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Special Issue 1.2024

What transition for cities?

Scientific debate, research, approaches and good practices

This Special Issue intended to wonder about the possible transformations for cities towards the sustainability transition. Hence, contributions coming from scholars as well as from technicians have been collected around three main topics: methodologies for prefiguring possible sustainable transitions; urban policies and drivers of the transition; possible projects and applications for sustainable transition. Reflections and suggestions elaborated underline the awareness that the transition process, above all, needs cooperation among decisions, information sharing, and social behaviour changes.

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Land Use, Mobility and Environment

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Editorial correspondence
Laboratory of Land Use Mobility and Environment
DICEA - Department of Civil, Architectural and Environmental Engineering
University of Naples "Federico II"
Piazzale Tecchio, 80
80125 Naples
web: www.serena.unina.it/index.php/tema
e-mail: redazione.tema@unina.it

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Urban planning for biodiversity

An assessment of green plans in Northern Italy

Luca Lazzarini[a*], Israa H. Mahmoud[b] and Maria Chiara Pastore[c]

[a] Laboratorio di Simulazione Urbana Fausto Curti
Department of Architecture and Urban Studies (DAStU)
Politecnico di Milano, Milan, Italy
e-mail: luca.lazzarini@polimi.it
ORCID: https://orcid.org/0000-0003-0237-1967
* Corresponding author

[b] Laboratorio di Simulazione Urbana Fausto Curti
Department of Architecture and Urban Studies (DAStU)
Politecnico di Milano, Milan, Italy
e-mail: israa.mahmoud@polimi.it
ORCID: https://orcid.org/0000-0003-0161-6096

[c] Department of Architecture and Urban Studies (DAStU)
Politecnico di Milano, Milan, Italy
e-mail: mariachiara.pastore@polimi.it.
ORCID: https://orcid.org/0000-0002-9577-0133

Abstract

In the recent debate on the urban planning-biodiversity nexus, much attention is being given to the identification of goals, targets, and indicators from the global, European, and national levels and the application of these at the local scale through targeted policies and specific actions. This article attempts to identify a theoretical framework for the integration of biodiversity in spatial planning processes at different scales, through mainstreaming the ecological transition, rightsizing the strategies and policies for biodiversity recovery, and overcoming the different challenges found in local contexts. Furthermore, a sample of green plans and strategies from the Italian context is analyzed across a deducted analytical framework including four dimensions: biodiversity goals, targets, commitment to implementation, and public participation. Results from the analysis emphasize that the focus of the green plans is generally oriented to the conservation of existing biodiverse urban areas rather than radically igniting new possibilities in spaces where biodiversity can be restored, or it is already present but not perceived by local communities. Lastly, the article highlights four gaps characterizing the biodiversity-planning nexus in its theoretical and operational implications.

Keywords

Urban biodiversity; Green plans; Monitoring; Public participation.

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1. Introduction

The latest research on the biodiversity and urban planning nexus calls special attention to the fundamental role of biodiversity on human well-being, healthy planetary systems, and economic prosperity for society. This has been strongly reaffirmed at the recent global UN Convention on Biodiversity during the 15th Conference of Parties (COP15) (CBD, 2022). While it is widely acknowledged that urbanization has several negative effects on biodiversity, at the same time rich nature can exist in cities. This includes several habitats for plants and animals, where also native and endangered species live. Cities have also the potential to play a critical role in biodiversity preservation and enhancement with initiatives that preserve habitats and species, improve landscape connectivity, mainstream urban green planning, and enhance residents' knowledge and stewardship of biodiversity (Rega-Brodsky et al., 2022). Nevertheless, despite advances in urban shared governance, biodiversity "in action" still encounters several obstacles at many scales. These include significant challenges at the policy and the operational levels as well as in the consolidation of the necessary stakeholders' engagement to address critical urban transitions. It is becoming apparent that complex processes are not manageable with traditional policy-making and incremental changes and, therefore, require some radical transformations (Bradley et al., 2022).

Nonetheless, the hurdles to integrating biodiversity-related actions within statutory planning, in general, and in strategic and thematic planning such as green plans and strategies, in specific, are many. Several authors point to the following aspects:

1) the spatial scales in which the specific biodiversity actions could be implemented consistently (Reckien et al., 2023; Uchida et al., 2021),
2) the difficulties in monitoring and evaluating the processes of biodiversity enhancement (Ronchi & Salata, 2022; Castaldo et al., 2021; Ruf et al., 2018),
3) the governance, financial and political willingness to pay for biodiversity co-benefits (Bulkeley et al, 2022), and lastly,
4) the challenges of citizen engagement and public participation in long-term urban regeneration processes, especially those related to natural capital and biodiversity (Pluchinotta et al., 2022).

The main objective of this research relates to the understanding of the role that biodiversity plays in urban plans in Italy, specifically looking at the degree to which a typology of thematic plans –the green plans– embeds objectives, actions, and indicators in favor of biodiversity conservation and enhancement in urban and peri-urban areas. The research questions that permeate the research are mainly two: How do green plans and strategies address the objectives of biodiversity preservation and enhancement? What attributes and indicators can be identified from the literature to assess the role of biodiversity in green plans?

The research is conducted as part of the National Biodiversity Future Center (NBFC), one of the five national research centers created and funded by the National Recovery and Resilience Plan (PNNR) which is dedicated to the topic of biodiversity conservation, monitoring, and enhancement in the Mediterranean context (https://www.nbfc.it/), and specifically of the Spoke 5 oriented to investigate the multiple challenges related to biodiversity in urban contexts.

The article is divided into four main sections: the theoretical framework based on a literature review, the methodology, the results, which also include the case-study analysis, and lastly a discussion and conclusion section. The research's main aim is a twofold analysis including:

- a literature review to identify the missing links (*fil rouge)* between the planning and policy guidelines considered at three scales (global, European and National) and the plans and regulations at the local level;
- an in-depth investigation of a sample of Green Plans and Strategies of provincial capital cities in Italy through a framework made of four main criteria of analysis, namely biodiversity goals, targets, commitment to implementation and public participation.

The originality of this research lies in the identification of specific indicators of performance against which an evaluation of the Green plans can be performed with respect to their role in leveraging urban biodiversity preservation and strengthening.

2. Literature Review

This section presents a literature review based on three different dimensions regarding the challenges to implement biodiversity actions: the global scale, the European scale, and the local scale. The main aim is to identify shortcomings that generally affect the commitment of the national governments to plan, implement and monitor urban biodiversity-related actions at the local scales of spatial planning. The literature review conducted in this section is constructed qualitatively through a snowballing technique practiced by the authors, in addition to several exchanges in the form of focus groups and public seminars on the urban biodiversity–planning nexus involving the experts of the Spoke 5 research group of NBFC.

2.1 Mainstreaming from the global level: towards ecological transition

The latest COP 15 adopted the "Kunming Montreal Global Biodiversity framework" (GBF) that consists of four goals related to the 2050 vision of biodiversity and the 23 targets to be achieved by 2030 within an overall framework for addressing biodiversity loss, restoring natural ecosystems and establishing sustainable relationships between humans and nature (CBD, 2022). Since then, the topic of ecological transition and increased biodiversity within the urban environment has become an important focus of attention, especially after the latest COVID-19 breakout. Furthermore, the role of nature has been associated with increasing social cohesion, health, and well-being in urban areas (Beute et al., 2020; Atiqul Haq et al., 2021).

Nonetheless, the actual biodiversity strategies put in place in several countries are not yet on the verge of meeting the needed co-benefits for significant improvements in well-being, especially with the lack of effective and measurable implementation of targets, which, consequently, requires coordination between different policy processes and high-level of political commitment across sectors/industries and adaptation measures (Cardona Santos et al., 2023; Salata and Yiannakou 2016). This integration of policies and their relative coordination requires a variety of scaling-out and scaling-up models for biodiversity-related actions at a larger scale, which makes their governance processes more complex and difficult to manage than those happening within municipal jurisdictions (Buijs et al. 2019).

From this perspective, the most evident shortcomings in implementing biodiversity-related actions on the global level fall on the challenges of mainstreaming the impacts and the propagation of co-benefits. This requires high levels of commitment from policy-makers and complex models of shared governance for ecosystem services in order to provide the enhancement and restoration of biodiversity over the long term.

2.2 Rightsizing at the European level: strategies and policies for biodiversity recovery and monitoring

The latest EU Biodiversity Strategy 2030 calls for a comprehensive strategy to put Europe's biodiversity on the path to recovery with 14 key commitments by 2030 (European Commission, 2020a). This strategy encompasses a variety of pledges to be taken by state members towards strengthening the legal framework for nature restoration, as well as proposing a dedicated EU Forest Strategy that roadmaps planting at least 3 billion additional trees by 2030.

On one hand, the emerging challenge from this amendment at the European level – besides stepping up the enforcement of EU environmental legislation – is building an integrated framework and a whole-society approach towards biodiversity, including businesses, governance, measurement of nature value, as well as, improving and raising awareness on the role of natural capital for human well-being.

This challenge also relates generally to the alignment of municipal, metropolitan and regional planning with the sustainable development goals (SDGs) and how they could possibly catalyze and promote concrete actions at local scales (Mahmoud et al., 2022; Rizzi, 2023).

On the other hand, one of the most known difficulties to scientists and researchers in the biodiversity field remains the possible monitoring methods and techniques to assess biodiversity performance against specific targets and standardized criteria (Kumar et al., 2021). Frequently, analysis of performance of specific biodiversity-related actions, such as nature-based solutions (NBS), are based on experimental approaches that take into consideration the challenges which these NBS were implemented for. In other words, specific urban regeneration projects do establish an agenda of detailed activities for which their planning phases aim to: enhance environmental resilience, increase social cohesion, enhance disaster risk reduction, or preparedness for natural hazards, etc. (Frantzeskaki et al., 2022). This agenda setting-process of renaturing, very often, does not consider the possible "spillovers" of biodiversity actions from the local scale to be considered at the larger scale of implementation, unless these are mandated by wider policy frameworks (Mahmoud, 2022; Neuman, 2019).

From this perspective, the most evident shortcomings fall on the effective planning of biodiversity-related actions that have a broader agenda based on larger and whole societal goals and targets that are not rightsized from the European level towards the national and/or subnational levels. Nonetheless, the challenges framing this agenda should be consistent with the monitoring and evaluation methods by which these actions could be observed.

2.3 Downscaling to the local level: challenges for the urban planning-biodiversity nexus

In urban settings, the implementation of biodiversity-related actions leading to ecological transition is seemingly correlated to spatial planning contexts and local scales in which the actual green and blue infrastructures are executed as concrete measures (Brunetta & Voghera, 2014; da Silva & Wheeler, 2017). Very often, at the local scales of municipality and neighborhood, those actions are not consistently planned with larger scale strategies and policies (e.g., regional, metropolitan). For instance, the metropolitan planning sector is responsible for considering the ripple effects of natural capital and ecosystem services, as associated with ecological corridors connecting urban and rural areas across different municipal jurisdictions (Lazzarini, 2021). However, the specific increase of public green – or blue – areas and the related species that become established should be considered for implementation at a local scale such as the district or the municipal scale. This discrepancy, or better, mismatch between the regional, metropolitan, and municipal plans and their actual biodiversity-related actions can cause a lack of consistency in the effective results of biodiversity performance. When local authorities at different scales do not dialogue, this is commonly referred to as siloed thinking in urban governance dynamics (Cordini et al., 2021) which often leads to a lack of alignment between the content of local plans, and the priorities and guidelines laid out in national strategies (Oke et al., 2021). For instance, in the Italian context, it is a contentious issue to determine whether and how the biodiversity-related priorities, set by national strategies such as the National Biodiversity Strategy 2030 (MASE, 2023), and regulations (e.g., Law 10/2013 and related implementation guidelines) are integrated into statutory or sectoral plans at metropolitan and municipal levels (Salata, 2023). Concerning these levels, a problem of consistency is frequently reported horizontally, especially between the sectoral plans (like the Green Plans investigated in this article) dealing with specific policy sectors (mobility, greenery, climate change, etc.), and the statutory municipal plans that are in charge of regulating the land-use transformations and localizing the new urban developments and the public infrastructures and services, including parks and green areas (Colavitti et al., 2013).

Lastly, one of the main challenges in implementing biodiversity-related actions, identified in the literature, is the difficulty in developing systemic public participation and stakeholder engagement in the governance of urban planning, regeneration, and transformation (Tozer et al., 2022; Xie et al., 2022; Bianconi et al. 2018). Several scholars call for "biodiversity as a meeting point" between humans and non-humans, whereas our *vis-à-vis* relationship with nature should be deliberated and discussed with local actors (Pascual et al., 2021). Hence, research on biodiversity-related actions at the local scales should provide a voice for "nature" to be recognized and heard throughout the process of sustainable urbanization and greening of cities (Mansur et al., 2022; Pereira & Baró, 2022).

Nonetheless, from several European Commission (Research and Innovation Actions) projects (European Commission, 2020b), a tentative stream is focused on helping local communities and citizens get engaged in long-term urban regeneration through co-creation and co-design – with aspects related to urban greening and NBS – in order to foster accountability on local policies towards enhancing biodiversity.

However, there are hurdles to overcome when engaging citizens in such co-created actions, such as the loss of interest and a reduced sense of belonging that may emerge in the long-term (Hartmann et al., 2018; Mahmoud & Morello, 2021; Kauark-Fontes et al., 2023). In addition, it can be hard to recreate the intangible immediacy of results at the 'right size' in multiple neighborhoods and to match local communities' commitment towards natural environment and biodiversity with that sense of local impact. This challenge is often considered a limitation to existing urban planning and policy mechanisms since the biodiversity-related actions and their socio-cultural impacts still lack a cohesive modeling and monitoring framework that puts all these aspects together while helping to downscale them in local communities.

At this level, the downscaling of biodiversity-related actions locally should be ultimately supported by citizen engagement and public participation encouraging shared responsibility and accountability on local policies over the long term. Nature and biodiversity actions are, by their nature, integrative and effective at breaking silos across different spatial scales of urban planning (Tulisi, 2017). To summarize, the embeddedness of biodiversity-related actions should be mainstreamed from the global level, rightsized at the European level, and downscaled to the local level (see Table 1). Table 1 puts together the three levels and the lens of analysis through which the case studies will be analyzed. The following section puts this framework of analysis into action by surveying eleven Green Plans and Strategies in Italy considered as case-studies, and identifies the indicators to connect the theoretical and the operational aspects. The objective is to investigate what role urban biodiversity plays in green planning at the local level, with an emphasis on exploring the biodiversity-related goals and quantitative targets, the commitment to implementation, and the public participation mechanisms employed for conserving and enhancing biodiversity.

Biodiversity related actions	**Relative guidelines and policy documents**	**Challenges to implementation from Literature**	**Analytical framework of analysis**	**State of the art and relative frameworks**
Mainstreaming from Global Level	IPCC, 2018 COP 15- CBD, 2022 SDGs 2030	• Social challenges • Health and wellbeing • Commitment to implementation	Biodiversity Goals	Nilon, et al (2017); Cardona Santos et al., (2023).
Rightsizing at European Level	EU Biodiversity strategy 2030, 2020	• Monitoring and evaluation • Financial challenges	Biodiversity Targets	Kumar et al., (2021)
Downscaling to Local Level	National Biodiversity Strategy 2030 (MASE, 2023) Law 10/2013	• Raising awareness and fostering accountability • Shared governance and breaking silos • Citizen engagement and public participation	Public Participation and Commitment to implementation	da Silva & Wheeler, 2017); Tozer et al., (2022); Xie et al., (2022); Mahmoud et al. (2021); Hartmann et al. (2018)

Tab.1 Theoretical Framework of analysis based on the literature with relative guidelines and policy documents

3. Methodology

As stated in the introduction, methodologically this contribution relies on a two-fold qualitative analysis, whose outcomes are the theoretical framework built through the literature review presented in section 2 and the operational framework analyzing a sample of Green Plans and Strategies adopted by provincial capital cities in Northern Italy. The decision to work on a specific typology of thematic plans is due to the fact that in Italy, the Green Plan represents the strategic policy instrument where typically the aspects related to the management and enhancement of urban green spaces are tackled. The Green Plan is a strategic sectoral plan elaborated and adopted by a municipal government whose objectives, strategies, and actions should be then integrated into statutory municipal plans (the so-called "Piani Regolatori Generali, PRG" as regulated by the National Planning Law n.1150/1942) (Colavitti et al., 2013). In particular, according to the Italian legislation (National Law 10/2013 and the related guidelines drafted by the Ministry of Environment in 2017), the Green Plan is defined as the instrument in charge of developing the strategic dimension of green space planning, and thus contains the analysis of the urban green system, as well as the strategic interventions for developing and enhancing the urban and peri-urban green spaces in the medium and long term (Comitato per lo Sviluppo del Verde Pubblico, 2017). As explicitly mentioned in the guidelines elaborated by the Committee for the Development of Urban Greenery, the Green Plans should «identify the areas of the municipality characterized by high biodiversity and landscape value and improve the overall conditions of the urban and peri-urban territory from the ecological and ecosystem point of view […], increasing the ecological connectivity» (Ibid., 2017: 15). Starting from the content of these guidelines, the research wants to recognize whether and how the objectives of biodiversity preservation and enhancement are embedded in the Green Plans.

To achieve this objective, eleven Green Plans were mapped after a survey conducted to identify the provincial capital cities in Italy having an adopted Green Plan or Strategy in their local policy framework (Figure 1).

The decision to work on the provincial capital cities of the 8 Northern Italian regions (Valle d'Aosta, Piemonte, Liguria, Emilia-Romagna, Lombardia, Trentino Alto Adige, Veneto, Friuli Venezia Giulia) matches with Task 3.1 of the NBFC research, which has at its core the objective to carry out a systematic screening of plans and policies in major Italian cities, and identify guidelines, recommendations, and advice for improving the capacity of planning and design and their tools and mechanisms to address urban biodiversity. While the POLIMI-DAStU research unit conducted the survey in Northern Italian regions (tab. 2), the other NBFC partners of Task 3.1 (Universities of Florence, University of Molise and University of Rome La Sapienza) have surveyed the Central and Southern regions. In this sense, more empirical work is be needed to investigate systematically the full sample of Green Plans mapped in the whole country and identify the related challenges and the potential areas of improvement.

City	Population	Municipal area	Population density	Year of adoption of the green plan
Torino	843,514 (2023)	130.01 km^2	6,488.07 ab/km^2	2021
Genova	560,455 (2023)	240.29 km^2	2,332.41 ab/km^2	2022
Sondrio	21,185 (2023)	20.88 km^2	1,014.61 ab/km^2	2007
Parma	197,945 (2023)	260.6 km^2	759.57 ab/km^2	2022
Reggio Emilia	170,819 (2023)	230.66 km^2	740,57 ab/km^2	2021
Ferrara	129,341 (2023)	405.16 km^2	319.23 ab/km^2	2019
Bologna	389,772 (2023)	140.86 km^2	2,767.09 ab/km^2	2022
Forlì	116,509 (2023)	228.2 km^2	510.56 ab/km^2	2021
Bolzano	105,939 (2023)	52.29 km^2	2,025.99 ab/km^2	2022
Padova	207,330 (2023)	93.03 km^2	2,228.64 ab/km^2	2022
Vicenza	110 133 (2023)	80.57 km^2	1,366.92 ab/km^2	2018

Tab.2 Demographic data about the provincial capital cities in Northern Italy having an adopted green plan

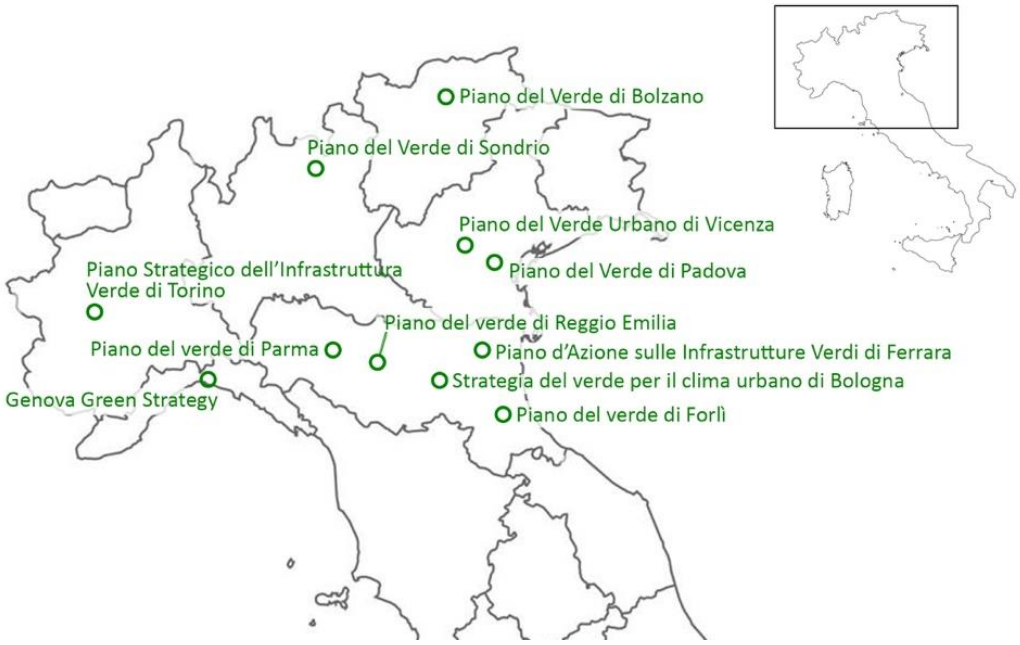

Fig.1 Localization of the green plans and strategies in Northern Italy

From the operational point of view, the survey has screened the official websites of the local governments to access and download the Green Plan documents.

In case of missing information, an e-mail was sent to municipal officers, to retrieve the planning documents. The data collected were then validated by using a national survey made in 2021 by the National Institute of Statistics (ISTAT) on the state of implementation of the already mentioned National Law 10/2013 that reported info about different topics, including the Green Plans and regulations.

After the survey, the main reports of the Green Plans *(relazione illustrativa)* were analyzed through a qualitative analysis taking into consideration four criteria:

- *Biodiversity goals*, meaning the presence in the plan of general and/or specific goals related to the protection, restoration, and management of urban biodiversity, animal and plant species, habitats, and natural capital resources in the urban environment;
- *Biodiversity targets*, which is to say the quantitative targets set by the plan for increasing urban biodiversity habitat area or species populations;
- *Commitment to implementation*, namely the instruments, devices, and actions present in the plan to monitor the implementation of urban biodiversity goals;
- *Public Participation*, meaning if the green plan mentions participatory approaches or mechanisms in relation to the identification of planning priorities and actions related to urban biodiversity and to their implementation.

The four criteria were identified after the previously stated literature review in section 2, aiming to define potential analytical frameworks for assessing the role of urban biodiversity in Green plans.

In particular, the three dimensions of biodiversity goals, targets, and commitment to implementation are considered by Nilon et al (2017), who proposed a model to investigate discursively the biodiversity-planning nexus in policy documents. T

he criterion of public participation was then added to the framework model as it represents a specific focus of the NBFC research examined by the authors (Mahmoud et al., 2021). The main report of each Green Plan was then investigated to determine the extent to which the four criteria are discursively tackled.

A scale of values from 1 to 5 reworked from the Priority Likert-type Scale was employed (Vagias, 2006).

In particular, the following guidance was used to apply the Likert scale to the analysis:

- Score 1: the criterion is not present or even mentioned in the plan.
- Score 2: the criterion is mentioned implicitly in the plan, meaning that an unexplicit reference to it is present.
- Score 3: the criterion is explicitly mentioned in the plan, although this has a marginal or lateral role in the plan.
- Score 4: the criterion has a major role in the plan, namely it is mentioned more than one time in the plan.
- Score 5: the criterion is the structuring principle of the plan; it is mentioned several times, and it has a central role in the corpus of the plan's strategies or objectives.

A performance indicator was then added based on the sum of the values attributed to the single criteria to compare the performances of Green plans against each other across the priority values given by the authors. The results of the analysis are shown in Table 3, graphically shown in Figure 2, and presented in the following section.

4. Results

The initial literature review showcases that there is a need for three levels of integration for biodiversity in urban planning mainly through:

1) mainstreaming of societal challenges and needs across the global scale of biodiversity strategies and policy recommendations,
2) rightsizing the actions at the subnational scales (regional, metropolitan, and intermunicipal) while monitoring their ripple effects at large scales, and lastly,
3) downsizing the actions at the local scales, namely the municipal, neighborhood and district scales, where the local communities could be directly involved in initiatives and projects oriented to improve or restore biodiversity within the built environment.

The survey highlighted a variety of approaches by which the Green Plans and strategies tackle the issues related to urban biodiversity according to the total scores below. Nevertheless, the main focus of the plans generally shifts to conserving existing biodiverse areas and to re-naturalizing high-value natural spaces, rather than radically igniting new possibilities in areas where biodiversity can be restored or is already present but not perceived by local communities.

	Turin Green Infrastructure Strategy	Genova Green Strategy	Sondrio Green Plan	Vicenza Green Plan	Parma Green Plan	Padova Green Plan	Bolzano Green Plan	Bologna Urban Climate Green Strategy	Reggio Emilia Green Plan	Ferrara Green Infrastructure Action Plan	Forlì Green Plan
Biodiversity goals	5	3	3	3	3	5	3	3	3	3	2
Biodiversity quantitative targets	1	1	1	1	3	3	2	3	1	1	3
Commitment to implementation	4	1	1	3	4	4	1	3	1	4	3
Public participation	3	1	1	3	3	4	3	4	1	3	3
Total score	13	6	6	10	13	16	9	13	6	11	11

Tab.3 Results of the survey regarding the role of the four criteria in the green plans

Regarding the criterion of biodiversity goals, the survey highlighted that just in the cases of the Green Plan of Padua and the Green Strategy of Turin the goal of biodiversity preservation and enhancement is interpreted as one of the structuring principles of the plan.

In the case of Padua, biodiversity is explicitly tackled by one of the five macro-strategies of the plan, which mentions the need to «propose and identify […] belts of connection between the ecological corridors and the urban areas where a biodiversity strategy should be implemented» (Comune di Padova, 2022: 407).

The biodiversity strategy is highlighted with reference to specific actions to be performed by the municipality, from the identification of the green areas with a biodiversity potential in the municipal territory, and their overlapping with the other green areas, road trees and the so-called "10,000 trees municipal strategy", to the identification of both the linear and transect elements that connect the various existing ecological corridors. The interesting point is that the strategy is then articulated in a set of several guidelines for specific species (pollinators, dragonflies, bats, etc.) with concrete and specific actions for preserving and managing the related habitats. In the case of Turin, biodiversity is developed in-depth in the section "ecosystem services" of the strategy where four strategic actions for incrementing the quality of ecological corridors and habitats and preserving biodiversity are pointed out: protection of high-value areas, completion of urban ecological corridors, re-naturalization of river areas, creation of widespread urban forestation (Comune di Torino, 2020).

In relation to the quantitative targets for increasing biodiversity habitats and species identified by the plans, 5 out of 11 plans (Parma, Padova, Bolzano, Bologna, and Forlì) employ and mention them, although none gives this criterion a central role in the green strategy.

In the case of Parma, the Green Plan includes a set of quantitative targets for increasing constructed habitats and ecological corridors for biodiversity purposes. It sets the commitment of the municipality to enlarge the horticulture areas of 16,500 sqm of public land, turning marginal and vacant lots into productive spaces available for urban agriculture, and identifies 12 new ecological corridors for a total of 58,6 km to be implemented in continuity with the existing cycling network and to be equipped with tree rows for diversifying the landscape and creating an environmental mitigation zone (Comune di Parma, 2022). The Green Plan of Padua introduces some quantitative targets for the increase of biodiversity habitat area, such as the rise of tree cover in the municipal area (from 1,8% to 5% with at least 20% of the tree species prone to adapt to climate change). Moreover, regarding the increase of tree biodiversity, the Plan provides that the abundance of a single species should not exceed the 6% and that the relative abundance of a single genus should be 10%. It also sets a long-term period of 20 years to achieve this target. Also in the Green Plan of Bolzano, a quantitative target dealing with the increase of biodiversity habitat area is introduced (665,000 sqm of new green areas, +92% than the current state), although this concerns green public spaces mentioned in general terms with no emphasis on biodiversity-related aspects, neither of commitment devices regarding the time or the funding sources needed to implement them. In the same vein, the Green Strategy of Bologna highlights the target of 1,300 trees per year to be planted in the city and of 30,000 sqm per year of new green areas to be created for strengthening the urban green system. As in the case of Padua, the Plan sets targets for the tree species composition of the new green areas so that the future green areas will host no more than the 10% of any tree species, no more than 20% of any genus, and no more than 30% of any family (Comune di Bologna, 2022).

The criterion of commitment to implementation is a critical aspect tackled by the majority (8 out of 11) of the Green plans under investigation (Turin, Milan, Vicenza, Parma, Padova, Bologna, Ferrara, and Forlì). The survey highlighted that the plans tackle this criterion following three main declinations:

- the presence of indicators to monitor the plan implementation.
- The mentions of specific economic sources needed to implement the plan objectives.
- The introduction of specific governance arrangements needed to implement the plan.

In the cases of Turin, Bologna, Parma, and Padua, the commitment to implementation is expressed in the presence of a set of indicators matching with different actions that deal with biodiversity preservation or enhancement (tab. 4). These refer to several aspects related to the increase of both habitat area (e.g., total green surface area, number of trees and their canopy cover, etc.), and biodiversity performances (e.g., number of animal species or percentage of tree species diversity reported in each portion of green area, as in the Plans of Parma and Padua).

The issue of financial sources needed to implement the plan actions is tackled by the Green Plan of Forlì where in a specific section the funding opportunities for implementing the objectives of the plan are highlighted.

For instance, synergies with the actions of the Rural Development Plan or other economic incentives to be activated by the Municipality for sustaining the initiative of agricultural entrepreneurs or citizens to realize the green interventions foreseen by the plan are mentioned (Comune di Forlì, 2020). A more pragmatic approach is taken by the Action Green Plan of Ferrara where each action included in the plan is developed with reference to the time and the estimated costs of implementation, and the potential funding sources to be activated (Comune di Ferrara, 2019).

Plan	Biodiversity-related actions	Indicator
Green Infrastructure Strategy of Turin (2020)	Protection and safeguarding of high natural value areas.	- n. of interventions / year
	Completion of urban ecological corridors through acquisitions and based on the local plan forecasts.	- sqm / year
	Re-naturalization of ecological corridors and river areas.	- sqm / year
	Widespread urban forestation in non-wooded publicly owned areas.	- no. trees in publicly owned areas / year
Bologna Urban Climate Green Assets Strategy (2022)	Forestry interventions in peri-urban areas	- n. of wooded areas and related surface
	Plantation in municipal and private systems of entomophilous plants and/or attractive to birds.	- % of tree species diversity planted - No. of projects/interventions with specific prescriptions
	Re-naturalization of the riverbanks to increase local biodiversity, through policies of reforestation both spontaneous and planned.	- n. of hectares of naturally evolving or re-naturalized areas within the riverbanks
	Design and maintenance of public green spaces according to the principles of urban ecology (e.g., maintaining and increasing spontaneous or low maintenance green areas).	- n. of hectares of green areas with low or zero maintenance.
	Plantation of species resistant to water deficiency.	- % of distribution of resistant species out of the total of the new plants
	Creation of productive urban landscapes and food forests in public spaces.	- sqm of food forests
Green Plan of Parma (2022)	Growth of total tree cover	- sqm of tree cover (ground projection of the canopy)
	Growth of the number of trees	- n. of trees presents within the municipal territory in the spaces planned for urban greenery
	Biodiversity improvement of the tree system	- % of abundance of tree species
		- % of abundance of tree species higher than 5%
Green Plan of Padua (2022)	Biodiversity improvement	- n. of animal species and their abundance detected in the territory.
		- Biodiversity index of the main parks of the city (n.)
		- Biodiversity of the tree system (n. of species higher than 6%)
		- n. of species/n. of trees x 100
		- n. of species higher than 5%
		- n. of species reported annually on the portal iNaturalist.

Tab.4 Indicators focusing on urban biodiversity in the green plans under investigation

The governance arrangements for implementing the plan objectives are a minor aspect of the plans investigated. Only the Green Plan of Vicenza gives this aspect a relevant role as it introduces a specific governance device, the framework agreement ("Accordo Quadro") for implementing the plan objectives.
In particular, this is interpreted as a device shaping the coordination between the different actors involved in the plan implementation, specifying their commitment and levels of engagement in the process (Comune di Vicenza, 2018). The criterion concerning public participation is tackled in 9 Plans out of 11 (all except Genova, Sondrio and Reggio Emilia). As in the previous case, this topic has several withholds and operationalizations in the documents analyzed. The more recurring one entails aspects of communication of the plan's contents and strategies related to urban biodiversity to the local community.
This is the case of the Green Plans of Parma and Forlì where the communication programs are explicitly addressed to inform citizens about the new green space management, and the related ecological and economic benefits that the low-maintenance green areas unfold (Comune di Parma, 2022; Comune di Forlì, 2020). Just in the case of Bolzano, the process and content dimension of participation is fully developed in the Green plan, with an emphasis both on the participatory tools employed (thematic focus groups with third sector representatives, citizens, and other stakeholders) and on the results achieved which concerns the demand for new green spaces manifested by citizens and the proposal to manage and maintain them collectively, through bottom up mechanisms and without the financial support of the municipality (LAND, 2021).
A reference to specific case studies where participatory approaches is employed to strengthen biodiversity is included in the Green Infrastructure Strategy of Turin and in the Action Plan of Ferrara. The first mentions the experience of Parco Michelotti, a former zoo area in the Po riverbank where an urban park was created after a consultation process involving local administration, volunteering associations and a local school (Comune di Torino, 2020).
The second includes a set of actions, each of which is spatialized in the municipal territory and developed with reference to the typology of stakeholders to be involved and the participatory mechanisms to activate for implementing those actions (Comune di Ferrara, 2019).

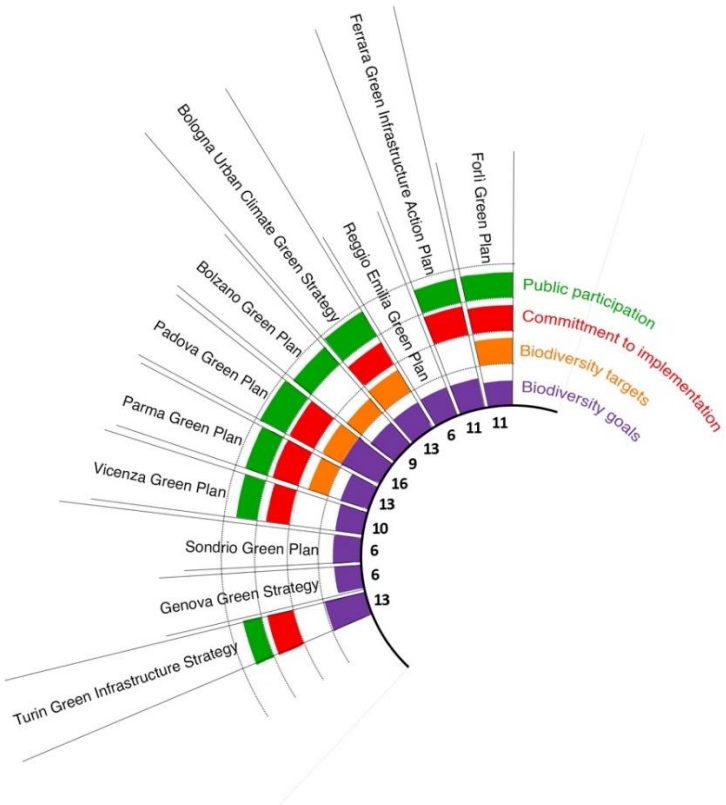

Fig.2 Graphical representations of the results of the survey on the eleven green plans investigated

5. Discussion and conclusions

The research has shown several shortcomings related to the policy and legal frameworks needed to institutionalize biodiversity in urban planning, especially after the increasing environmental pressures highlighted by the recent IPCC (2018) report. While it is increasingly acknowledged in the debate that statutory planning stands as a crucial policy field for promoting the ecological transition of cities (Bush, 2020), this contribution stems from the idea that also strategic policy tools like the Green Plans can make a relevant contribution to operationalize this transition. Four fundamental issues can be highlighted, based on the analysis carried out in this article. Each issue matches with a specific gap characterizing the biodiversity–planning nexus, in its theoretical and operational implications.

The first issue is merely at the theoretical level. As mentioned in section 2, a mismatch between the literature on human-nature health and wellbeing improvement and the possible relationship to biodiversity-related actions should be acknowledged. Henceforth, there is a need for a standardized and cohesive framework for monitoring social and environmental aspects altogether, using quantitative and qualitative methods. The scientific research on urban biodiversity puts a clear distinction between the *mainstreaming* process of planning and policies from the global level which are barely *rightsized* at the European level and met according to the national and subnational strategies and standards in many countries, and the *downscaling* process of translating them at the local scale.

The second issue is related and concerns the procedural level. It entails the lack of consistency which connotes the downscaling process of integrating the contents and priorities set from the national and subnational level in the local plans (Oke et al., 2021). In the case of the Green Plans, this aspect is particularly relevant as the Italian National Government, in the guidance documents drafted by the Ministry of Environment (Comitato per lo Sviluppo del Verde Pubblico, 2017), has introduced a set of guidelines regarding objectives, contents and implementation mechanisms to guide the elaboration of the Green plans. Despite this, the analysis has pointed out that these guidelines have a low degree of cogency and were followed only partially by the Green plans under investigation. This demonstrates that an approach to differentiation rather than standardization still prevails in the field of green strategic planning (Nilon et al., 2017). Another aspect emerging from the green plans analyzed is the recency of their adoption; most plans were elaborated and adopted in the period from 2018 to 2022. This makes notable the possibility to match their priorities and actions with the recent global frameworks such as the GBF of 2030 (IPCC, 2018) and their relative targets.

The third critical aspect concerns the impact level and the commitment to implementation. The results from the survey analysis emphasize the lack of distribution of the resources needed to catalyze the biodiversity net gain in urban areas. Indeed, the focus generally shifts to conserving existing biodiversity in urban areas rather than radically igniting new possibilities in areas where biodiversity is not high or perceived as important. Moreover, a mismatch between the quantitative targets and the possible monitoring indicators for increasing biodiversity habitats and species emerges in the Green Plans investigated. Emphasis is mostly placed on the indicators, with scarce or no attention oriented to the target thresholds to be met. In other terms, several Green Plans introduce a set of specific indicators for monitoring the achievement of biodiversity objectives, but they do not establish any quantitative target for these objectives, making their commitment to implementation weak. Also, the analysis highlighted that the Green Plans rarely specify the financial resources and the governance mechanisms needed to implement the objectives and actions identified, making the implementation hard to monitor. Only in the case of Ferrara, the Action Plan on Urban Green Infrastructures includes a specific mention of the time, costs, and potential funding sources to retrieve for implementing the actions, specifying a solid guidance for its execution.

The last issue regards the discourse level and involves the topic of human-nature relationships in the public participation processes underlying the Green Plans. Though the analysis has shown that participatory mechanisms and approaches related to biodiversity preservation and enhancement are topics frequently

mentioned in the plans, these are mainly framed in traditional terms. For instance, participatory processes are employed to inform local inhabitants about the plan objectives and actions and/or consult and gather inputs for identifying specific priorities. In this case, a mismatch between theory and practice is present and this relates to what role nature plays in participatory planning processes. Despite the growing perspective in the debate that our relationship with nature should be openly discussed in public arenas and that the nature itself should be considered as an actor to be heard in policy-making processes (Pascual et al., 2021), the Green Plans still frame the human-nature relationship in univocal and often "opportunistic" terms. They thus interpret nature as a generator of benefits that humans can take advantage of for improving their capacity to adapt to climate change and resources shortage, rather than as a plural entity shaping patterns of interdependency and coexistence between human and non-human agents.

Alongside the results emerged so far, one shortcoming of the research concerns the sample of analysis which is limited to a specific typology of sectoral plans, the Green Plans and strategies, elaborated by provincial capital cities in a specific geographical context (Northern Italy). Thus, the article lacks a comprehensive focus on the different typologies of sectoral plans where the biodiversity objectives are potentially tackled (e.g., the Sustainable Energy and Climate Actions Plans) as well as on the statutory plans that, as already mentioned, have a direct impact on the increase or loss of biodiversity in cities. Following this shortcoming, a future development of the research would be to extend the sample of analysis in terms of the number and typology of plans. Here it is suggested that the analysis should cover other sectoral and statutory plans and focus on the whole National context. Widening geographically the sample would allow to describe the territorial distribution of plans across the whole Country and, more importantly, to identify the approaches by which different municipal administrations – through different sectoral and statutory plans – tackle the objectives of biodiversity preservation and enhancement and highlight the barriers and obstacles that characterize the integration of these objectives in the planning process. The large dimension of the sample would also require the construction of a more sophisticated framework of analysis, made of a set of indicators through which assessing the attributes related to urban biodiversity in a technically sound way.

Authors' contribution

L.L. and I.M. share first authorship rights, the order is purely alphabetical. Conceptualization: L.L., I.M. and M.C.P.; methodology: L.L. and I.M.; validation: L.L. and I.M.; investigation: L.L. and I.M.; writing—original draft preparation: L.L. and I.M.; writing—review and editing: L.L. and I.M.; visualization: L.L.; funding and supervision: M.C.P. All authors have read and agreed to the published version of the manuscript.

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Image Sources

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Authors' profile

Luca Lazzarini, PhD, Assistant Professor (rtda) in Spatial Planning at the Department of Architecture and Urban Studies (DAStU) of Politecnico di Milano. As member of the research group of DAStU, he currently collaborates with the National Biodiversity Future Center (NBFC) on the mapping and monitoring of the socio-spatial impacts of the biodiversity interventions in urban contexts. His research topics mainly concern urban/rural relationships, territorial governance and cohesion, experiential walking, and social innovation in inner peripheries.

Israa H. Mahmoud, PhD, Assistant Professor in Urban and Regional Planning at Department of Architecture and Urban Studies (DAStU), Politecnico di Milano. She collaborates with the National Biodiversity Future Center (NBFC). With more than 50 publications, her research focuses on urban biodiversity, nature-based solutions, social inclusivity, co-creation processes and urban governance. Recently, she has led the "Greening Cities, Co-creating Cities" research stream at LabSimUrb. She co-edited the book "Nature-based Solutions for Sustainable Urban Planning" (2022) and authored the monograph "Placemaking for Green Urban Regeneration" (2022).

Maria Chiara Pastore, PhD, Assistant Professor in Urban and Regional Planning at the Department of Architecture and Urban Studies (DAStU) of Politecnico di Milano. She coordinates with Massimo Labra the Spoke 5 of the National Biodiversity Future Center (NBFC) and was the scientific manager for the project "Forestami" aimed at the implementation of the green system in Greater Milan 2030. She also collaborated on the works for several masterplan in Albania, Malawi, Tanzania, TU Graz.