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Are spatial plans transformative for biodiversity and ecosystem services? Insights from seven European countries

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ABSTRACT

This study explores how spatial plans hold transformative potential for biodiversity and ecosystem services (ES) valorisation. It develops a conceptual framework that unpacks transformative change for biodiversity-inclusive spatial planning, analysing plans' components—visions, strategies, information baseline, actions, instruments and regulations—through four analytical elements: governance, mitigation hierarchy, spatial planning provision of sectors and biodiversity/ES. The framework assesses transformative potential using five characteristics: restructuring (i.e., system's components variations), multiscale (i.e., spatial and temporal scales and actors), path-shifting (i.e., redirection of current trends and principles), innovative (i.e., uptake of new knowledge) and phasing-out (i.e., outdated practices' elimination). We tested it through content analysis of 28 plans from seven European countries with good Biodiversity Strategy 2020 performance (Italy, Denmark, Germany, Portugal, Scotland, Spain and Switzerland), spanning NUTS levels. The results reveal varying transformative potential across plan components, with visions and strategies showing higher transformation commitment than other components. While governance and biodiversity/ES considerations demonstrate emerging transformative practices, the mitigation hierarchy and sectoral provisions remain underutilised. Plans tend to favour restructuring over more disruptive changes like path-shifting, innovation and phase-out. We identify critical interventions for fostering biodiversity-inclusive planning, including strengthening sectoral engagement, addressing temporal misalignments, reforming bureaucratic processes and shifting planning paradigms towards net biodiversity gains.

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1. Introduction

Transformative change (TC) has emerged as a critical concept in the discourse surrounding spatial planning, governance, and biodiversity (Arias-Arévalo et al. 2023; Avelino 2017; Linnenluecke et al. 2017). It underscores the need for fundamental shifts in spatial planning and societal systems to address contemporary interlinked challenges such as biodiversity loss, climate change, pollution, continued urbanization and land take, and social inequality. The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) defines TC as '*a fundamental, system-wide reorganization across technological, economic and social factors, including paradigms, goals and values, needed for the conservation and sustainable use of biodiversity, good quality of life and sustainable development*' (IPBES 2022, 32). The concept of TC advocates for pathways of change beyond incremental improvements in the practice of (planning) systems, their instruments and decision-making processes to achieve a 'good Anthropocene' (Bennett et al. 2016) (McPhearson et al. 2021; Friedman 1987). As Patterson et al. (2017) argue, engaging with the governance and politics of transformation is crucial for TC to shape actions effectively. TC should, therefore, contribute to addressing direct and indirect drivers (root causes) of biodiversity loss, such as land use change (Díaz et al. 2019), which, to a large extent, is determined through spatial planning (Nadin et al. 2018; EC 1997).

Spatial planning can play a dual role in biodiversity and ecosystems. On the one hand, it can negatively impact ecosystems and ecosystem services (ES) supply through land use changes that favour land take, soil sealing, and urban area expansion. In this regard, the last IPBES Global Assessment Report on Biodiversity and Ecosystem Services highlighted land use change as the main direct driver of terrestrial biodiversity loss (IPBES 2019). On the other hand, Targets 11 and 14 of the Kunming-Montreal Global Biodiversity Framework emphasize the potential of spatial planning to positively contribute to halting biodiversity loss (CBD 2022). However, incorporating ecosystem knowledge and biodiversity values into spatial planning requires more radical and disruptive systemic changes (Næss 2023), depending on the socioeconomic and political context (Albert et al. 2020).

This research focuses on 'how' TC can unfold in spatial planning, specifically in spatial plans as one of the formalized tools outlining planning decisions on the physical and socioeconomic arrangement of the space within a given territory (Faludi 2000; Moroni 2023). It addresses the following research question: How transformative are spatial plans for the valorization of biodiversity and ES in diverse European planning contexts? To answer this questions, this study proposes a conceptual framework that sets the ideas for changes in spatial planning, including biodiversity and ES conservation and enhancement goals and measures, governance arrangements, and development regulations. It is grounded in a review of several policy frameworks for sustainable development and biodiversity (UN 2018; European Union 2020b; EC 2021a; European Union 2020a) to narrow down the TC concept into specific characteristics that hold transformative potential. These characteristics are: *restructuring* (i.e. reorganization of spatial planning components and processes), *multiscale* (i.e. involving several spatial and temporal scales, sectors, and actors), *path-shifting* (i.e. shifting the values at stake), and *innovative* (i.e. introducing a new practice for the specific planning context). Moreover, based on

sustainability transitions theory and its implementation to socio-ecological systems (Wittmer et al. 2021; Loorbach and Oxenaar 2018), the framework considers *phasing out* as an essential fifth characteristic that highlights the need to eliminate old and unsustainable planning practices and instruments. These characteristics are applied to the components of spatial plans – such as visions, strategies, information baseline, actions, instruments, and regulations – within four analytical elements: (i) governance of spatial planning systems, (ii) the mitigation hierarchy, (iii) provisions for various sectors, and (iv) biodiversity and ES. The paper tests the proposed framework through a qualitative content analysis of 28 planning documents from seven European countries, including 25 plans and three national legal frameworks. The analysis extracts plans' components that address one of the four analytical elements and exhibit transformative potential within one of the five characteristics. The study sheds light on plans' ability to incorporate TC and phase out harmful practices for biodiversity-inclusive spatial planning across Europe.

The article is structured as follows: Section 2 delves into the theoretical frameworks employed to analyze the 28 documents, describing the plans' components, the analytical elements, and the characteristics holding transformative potential. Section 3 presents the methodology and criteria for selecting representative countries and conducting the content analysis. Section 4 presents the analysis results, while Section 5 discusses the main emerging trends of transformative potential and insights for biodiversity-inclusive spatial planning. Finally, section 6 concludes and provides directions for future research.

2. Developing the spatial planning conceptual framework

The conceptual framework comprehends three blocks: plans' components, analytical elements of spatial planning systems, and characteristics that hold transformative potential, briefly presented in Table 1 and Figure 1.

Based on previous content analysis studies of spatial planning documents (Cortinovis and Geneletti 2018; Geneletti and Zardo 2015; Berke and Godschalk 2009), four main components can be depicted as common for different spatial plans and planning systems: (i) visions, i.e. common aspirational general view for the long-term future of an area (Mastop and Faludi 1997); (ii) strategies, i.e. specific qualitative and quantifiable objectives and targets derived from the visions (Mastop and Faludi 1997); (iii) information baseline, i.e. knowledge background, built upon the analysis of current and future conditions; and (iv) actions, instruments, and regulations, i.e. used to implement planning strategies and achieve planning visions (Albrechts 2004; Stead 2021; Dühr 2022).

Table 1. Purpose of the conceptual framework's blocks.

Blocks of the framework	Purposes
Components of spatial plans	Serve to structure the content of plans as a key document containing spatial planning decisions
Analytical elements of spatial planning systems	Serve to structure critical aspects of spatial planning systems in relation to transformative approaches towards biodiversity and ES valorization
Characteristics holding transformative potential	Serve to describe the different ways in which transformative change can occur in a system

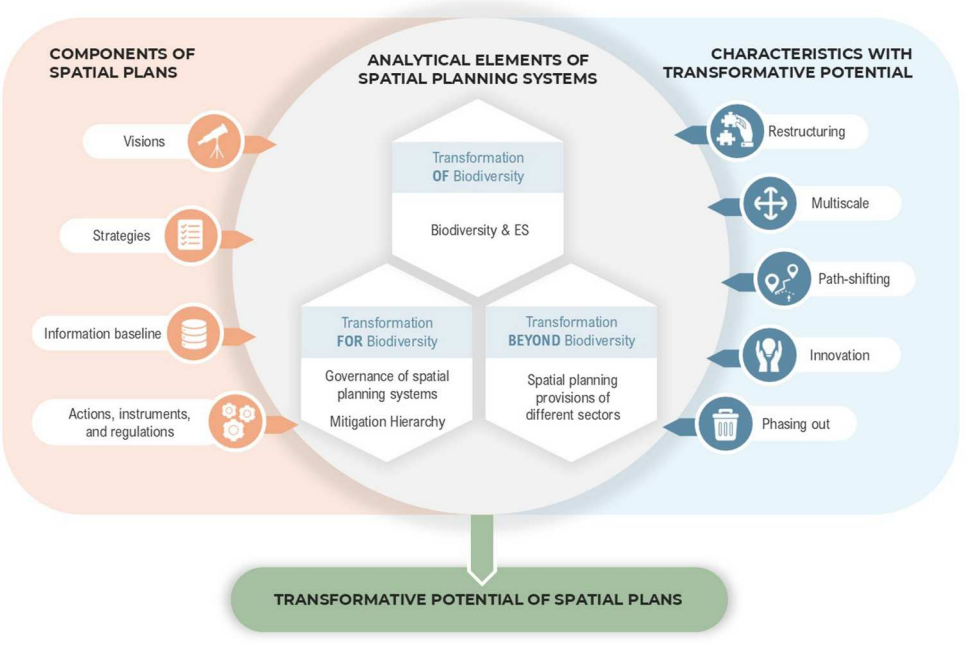

Figure 1. Spatial planning conceptual framework to analyze the transformative potential of spatial plans.

Building on the authors' spatial planning expertise, the framework considers four analytical elements of spatial planning that align with the IPBES actions for transformative change, structured into the categories of transformation 'for', 'beyond' and 'of' biodiversity (Gurung et al. 2024). The first two elements include (i) the *governance of spatial planning systems*, and (ii) the *mitigation hierarchy*, to capture changes in systems' structures and rules 'for' biodiversity conservation and valorization. Specifically, the *governance* describes how spatial planning takes and implements decisions for biodiversity (Nadin et al. 2018; Pascual et al. 2022), and the *mitigation hierarchy* is conceived as a tool to guide the setting of visions, strategies, and actions for enhancing biodiversity and avoiding, minimizing, restoring and offsetting impacts on ecosystems (The Biodiversity Consultancy 2015; Kørnøv et al. 2025). The third analytical element, (iii) *spatial planning provisions for different sectors,* considers the role of other realms 'beyond' biodiversity (e.g. mobility, energy, agrifood sectors) in impacting conservation and restoration. The fourth analytical element, (iv) *biodiversity and ES*, describe the transformation 'of' the structure and functioning of ecosystems, including size, diversity, conditions, and ES supply.

The framework interprets five characteristics holding transformative potential individually and combined, in the context of the above-mentioned four analytical elements: restructuring, multiscale, path-shifting, innovation, and phasing-out. The first four characteristics come from a scientific literature review by Fedele et al. (2019) in the context of climate change and correspond to phasing-in pathways – that is, they build up and expand positive practices for transformation (Ghosh et al. 2021). In contrast, the fifth characteristic, phasing-out, captures the disruptive dimension of change – the

active dismantling of unsustainable planning practices. This follows insights from sustainability transitions theory and its implementation to socio-ecological systems, which emphasizes thar enabling systemic transformation also requires the breakdown of dominant regimes (Loorbach and Oxenaar 2018; Wittmer et al. 2021).

The next section elaborates on the definitions of the characteristics that hold transformative potential for the analytical elements. The interpretations of characteristics for the specific element of *spatial planning provisions across different sectors* were guided by a rationale akin to that used in the *governance of spatial planning systems*. Specifically, during the content analysis, we referred to the definitions developed for the *governance within spatial planning systems*, adapting them to the unique contexts of each sector. Additionally, we set a precondition when addressing the element of different sectors: spatial planning provisions must involve a tangible spatial transformation of the territory.

2.1. Characteristics holding transformative potential

Building on Fedele et al. (2019) definitions, restructuring concerning the *governance* element involves reorganizing planning procedures, instruments, and actors, e.g. merging several regulations and instruments and simplifying procedures to speed up the planning process and foster coherency of planning outcomes (Nadin et al. 2018). In *mitigation hierarchy*, restructuring emphasizes proper sequential application, ensuring avoidance is prioritized, and offsetting is a last resort (de Witt et al. 2019; Savilaakso et al. 2023). This aligns the Habitat and Bird Directives, which underscore the importance of proactive avoidance measures in biodiversity conservation. Concerning the *spatial planning provisions of different sectors*, restructuring manifest through urban space redesigning urban spaces for sustainable transportation modes. For *biodiversity and ES*, restructuring focuses on optimizing ecosystem spatial arrangement to enhance size, diversity, and distribution, supporting EU Biodiversity Strategy for 2030 objectives of expanding and improving ecological connectivity and quality (EC 2021).

Multiscale embraces principle of plurality of stakeholders, sectors and levels and synergies among them (Visseren-Hamakers et al. 2021; Fedele et al. 2019). For the *governance* element, it promotes sectoral bridging and involving diverse actors and stakeholders. It aims to empower underrepresented groups and foster cooperation among companies, governments, and civil society (Pascual et al. 2022). This approach also coordinates planning decisions across spatial and temporal scales. In the context of the *mitigation hierarchy*, a multiscale characteristic involves coordinating mitigation requirements and goals across planning scales, such as integrating mitigation measures into a broader green network strategy. For the *biodiversity and ES* element, multiscale improves connectivity between ecosystems across jurisdictions and ensures the supply of multiple ES to benefit a wide range of stakeholders (EC 2021; European Union 2020b).

Path-shifting promotes pluralistic and adaptive spatial planning governance, challenging the reductionist view of nature as just a resource (Pascual et al. 2017; Wittmer et al. 2021; Michalski 2021). The IPBES Value Assessment identifies this narrow perspective as a root cause of the ecological-climate crisis, noting its marginalization of indigenous knowledge systems (IPBES 2022a). Spatial planning should ensure the coexistence of diverse knowledge systems and values – intrinsic, instrumental, and relational (Jacobs et al. 2022). Policy frameworks like the EU Territorial Agenda and Targets 11 and 16

of the UN Sustainable Development Goals support this holistic view, emphasizing biodiversity's multifunctional role and iterative learning (European Union 2020a; UN 2018). Path-shifting in the *mitigation hierarchy* necessitates a transition from reactive to anticipatory planning for biodiversity enhancement, aligning with the Leipzig Charter's environmental protocol (European Union 2020b). *Sectors* transformations can be exemplified by organic agricultural adoption and post-fossil fuel transportation. Path-shifting for *biodiversity and ES* demands reversing species and ecosystem service decline while designing green spaces to meet local needs (European Union 2020b).

Innovative plans integrates new knowledge, policies, and technologies through scaling mechanisms for biodiversity and ES enhancement (Fedele et al. 2019; Wittmer et al. 2021; Boyer 2015). Innovation in *mitigation hierarchy* and *biodiversity and ES* manifest through nature-based solutions, green infrastructure supporting ES, and grassroots initiatives supporting Not Net Loss targets and biodiversity goals, aligning with the EU Biodiversity Strategy 2030 and the Leipzig Charter (EC 2021; European Union 2020b). Nature-based solutions demonstrate innovation procedurally, by integrating ecological principles, participatory approaches and environmental justice into traditional spatial planning (van der Jagt et al. 2020; Kato-Huerta and Geneletti 2022; Kabisch, Frantzeskaki, and Hansen 2022), and as end-products, providing multiple co-benefits for people and biodiversity while incorporating technological elements like green roofs and constructed wetlands (Bell et al. 2019). Innovation in *biodiversity and ES* includes introducing native and climate-resilient species (Palomo et al. 2021) and considering socio-technological factors moderating the value and distribution of ES (Keeler et al. 2019).

Phasing out complements phasing-in dynamics in TC by intentionally removing harmful practices, technologies, regulations, subsidies, and institutional setups impeding biodiversity conservation (Wittmer et al. 2021; Rosenbloom and Rinscheid 2020). The goal is not to enhance or partially substitute unsustainable practices but to gradually eliminate them from the system (Trencher et al. 2022). This approach, prominent in decarbonization policies, manifests across *sectors* through fossil fuel elimination, private transport restrictions, and pesticide bans (Isaksen, Trippl, and Mayer 2022). The European Environmental Agency identifies key threats requiring phase-out interventions, including intensive grazing and land conversion to urban development (EEA 2020). The proposed framework considers elements of *governance*, *mitigation hierarchy*, *different sectors*, and *biodiversity and ES* that have been phased out, as well as spatial planning regulations, legislation, and standards supporting this transition.

3. Method

The conceptual framework, outlined in its three blocks, was applied to 28 plans at different spatial scales across seven European countries through theory-driven qualitative content analysis. Sections 3.1 and 3.2 elaborate on the criteria for countries and plans' selection based on biodiversity performance as well as the content analysis organization.

3.1. Selecting representative countries and related plans

The framework was applied to seven countries: Italy, Spain, Portugal, Germany, Denmark, Switzerland, and Scotland. Three criteria guided the selection: (i) coverage

of spatial planning systems, (ii) countries' biodiversity performances, and (iii) language feasibility. The sample of countries includes representatives of the four spatial planning systems and traditions identified in the Third Interim Report of the ESPON Project (ESPON Project 2006). The second criterion focuses on selecting countries with satisfactory biodiversity outcomes to correlate these with transformative planning practices. The chosen countries perform relatively well (above average) on three biodiversity indices: the biodiversity habitat index, the biodiversity intactness index, and a self-developed biodiversity strategy index. The biodiversity habitat index assesses global habitat loss, degradation, and fragmentation (GEO BON 2014a). The biodiversity intactness index measures the average abundance of native terrestrial species compared to their abundance without human impacts (GEO BON 2014b). The self-developed biodiversity strategy index, crucial for selection, evaluates progress towards Targets 1, 2, 3, 4, and 6 of the EU Biodiversity Strategy 2020 (EC 2011). It was built by combining the Targets indicators' values, which represent the countries' performance of biodiversity. Table SMA 1 of the Supplementary Material A lists European countries and their performance on these biodiversity indices. The final selection criterion addresses the feasibility of analyzing planning documents in languages known by the co-authors.

Several plans were identified for each selected country. Three criteria guided this national selection of plans: (i) they should explicitly address biodiversity and/or ES-related goals, (ii) cover several NUTS (Nomenclature of Territorial Units for Statistics) levels as much as possible to explore the transformative potential at different planning scales, and (iii) be recent and/or recognized as innovative by being awarded national and internationally, to increase the possibilities of embedding characteristics with transformative potential. Table 2 shows the selected plans along with their respective country, NUTS level, and year of development/adoption. Among the selected plans, we included three national laws and legal frameworks in the analysis for the Portuguese and Scottish planning context, as considered of relevance for these two planning contexts.

3.2. Content analysis of planning documents

With expertise in each selected country, the authors conducted the theory-driven qualitative content analysis and coding of planning documents with rigorous and systematic methodologies, ensuring consistency and reliability across the study. Two qualitative analysis softwares – MAXQDA and NVivo – were employed to facilitate this process. These tools are widely used in qualitative research for capabilities in organizing and coding text, analyzing documents in different languages, identifying data patterns, and enabling comparison between coders (Kuckartz and Rädiker 2019; Allsop et al. 2022; Selvi 2020). Their selection was based on authors' familiarity with the platforms and the availability of licenses of their respective institutions. Text fragments were identified and coded according to various plans' components (i.e. vision, strategies, information baseline, actions, instruments, regulations), analytical elements (i.e. *governance*, *mitigation hierarchy*, *spatial planning provisions for sectors*, and *biodiversity and ES*), and characteristics with transformative potential (i.e. restructuring, multiscale, path-shifting, innovation and phasing-out).

The comprehensive coding scheme, which included 80 codes, is detailed in Table SMA 2 of the Supplementary Material A. Following the framework in Section 2, the authors

Table 2. Selected plans for content analysis.

Country	Plans	NUTS levels	Year of development/ adoption
Italy	Regional Territorial Plan of Emiglia Romagna	NUTS - 2	2010
	Territorial Metropolitan Plan of Bologna	NUTS - 3	2021
	Urban Plan of Bologna Municipality	LAU	2021
Denmark	Copenhagen Municipal Biodiversity Strategy	LAU	2022
	Action Plan of the Copenhagen Municipal Biodiversity Strategy	LAU	2022
	Municipal Spatial Plan for Skive Municipality	LAU	2016
	Framework Local Plan for GreenLab Area in Skive Municipality	LAU	2016
Germany	Berlin Strategy: Urban Development Concept Berlin 2030*	LAU	2015
	Land Use Plan Berlin*	LAU	2015
	City Development Plan - Mobility and Transport Berlin 2030*	LAU	2021
	City Development Plan - Housing 2030: New Houses for Berlin*	LAU	2019
	City Development Plan - Climate: Securing Urban Quality of Life in Climate Change (Berlin)*	LAU	2011
Portugal	General Law of Public Policies for Soil, Territorial Development, and Urbanism	NUTS - 1	2014
	Portuguese Legal Framework of Territorial Management Instruments	NUTS - 1	2015
	National Program of Territorial Planning Policy	NUTS - 1	2019
	Regional Program of the Lisbon Metropolitan Area	NUTS - 2	2002
	Management Plan of the Arrábida Natural Park	NUTS - 2	2005
	Municipal Master Plan of Setúbal	LAU	2021
Scotland	National Planning Framework	NUTS - 1	2023
	National Land Use Strategy	NUTS - 1	2021-2026
	Scottish Planning Policy	NUTS - 1	2014
	Cairngorms National Park Local Development Plan 2020	LAU	2020
Spain	Regional Planning Guidance of Basque Country	NUTS - 2	2019
	Partial Territorial Plan of Central Álava	NUTS - 3	2022 (revision of the Plan of 2004)
	General Urban Development Plan of Vitoria-Gasteiz	LAU	2023 (revision of the Plan of 2001)
Switzerland	Territorial project Switzerland	NUTS - 1	2012
	Cantone-Ticino Master Plan Revision (explanatory Report)	NUTS - 3	2009
	Municipal action programme (city of Bellinzona)	LAU	2020

*Despite Berlin's plans are classified as LAU, Berlin is defined as a Federal State in Germany.
Note: NUTS – 1: major socio-economic regions (national level of the Member States). NUTS – 2: basic regions (for regional policies). NUTS – 3: small regions (for specific diagnoses). LAU: local administrative units.

conducted full-text content analysis of all selected planning documents. The coding process involved understanding each plan component described in text fragments, identifying relevant analytical elements and assigning corresponding characteristics with transformative potential. For example, a text fragment from the General Urban Development Plan of Vitoria-Gasteiz (Spain) stating, '*An integrated and inclusive approach for managing natural resources of the territory is fundamental*' was coded as a vision related to *governance of spatial planning systems* and with a multiscale character. To further aid the identification of text fragments, a list of guiding questions was developed for each analytical element (See Table SMA 3 of Supplementary Material A). This methodological approach facilitated thorough and consistent coding and ensured that each planning document's key aspects were systematically analyzed.

The extracted text fragments were organized into separate Excel spreadsheets, each dedicated to a specific plan. These spreadsheets included critical information, such as the document name, the original text fragment, page numbers containing the fragment, assigned codes, and the reviewer's name. Subsequently, fragments were categorized by codes, translated into English, and summarized to eliminate redundancy – particularly

where multiple fragments from the same plan were assigned the same code. Table SMA 4 of the Supplementary Material A presents an example of how raw data was processed in the spreadsheets.

Two strategies were employed to mitigate potential reviewer biases and inconsistencies during the coding stage. Firstly, periodic consultations among all reviewers were conducted to clarify distinctions between codes and to cross-check ambiguous fragments. Secondly, a second round of revision was carried out, involving a different reviewer who validated the consistency of results with the definitions outlined in the conceptual framework. This second review step provided an additional layer of quality control, enhancing the reliability and validity of the coding process.

4. Results

Sections 4.1–4.4 present quantitative and qualitative findings related to the four components of plans: visions, strategies, information baseline, and actions, instruments and regulations. Quantitative results offer an overview of the prevalence of characteristics with transformative potential across the 28 reviewed plans. These results reflect the number of plans in which at least one characteristic was identified for a given plan component and analytical element, without applying any weighting or aggregated scoring of transformative potential. For example, Figure 2 shows that eight plans included visions on the *governance of spatial planning systems* with restructuring potential. Qualitative findings highlight examples of plans' components that exhibit transformative potential. Tables SMB 1- 4 of the Supplementary Material B present an overview of visions, strategies, information baseline and actions, instruments and regulations with transformative potential extracted from the sample of plans, supported by representative examples from the reviewed plans.

4.1. Planning visions

Figure 2 shows, in general, a low to medium number of plans with visions that uptake characteristics holding a transformative potential. The most represented characteristics

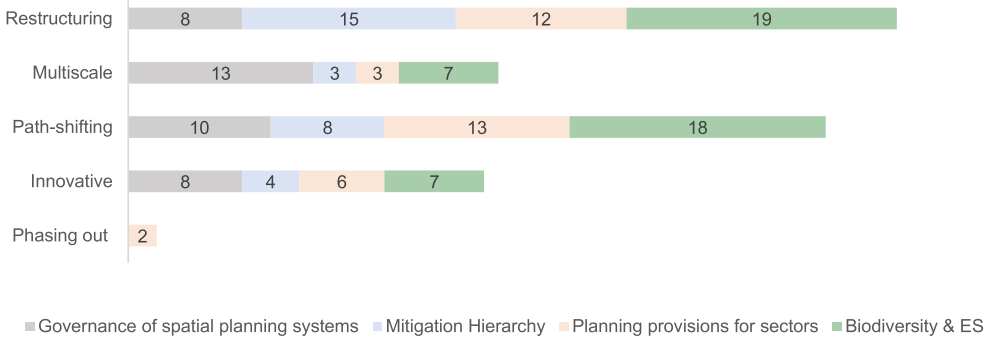

Figure 2. Number of plans with visions holding transformative potential by analytical element.

were restructuring and path-shifting, and the analytical element widely covered was *biodiversity and ES*.

The identified visions that hold a transformative potential to enhance biodiversity emphasize safeguarding ecological structures and functions, aspiring towards green cities to preserve ecosystems' size and landscape location. Visions holding restructuring potential related to the *mitigation hierarchy* advocate for high-quality, dense urban and rural areas, phasing out further land take and resource depletion. Concerning the *spatial planning provisions for sectors*, a complementary approach is seen in phasing out petrol and diesel cars while promoting sustainable, pedestrian-friendly public mobility and renewable and bioenergy production. In terms of *governance of spatial planning systems*, only the Regional Territorial Plan of Emilia Romagna envisioned simplified planning procedures. Most visions with restructuring potential combine environmental, social, and economic goals for long-term well-being. Examples include aligning sustainable land use with economic priorities, fostering resilient communities while protecting the environment (Scotland National Land Use Framework), and reconciling economic development with nature preservation (Management Plan of the Arrábida Natural Park).

A vision holding multiscale potential is broad public participation in an inclusive planning process, fostering dialogues across sectoral systems to achieve ecological and economic transformation, social cohesion, justice, and territorial equality. Some visions adopt a more comprehensive notion of nature, considering the well-being of all living beings and promoting inclusive processes. Additionally, two plans emphasize enhanced ecological connectivity, such as preserving settlement-free spaces and connecting large open areas (Cantonal-Ticino Master Plan Revision).

Visions holding path-shifting potential for the *governance within spatial planning systems* recognize both the instrumental and relational values of nature as essential for biodiversity preservation. For example, the Copenhagen's Municipal Biodiversity Strategy aims to make biodiversity central to development and growth while making nature a space for social learning and community engagement. These planning visions acknowledge nature's importance for a sustainable future environmentally, e.g. increasing biodiversity, climate resilience, environmental balance, and quality, socially, e.g. improving physical and psychological well-being, and economically, e.g. offering renewable wood resources. The General Urban Development Plan of Vitoria-Gasteiz exemplifies this by emphasizing the multifaceted value of the green belt and its ES as foundational for planning strategies and urban interventions (Table SMB 1 of the Supplementary Material B). Moreover, Setubal's Municipal Master Plan presented a vision with path-shifting potential for the tourism sector: introducing environmental qualification and protection into the tourism development model.

Visions holding innovative potential integrate human and natural well-being impacts, delivering on the UN Sustainable Development Goals, and considering global repercussions, e.g. the Partial Territorial Plan of Central Alava recognizes the importance integrating global-scale human-nature impact assessments into spatial planning. Adopting an ecosystem-based approach to land use and using nature-based solutions was also pointed out for biological diversity and climate change. The Scottish planning context demonstrates innovation through capital-thinking, recognizing natural capital's equivalence with human, social, and economic capital and promoting green infrastructure investment. The National Land Use Framework advocates innovative financing for

nature-based solutions benefiting multiple public and private sectors. Such conciliation between economic development and preservation of natural/environmental values was also found innovative in the context of the Municipal Master Plan of Setubal.

4.2. Planning strategies

Most plans include strategies that hold a restructuring potential for all analytical elements. However, minor differences were found compared to strategies holding multiscale, path-shifting, and innovative potentials (Figure 3). Similar to the results of the planning visions (Section 4.1), we found an under-representation of phasing-out strategies in plans. *Biodiversity and ES* was the analytical element mostly covered, while the *mitigation hierarchy* was the least addressed.

Strategies holding restructuring modify planning procedures by introducing new tools or institutionalizing new actors. Examples include biodiversity strategies and action plans in Denmark, sector-specific conservation plans in Portugal, and Conservation Area Pla guidelines in Switzerland. New actors include neighbourhood communities in Italy, the Euroregion mediating regional interactions in Spain, and the Canton Land Observatory monitoring land development in Switzerland. In relation to the *mitigation hierarchy*, strategies focus on curbing land take through measures such as prioritizing inner-city compensation measures to encourage urban redevelopment, reuse and rehabilitation of vacant land, re-densifying urban areas, confining development within urban boundaries, rezoning for future growth, implementing temporary land use, and limiting second homes. For *biodiversity and ES*, strategies emphasize restoring degraded ecosystems, unsealing and re-naturalizing unoccupied spaces, and creating well-connected green spaces to enhance citizen health and quality of life. The General Urban Development Plan of Vitoria-Gasteiz seeks to optimize public green space, reallocating surplus green space from well-served neighbourhoods to those with limited natural features and projected population growth (Table SMB 2 of the Supplementary Material B).

Strategies with multiscale potential promote participatory planning process supported by appropriated regulations and tools, such as cooperation platforms, territorial agreements, and inter-municipal planning tools. Capacity-building activities for cooperative and inclusive institutions facilitate dialogue among various stakeholders, including

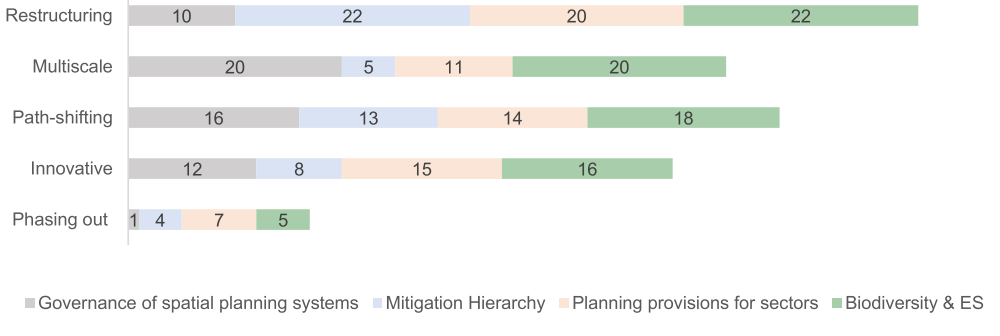

Figure 3. Number of plans with strategies holding transformative potential by analytical element.

administrative bodies, academia, property owners, housing companies, communal enterprises, business representatives, and civil society associations. This participatory approach extends to the transport, energy, and housing sectors. For example, some plans aim to balance benefits between developers (e.g. wind farm projects) and local communities, proposing community ownership to ensure local economic gains. To foster a systemic understanding of the territory, plans advocate integrating the green infrastructure concept at all planning scales and mapping its elements to prioritize areas for enhancing ecological connectivity and define compatible land uses. The Berlin Strategy: Urban Development Concept Berlin 2030 exemplifies this by proposing 20 greenways around the city to connect open spaces (Table SMB 2 of the Supplementary Material B).

Strategies holding path-shifting potential link up with the above-mentioned visions of balancing nature conservation with economic and tourism objectives, where nature is recognized as the foundation of the economy. These strategies emphasize protecting and efficiently using environmental assets within ecological limits while reversing the trend of exceeding planetary boundaries. They also recognize the diversity of ecological functions associated with land uses to prevent changes that diminish this diversity. They consider nature's values in sectors such as agriculture, tourism, and energy, integrating nature-based recreational and educational activities for tourism. For example, the Copenhagen Municipal Biodiversity Strategy aims to develop experiences and learning activities through and about nature to improve biodiversity knowledge (Table SMB 2 of the Supplementary Material B).

Innovation in plans includes integrating grassroots and bottom-up initiatives to define specific local and long-term goals. The Scottish Government, for instance, aims to invest £275 million in community-led initiatives to revitalize town centres and improve community well-being. Another innovation is promoting nature-based solutions and integrating them into built infrastructure to deliver positive biodiversity outcomes while addressing challenges like stormwater management. Close collaboration with the scientific community by partnering with EU research projects was another strategy to innovate how spatial planning addresses biodiversity loss and climate change. For example, the General Urban Development Plan of Vitoria-Gasteiz collaborated with the POSIDON research project to implement innovative phytoremediation techniques for enhanced biodiversity and ES (Table SMB 2 of the Supplementary Material B).

4.3. Information baseline

Figure 4 presents a few revised plans incorporating characteristics holding transformative potential into their information baseline, yielding interesting results for the *governance within spatial planning systems*, *the mitigation hierarchy*, and *biodiversity and ES*. For *governance*, the Partial Territorial Plan of Central Álava highlights the importance of moving beyond a purely descriptive role towards a dynamic, iterative information baseline for planning strategies and actions. Regarding the *mitigation hierarchy*, restructuring potential emerged in the temporal analysis of land use and consumption, including past, present, and future projections, to understand territorial change dynamics. GIS tools were used to assess land use-related indicators, such as the residential capacity index, the percentage of abandoned industrial areas, and the percentage of urbanized land, sometimes correlating these with demographic and commuting data.

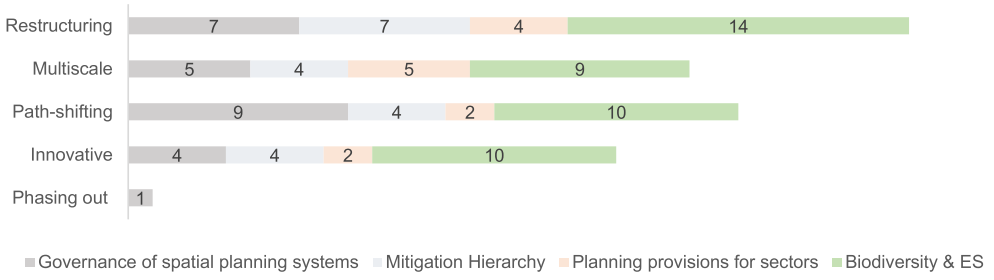

Figure 4. Number of plans with information baseline holding transformative potential by analytical elements.

For *biodiversity and ES*, the information baseline of plans includes green spaces and species inventory, detailing spatial extension, connectivity, accessibility, biological diversity, non-native species, and species' degree of affection. Maps of ecological networks and connectivity indexes inform restoration intervention locations. The Cantonal-Ticino Master Plan Revision emphasizes considering district and local landscape elements. The Scotland National Planning Framework exemplifies a path-shifting characteristic by highlighting the importance of re-naturalized brownfields' biodiversity values when determining land use changes. Additionally, the integration of ES supply mapping and assessment at all NUTS levels in the Spanish case study serves as a tool for sustainable natural resource management and identifying critical areas for protection and restoration within green infrastructure. Specifically, the General Urban Development Plan of Vitoria-Gasteiz used this information to define regulations for non-developable areas (see Section 4.4). The Municipal Urban Plan of Bologna qualitatively analyzed ES in urban and rural areas in Italy. Moreover, innovative practices included assessing green space availability per capita, considering different types of green spaces and distances from populated areas, comparing results with World Health Organization's standards, and assessing territorial performance against planetary boundary thresholds.

Interestingly, only one plan, the Management Plan of the Arrabida Natural Park (Portugal), reports on its information baseline a fragment holding a phasing out potential: 'the rigidity and slowness of the territorial management system identified as a threat to respond in good time to territorial dynamics' (Table SMB 3 of the Supplementary Material B).

4.4. Actions, instruments, and regulations

We observed notable differences in the number of plans outlining actions, instruments, and regulations with restructuring potential compared to those with innovative, multiscale, and path-shifting potential (Figure 5). Actions with restructuring potential predominate across all analytical elements except *governance*, where multiscale potential prevails. Consistent with the findings on planning visions and strategies (Sections 4.1 and 4.2), the *mitigation hierarchy* and the phasing-out characteristic are less frequently addressed in planning actions, instruments, and regulations. Similarly, *spatial planning provisions for sectors* are relatively under-represented compared to strategies and information baseline.

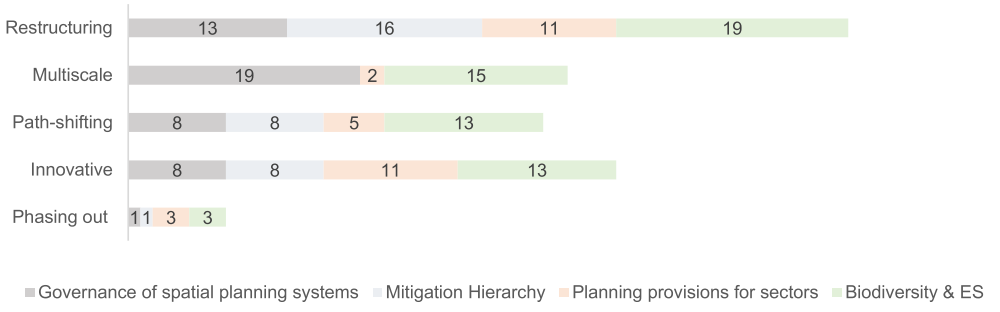

Figure 5. Number of plans with actions, instruments, and regulations holding transformative potential by analytical elements.

Among the actions holding restructuring potential for the *governance within spatial planning systems*, three plans emphasize decentralizing decision-making. The Portugal General Law of Public Policies, the Partial Territorial Plan of Central Álava, and the Berlin Land Use Plan establish legislative frameworks to enhance municipal autonomy and accountability for approving and implementing locally tailored plans. An action concerning the *mitigation hierarchy* transferring development rights to rezone key areas (e.g. vacant lots), thereby promoting urban density and compactness (Table SMB 4 of the Supplementary Material B). Regarding *spatial planning provisions for sectors*, the Scotland's National Land Use Framework established five farmer-led groups, such as the Suckler Beef Climate Group, to advise transitions to low-carbon practices and support biodiversity and climate goals. In Vitoria-Gasteiz, land-use constraints were imposed on high carbon-sequestration areas as part of climate adaptation strategies. Concerning *biodiversity and ES,* selected plans feature actions ranging from ecological restoration, such as reforesting degraded areas, to protective measures, including land-use restrictions and controlled activities in ecologically sensitive zones. Other actions target private properties, including expropriating agricultural, forestry, and green spaces to ensure green infrastructure implementation, integrating community gardens into private space regulations, and mandating minimum vegetation coverage on private land.

Actions holding multiscale potential in the *governance within spatial planning systems* include establishing dialogues and regular interactions between municipal departments, business communities, associations, landowners, and developers through workshops, interviews, and online roundtable discussions. Some plans designated specific actors responsible for coordinating and cooperating throughout the planning process while ensuring alignment with other policies and plans. For instance, the Cantonal-Ticino Master Plan Revision created an Interdepartmental Working Group to oversee nature park projects and collaborate with the federal government (Table SMB 4 of the Supplementary Material B). Other actions related to *biodiversity and ES* include identifying fragmented ecological areas through comprehensive mapping of the Green Infrastructure to prioritize restoration interventions and land-use constraints. Moreover, funds are dedicated to realizing local green infrastructures, such as the Scottish Green Infrastructure Fund and the Green Infrastructure Community Engagement Fund.

One instrument with path-shifting potential for the *mitigation hierarchy* is the reclassification of land use in urban zoning. Specifically, the General Urban Development Plan of

Vitoria-Gasteiz reclassifies certain undeveloped areas by assigning them new land use categories including preservation and improvement goals, such as natural environment enhancement, human-influenced environment enhancement, and surface water protection. Each category imposes development constraints, e.g. the green infrastructure constraint for expanding the city green belt and the natural hazards constraint addressing aquifer pollution, soil erosion, areas with carbon sequestration potential. Other actions with path-shifting potential for *biodiversity and ES* include assessing biodiversity values (e.g. wildlife species) in areas for new development, taking appropriate actions to protect these values, and incorporating nature-based solutions and sustainable urban drainage systems in social housing projects for stormwater management and climate change mitigation.

The Territorial Metropolitan Plan of Bologna introduced an innovative intermunicipal equalization mechanism, compensating municipalities with lower revenues because of restricting development to protect valuable ecosystems. Portugal's Territorial Management Framework mandates reclassification of developable land to urban areas, promoting infrastructure accountability and controlling speculation. A similar approach was applied in Vitoria-Gasteiz, where the plan created a new land use class that established a non-developable regime in urban areas with high ecological values. Innovations also included incorporating bioclimatic criteria and new standards for public greenery into land use and building regulations at lower planning scales. Implementing a variety of nature-based solutions to reduce heat island effects, runoff, and air pollution while addressing biodiversity loss was considered innovative in several planning contexts.

Regarding phasing-out actions, efforts mainly focused on eliminating certain land use categories that do not support biodiversity goals, such as 'undefined use' and 'developable land'. This approach was found in the Regional Planning Guidance of the Basque Country, the Portuguese Legal Framework of Territorial Management Instruments, and the General Urban Development Plan of Vitoria-Gasteiz.

5. Discussions

5.1. The transformative potential spectrum of revised plans

5.1.1. Plans' components

The content analysis of the selected sample of plans revealed diverse transformative potentials across plans' components – visions, strategies, information baseline, action, instruments and regulations – suggesting that not all of them hold the same capacity to induce change. We noted that plans' visions and strategies present a higher transformative potential, while less evidence of this was found in the information baseline, actions, instruments and regulations. Plans' visions and strategies were the components where path-shifting and innovative potential found more space, allowing them to be more disruptive for radical changes. This mirrors the intentional, ambitious, and aspirational purposes of the initial stage of the spatial planning process, which aims at identifying objectives (Albrechts, Barbanente, and Monno 2020; Steiner 2008). Often with significant public participation, this initial stage provides an opportunity to break with past practices, chart new directions, and establish new commitments and a shared understanding among stakeholders. In contrast, the information baseline is typically objective and evidence-based, and the actions, instruments and regulations are grounded in

established procedures and constrained by negotiated agreements among stakeholders' interests, making it difficult to mainstream TC and innovate at the operational level. Nonetheless, some revised plans succeeded in presenting an information baseline and actions with path-shifting and innovative potential. A representative example is the assessment of various ES across multiple spatial scales, using this knowledge to guide local planning actions for balancing accessibility to environmental and social benefits.

5.1.2. Analytical elements

Results indicate that the extent to which the four analytical elements – *governance within spatial planning systems, mitigation hierarchy, spatial planning provisions for sectors, and biodiversity and ES* – are utilized to drive transformative change also differs, indicating a nuanced application of these elements in fostering transformation within spatial planning. *Biodiversity and ES* are frequently addressed across all components, likely due to strong European and national policies on biodiversity protection over the years (e.g. the EU Biodiversity Strategy 2030, the EU Forest Strategy for 2030 (EC 2021b), the Birds and Habitat Directives and Nature 2000 (EC 2015), National Biodiversity Strategies and Action Plans (CBD n.d.), the EU Pollinators Initiative (EC 2018), and so on). This result is consistent with the selection criteria of countries (i.e. performing well on biodiversity indicators), highlighting the effectiveness of revised plans in delivering tangible positive outcomes for biodiversity and ES.

The *governance within spatial planning systems* is also commonly referred to, but with an evolving interpretation from a traditional hierarchical structure (Nadin et al. 2018), to a more collaborative approach, as the results on multiscale potential suggest. However, this shift has not necessarily led to transformative change since preferences for maintaining stability and continuity remain if we consider the poor results obtained for innovation and phasing-out practices across all plans' components for the *governance* analytical element. Possibly, this could be due to the low commitment to biodiversity of those already involved in the planning process and the amount of power in decisions of those fully committed as agents of change for biodiversity. Concerns about legal security in real estate markets and the broader capitalist system primarily drive the preference for stability (UK Department for International Development 2014). Legislators typically favour gradual adaptations that preserve existing systems rather than radical reforms. Yet, there is promise in emerging (path-shifting) visions that embrace a more holistic view of nature, considering the well-being of all living beings.

The *mitigation hierarchy* and the *spatial planning provisions for sectors* were less addressed. The mitigation hierarchy is not a common concept in spatial planning, and it has not traditionally focused on systematically applying these steps to reduce environmental impacts (Bigard, Pioch, and Thompson 2017).

5.1.3. Characteristics holding transformative potential

The revised plans predominantly feature components holding restructuring potential, suggesting a preference for incremental change that maintains process continuity, such as 're-densifying urban areas', 're-using and regenerating built-up areas', and 'encouraging temporal land uses', that maintain the basic urban fabric or do not require permanent structural changes. In contrast, practices that could drive path-shifting, innovative, or phased-out changes are less frequent. While some public or private actors may support

radical changes in sectoral areas (e.g. mobility), others resist due to conflicts with their interests and policies. Hansen et al. (2023) also find that incremental strategies dominate in urban green spatial planning, with more radical approaches that challenge existing institutions being less common.

The phasing-out characteristic was notably absent in most plans, particularly regarding visions and information baseline. This gap likely stems from European planning's emphasis on consensus-building through stakeholder participation (Nadin et al. 2018), which may inadvertently favour conservative approaches. When participation is limited to vested interests, radical changes that require phasing out existing practices are less likely to emerge. The information baseline's current descriptive nature might further compound this limitation. There is a need to transform the information baseline from a static description into a dynamic tool based on constant stakeholders' dialogues that incorporate biodiversity monitoring, ES data, and ecological threats. This would enable more systematic identification of elements requiring elimination and support more responsive decision-making.

5.2. Opportunities for biodiversity-inclusive spatial planning

Despite our study focused on how spatial plans can hold transformative potential for biodiversity and ES valorization, the success of transformative change in spatial planning also depends on a high-quality planning process (Carmona and Sieh 2004). In this sense, our findings reveal several opportunities for biodiversity-inclusive spatial planning.

The governance of spatial planning across scales emerges as a fundamental factor for biodiversity conservation. The capacity to bridge comprehensive policy objectives with context-specific interventions creates opportunities for coordinated implementation. This multiscale approach enables the enhancement of biodiversity outcomes by aligning local, regional, and national initiatives, fostering systemic coherence rather than fragmented interventions. Underutilized opportunities also exist in integrating sectors – energy, transportation, and agriculture – with biodiversity objectives. For instance, aligning renewable energy infrastructure with habitat restoration or designing transportation networks that enhance ecosystem connectivity could catalyze systemic transformation, ensuring that their activities support, rather than hinder, biodiversity preservation. Such integration necessitates robust regulatory frameworks and governance structures facilitating cross-sectoral collaboration (Næss 2023).

The selected plans largely neglected the critical issue of temporal misalignment in spatial planning. While ecosystem processes operate on extended timeframes, human activities, political cycles, market dynamics and landowner investments typically have shorter horizons. These divergent temporal regimes remain unreconciled in current planning practices. The threat to biodiversity also stems from this disconnection between ecosystem processes and human-driven activities, leading to fragmentation, simplification, and degradation (Botequilha Leitão and Ahern 2002; Antrop 2004). Biodiversity-inclusive planning must explicitly address these temporal disparities by articulating and reconciling different timeframes through integrated long-term strategic planning and short-term operational actions. This requires spatial planning processes capable of knowing (information baseline), anticipating (visions), incorporating (strategies), and triggering (actions, instruments, and regulations) changes with transformative potential across different temporal scales.

Biodiversity-inclusive spatial planning should also be able to phase outdated and unsustainable practices out, like excessive land take, while introducing innovation. Nature-based solutions, the integration of ES, and community-led initiatives emerged as promising approaches in the reviewed plans, with several examples showcasing the successful integration of biodiversity into planning outcomes. Civil society and other agents of change (e.g. grassroot initiatives) play a crucial role in dialoguing with the professional planning community about which practices must be phased out and which should be introduced, aligning them with measurable biodiversity goals. Such collaborative discourse can influence political agendas to mobilize disruptive changes, ultimately translating into concrete phasing-out and phasing-in planning objectives. Implementation requires flexible planning frameworks and economic instruments (e.g. taxes), with urban planners playing an active role in interpreting and applying them.

An additional opportunity lies in a more ambitious mitigation hierarchy implementation to shift from a 'not net loss' mindset to one focused on achieving 'net gain' for biodiversity. Rather than being confined to reactive mitigation or harm minimization, spatial planning through Strategic Environmental Assessment should evolve into a proactive driver of transformation. This paradigm shift requires moving beyond compensatory measures to actively identify and create opportunities for biodiversity enhancement (Phalan et al. 2018). Integrating biodiversity objectives early in the planning process would ensure plans are designed to embed biodiversity enhancement as a core planning element rather than a secondary consideration to be mitigated.

5.3. Limitations of the study

The proposed framework includes a substantial number of elements – four plan components, four analytical elements of spatial planning, and five characteristics with transformative potential. The characteristics used to describe transformative potential, particularly, are not mutually exclusive, and vision, strategy, or action can exhibit multiple types of transformative potential. As a result, the content analysis is affected by the risk of inconsistent interpretations, particularly in the overlapping areas. Similarly, analyzing plans with diverse functions, including legal frameworks, directives, strategies, and zoning plans, implies that the components do not always align neatly with the document structures. The reviewers were responsible for applying the framework consistently based on their experience and expertise, mostly on their own national planning systems, which introduced a risk of inconsistent interpretations and potential bias.

A key area for improvement of this study is expanding the sources of information beyond planning documents alone. The presence of transformative elements in the documents does not guarantee that actual planning practices or territorial development patterns reflect this transformative potential. Additionally, assessing path-shifting, innovative, or restructuring potential would benefit from a longitudinal analysis of prior plans and legal frameworks in the same regions, which was beyond the scope of this study. Extending the sample of plans and considering additional classifications, such as plan type, scale, and territorial characteristics is important. This would improve comparative analysis and provide a deeper understanding of planning cultures. Expanding the research beyond Europe would also offer insights into the diverse ways in which spatial planning systems operate globally.

6. Conclusions

This paper developed and tested a conceptual framework to address an important question in the TC debate: how transformative are spatial plans for biodiversity and ES? Our findings offer an overview of practices with varying transformative potential for biodiversity and ecosystem services, illustrated through representative examples from spatial plans across Europe. These findings contribute to bridging the gap between conceptual understanding and practical implementation of TC, providing a foundation for inspiring change in other spatial planning contexts, if appropriately adapted to their specific reality.

Despite positive evidence in the reviewed plans, relevant gaps remain in realizing transformative potential. The implementation of actions, instruments, and regulations with high transformative potential – such as path-shifting, innovation, and phasing out – still lags, suggesting institutional resistance to change. This highlights the need to critically redesign more flexible regulatory frameworks and responsive bureaucratic structures. The planning community should urgently communicate and embrace the need for change, particularly the dual processes of phasing in and phasing out. Alongside, strengthening dialogue between planners and sectoral policymakers around biodiversity and its benefits could be a pivotal mechanism for repositioning spatial planning as a collaborative arena for territorial transformation, with biodiversity at its core. In conclusion, we view TC not as a finite outcome but as an ongoing process of challenging spatial planning practices to position biodiversity as a core societal value. The proposed framework offers a tool for analyzing, monitoring, and advancing transformative potential, enriching our understanding of how spatial planning can evolve to prioritize biodiversity and ES in decision-making.

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