innovation are crucial components in promoting UF-NBS. Encouragement for this comes from:

- Providing financial support: One of the primary barriers to entrepreneurship and innovation is access to funding. Providing financial support, such as grants, loans, or venture capital, can help budding entrepreneurs and innovators to develop and implement their ideas.
- Fostering collaboration: Collaboration between entrepreneurs, innovators, government agencies, and other stakeholders can lead to innovative solutions that address the challenges of urban forest management.
- Promoting education and training on innovations: Providing education and training opportunities can help to build a skilled and knowledgeable workforce that is better equipped to develop and implement innovative NBS solutions.
- Encouraging experimentation: Innovation involves trial and error. Encouraging experimentation and providing opportunities for entrepreneurs and innovators to test their ideas can help to spur innovation in UF-NBS. Failure is not a discouragement, but an opportunity to learn what does and does not work.
- Supporting market development: Creating markets for products and services that are related to urban forest management can help to incentivise entrepreneurship and innovation. For example, developing a market for sustainably harvested timber from the urban forest can provide an economic incentive for managing these forests sustainably and develop artisan micro-businesses.
- Celebrating success: Recognising and celebrating successful entrepreneurship and innovation can help to inspire others and build momentum for change. Awards, prizes, and recognition programmes can all be effective ways to highlight successful initiatives and inspire others to act.

Citizen science for change

Citizen science has emerged as an innovative approach to engage non-scientific public and citizens in scientific research, monitoring and data collection (Bonney et al., 2014). The main idea of citizen science in UF-NBS is to involve and engage non-expert citizen voluntarily in scientific data collection, monitoring and analysis to help researchers better understand the benefits and functions of trees in urban setting. Citizen science has multiple benefits. Firstly, it can provide researchers and decision-makers with a large amount of data that they would not be able to collect on their own (Bonney et al., 2009). For instance, volunteers can help to monitor the health and growth of trees in different parts of a city, providing researchers with data that can help them to identify factors that affect tree growth and health. Furthermore, citizen science can help to raise awareness among the public about the importance of urban trees and green spaces (Lerman & Warren, 2011).

There are also some challenges associated with citizen science. The main challenge is the quality of the data collected by volunteers (Shirk et al., 2012). Citizen science projects often rely on non-experts to collect data, which can lead to errors and inconsistencies in the data. To address this, researchers need to provide volunteers with adequate training and support to ensure that they are collecting accurate data. Another obstacle is the recruitment and retention of volunteers (Dickinson et al., 2012). Citizen science projects usually rely on volunteers, and within that, it can be challenging to attract and retain enough volunteers to collect data over an extended period. There are numerous examples of successful citizen science projects in urban forests.

Education for change

Education also plays an important role in promoting change in organisations, that are responsible for managing and maintaining urban forests. Supporting various types of education and knowledge creation about UF-NBS should be promoted in organisations that manage urban forests. Current employees are encouraged to enhance their expertise and acquire new skills through continuous learning and adaptation. They need to be trained and upskilled through professional development. On the other side, new employees should have more focus and understanding the role of NBS. UF-NBS principles should be integrated in existing education about urban forest and arboriculture curricula, to equip new professionals with adequate knowledge.

Another level of education is for politicians about importance and role of UF-NBS. They should be encouraged to take up these principles in decision making. This can be done by production of simple material that contains key facts and information. Davies et al. (2017) suggests that communicating the benefits of urban forests to politicians, citizens and urban managers is needed for creating support and understanding of their importance. They also point out that scientific knowledge in various forms should present evidence both on services and disservices to provide a scientific base for urban management decisions.

The CLEARING HOUSE project has also developed 'City of Trees' an educational package for schoolchildren 10 – 14 years old and teachers.

Conclusion

Urban forests as nature-based solutions is an important tool available to organisations, ranging from government through to civil society. Most organisations will to some extent, already be equipped to deal with this new approach to urban tree management, but almost all to a greater or lesser extent will need to win gauge with change management and institutional reform in pursuit of an optimal outcome.

Key messages on change management and institutional reform for urban forests as nature-based solutions

1	There is a key role for mentoring bodies notably including government agencies and NGOs to kickstart initiatives.
2	Collaborating across political boundaries at the regional level is essential to maximise the impact of green infrastructure and network benefits.
3	Place high importance on the financial and other incentives that galvanise activity both planned and opportunistic and lever in additional funding from non-traditional sources.
4	Linking actions at the policy-level change through tiered and integrated policies that mesh at different levels, including cross-cutting policies is beneficial.
5	Integrate top-down with bottom-up initiatives through effective and receptive partnership structures, harnessing the potential of the local community and voluntary groups.
6	A simple forward-looking vision for the urban forest that delivers multiple benefits across different themes and explaining these in lay-persons language is a communications asset
7	Capacity building and adaptation of existing structures for UF-NBS, such as local delivery mechanisms are a change management necessity
8	Training and upskilling of staff by inviting external experts to enhance skills and capacity within organisations and demonstrate the potential of UF-NBS is advised
9	Showcase examples of UF-NBS best practices, both within and outside the organisation
10	Recognising that UF-NBS solutions cannot be universally applied and should be tailored to fit the specific local working practices and structures.
11	Establishing champions and ambassadors to promote UF-NBS initiatives locally and globally and make good use of media to communicate and promote UF-NBS initiatives.

Case study links (see case studies section)

Fu Forest Trail, Beijing Plain Area Afforestation Programme (BPAP), Ruhr Metropolitan Region (Industrial Forest Project), Drwinka River Park, Metropolitan Area of Barcelona (Llobregat&Co).

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CASE STUDIES ON URBAN FORESTS AS NATURE-BASED SOLUTIONS (UF-NBS)

Link between guidelines and case studies – strong links shown as most projects do to some degree have relevance to all guidelines.

	Planning, policy and delivery for urban forests as nature-based solutions	Cost-effective restoration and rehabilitation management	Mechanisms for public and stakeholder engagement	Change management and institutional reform
Fu Forest Trail (China)	X			X
Shenzhen Urban Forest (China)	X	X		
Beijing Plain Area Afforestation Programme (China)	X	X		X
Kamp Beverlo (Belgium)	X	X		
Ruhr Metropolitan Region (Germany)	X	X	X	X
Lochend Community Woodland (Scotland)			X	
Drwinka River Park (Poland)	X	X		X
St Gallen (Switzerland)	X		X	
Metropolitan area of Barcelona (Catalonia, Spain)	X	X	X	

Fu Forest Trail: CHINA

Forest ecotourism design guidelines based on ecological protection and an immersive visitor experience.



Figure 1: Fuzhou Forest Trail gives a tree top experience. Source: Fuzhou Forestry Administration

Introduction

The City of Fuzhou is the capital city of China's Fujian province and the venue for an important urban forest ecotourism project. The Chinese National Forestry and Grassland Administration (NFGA) is promoting the development of urban forest ecotourism and has issued guidance on "Promoting the High-Quality Development of Forestry and Grassland Industries". This guidance emphasises the importance of strengthening the construction of pilot demonstration projects including creating 'national' forest trails, specialised forest ecotourism routes, and emerging forest ecotourism branding. The guidance was produced with the aim of meeting outdoor recreation needs while prioritising ecological considerations, enhancing the connectivity and integration functions of forest trails, promoting the physical and mental well-being of urban residents and providing an enriching forest experience.

Project description

Six objectives underpin the Fuzhou Forest Trail project:

1. Identification of various types of forest trails in Fuzhou, considering their unique characteristics and features.

2. Clarification of trail alignment requirements to ensure optimal routes and connectivity.

3. Determination of trail construction and ecological protection measures to safeguard the natural environment and preserve biodiversity.

4. Establishment of requirements for supporting facilities to enhance visitor experiences and provide necessary amenities.

5. Implementation of safety standards and guidance for trail construction to ensure the well-being and security of trail users.

6. Definition of criteria for assessing the construction effects of the forest trails, enabling the monitoring and evaluation of their effectiveness and impact.

During the preparation phase, Fujian Agriculture and Forestry University, as the lead institution, collaborated closely with the Fuzhou Forestry Bureau conducting comprehensive field research and gathered insights from 10 completed forest trails and well-preserved ancient trails within the Fuzhou city region. Drawing from municipal surveys and thematic studies, the preparation team assimilated relevant experiences from the construction of national forest trails both domestically and internationally. They sought extensive input through expert consultation meetings and interactions with forestry authorities.

Terms and definitions of forest trails thus provided clarity and standardisation, including:

- General rules governing forest trail construction, ensuring adherence to established principles.

- Classification of forest trails, categorising them based on their unique characteristics and attributes.

- Forest trail planning, emphasising the importance of strategic and well-thought-out plans.

- Trail construction, encompassing technical aspects and good practices for trail development.

- Trail support facilities, addressing the requirements for amenities and services along the trails.

- Evaluation of trail construction, establishing criteria and methodologies for assessing the effectiveness and impact of trail projects.

UF-NBS learning points (LP)

The development of the guidance has provided valuable lessons that can be applied to similar projects both in China and internationally.

LP1: the process of writing the guidance emphasised the importance of conducting practical research to gather relevant data and insights. This hands-on approach ensured that the guidance was grounded in real-world experiences and reflected the specific context of Fuzhou.

LP2: an understanding of the diverse requirements and expectations of different stakeholders emerged as a crucial factor. By engaging with various stakeholders, including local communities, authorities and experts, the guidance was able to incorporate a range of perspectives.

LP3: Clear and easily understandable illustrations of the construction regulations proved essential in facilitating effective implementation. The guidance recognised the significance of providing visual aids and explanatory materials, enabling practitioners to comprehend and follow the prescribed procedures accurately.

LP4: The importance of protecting special forest trails, such as ancient post trails, emerged as a key consideration. This lesson emphasised the need to identify and preserve trails with historical or cultural ecosystem service significance, ensuring their conservation for future generations to appreciate and enjoy.

LP5: The project highlighted the potential for simultaneously conducting ecological conservation and nature education efforts. By integrating these two components, the project achieved synergistic outcomes, promoting environmental awareness, and fostering a deeper appreciation for the natural surroundings.

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More information

Fuzhou Municipal Forestry and Parks Bureau,
Fudao Park Service Centre Fuzhou, China.
Tel: + 86 (0591) 83768730 WeChat: FuForestTrail

Shenzhen Urban Forest: CHINA

Unlocking the ecosystem services potential of Shenzhen's Urban Forests through a quality improvement approach.



Figure 1: Shenzhen urban forest is extensive but is needing ecosystem improvements.

Introduction

Shenzhen in Southeast China is a major global city which acts as a gateway to Hong Kong and mainland China beyond. It has a vast forest area totalling 68,662 hectares. However, in ecosystem terms, some of these urban forests are of poor-quality including over 7,000 ha of monocultural eucalyptus and acacia and nearly 1,600 ha of invasive Mikania micrantha. There is the problem of ecological instability too, with a significant proportion totalling 22,000 hectares of young and middle-aged forests which need adaptative management. Facing this challenge, in 2018 Shenzhen launched an improvement project for forest quality, with a substantial investment of 1.06 billion yuan. This project prioritises the preservation of existing forest vegetation while optimising ecological and landscape functions, centred around the incorporation of local broad-leaved tree species. An ecosystem-based approach has been taken involving biodiversity conservation, leisure amenities, and health-promoting features with the aim to gradually transform the existing eucalyptus and acacia forests, restoring ecological balance throughout and showcasing the aesthetic beauty of subtropical monsoon evergreen broad-leaved urban forests.

Project description

The main actors involved in the project include the Shenzhen Municipal Government and the Shenzhen District Governments, which have provided the necessary investments for its implementation. The Shenzhen Municipal Urban Management and Comprehensive Law Enforcement Bureau has undertaken the responsibility of overseeing and managing the project. In the early 1990s, Shenzhen carried out a large-scale "campaign to eliminate wasteland and restore green" which led to many acacia and eucalyptus trees being planted on barren mountains which quickly formed forests and became the most dominant tree species. Now mature these trees exhibit a lack of ecosystem structure and have poor resistance to stressors. This led to new objectives being agreed based on enhancing ecosystem services. Namely, transforming 7,000 ha of the eucalyptus and acacia plantations to improve their quality and succession; adaptive management of 22,000 ha of young and middle-aged forests, to maximise their role as a carbon sink; management of 1,600 ha of invasive Mikania to conserve biodiversity; and maximising the aesthetic value of tropical monsoon, evergreen broadleaved forest.

To preserve the integrity of the original vegetation and protect the habitats of local flora and fauna, a key principle guiding the project is to avoid the cutting and burning of forests. Instead, emphasis is placed on minimising damage and promoting harmonious coexistence between humans and nature. To this end, the initiative includes the replanting of honey plants and fruit trees, further fostering symbiotic relationships between humans and the natural environment. Furthermore, the restoration and management approach for degraded and inefficient forests necessitates a shift from mere "reduction" replanting to "addition" replanting. This new paradigm seeks to improve forest quality, transform tree species structure, and enhance the overall health and stability of forest ecosystems while maintaining sustainable vegetation coverage. Methods such as thinning replanting, artificially induced natural regeneration, and gradual tree species replacement are gradually adopted to achieve these objectives without causing significant disturbances to the forest habitat.

Much of the work is now complete and the diversity of urban forest in Shenzhen has been greatly improved. Replanted tree species are already forming a new urban forest landscape and many endangered species have been reintroduced. Given the magnitude of this project it involved a significant number of professional technical personnel backed up with adequate resources. Nevertheless, there is an ongoing need for stable funds and dedicated experts to nurture the development of young and middle-aged forests, as well as to uphold the integrity of existing landscapes and infrastructure functions.

UF-NBS learning points (LP)

LP1: The successful implementation of the integrated ecological transformation required a systematic approach and the adoption of key strategies backed up by a substantial investment of money and the skills of numerous technical personnel.

LP2: By adhering to ecological priorities and incorporating ecological considerations throughout the entire project process, the transformation appears to have been successful.

LP3: Communication and consultation with relevant departments has proven to be crucial in ensuring the success of the project whilst the involvement of stakeholders, public engagement, and awareness campaigns, has led to public support and promoted understanding.

LP4: The project has also aligned with the broader municipal objectives such as creating a forest city and connecting mountains and seas.

LP5: Leveraging local conditions and characteristics has been key to maximising ecological functions and a revitalised landscape.

Beijing Plain Area Afforestation Programme (BPAP): CHINA

An ambitious and participatory urban and peri-urban afforestation programme to transform the City's landscape, mitigate environmental pressures and improve urban resilience.



Figure 1: Highway afforestation, Tongzhou District, Beijing. Source: Beijing Municipal Forest and Parks Bureau

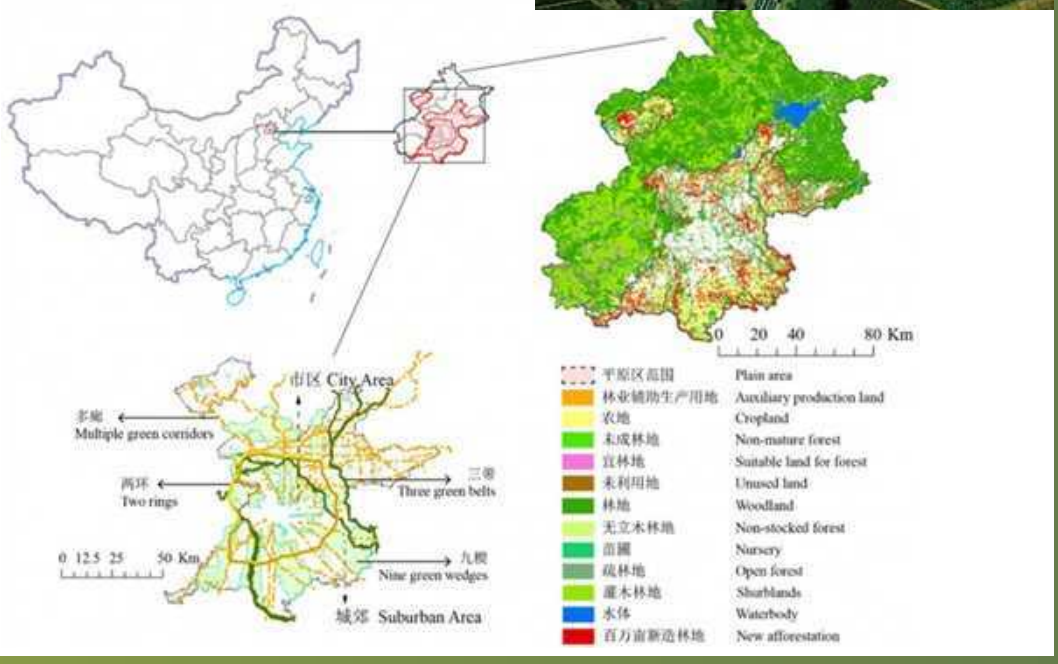


Figure 2: Map showing the area of the BPAP. source: Network Nature

Introduction

Beijing in the north of China has a metropolitan area of 16,410 km^2. It is a densely populated City with a historically low forest coverage in its hinterland. Beijing faces notable environmental challenges such as air pollution and the urban heat island effect. Prompted by this, in 2012, the municipal government launched a large urban forest programme as a nature-based solution (UF-NBS). The aim was to create huge forest patches, develop urban forest park clusters and optimise the large-scale forest patterns. BPAP is based on nine green wedges, multiple greenbelts, and green corridors around the old city centre. The initial success of BPAP led to the launch of an inner-city UF-NBS programme during 2016-2020, which planted another 67,293 hectares of trees in Beijing City (Chen et al., 2021). To meet public demands, a participatory process was launched to explore societal perceptions regarding the ecosystem services and disservices, providing technical support during implementation, and link the BPAP to local policies. The participatory process involved public consultation through online and paper questionnaires.

Project description

The lead organisation for BPAP is the Metropolitan City of Beijing and the Beijing Gardening and Greening Bureau (Capital Greening Office) with multiple other stakeholders involved including municipal and technical associations, paid park wardens, municipal districts, public, academic, and private institutions, and landscape architects. The UF-NBS benefits being sought by the Metropolitan City administration and the stakeholders include an increase in biodiversity and the connectivity of urban greenspaces, improved public health and well-being using recreation facilities and educational facilities for residents and visitors.

Between 2012 and 2015 the BPAP project converted vacant land, croplands, sand excavation pits and brownfields to forests, parks and wetlands. Additional activities include the improvement of urban forest landscape connectivity by planting trees along roads and rivers to establish ecological corridors and the construction of multifunctional urban parks. The BPAP has engaged in allied activities including recycling of construction waste (e.g. using concrete from removed buildings in landscape architecture such as park paths and garden ornaments), recreational and environmental education activities (workshops for urban birds, bees, or butterfly biodiversity), and provides an urban forest field station.

Several types of participation approaches have been used. During the process of BPAP planning and design, the government released a planning document on the official website of Beijing Municipal Forestry and Parks Bureau as public information. This was followed up by a consultation through an online and paper questionnaire. A consultation process was also run with experts in the field of urban forestry, ecology, forestry, biodiversity and forest management. The main objective being that these experts join the process of the BPAP planning and provide comments and suggestions based on their professional knowledge. To maximise the nature-based benefits of BPAP an evaluation of afforestation ecosystem services was carried out by CAF-RIF (Centre for Assessment and Monitoring of Forest and Environmental Resources). The primary source of funding for BPAP are revenues generated by municipal and district governments. A limited number of non-governmental investments were also made, driven by various economic factors such as tourism.

By the end of 2015, BPAP has increased the forest coverage from 14.8% (2011) to 25% (2015) in the plain area, more than 70,000 hectares of forest (more than 54 million trees) have been planted and the survival rate has exceeded 95% (Food and Agriculture Organization of the United Nations, 2018).

UF-NBS learning points (LP)

LP1: The plain area of Beijing is densely populated and highly developed hence finding suitable land for afforestation and creating expansive forest patches has been a challenge. Conflicts arise when converting vacant land, croplands, sand excavation pits, and brownfields to forests, parks, and wetlands, due to competing land uses and ownership disputes.

LP2: Existing urban forests in Beijing are small and fragmented. Integrating these patches and creating ecological corridors can lead to resistance from property owners, developers, or other stakeholders who may prioritise alternative land uses or have concerns about the impact on property values.

LP3: While urban forests can help mitigate urban challenges (clean air, urban heat island etc), conflicts may arise in determining the effectiveness of afforestation in addressing specific issues or in choosing alternative solutions with different trade-offs.

LP4: BPAP is a good example of top-down UF-NBS that can be applied to rapidly urbanising cities with limited lands for urban greenspace. It is recognised that Citizens' participation could have been improved during the planning and implementation of this project.

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More information

Beijing Municipal Forestry and Parks Bureau (Office of Beijing Greening Commission), Beijing, China. Email: bjyl@yllhj.beijing.gov.cn

Kamp Beverlo: BELGIUM

Managing defence land urban forests as nature-based solutions.



Figure 1 and 2: Views of the urban forest of Kamp Beverlo. Top – wood heath; Below – American Oak and mixed stand. Source: Andrea Armstrong.

Introduction

In Belgium, defence domains are amongst the most unspoilt and extensive natural habitats. Kamp Beverlo in the Belgian province of Limburg demonstrates the successful integration of defence activities, recreational activities and ecological preservation in a large defence owned natural area. The complex web of stakeholders involved in the management and maintenance of such natural areas range from defence establishments, municipalities, hunters, recreational users (shooting club, fishing, cycling and hikers) and tourists. This introduces great complexity. Kamp Beverlo demonstrates how different and often competing agendas can be accommodated through collaboration and cooperation and bring nature-based benefits to wildlife and people.

Project description

Kamp Beverlo and the neighbouring brook valleys and forests, stand as a biodiversity hotspot in Flanders, whilst the area outside of the defence domain has altered dramatically due to agricultural intensification and urbanisation. The extensive size and diverse habitats and species in Kamp Beverlo make it an exemplary model for integrating defence activities and ecological preservation. This large domain (55km^2) boasts a diverse landscape with coniferous and deciduous forests interconnected with open heathland, grassland and fens. Site management aims to conserve Kamp Beverlo's extensive natural habitats and biodiversity, while accommodating the interests of multiple stakeholders. Two key policies impact the management and maintenance of Kamp Beverlo: the designation of the defence domain and surrounding areas as Natura 2000 Special Protection Areas (SPAs), and a signed agreement since 1999 between the ANB and the Belgian Ministry of Defence for nature conservation and forest management. Additionally, in 2004, both parties signed an agreement for the European LIFE project DANAH, outlining measures for habitat and species restoration in twelve defence areas, including Kamp Beverlo. The site has become famous for the presence of wolves which have migrated from Germany and elsewhere and are highly protected.

UF-NBS Learning points (LP)

LP1: Site managers faces a range of challenges, including the need to balance defence activities needs with forest management, leading to decisions such as maintaining clear open spaces in some places while keeping dense tree canopies for concealment in others. Given the nature of activities addressing issues of unauthorised entry by various recreational groups also needs management.

LP2: Communication challenges arise due to the defence nature of the area, making it difficult to raise awareness about the project's significance and manage diverse interests within its scope. This may be a common issue in UF-NBS on defence lands.

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More information

Dr Andrea Armstrong, Research Director,
Silent Spring Consultants Ltd,
Email: andrea@silentspringconsultants.com and
Senior Researcher, Vrije Universiteit Brussel (VUB).
Email: andrea.armstrong@vub.be

Ruhr Metropolitan Region: GERMANY

The industrial forest project an initiative designed to address environmental and social challenges.



Figure 1: The industrial urban forest at Rheinelbe, Gelsenkirchen. Source: Oliver Balke

Introduction

The Ruhr region of western Germany is best known for its industrial heritage of coal mining and steel production. Today, it is much transformed and regarded by many as an example of how urban greening can be used as a regeneration tool. The transformation is the result of a remarkable initiative. The International Building Exhibition Emscher Park conceptualised the project with the aim to revitalise brownfield sites in the Ruhr region. The initiative that drove much of the urban greening is the Industrial Forest Project, an example of UF-NBS leading to significant ecosystem improvements, preserving cultural heritage, and renaturing a despoiled landscape.

Project description

The International Building Exhibition Emscher Park (IBA) conceptualised the project, with support from NRW Urban GmbH & Co. KG, who provided land, existing buildings and administrative assistance. The Ministries of Environmental Protection and Urban Development showed a willingness to endorse the idea and offered financial

backing. The Forest Authority "Wald und Holz Nordrhein-Westfalen" and the Regional Forest Office Ruhrgebiet employed three qualified foresters to oversee the maintenance of the area. Research activities were coordinated by the Biological Station Western Ruhr Area.

By converting former industrial sites into forest areas through natural succession, the Industrial Forest Project has succeeded in revitalising the region and improving its resilience. It has added to the quality of life for residents and visitors by providing opportunities for recreation and fostered ecosystem services such as carbon sequestration, air purification and cooling, natural habitats restoration, and new soil development. It has also created an impressive landscape setting for industrial monuments.

The Industrial Forest Project has evolved over the years, becoming a "valuable wilderness". By 2021, a single site, Rheinelbe in Gelsenkirchen had over 93,000 visitors, highlighting its significance. The industrial forest project success aligns with the UN Decade for Ecosystem Restoration, emphasising the importance of such projects in addressing urbanisation, climate change, and biodiversity loss.

It also fostered public engagement to create a sense of ownership and responsibility and succeeded in securing the support needed as visitor numbers grew, to find the right balance between providing social forest functions and protecting the ecosystem.

The industrial urban forest which is managed centrally by Wald und Holz NRW, Germany, employs 3.5 persons on the project, maintains a forest station, equipment and organises technical assistance workshops and educational material and costs approximately €364,000 per annum to run.

UF-NBS learning points (LP)

LP1: Project partners have worked hard to overcome financial constraints which was overcome by implementing a cost-effective forest management strategy.

LP2: The project has fostered public engagement to create a sense of ownership and responsibility and succeeded in securing the support needed as visitor numbers grew, in doing so a balance between providing social forest functions and protecting the ecosystem became necessary.

LP3: The project is now internationally known for its urban forest collaboration and is widely regarded as a living laboratory and heavily studied by researchers.

LP4: It is a leading international exemplar of how ecological connectivity between former industrial sites can provide a strategic green infrastructure for a polycentric region.

LP5: By using natural regeneration, a low cost, and culturally resonant ecosystem has evolved relevant to the former land uses and populace that worked in the area during the period of intense industrial activity post 1945.

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More information

Oliver Balke,
Email: Oliver.Balke@wald-und-holz.nrw.de and
Barbara Darr,
Email: Barbara.Darr@wald-und-holz.nrw.de

Lochend Community Woodland: SCOTLAND

A community-led Green Infrastructure management and sustainability project



Figure 1: **Images of community action at the Lochend Community Woodland in Scotland. Source: Lochend Community Woodland project.**

Introduction

The Lochend Community Woodland project has successfully demonstrated the effectiveness of managing a peri-urban forest by a local community woodland group. It serves as an example of how community woodland ownership can successfully take the lead in creating green infrastructure delivering diverse benefits including health, well-being, social interaction, recreation, biodiversity, and ecological benefits. It demonstrated that local community ownership fosters a sense of motivation and enables better control and decision-making.

Project description

The Lochend Community Woodland project is a case study of community-led management of a peri-urban forest. Key actors include the Dunbar Community Development Company (DCDC) and the Lochend Community Woodland Group, with support from organisations such as Forestry Commission Scotland and the Community Woodlands Association. The 33-hectare woodland is owned by DCDC and managed by the Lochend Community Woodland Group.

The project shows that direct ownership of the site by the local community is a key motivation allowing for a high level of control and effective decision making. This has been facilitated through agreements that allow for the effective division of labour and responsibilities between the community woodland group and their parent body, the Dunbar Community Development Company. Overarching legal and financial matters are coordinated by the parent body allowing the community

woodland group to focus on hands-on practical management issues.

The project, ongoing since 2007, aims to provide various benefits to the local community and for nature conservation. The objectives include managing the forest for community use, enhancing educational and recreational opportunities, valuing wildlife, maintaining pathways and waterways, and ensuring the woodland's preservation for future generations. Activities include tree planting, maintenance, wildlife monitoring, and the development of amenities like a cycle fitness track and a community gathering space. Local partnerships with external civil society groups such as scouts, schools, sports organisations and local rotary clubs have maximised the potential stakeholder participation in the site and harnessed local people power through exploiting local networks and existing capacity within the community.

The project was funded through a Development Company capital contribution and funding from Forestry Commission Scotland (now Forestry and Land Scotland) 'Woods in and Around Town' (WIAT) programme. The Trust for Conservation Volunteers (TCV) accommodated tidying of the woods following the large-scale felling operation under the WIAT bid. Scottish Native Woods and The Woodland Trust provided tree saplings without cost. The project won £1,000 prize money by ending as runner-up in the Scottish Finest Woods Awards, which was spent on purchasing equipment.

UF-NBS learning points (LP)

LP1: The project emphasises the importance of direct ownership of green sites by the local community, the potential for high-level participation through hands-on volunteering, and the necessity for good communication and legal agreements between groups in achieving successful community-led management of green infrastructure.

LP2: There is a strong motivation to manage it locally through a culture of active participation and the site is perceived positively by the local community as a positive asset which provides many important benefits to local people.

LP3: The advisory role of the Community Woodlands Association as a national mentoring and support organisation is seen as a significant success factor.

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More information

Isobel Knox, Lochend Community Woodland Group, Email: isobelknox@aol.com

Drwinka River Park: POLAND

Community engagement to protect urban wilderness in highly urbanised Krakow.

Introduction

The Drwinka River Park showcases urban forest management challenges in a complex setting. The Park faces challenges in maintaining urban green spaces in a heavily built-up area of Krakow, which is crucial for biodiversity conservation. It is an essential natural area with high ecological value, including aquatic ecological corridors. Drwinka River Park showcases how grassroots initiatives and resident involvement can lead to formal protection through zoning, which has led to the formation of the Drwinka River Association, which helped shape protection measures.



Figure 1: Drwinka River Park. Source: Krakow Municipal Greenspace Authority (ZZM)

Project description

The Drwinka River Park exemplifies the challenges associated with ensuring the availability of urban



Figure 2: Plan of the Drwinka River Park. Source: Krakow Municipal Greenspace Authority (ZZM)

green spaces in Polish cities. It is considered as a vital resource for biodiversity preservation in a heavily built-up area of Krakow. Parts of the Park are designated as areas of the highest natural value according to the Natural Valorisation of the Green Ring of Podgórze in terms of ecological connections. The Drwinka River Park includes areas designated as aquatic ecological corridors, which are very important for maintaining the cohesion of Krakow's water and tree ecosystems. Since it is situated in a highly urbanised region, this area constantly faces significant pressures from private actors like developers and investors as well as various organisations responsible for overseeing the city's technical infrastructure, putting at risk the Park's natural character. The project has also faced differing opinions, with residents having conflicting views, some advocating for a wild park, while others wanted to introduce recreational infrastructure and more intensive development, such as lighting and paved paths.

Grassroots initiatives and resident involvement led to the formal protection of the area which, resulted in the formation of the Drwinka River Association in 2017. This dedication influenced the area's current legal status, with informal institutions playing a significant role in shaping formal protection measures, including zoning plans. As a result, the project protected 40 hectares of green areas through zoning, identified 700 species through comprehensive ecological studies, fostered nature-based solutions by prioritising ecosystem services over traditional urban park norms, modified a pipeline route to safeguard valuable aquatic habitats of the park, fostered ecological connectivity through the Green Ring of Podgórze concept and implemented educational initiatives.

The total spending on maintenance and investment from a budget of the Kraków Municipal Greenspace Authority for 2022 and 2023 was 433,089,60 zł (ca. €108 272) equating to an annual spend of 216 544,80 zł (€54,136).

UF-NBS learning points (LP)

LP1: The project underscores the importance of stakeholder collaboration and formal protection measures in safeguarding urban forests.

LP2: Balancing the involvement of both formal and informal institutions is essential as residents' inputs in discussions and planning are crucial for success, while formal support from the City Office is equally vital to ensure effective participation.

LP3: Formal protection measures such as zoning plans and city land acquisition are imperative to secure long-term preservation.

LP4: Urbanisation pressures from private developers and differing resident opinions pose threats to the natural character.

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More information

Agnieszka Mędrek,
Email: stowarzyszeniedrwinka@gmail.com,
President of the Drwinka Association
and dr Łukasz Mielczarek,
Email: lmielczarek@zzm.krakow.pl,
Specialist at Forest and Nature Team, Krakow Municipal Greenspace Authority (ZZM)

St Gallen: SWITZERLAND

The contribution of citizens in UF-NBS participatory planning and management processes.



Figure 1: Participatory meeting at St Gallen, Switzerland.

Introduction

The City of St. Gallen with 80,000 inhabitants, lies elongated between two pre-Alpine hills above Lake Constance in eastern Switzerland. In addition to its diverse history and the UNESCO Abbey District, the city is characterised by its “green ring”, which is to be protected and preserved in its character through various municipal and cantonal instruments. This “green ring” serves as a local recreation area for the population and, in addition to the typical local recreation infrastructure, also includes nationally significant natural values such as the Sitterschutzgebiet – geologically revealing steep-wall complexes with often rare forest communities.

Project description

A project area which has been used agriculturally, is recommended for upgrading and opening up as part of the "Grünzug Ost" (eastern green corridor) in the municipal structure plan. The green space covers part of the urban motorway, and a site redesign is intended to fulfil the mandate of the structure plan. There is a well-founded and comprehensive study "Green Gallus Valley" commissioned by civil society and numerous stakeholders which also attests to the considerable potential for upgrading the area and outlines recommendations for action. Since 2021, the City of St. Gallen has had comprehensive participation regulations in which all population groups of the City can get involved – even those without voting rights. These regulations stipulate that the City must involve the population in all projects that have an impact on the public. Relevant stakeholders were identified based on a stakeholder mapping run in cooperation with the relevant municipal departments (urban planning, neighbourhood work etc). A total of 35 stakeholder groups were identified. These were clustered into 7 groups. All the stakeholder groups were invited to participate in the project based on their interest and the influence they have on the project. Thus, the level of participation differs according to how affected they are by the project development.

In addition to an initial information event for the direct residents, two workshops were held. The participants were involved at the "information", "consultation" and "joint decision" levels. The participants were able to develop, evaluate and weigh their own variants to the scheme within the formulated and clearly communicated framework conditions. At the beginning of November 2022, two "neighbourhood variants" were submitted to the City Council, both of which enjoyed the support of most of the neighbourhood and the interest groups but had little support within the administration.

The City Council finally decided that the variant "Edible Park" should be implemented. The city administration stays in contact with the stakeholders via an 'echo-chamber', in which representatives of all stakeholder clusters are represented. The "Edible Park" will be realised and opened to the public in 2024 and the 'echo-chamber' will remain working until 2025.

A total of 244 hours were spent on the participation involving the preparation of a concept note, talks, workshops, evaluations, 'echo-chambers', project adjustments and reports. The estimated costs of the participatory planning and management process being 30,500 CHF.

UF-NBS learning points (LP)

LP1: participatory processes can present alternatives that may be challenging, or even unacceptable to administrations. Before engaging in participation, this possibility should be recognised, and strategies agreed on how differences of opinion will be resolved should they occur.

LP2: Levels of participation should be modulated according to how affected a stakeholder is by the project's development.

LP3: Stakeholder mapping is an essential component of participatory planning and management to ensure that all interested parties can participate.

More information

Contact person; Florim Sabani.
Email: florim.sabani@stadt.sg.ch

Metropolitan area of Barcelona, CATALONIA, SPAIN

Llobregat&Co – a collaborative effort, to promote urban forests as nature-based solutions using co-creation and gamification.



Figure 1: The river corridor in its lower reaches is highly compromised by grey infrastructure. Source: Manuel Jurado Arxiu Aeri

Introduction

The Llobregat&Co project in Catalonia addresses challenges in the metropolitan section of the Llobregat River (Lower Valley and Delta Area). This section is 34Km long, comprises 16 different municipalities and it is an important landscape feature and the main water source for Barcelona and its metropolitan area. The project explores the potential of urban forests as nature-based solution to prioritise ecosystem services and underscores the importance of collaboration between regional administrations, research institutions, municipalities, NGOs, and citizens in addressing environmental challenges. To create the knowledge and conditions for locally appropriate nature-based solutions, the project employs innovative approaches, using co-creation workshops and collective activities to collect relevant information and foster networking among actors. By involving diverse stakeholders, the strategy allowed for multidisciplinary views when sharing knowledge about the challenges of possible UF-NBS interventions.

Project description

A partnership between the Area Metropolitan Barcelona (AMB), a local administration, and CREAF, a research centre, joined forces to create the Llobregat&Co collaborative project. The project partners worked with other administrations who hold territorial planning competences, including public consortia and various stakeholders to reach a consensus with people from different disciplines who work in the fluvial space. Most of the area belonging to the lower valley of Llobregat river which is in part a protected area. It follows a mostly rectilinear route, channelled for the most part and lacking any natural meanders or riparian forest. The Llobregat&Co collaboration is exploring the potential of urban forests as a locally appropriate nature-based solution. Using co-creation workshops and collective activities the aim is to collect relevant information, fill knowledge gaps, and encourage networking. Gamification, collaborative mapping, and the concept of "discovering and learning together" are the key methods used for participation. The Area Metropolitan Barcelona contrbuted €53,390 with additional time contrbuted by CREAF and others.



Figure 2: Stakeholders gather for a site visit to 'ground truth' the location and site related issues. Source Llobregat&Co



Figure 3: Launch event with guest speaker held on 8th October 2020



Figure 4: Materials for the gamification exercise. The large-scale map was a key resource. Source Llobregat&Co



Figure 5: Materials for the gamification exercise in use. Source Llobregat&Co

UF-NBS learning points (LP)

LP1: Several barriers had to be addressed including the lack of a well-defined governance model for the planning, design, and management of urban green spaces in the context of multiple actors involved.

LP2: Climate change impacts, such a water availability and periods of drought and urban conservation measures also presented themselves as challenges.

LP3: Knowledge gaps emerged including a lack of data on biodiversity, insufficient data on riparian forests and river pollutants, and a need for better institutional collaboration and policy frameworks at the metropolitan level to enable better planning and implementation of NBS.

LP4: The project has highlighted the importance of collaboration between regional and local administrations, research institutions, municipalities, NGOs, and citizens.

LP5: Co-creation workshops and collective activities fostered knowledge sharing, networking, and the involvement of diverse stakeholders.

LP6: The use of online GIS tools and participatory mapping facilitated data sharing and visualisation. This approach can be applied in other contexts to identify knowledge gaps, collect relevant information, and promote open access to data, enabling better planning and management of natural resources.

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More information

Eugènia Vidal-Casanovas: Head of Spatial Planning Office of the Green Infrastructure Service at Area Metropolitana de Barcelona.
Email evidal@amb.cat

Laura Cid: Head of Environmental Management Office of the Green Infrastructure Service at Area Metropolitana de Barcelona. Email lcid@amb.cat

Corina Basnou: Researcher at CREAF
c.basnou@creaf.uab.es







The CLEARING HOUSE project gathered 26 partners in Europe and China, to provide evidence and tools that facilitate the mobilisation of the full potential of Urban Forests as Nature-Based Solutions (UF-NBS) for rehabilitating, reconnecting, and restoring urban ecosystems.
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