

Policies and regulatory frameworks for urban and riverine nature restoration

Giulio Hasanaj, Costanza Carbonari, Lorenzo Nofroni

Abstract: The paper examines the evolution of policies concerning urban and riverine biodiversity at the global, European and national scales, with particular attention to the Italian context. At the international level, the Rio Conference (1992) marked the beginning of a process which, through the Convention on Biological Diversity (CBD), progressively integrated urban and riverine dimensions into conservation and restoration strategies. Subsequently, the Strategic Plan for Biodiversity 2011–2020 and the Kunming–Montreal Global Biodiversity Framework (2022) reinforced the role of cities and river areas as priority spaces within multilevel governance. In parallel, the European Union developed an increasingly binding body of legislation: from the Habitats and Birds Directives to the EU Biodiversity Strategy for 2030 and the *Nature Restoration Regulation* (2024), which introduces quantitative targets and reporting obligations also for urban ecosystems. In Italy, the regulatory trajectory reveals a gradual shift from sectoral approaches, centred on protected areas (Law 394/1991), towards integrated instruments for urban planning and management, such as Law 10/2013 on urban green spaces, the Minimum Environmental Criteria for public green areas, the National Biodiversity Strategy 2030, and, most recently, the National Climate Change Adaptation Plan. Nonetheless, significant challenges remain, including institutional fragmentation, weak integration between environmental, urban and climate policies, and the lack of effective monitoring tools. The study highlights how cities and surface watercourses are not merely sites of environmental impacts, but also spaces of opportunity for the implementation of Nature-based Solutions (NbS), capable of enhancing climate resilience, quality of life and social cohesion. The paper underscores the need to strengthen multilevel governance and participatory processes, promoting place-based approaches capable of adapting global and European objectives to local specificities. Urban and riverine nature constitutes a fundamental infrastructure for the ecological transition, yet the shift from ambitious goals to concrete action requires greater regulatory, institutional and design integration.

Keywords: Urban biodiversity policies, Biodiversity Strategy, Nature restoration regulation, Global Biodiversity Framework, Multilevel governance

1. Urban and riverine biodiversity: from the origin of the term to the global policy frameworks

The term *biodiversity* emerged as a contraction of *biological diversity* and was first introduced by Walter G. Rosen in 1985, in the context of preparations for the National Forum on BioDiversity. The worldwide dissemination of the concept is, however, attributed to Edward O. Wilson, who in 1988 published the volume *Biodiversity*, thereby establishing the term as standard usage within the scientific community. Formal recognition was achieved in 1992 with the Convention on Biological Diversity (CBD), adopted at the Rio de Janeiro Conference, which, in Article 2, defines biodiversity as «the variability among living organisms from all sources, including, inter alia, terrestrial, marine and freshwater ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems (UN 1992, p. 4)». Since that time, biodiversity conservation and restoration policies have evolved progressively, moving towards regulatory frameworks of increasing binding

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force and characterised by a growing recognition of the strategic role of cities and riverine ecosystems within multilevel governance structures (MASE 2023b).

Cities constitute central actors in biodiversity conservation and climate adaptation: in addition to hosting a large share of the global population, they exert significant pressures on ecosystems through land consumption, habitat fragmentation, pollution and the intensification of climate-related hazards (Seto, Güneralp, and Hutrya 2012). At the same time, they represent spaces of opportunity, capable of sustaining high levels of biological diversity through parks, gardens and surface water bodies, which provide vital habitats for numerous species (Aronson et al. 2014). These natural spaces within cities also deliver essential ecosystem services, including microclimatic regulation, air purification, cultural benefits such as recreation and place identity, and, in some cases, provisioning services linked to food and plant resources. (Elmqvist et al. 2015).

Within this framework, connections with the hydrographic network, or *blue infrastructure*, also acquire significance, implying an integrated approach in which the city is conceived as an inseparable component of the broader landscape (Wagner and Breil 2013; Krauze and Wagner 2019). Rivers, in particular, are regarded as the backbone of ecological restoration, yet they remain highly vulnerable to anthropogenic and climatic pressures: increasing water demand, rising temperatures, flow discontinuities and invasive species have accelerated the decline of freshwater biodiversity, at a rate faster than that observed in marine and terrestrial ecosystems (Dudgeon et al. 2006; Dudgeon 2019; Harrison et al. 2018). This is particularly evident in European rivers, which have lost connectivity and natural processes, especially in urban contexts.

Nevertheless, rivers, smaller watercourses and canals possess high ecological potential due to riparian zones and their function as ecological corridors connecting urban and peri-urban areas (Chester and Robson 2013; Carbonari and Solari 2025). They provide important regulatory and provisioning services, which restoration can further enhance. Managed across both rural and urban areas, watercourses enable the sustainable transfer of critical ecosystem services (Krauze and Wagner 2019; Basak et al. 2021).

At the policy level, the Kunming–Montreal Global Biodiversity Framework explicitly recognises cities as a priority domain, introducing through Target 12 the objective of increasing both the quality and the extent of urban green and blue spaces (CBD 2022). The European Union has likewise emphasised the urban and riverine dimension through the Water Framework Directive, the Biodiversity Strategy for 2030 (EC 2021c) and, more recently, the Nature Restoration Regulation (EC 2025a). In Italy, instruments such as the Environmental Code (Legislative Decree 152/2006), the Minimum Environmental Criteria (MATM 2020), the National Biodiversity Strategy 2030 (MASE 2023b) and the National Climate Change Adaptation Plan (MASE 2023a) identify cities and surface water bodies as hotspots for promoting Nature-based Solutions (NbS) and initiating an effective ecological transition.

The paper analyses the evolution of policies and regulatory instruments for the protection of urban and riverine nature, situating the Italian case within the broader global and European frameworks. It demonstrates how the governance of urban and river biodiversity is shifting from sectoral approaches to an integrated model that recognises nature as strategic infrastructure for climate resilience, public health and social cohesion. The article adopts a chronological approach, tracing the temporal evolution of biodiversity policies from the global to the national scale, thereby constructing a multi-level framework and applying a spatially consistent perspective. Section 2 reconstructs the evolution of global environmental policies, from the Brundtland Report to the Convention on Biological Diversity and up to the Kunming–Montreal Global Biodiversity Framework, illustrating how cities and river areas have gradually

been acknowledged as strategic actors and spaces for conservation and restoration. Section 3 examines the European framework, highlighting how the European Union has translated these principles into binding legal instruments, from the founding directives (Habitats and Birds) to the most recent strategies and regulations, culminating in the Nature Restoration Regulation, which introduces quantitative targets also for urban and river ecosystems. Section 4 focuses on the Italian case, emphasising the shift from sectoral legislation centred on protected areas to an integrated approach that frames urban nature and river networks as ecological infrastructures, through laws, environmental criteria and national strategies aligned with European directives.

The research draws mainly on scientific literature and secondary data sources (including articles from accredited journals, government reports, and legislative documents). The materials were gathered from carefully chosen academic databases and trustworthy sources, in order to ensure that the data are both reliable and relevant to the research themes.

2. Evolution of the global environmental policies from the Brundtland Report to the Kunming–Montreal Global Biodiversity Framework

The Brundtland Report, *Our Common Future* (1987), represents a milestone in global environmental policy. The document systematically introduced the concept of sustainable development, asserting the integration of economic, social and environmental dimensions within a unified perspective (Meadowcroft 2000). The Report played a dual role: on the one hand, it provided a shared theoretical framework and a common language; on the other, it served as the starting point for the Rio de Janeiro Conference of 1992, where its principles were translated into legal and programmatic instruments (Sachs 2015).

The Rio Conference marked the beginning of global environmental policies and led to the adoption of three fundamental conventions: the Convention on Biological Diversity (CBD), the United Nations Framework Convention on Climate Change (UNFCCC) and the United Nations Convention to Combat Desertification (UNCCD) (UN 1992). However, the primary addressees of these policies were nation states; cities were not mentioned, and riverine areas appeared only in Agenda 21, Chapter 18, in relation to the protection of the quality and availability of freshwater resources, promoting integrated approaches to the development, management and use of water resources. The Brundtland Report thus constituted the epistemological and normative foundation that enabled multilateral consensus on binding treaties, paving the way for subsequent global frameworks, from *Agenda 2030* to the Kunming–Montreal Global Biodiversity Framework (Dodds et al. 2012; UN 2015).

A crucial milestone in nature policies was the Strategic Plan for Biodiversity 2011–2020 (SPB), adopted at COP 10 in Nagoya. Developed in response to the failure to achieve the 2010 targets (Butchart et al. 2010), the SPB introduced a measurable framework for action (CBD 2010a; Perrings et al. 2011). The vision *Living in harmony with nature* outlined the long-term goal, while the short-term mission called for urgent measures to halt biodiversity loss. At the core of the plan were the twenty Aichi Biodiversity Targets, grouped into five strategic areas ranging from the reduction of anthropogenic pressures to the integration of biodiversity into sectoral policies.

It was in this context that, for the first time, the CBD introduced an explicit reference to urban areas. Decision X/22 (CBD 2010b) initiated a phase of institutional inclusiveness, recognising cities, subnational governments and local communities as strategic actors (Puppim de Oliveira et al. 2011). It invited cities to develop Local

Biodiversity Strategies and Action Plans (LBSAPs) (CBD 2012), urged Parties to include local authorities within their National Biodiversity Strategies and Action Plans (NBSAPs), acknowledged the value of transnational networks (ICLEI 2011), and promoted local community engagement, emphasising the importance of educational programmes (CBD 2010b). Although many of the Aichi Targets were not achieved by 2020 (CBD 2020), the SPB laid the foundations for the subsequent Kunming–Montreal Global Biodiversity Framework (GBF), which expanded upon its structure by adapting it to the new post-2020 global agenda (UN 2015). Adopted in 2022, the GBF set as its central objective the protection of 30% of terrestrial and marine areas by 2030 (Target 3), extending the Aichi goals (17% terrestrial and 10% marine) and rendering the framework more ambitious and aligned with scientific recommendations (Lo and Jang 2022).

The new framework incorporates the *One Health* approach, which seeks to optimise sustainably the health of people, animals and ecosystems by recognising their interdependence (WHO 2021). It reaffirms the importance of local communities and, for the first time, designates urban areas as a strategic priority, in line with UN projections estimating that 68% of the global population will reside in cities by 2050 (UN DESA 2019). Target 12 establishes that conservation cannot be confined to protected areas but must integrate nature within the urban fabric through NbS that enhance ecological connectivity, climate mitigation, adaptation and social well-being (Kabisch et al. 2017; CBD 2022). Target 12 addresses a long-standing gap in the CBD, strengthening the role of cities as central actors in multilevel governance, translating the *One Health* paradigm into integrated urban policies, and providing the operational basis for the development of LBSAPs.

3. The European biodiversity policies: from the founding directives to the Nature Restoration Regulation

3.1. The foundational European legal framework for biodiversity protection: the Habitats Directive and the Birds Directive

Over the past three decades, European biodiversity policy has evolved along a regulatory trajectory that, beginning with the protection of habitats and species, has progressively incorporated more complex objectives of urban planning, ecological resilience and environmental restoration. The European Union's legal framework rests upon two historical pillars: the Habitats Directive (92/43/EEC) and the Birds Directive (2009/147/EC), which regulate conservation across the entire territory of the Union, including peri-urban and urban areas (CEU, 1992). The Habitats Directive introduced the protection of natural habitats and species of Community interest and established the Natura 2000 network, the largest coordinated network of protected areas in the world (CEU, 1992, Evans 2012). From an urban perspective, this network connects natural environments and anthropised contexts, encompassing peri-urban or transitional zones when relevant for habitats or species. In parallel, the Birds Directive regulates the protection of wild bird populations, safeguarding both migratory and resident species that breed or overwinter in urban contexts, while acknowledging the adaptation of many species to artificial landscapes (Donald et al. 2007). The deliberately broad wording of both directives makes it possible to include city parks, historic gardens, urbanized riverbanks and peri-urban woodlands within conservation policies, thereby reinforcing a concept of multilevel governance that integrates cities into the European ecological network.

3.2. The EU Biodiversity Strategy for 2030

The main reference framework for the current decade is the EU Biodiversity Strategy for 2030 (EUBS 2030), adopted in 2020 and integrated into the European Green Deal in 2021. It responds to global alarms concerning the state of nature: IPBES (2019) estimates that up to one million species are at risk and identifies habitat loss, pollution and climate change among the main drivers; the final evaluation of the Aichi Targets demonstrated that none of the twenty goals had been fully achieved (CBD 2020). At the European level, the review of the 2011–2020 Biodiversity Strategy showed that, despite the expansion of the Natura 2000 network, biodiversity loss had not been halted, in almost all environments, ranging from urban and agricultural ecosystems to aquatic ones (EC 2019a).

On this basis, the EUBS 2030 commits Member States to protect at least 30% of EU terrestrial and marine territory, aligning with the “30 by 30” target of the Kunming–Montreal GBF (CBD 2022); of this share, at least one third must be strictly protected. A second innovative commitment concerns the urban dimension: all cities with more than 20,000 inhabitants are required to adopt Urban Greening Plans (UGPs), with measures to expand green and blue spaces, improve ecological connectivity and contribute to well-being (EC 2021c), in line with the *One Health* approach and SDG 11 (Kabisch et al. 2017). UGPs are conceived as an overarching framework for “biodiversity-positive” and “climate-resilient” planning and design, integrating NbS across multiple sectors (Wilk et al. 2021). They aim to expand green and blue areas through parks, ecological corridors, green roofs and façades; reduce soil sealing; restore degraded urban ecosystems (canalised rivers, brownfields); and generate co-benefits for health, mitigation and climate adaptation (Kabisch et al. 2017).

UGPs are structured around three main design approaches: (i) conceiving buildings as part of the urban ecological network through green roofs, vegetated façades and sustainable urban drainage systems (SUDS); (ii) bioclimatic design and the integration of natural elements to reduce energy consumption, mitigate heat islands and improve comfort (Beatley 2016); (iii) resilient and ecological construction materials and solutions that foster permeability and renaturalization. This results in spatial planning oriented towards the development of green and blue infrastructures, recognizing corridors and natural areas as genuine structural infrastructures (EC 2013), promoting ecological regeneration of artificial spaces, adopting adaptive planning approaches to address climatic, hydraulic and health risks (EEA 2019), and at the same time ensuring environmental justice by guaranteeing equitable access to high-quality green spaces for all communities (Wolch, Byrne, and Newell 2014). UGPs, therefore, are not merely environmental instruments but an integrated planning framework, which nonetheless requires alignment with existing plans, measurable objectives and monitoring through SMART indicators harmonised with EU and international frameworks.

A third commitment of the EUBS 2030 concerns the restoration of freshwater ecosystems and in particular rivers, recognising their role in ecological regulation, water supply and the reduction of flood and drought risks (EEA 2019). Priority actions include river renaturalization and the removal of artificial barriers. Moreover, the strategy foresees a 50% reduction in the use and risk of pesticides by 2030, linked to the protection of pollinators and the quality of soil and water, in synergy with the Farm to Fork Strategy (EC 2021c). The 2030 Strategy thus transcends conservation in the strict sense, integrating biodiversity into urban, agricultural, energy and health policies and contributing to the European implementation of the GBF and the 2030 Agenda.

3.3. The Nature Restoration Regulation

With the approval of the Nature Restoration Regulation (NRR) in 2024, the EU introduced the first binding instrument for the large-scale restoration of urban, terrestrial and marine ecosystems. As a regulation, the NRR is directly applicable in all Member States and makes the long-term objectives of the EUBS 2030 legally binding (EC 2025a). Its purpose is the lasting recovery of biodiversity and ecosystem resilience, while contributing to climate change mitigation and adaptation, land degradation neutrality, food security and the fulfilment of international commitments. Quantitatively, it requires the implementation of restoration measures on at least 20% of urban, terrestrial and marine areas by 2030, extending to all degraded ecosystems by 2050 (EC 2025a).

The NRR sets binding objectives accompanied by precise temporal milestones: the improvement of 30% of degraded habitats by 2030, 60% by 2040 and 90% by 2050. It further requires Member States to prepare a National Restoration Plan by 2026, to be formally adopted by 2027, and introduces a particularly rigorous monitoring and reporting system, based both on standardised indicators—such as urban tree cover, pollinator status and wildlife indices—and on satellite data from the Copernicus programme (EC 2025a).

The NRR identifies seven priority areas: (1) terrestrial, coastal and freshwater ecosystems; (2) marine ecosystems, with a focus on high-carbon storage habitats and breeding grounds; (3) river connectivity and floodplains; (4) pollinator populations; (5) agricultural ecosystems, including drained peatlands and landscape diversity; (6) forest ecosystems, with the objective of three billion trees by 2030; and (7) urban ecosystems. For the latter, the NRR requires no net loss of green space and tree cover by 2030 (relative to 2024 levels) and a subsequent progressive increase, to be defined through national benchmarks (by 2030) and an EU methodological framework (by 2028). Member States must map urban ecosystems by 2026, identify priority areas, and integrate NbS into urban planning and architectural design (EC 2025a).

As early as 2021, the European Commission had published guidelines and a toolkit for Urban Nature Plans (UNPs) to support the integration of nature into urban planning in line with the EUBS 2030 (EC 2021a; EC 2021a). The UNP guidelines propose a ten-step process—from political commitment to governance, from co-creation to vision, from state analysis to indicators, from the selection of actions to financing, and finally communication, monitoring, adoption and implementation—promoting an integrated and interdisciplinary approach (Federal Agency for Nature Conservation 2024; NetworkNature 2021). The operational toolkit translates the strategy into concrete interventions (green roofs and façades, ecological corridors, urban forests, community gardens) with clear climatic, environmental and social co-benefits (EC 2021a).

For rivers and freshwater ecosystems, the NRR establishes the restoration of connectivity and ecological functioning, with the objective of achieving at least 25,000 km of free-flowing rivers by 2030 compared to 2020. Article 9 provides for an inventory of barriers (9.1), the removal of obsolete or unnecessary ones (9.2), and the restoration of lateral connectivity and floodplain functions (9.3–9.4). Among the innovative elements introduced by the NRR with regard to river and freshwater ecosystems are the establishment of specific quantitative targets for rivers and floodplains, the adoption of a broad-scale perspective for assessment and restoration interventions, the extension of restoration goals beyond the boundaries of Natura 2000 sites (EC 2008), and, finally, the emphasis not only on conservation but also on the recovery of the most degraded habitats (Stoffers et al. 2024).

However, the NRR also presents intrinsic weaknesses for these ecosystems. The main issue concerns the absence of clear criteria for determining which rivers should

be prioritised for restoration (Stoffers et al. 2024). Article 9.2 suggests the removal of obsolete barriers, such as those no longer required for hydropower, water supply or flood protection. Yet this approach does not ensure that interventions focus on areas where the benefits for ecosystems, water resources and ecosystem services would be greatest. It also leaves unresolved whether priority should be given to restoring highly degraded urban reaches or safeguarding rural watercourses with better ecological conditions and greater potential.

Another limitation relates to harmonisation with other European policies. While synergies exist, conflicts also emerge due to competing uses of water resources (Stoffers et al. 2024). The most significant include those with the Common Agricultural Policy (EC 2012), which, through subsidies for intensive practices and water-demanding crops, damages habitats and water resources, and with the Renewable Energy Directive (EPCEU 2018), which recognises hydropower as an activity of public interest, even though it entails the construction of dams contrary to river connectivity restoration.

Interactions with the Water Framework Directive (EPCEU 2000) are particularly significant. This directive, based on a river basin approach, aims to achieve good ecological status and ecological flows (EC 2016), objectives consistent with the NRR. However, measures to address drought and water scarcity, such as new dams and reservoirs, risk undermining connectivity itself (EC 2015). Similarly, the Floods Directive (EPCEU 2007), while aiming to reduce risks, often promotes rigid engineering works that hinder ecological restoration, particularly in urbanized contexts.

A way forward in overcoming such conflicts could lie in the adoption of Natural Water Retention Measures (Burek et al. 2012; EC 2014; EC et al. 2015), which offer more nature-based alternatives compared to grey infrastructures. Nonetheless, their application remains marginal, as Member States continue to prioritise traditional approaches that are poorly integrated with NbS (EC 2025b).

Overall, from the Habitats Directive to the NRR, the EU has constructed a progressive framework which, moving from the protection of habitats and species, now extends to urban strategies, water management and binding restoration measures. This represents a paradigm shift: biodiversity is no longer regarded as a heritage confined to natural areas, but as a structural component of cities and anthropised ecosystems, intrinsically linked to health, well-being and climate resilience. Alongside quantitative targets (e.g. urban green cover), ensuring the ecological quality of spaces (Klaus et al. 2025) remains central, as an essential condition for the actual effectiveness of the new regulatory framework.

4. Italian biodiversity policies: from the proliferation of sectoral laws to harmonisation with European directives

4.1. The Italian regulatory pathway towards the Environmental Code

Biodiversity protection in Italy has undergone a progressive regulatory and strategic consolidation which, from the 1990s to the present, has increasingly incorporated the urban dimension and the role of NbS in spatial planning and architectural design.

Law No. 394/1991 constitutes the first comprehensive reference on protected natural areas: it established national and regional parks and nature reserves, while also envisaging urban parks and local protection areas with the dual purpose of safeguarding ecosystems and enhancing green spaces for quality of life in cities (MATTM 2016; Legambiente 2021; NBFC 2023). Nevertheless, the law was shaped by a predominantly territorial conception of conservation, without fully embedding an integrated framework for environmental management.

Towards the end of the 1990s, EU alignment reshaped the architecture of national environmental policies. On the one hand, the Habitats and Birds Directives were transposed, leading to the establishment of the Natura 2000 network; on the other, a range of sectoral regulations on waste, remediation and water were introduced, although this generated a fragmented framework (ISPRA 2023).

The first comprehensive codification of environmental matters in Italy, harmonising VAS and VIA, water protection, waste and remediation, air and soil, is the Environmental Code (Legislative Decree 152/2006). Although not directly aimed at urban biodiversity, the Code introduced cross-cutting instruments with implications for green space planning and for reducing ecological fragmentation in urbanised contexts, and has evolved over time to align with EU legislation (Sassone 2014). It is within this Code that the Water Framework Directive is transposed, which introduced a management system based on district basin authorities responsible for the preparation of integrated management plans (MASE n.d.). The Floods Directive was transposed through Legislative Decree 49/2010 (MASE n.d.). Nevertheless, at the national level conflicts persist between restoration measures, land uses and existing infrastructures, linked to competing demands on water resources and ongoing land consumption.

A peculiarity of the Italian context is the excessive fragmentation of competences, distributed among a multiplicity of bodies with differing mandates and authorities. This fragmentation, further compounded by a stratification of instruments, generates uncertainty regarding responsibilities and the scope of intervention, and fails to ensure adequate coordination between planning, programming and implementation. The result is a marked disconnection between those who formulate strategies and those tasked with implementing and monitoring them, with negative repercussions for the effectiveness of interventions.

4.2. The contributions of Law 10/2013, the Minimum Environmental Criteria and the National Integrated Energy and Climate Plan

Since 2010, alongside “hard law”, a new phase of strategies and policies for urban ecosystems has emerged. Between 2011 and 2020, Urban Green Plans (UGPs) and local strategies became widespread, also through networks such as Local Agenda 21, while many municipalities experimented with regulations and integrated ecological plans that recognise the city as a complex ecosystem in which green and blue infrastructures support regeneration (CSVP 2019). Within this context lies Law 10/2013, “Provisions for the development of urban green spaces”, a key reference for the management and enhancement of urban nature. The law recognises the multifunctional role of urban green spaces (climate regulation, pollution reduction, biodiversity conservation, well-being) and promotes the notion of green as ecological infrastructure, rather than mere ornament (Salbitano et al. 2016).

Among its measures, the law introduced the obligation for municipalities with more than 15,000 inhabitants to undertake tree censuses and encouraged the promotion of UGPs, although without formal obligation (MTE 2017), as well as educational initiatives (e.g. “National Tree Day”) and citizen engagement. Nevertheless, limitations persist: the absence of shared operational standards, uneven implementation, weaknesses in monitoring and indicators, as well as poor integration with urban planning, resulting in territorially heterogeneous outcomes (Hasanaj et al. 2025). Although it did not introduce a generalized obligation for UGPs, the law anticipated orientations later reinforced at European level by the EUBS 2030 and the NRR,

marking a cultural shift towards conceiving nature as ecological infrastructure for adaptation and social cohesion.

Another significant milestone is the Ministerial Decree of 10 March 2020, which introduced the Minimum Environmental Criteria (CAM) for the design, implementation and maintenance of public green areas and for the supply of products for green care. Mandatory for all contracting authorities, the CAM reduce the environmental impact of urban green spaces by orienting them towards biodiversity conservation, water and energy efficiency, and low-impact management (MATTM 2020). The objectives include the use of native species and the limitation of invasive ones, the ecological and climatic functions of green infrastructures, sustainable maintenance, reduction of pesticides and efficient use of water.

The CAM specify requirements for the different phases of design (use of local species, climate resilience, reduction of soil sealing, connectivity), implementation (protection of soil fertility, sustainable materials, SUDS), and management (reduced pesticide use, organic practices, efficient irrigation). As a result, sustainability in urban green procurement becomes a binding requirement, influencing both administrations and designers, while also aligning with the EUBS 2030 and the National Biodiversity Strategy 2030.

Within the CAM, references to blue infrastructure are very limited. Water is considered primarily in relation to plant irrigation and the water requirements of different species; it is further mentioned in connection with NbS such as sustainable drainage systems (e.g. rain gardens, bioretention channels), the use of which is recommended. The only NbS relating to riverine landscapes that is briefly mentioned in the CAM is riverbank bioengineering. There is no recommendation regarding the use of the wide variety of NbS for riverine landscapes (such as riparian vegetation restoration, natural wetlands restoration, artificial wetlands; see Carbonari and Solari 2025), nor is the issue of water bodies, their ecological functioning and the restoration of connectivity with the surrounding landscape addressed.

Nevertheless, the CAM standardize practices and consolidate the vision of green and blue as ecological infrastructures delivering environmental, social and climatic benefits (Alatri 2023).

Urban biodiversity also intersects with energy and climate policies: the National Integrated Energy and Climate Plan (PNIEC), although not explicitly focused on urban biodiversity, links ecological transition with nature conservation. Decarbonisation measures and the reduction of greenhouse gas emissions contribute to mitigating the effects of climate change, one of the principal threats to urban ecosystems (EC 2019b). Furthermore, interventions in energy efficiency and urban regeneration can support the integration of green and blue infrastructures and the widespread use of NbS, thereby enhancing ecological resilience and environmental quality (Frantz-eskaki et al. 2019). Embedded within the framework of the Green Deal and the EU Biodiversity Strategy for 2030, the PNIEC thus contributes to strengthening the coherence and interdependence among climate, energy and environmental policies (MASE 2024).

4.3. The National Biodiversity Strategy 2030 in Italy

The National Biodiversity Strategy 2030 (SNB 2030) constitutes the instrument through which Italy transposes the commitments undertaken at the international level under the CBD and at the European level through the EUBS 2030 and the Green Deal (MASE 2023b). Approved in 2022, the strategy is considering for the first time cities

as complex ecosystems, and acknowledges the need to safeguard and enhance biodiversity even in highly anthropised contexts. From this perspective, it integrates urban green and blue areas into the national ecological network and reinforces the contribution of the Natura 2000 network.

Action B10 constitutes the cornerstone of the strategy for urban and peri-urban ecosystems, structured along three main axes.

The first (B10.1) foresees the expansion of urban and peri-urban greenery through the creation and management of woodlands, parks and ecological corridors, the implementation of greening plans in cities with more than 20,000 inhabitants, and the diffusion of NbS such as green infrastructures, green roofs and façades, SUDS and urban gardens. These actions are coordinated with the National Urban Green Strategy, with European initiatives such as the Green City Accord, and with the application of the CAM in procurement (MASE 2023b).

The second axis (B10.2) focuses on halting urban biodiversity loss, promoting tree censuses, biodiversity atlases and sustainable management practices. Priority measures include de-sealing interventions, the reduction of pesticides and biocides, the limitation of intensive mowing, and the strengthening of municipal resources for green space management. Citizen involvement is also significant, through citizen science initiatives and the promotion of pollinator-friendly plant species (MASE 2023b).

The third axis (B10.3) concerns the integration of NbS into urban planning, through innovative administrative and financial instruments, including support from private investment. The strategy also encourages the adoption of standardised monitoring systems to assess the benefits of NbS in terms of climate adaptation, pollution reduction, urban well-being and new governance models (MASE 2023b).

In the hydraulic–fluvial domain, Action B.11 of the SNB 2030 addresses the restoration of freshwater ecosystems and the natural functions of water bodies, setting the objective of achieving “good status” by 2027 in line with the Water Framework Directive. This is complemented by other actions, including A.3, B.2, B.8 and B.10, related to aquatic biodiversity, pollutant reduction and the mitigation of natural risks, particularly hydraulic risks. Significantly, the Strategy devotes considerable attention to the physico-chemical and abiotic dimensions of ecosystems, since ecological restoration can only be considered complete if the anthropogenic pressures responsible for degradation are addressed (Carbonari and Solari 2025).

4.4. Biodiversity and climate change in urban processes for ecological regeneration and vulnerability reduction

With the approval of the National Climate Change Adaptation Plan (PNACC) in 2023, Italy introduced a framework for climate adaptation that integrates biodiversity into urban and territorial planning processes, promoting ecological regeneration, NbS and measures to reduce the vulnerability of cities to extreme events. The plan identifies urban settlements as climate risk hotspots due to the concentration of population, infrastructures and services: heatwaves, floods, droughts and air pollution affect urbanized areas with particular intensity (MASE 2023a).

To address these challenges, the PNACC proposes integrated actions combining environmental, social and planning dimensions. A priority is the reduction of urban heat islands through the increase of tree cover, the expansion of green infrastructures (parks, green roofs and façades, tree-lined avenues) and the use of reflective materials to reduce thermal accumulation. A second area concerns the sustainable management of rainwater, with the adoption of SUDS and the renaturalisation of urban and

peri-urban watercourses, aimed at mitigating hydraulic risk and restoring ecological dynamics (EC 2021b). A third strand is the ecological regeneration of degraded and abandoned areas, through renaturalisation interventions and the expansion of accessible green spaces centred on NbS. Finally, the plan emphasises the integration of adaptation criteria into urban planning, promoting coherence with existing instruments and strengthening synergies with the CAM (MATTM 2020).

However, despite the relevance of urban spaces, the PNACC exhibits significant limitations: of the 361 actions envisaged, only 46 are related to green infrastructure, highlighting the limited valorisation of NbS, which are also presented in generic terms and without technical or design detail. The planning process appears weakly integrated, with postponements and poorly defined priorities, while multilevel governance remains fragmented and responsibilities insufficiently specified. Finally, there is an urgent need to improve monitoring and objectives by introducing measurable targets, defined financial resources and greater alignment with European instruments such as the NRR and the EUBS 2030 (ASviS 2023).

Overall, the evolution of Italian regulation illustrates the shift from a protection model centred on traditional protected areas to a systemic vision in which urban biodiversity is a structural component of environmental, urban and climate policies. UGPs, CAM for public green areas, the SNB 2030 and the PNACC mark a paradigm shift: the city is no longer conceived in opposition to nature, but as a space to be regenerated through ecological infrastructures and integrated solutions oriented towards well-being and resilience.

5. Challenges and needs for the policy integration of biodiversity in the urban and riverine environment

The regulatory and strategic evolution at the global, European and national levels reflects a paradigm shift: biodiversity is no longer understood solely as a heritage to be preserved within protected areas, but as a fundamental infrastructure also within urban spaces, capable of delivering multiple benefits in terms of climate resilience, health, quality of life and social cohesion (NBFC 2023). Nonetheless, critical issues persist, linked to the fragmentation of competences and the difficulty of translating ambitious objectives into integrated, measurable and effective actions (Hasanaj et al. 2025).

The governance of urban biodiversity, as with climate governance, suffers from structural limitations: fragmentation, weak multilevel mechanisms and limited continuity in participatory processes. Since each city presents specific economic, social and environmental conditions, there are no universal rules for nature restoration; rather, place-based approaches are required, capable of integrating local economies and ecologies and of actively engaging stakeholders (Alberti et al. 2025).

Against the backdrop of an increasingly articulated European and national regulatory framework—which includes binding instruments such as the EU Biodiversity Strategy 2030 and the Nature Restoration Regulation (EC 2021c; EC 2025a)—Italian local policies and plans often remain fragmented and sectoral. In urban planning, ecological objectives are predominantly declarative, lacking operational tools and monitoring indicators; in urban projects, biodiversity is treated as an accessory element rather than as a central ecological infrastructure, confirming a “dis-integrated” approach. This highlights the need for greater alignment between global, European and local policies, alongside the strengthening of planning, monitoring and civic engagement instruments, in order to make urban biodiversity an integral part of the ecological transition (Lapenna et al. 2024).

References

- Alatri, Federica. 2023. "Criteri minimi ambientali per la gestione del verde pubblico." *Qualità* 6. <https://federica-alatri.it/wp-content/uploads/2024/01/CAM-ARTICOLO-ALATRI-062023-RIVISTA-QUALITA-qb.pdf> (2025-06-21).
- Alberti, Francesco, Michael Maks Davis, Alba Lucía González Solís, Eleonora Giannini, e Giulio Hasanaj. 2025. "Urban Strategies Towards Sustainability. Exchanging Knowledge between Global North and Global South: Insights from an Interdisciplinary Workshop in Nayón, Quito." *Contesti. Città, Territori, Progetti* 1: 114-41. <https://doi.org/10.36253/contest-16159>.
- Alleanza Italiana per lo Sviluppo Sostenibile (ASviS). 2023. *Gli insediamenti urbani nel Piano Nazionale di Adattamento ai Cambiamenti Climatici*. Position paper del Gruppo di lavoro ASviS sul Goal 11 "Città e comunità sostenibili". https://asvis.it/public/asvis2/files/Pubblicazioni/PositionPaper/2023/PositionPaperASviSGoal11_Pnacc_Insedimenti_Urbani_nov2023.pdf (2025-06-21).
- Aronson, Myla F.J., Frank A. La Sorte, Charles H. Nilon, Madhusudan Katti, Mark A. Goddard, Christopher A. Lepczyk, Paige S. Warren, Nicholas S.G. Williams, Sarel Cilliers, Bruce Clarkson, Cynnamon Dobbs, Rebecca Dolan, Marcus Hedblom, Stefan Klotz, Jip Louwe Kooijmans, Ingolf Kühn, Ian MacGregor-Fors, Mark McDonnell, Ulla Mörtberg, Petr Pyšek, Stefan Siebert, Jessica Sushinsky, Peter Werner, e Marten Winter. 2014. "A Global Analysis of the Impacts of Urbanization on Bird and Plant Diversity Reveals Key Anthropogenic Drivers." *Proceedings of the Royal Society B: Biological Sciences* 281, 1780: 20133330. <https://doi.org/10.1098/rspb.2013.3330>.
- Basak, Sayantani M., Md Sarwar Hossain, Joanna Tusznio, e Malgorzata Grodzińska-Jurczak. 2021. "Social Benefits of River Restoration from Ecosystem Services Perspective: A Systematic Review." *Environmental Science & Policy* 124: 90-100. <https://doi.org/10.1016/j.envsci.2021.06.005>.
- Beatley, Timothy. 2016. *Handbook of Biophilic City Planning & Design*. Washington DC: Island Press.
- Burek, Peter, Sarah Mubareka, Rodrigo Rojas Mujica, Ad De Roo, Alessandra Bianchi, Claudia Baranzelli, Carlo Lavalle, e Ine Vandecasteele. 2012. *Evaluation of the Effectiveness of Natural Water Retention Measures - Support to the EU Blueprint to Safeguard Europe's Waters*. EUR 25551 EN. Luxembourg: Publications Office of the European Union. <https://data.europa.eu/doi/10.2788/5528>.
- Butchart, Stuart H.M., Matt Walpole, Ben Collen, et al. 2010. "Global Biodiversity: Indicators of Recent Declines." *Science* 328, 5982: 1164-68. <https://doi.org/10.1126/science.1187512>.
- Carbonari, Costanza, e Luca Solari. 2025. "Riverscape Nature-Based Solutions and River Restoration: Common Points and Differences." *Sustainability* 17, 13: 6108. <https://doi.org/10.3390/su17136108>.
- Chester, Edwin T., e Belinda J. Robson. 2013. "Anthropogenic Refuges for Freshwater Biodiversity: Their Ecological Characteristics and Management." *Biological Conservation* 166: 64-75. <https://doi.org/10.1016/j.biocon.2013.06.016>.
- Comitato per lo sviluppo del verde pubblico. 2019. *Relazione annuale 2019 sullo stato di attuazione della legge n. 10/2013 "Norme per lo sviluppo degli spazi verdi urbani"*. Roma: Ministero dell'Ambiente e della Tutela del Territorio e del Mare. https://www.mase.gov.it/portale/sites/default/files/archivio/allegati/comitato%20verde%20pubblico/relazione_annuale_csvp_2019.pdf (2025-06-21).
- Convention on Biological Diversity. 2010a. *Strategic Plan for Biodiversity 2011–2020 and the Aichi Biodiversity Targets*. Montreal: CBD. <https://www.cbd.int/doc/strategic-plan/2011-2020/Aichi-Targets-EN.pdf> (2025-06-21).
- Convention on Biological Diversity. 2010b. *Decision X/22: Plan of Action on Subnational Governments, Cities and Other Local Authorities for Biodiversity*. Nagoya: CBD. <https://www.cbd.int/decision/cop/?id=12288> (2025-06-21).
- Convention on Biological Diversity. 2012. *Cities and Biodiversity Outlook: Action and Policy*. Montréal: Convention on Biological Diversity. <https://www.cbd.int/doc/health/cbo-action-policy-en.pdf> (2025-06-21).

- Convention on Biological Diversity. 2020. *Global Biodiversity Outlook 5*. Montréal: Convention on Biological Diversity. <https://www.cbd.int/gbo5> (2025-06-21).
- Convention on Biological Diversity. 2022. *Kunming-Montreal Global Biodiversity Framework*. <https://www.cbd.int/gbf> (2025-06-21).
- Council of Europe. 2000. *European Landscape Convention (ETS No. 176)*. <https://www.coe.int/en/web/landscape> (2025-06-21).
- Council of the European Union. 1992. *Habitats Directive, 1992/43/EEC*. <http://data.europa.eu/eli/dir/1992/43/oj> (2025-06-21).
- Dodds, Felix, Michael Strauss, e Maurice F. Strong. 2012. *Only One Earth*. London: Routledge. <https://doi.org/10.4324/9780203107430>.
- Donald, Paul F., Fiona J. Sanderson, Ian J. Burfield, Stijn M. Bierman, Richard D. Gregory, e Zoltan Waliczky. 2007. "International Conservation Policy Delivers Benefits for Birds in Europe." *Science* 317, 5839: 810-13. <https://doi.org/10.1126/science.1146002>.
- Dudgeon, David, Angela H. Arthington, Mark O. Gessner, et al. 2006. "Freshwater Biodiversity: Importance, Threats, Status and Conservation Challenges." *Biological Reviews* 81, 2: 163-82. <https://doi.org/10.1017/S1464793105006950>.
- Dudgeon, David. 2019. "Multiple Threats Imperil Freshwater Biodiversity in the Anthropocene." *Current Biology* 29, 19: R960-67. <https://doi.org/10.1016/j.cub.2019.08.002>.
- Elmqvist, Thomas, Heikki Setälä, Steven N. Handel, Sander Van der Ploeg, James Aronson, James N. Blignaut, e Rudolf Groot. 2015. "Benefits of Restoring Ecosystem Services in Urban Areas." *Current Opinion in Environmental Sustainability* 14: 101-08. <https://doi.org/10.1016/j.cosust.2015.05.001>.
- European Commission. 2008. *Natura 2000 - Protecting Europe's Biodiversity*. <https://eur-lex.europa.eu/EN/legal-content/summary/protecting-europe-s-biodiversity-natura-2000.html> (2025-06-21).
- European Commission. 2013. *Green Infrastructure (GI): Enhancing Europe's Natural Capital (COM(2013) 249 final)*. <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A52013DC0249> (2025-06-21).
- European Commission. 2019a. *Evaluation Study to Support the Fitness Check of the Birds and Habitats Directives*. Luxembourg: Publications Office of the European Union. <https://data.europa.eu/doi/10.2779/366025>.
- European Commission. 2019b. *The European Green Deal*. Brussels: European Union. <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM%3A2019%3A640%3AFIN> (2025-06-21).
- European Commission. 2021a. *Urban Nature Plans: Guidance Document*. Luxembourg: Publications Office of the European Union. https://environment.ec.europa.eu/topics/urban-environment/urban-nature-platform_en (2025-06-21).
- European Commission. 2021b. *Forging a Climate-Resilient Europe – The New EU Strategy on Adaptation to Climate Change*. Luxembourg: Publications Office of the European Union. <https://doi.org/10.2834/437>.
- European Commission. 2021c. *EU Biodiversity Strategy for 2030: Bringing Nature Back into Our Lives*. Luxembourg: Publications Office of the European Union. <https://doi.org/10.2779/677548>.
- European Commission. 2025a. *The Nature Restoration Regulation*. Luxembourg: Publications Office of the European Union. https://environment.ec.europa.eu/topics/nature-and-biodiversity/nature-restoration-law_en (2025-06-21).
- European Commission: Directorate-General for Agriculture and Rural Development. 2012. *The Common Agricultural Policy – A Partnership between Europe and Farmers*. Luxembourg: Publications Office of the European Union. <https://data.europa.eu/doi/10.2762/31102>.
- European Commission: Directorate-General for Environment. 2014. *EU Policy Document on Natural Water Retention Measures*. Luxembourg: Publications Office of the European Union.
- European Commission: Directorate-General for Environment. 2015a. *Application of Water Balances for Supporting the Implementation of the WFD. Guidance Document No 34*. Luxembourg: Publications Office of the European Union.

- European Commission: Directorate-General for Environment. 2015b. *A Guide to Support the Selection, Design and Implementation of Natural Water Retention Measures in Europe – Capturing the Multiple Benefits of Nature-Based Solutions*. Luxembourg: Publications Office of the European Union. <https://data.europa.eu/doi/10.2779/761211>.
- European Commission: Directorate-General for Environment. 2016. *Ecological Flows in the Implementation of the Water Framework Directive. Guidance Document No 31*. Luxembourg: Publications Office of the European Union.
- European Commission: Directorate-General for Environment. 2021. *EU Biodiversity Strategy for 2030 – Bringing Nature Back into Our Lives*. Luxembourg: Publications Office of the European Union.
- European Commission: Directorate-General for Environment. 2022. *Nature Restoration Law – For People, Climate, and Planet*. Luxembourg: Publications Office of the European Union.
- European Commission: Directorate-General for Environment. 2025b. *7th Report on the Implementation of the Water Framework Directive (2000/60/EC) and the Floods Directive (2007/60/EC)*. Luxembourg: Publications Office of the European Union.
- European Commission: Directorate-General for Environment, AC Teon, Amec Foster Wheeler, IMDEA, e P. Strosser, et al. 2015. *A Guide to Support the Selection, Design and Implementation of Natural Water Retention Measures in Europe – Capturing the Multiple Benefits of Nature-Based Solutions*. Luxembourg: Publications Office of the European Union. <https://data.europa.eu/doi/10.2779/761211>.
- European Environment Agency. 2019. *Rivers and Lakes in European Cities: Past and Future Challenges*. Copenhagen: European Environment Agency. <https://www.eea.europa.eu/en/analysis/publications/rivers-and-lakes-in-cities> (2025-06-21).
- European Parliament and Council of the European Union. 2000. *Water Framework Directive, 2000/60/EC*. <https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:32000L0060> (2025-06-21).
- European Parliament and Council of the European Union. 2007. *Floods Directive, 2007/60/EC*. <https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=celex:32007L0060> (2025-06-21).
- European Parliament and Council of the European Union. 2009. *Birds Directive, 2009/147/EC*. <https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:32009L0147> (2025-06-21).
- European Parliament and Council of the European Union. 2018. *Renewable Energy Directive, 2018/2001/EU*. <https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:32018L2001> (2025-06-21).
- Evans, Douglas. 2012. “Building the European Union’s Natura 2000 Network.” *Nature Conservation* 1: 11-26. <https://doi.org/10.3897/natureconservation.1.1808>.
- Federal Agency for Nature Conservation. 2024. *Urban Nature Plan: Considering Quality of Life, Climate and Biodiversity Together! A Guide to Implementing the EU Biodiversity Strategy 2030 in Urban Areas*. Bonn: Federal Agency for Nature Conservation. <https://www.ecologic.eu/sites/default/files/publication/2025/50098-Urban-Nature-Plan-EN.pdf> (2025-06-21).
- Frantzeskaki, Niki, Timon McPhearson, Marcus J. Collier, Dave Kendal, Harriet Bulkeley, Adina Dumitru, Claire Walsh, Kate Noble, Ernita Van Wyk, Camilo Ordóñez, Cathy Oke, e László Pintér. 2019. “Nature-Based Solutions for Urban Climate Change Adaptation: Linking Science, Policy, and Practice Communities for Evidence-Based Decision-Making.” *BioScience* 69, 6: 455-66. <https://doi.org/10.1093/biosci/biz042>.
- Harrison, Ian, Robin Abell, William Darwall, Michele L. Thieme, David Tickner, e Ingrid Timboe. 2018. “The Freshwater Biodiversity Crisis.” *Science* 362, 6421: 1369. <https://doi.org/10.1126/science.aav9242>.
- Hasanaj, Giulio, Anna Lambertini, Livia Marchetti, Lorenzo Nofroni, e Fabio Salbitano. 2025. “Urban Forestry and Biodiversity in Green Plans, Regulations and Programs: A Screening in Central Italy and Islands.” In *Urban and Transit Planning (Vol. 1): Strategies, Innovations and Climate Management*, edited by Francesco Alberti, Simon Elias Bibri, Cristina Piselli, et al., Advances in Science, Technology & Innovation. Cham: Springer Nature Switzerland. https://doi.org/10.1007/978-3-031-76096-9_5.

- ICLEI. 2011. *Local Action for Biodiversity: Guidebook*. Bonn: ICLEI – Local Governments for Sustainability. <https://portals.iucn.org/library/node/45803> (2025-06-21).
- IPBES. 2019. *Global Assessment Report on Biodiversity and Ecosystem Services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services*. Version 1. A cura di Eduardo Brondizio, Sandra Diaz, Josef Settele, e Hien T. Ngo. Zenodo. <https://doi.org/10.5281/ZENODO.3831673>.
- ISPRA. 2023. *L'Italia e l'Ambiente: Stato, Prospettive e Scenari*. Roma: Istituto Superiore per la Protezione e la Ricerca Ambientale. <https://www.isprambiente.gov.it/files2023/publicazioni/publicazioni-di-pregio/italia-e-ambiente.pdf> (2025-06-21).
- Kabisch, Nadja, Matilda Van Den Bosch, e Raffaele Laforteza. 2017. "The Health Benefits of Nature-Based Solutions to Urbanization Challenges for Children and the Elderly – A Systematic Review." *Environmental Research* 159: 362-73. <https://doi.org/10.1016/j.envres.2017.08.004>.
- Klaus, Valentin H., Klára Řehounková, Orsolya Valkó, Polina Degtjarenko, e Stephanie Schelfhout. 2025. "Countries Need Ambitious Urban Biodiversity Targets under the EU Nature Restoration Law." *npj Urban Sustainability* 5, 1: 22. <https://doi.org/10.1038/s42949-025-00218-8>.
- Krauze, Kinga, e Iwona Wagner. 2019. "From Classical Water-Ecosystem Theories to Nature-Based Solutions — Contextualizing Nature-Based Solutions for Sustainable City." *Science of the Total Environment* 655: 697-706. <https://doi.org/10.1016/j.scitotenv.2018.11.187>.
- Lapenna, Annarita, Luca Lazzarini, Israa H. Mahmoud, e Maria Chiara Pastore. 2024. "Dis-Integrated Urban Biodiversity: An Analysis of Urban Policies and Plans in Italy." *AESOP Annual Congress Proceedings*, 1-12. <https://archive.aesop-planning.eu/server/api/core/bitstreams/4f4f3187-e392-4d8b-89c5-3ea5a686a9ca/content> (2025-06-21).
- Legambiente. 2021. *La legge quadro sulle aree naturali protette compie 30 anni: aggiornare la legge per rafforzare la tutela della biodiversità contro la crisi climatica*. <https://www.legambiente.it/wp-content/uploads/2021/11/30-ANNI-DELLA-LEGGE-394.pdf> (2025-06-21).
- Lo, Veronica, e Nicole Jang. 2022. *The Global Biodiversity Framework's "30x30" Target: Catchy Slogan or Effective Conservation Goal?* Winnipeg: International Institute for Sustainable Development. <https://www.iisd.org/articles/insight/global-biodiversity-framework-30x30-target> (2025-06-21).
- Meadowcroft, James. 2000. "Sustainable Development: A New(ish) Idea for a New Century?" *Political Studies* 48, 2: 370-87. <https://doi.org/10.1111/1467-9248.00265>.
- Ministero dell'Ambiente e della Sicurezza Energetica. 2023a. *Piano Nazionale di Adattamento ai Cambiamenti Climatici (PNACC)*. Roma: MASE. <https://www.mase.gov.it/portale/piano-nazionale-di-adattamento-ai-cambiamenti-climatici-pnacc> (2025-06-21).
- Ministero dell'Ambiente e della Sicurezza Energetica. 2023b. *Strategia Nazionale per la Biodiversità 2030*. Roma: MASE. https://www.mase.gov.it/portale/documents/d/guest/2_snb_2030_marzo_23-pdf (2025-06-21).
- Ministero dell'Ambiente e della Sicurezza Energetica. 2024. *Piano Nazionale Integrato per l'Energia e il Clima (PNIEC)*. Roma: MASE. https://www.mase.gov.it/portale/documents/d/guest/pniec_2024_revfin_01072024-pdf (2025-06-21).
- Ministero dell'Ambiente e della Sicurezza Energetica. s.d. "Recepimento della Direttiva Quadro Acque." <https://www.mase.gov.it/portale/recepimento-della-direttiva-in-italia> (2025-06-21).
- Ministero dell'Ambiente e della Tutela del Territorio e del Mare. 2016. *Relazione al Parlamento sullo stato di attuazione della legge 6 dicembre 1991, n. 394 ("Legge quadro sulle aree protette")*. Roma. https://www.mase.gov.it/portale/documents/d/guest/relazione_1_394_del_1991_-_anno_2016-pdf (2025-06-21).
- Ministero dell'Ambiente e della Tutela del Territorio e del Mare. 2020. *Decreto 10 marzo 2020: Criteri ambientali minimi per il servizio di gestione del verde pubblico e la fornitura di prodotti per la cura del verde*. Gazzetta Ufficiale della Repubblica Italiana, n. 90, 4 aprile 2020. https://www.bosettiegatti.eu/info/norme/statali/2020_dm_10_03_cam_verde_pubblico.pdf (2025-06-21).

- Ministero della Transizione Ecologica. 2017. *Linee guida per la gestione del verde urbano e prime indicazioni per una pianificazione sostenibile*. Roma: MITE. https://www.mase.gov.it/portale/documents/d/guest/linee_guida_finale_25_maggio_17-pdf (2025-06-21).
- National Biodiversity Future Center. 2023. *La biodiversità è la soluzione: Primo rapporto annuale sulla biodiversità in Italia*. Palermo: NBFC. https://www.nbfc.it/assets/files/Primo_rapporto_annuale_sulla_biodiversità_in_italia_NBFC.pdf (2025-06-21).
- NetworkNature. 2021. "Urban Nature Plans: Supporting Cities in Imagining a More Sustainable and Inclusive Future." <https://networknature.eu/networknature/article/new-project-unppplus-supports-cities-imagining-more-sustainable-and-inclusive-future> (2025-06-21).
- Perrings, Charles, Anantha Duraiappah, Anne Larigauderie, e Harold Mooney. 2011. "The Biodiversity and Ecosystem Services Science-Policy Interface." *Science* 331, 6021: 1139-40. <https://doi.org/10.1126/science.1202400>.
- Puppim De Oliveira, Jose A., Osman Balaban, Christopher N.H. Doll, Raquel Moreno-Peñaranda, Alexandros Gasparatos, Deljana Iossifova, e Aki Suwa. 2011. "Cities and Biodiversity: Perspectives and Governance Challenges for Implementing the Convention on Biological Diversity (CBD) at the City Level." *Biological Conservation* 144, 5: 1302-13. <https://doi.org/10.1016/j.biocon.2010.12.007>.
- Sachs, Jeffrey D. 2015. *The Age of Sustainable Development*. New York: Columbia University Press. <https://doi.org/10.7312/sach17314>.
- Salbitano, Fabio, Simone Borelli, Michela Conigliaro, e Yujuan Chen. 2016. *Guidelines on Urban and Peri-Urban Forestry*. FAO Forestry Paper 178. Rome: Food and Agriculture Organization of the United Nations.
- Sassone, Stefano. 2014. *Vademecum dell'ambiente: Guida pratica agli adempimenti, obblighi e autorizzazioni per le imprese*. Roma: EPC. https://www.epc.it/contenuti/vademecum_ambiente_sito.pdf (2025-06-21).
- Seto, Karen C., Burak Güneralp, e Lucy R. Hutyrá. 2012. "Global Forecasts of Urban Expansion to 2030 and Direct Impacts on Biodiversity and Carbon Pools." *Proceedings of the National Academy of Sciences* 109, 40: 16083-88. <https://doi.org/10.1073/pnas.1211658109>.
- Stoffers, Twan, Florian Altermatt, Damiano Baldan, Olena Bilous, Florian Borgwardt, Antoine D. Buijse, Elisabeth Bondar-Kunze, Nuria Cid, Tibor Erős, Maria T. Ferreira, Andrea Funk, Gertrud Haidvogel, Severin Hohensinner, Johannes Kowal, Leopold A.J. Nagelkerke, Jakob Neuburg, Tianna Peller, Stefan Schmutz, Gabriel A. Singer, Günther Unfer, Simon Vitecek, Sonja C. Jähnig, e Hein Thomas. 2024. "Reviving Europe's Rivers: Seven Challenges in the Implementation of the Nature Restoration Law to Restore Free-flowing Rivers." *WIREs Water* 11, 3: e1717. <https://doi.org/10.1002/wat2.1717>.
- UN DESA. 2019. *World Urbanization Prospects: The 2018 Revision*. New York: United Nations. <https://population.un.org/wup/> (2025-06-21).
- United Nations. 2015. *Transforming Our World: The 2030 Agenda for Sustainable Development*. New York: United Nations. <https://sdgs.un.org/goals> (2025-06-21).
- Wagner, Iwona, e Pascal Breil. 2013. "The Role of Ecohydrology in Creating More Resilient Cities." *Ecohydrology & Hydrobiology* 13, 2: 113-34. <https://doi.org/10.1016/j.ecohyd.2013.06.002>.
- Wilk, Barbara, Andrea Vetter, e Anja Schröder. 2021. *Tackling the Climate and Biodiversity Crises in Europe through Urban Greening Plans: Recommendations for Avoiding the Implementation Gap*. Dessau-Roßlau: German Environment Agency. <https://www.umweltbundesamt.de/en/publikationen/tackling-the-climate-biodiversity-crises-in-europe> (2025-06-21).
- Wolch, Jennifer R., Jason Byrne, e Joshua P. Newell. 2014. "Urban Green Space, Public Health, and Environmental Justice: The Challenge of Making Cities 'Just Green Enough'." *Landscape and Urban Planning* 125: 234-44. <https://doi.org/10.1016/j.landurbplan.2014.01.017>.