ESPON NoStaGeo. Territorial governance of non-standard geographies. Final Report

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ESPON NoStaGeo

Territorial governance of non-standard geographies

Final Report // December 2025

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Abbreviations

ATL	Ens d'Abastament d'Aigua Ter-Llobregat (Barcelona)
CF	Cohesion Fund
CLLD	Community-led local development
ECI	European Citizens' Initiative
ECRINS	European catchments and Rivers network system
EFA	Ecological Focus Area
ENTSO-E	European Network of Transmission System Operators for Electricity
EPR	Extended Producer Responsibility
ERDF	European Regional Development Fund
FLAG	Fisheries Local Action Group
FRA	Functional Rural Areas
FUA	Functional Urban Areas
GBI	Green and Blue Infrastructure
GBI	Green and Blue Infrastructure
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GVA	Gross Value Added
ITI	Integrated Territorial Investment
LLMA	Local Labour Market Areas
MAPTAM	Loi de modernisation de l'action publique territoriale et d'affirmation des métropoles
NGO	Non-Governmental Organisation
NOTRe	Nouvelle Organisation Territoriale de la République
NUTS	Nomenclature Unifiée de Territoires Statistiques
OECM	Other Effective area-based Conservation Measure
PA	Protected Area
RBMP	River Basin Management Plan
SEAP	Sustainable Energy Action Plan
SECAP	Sustainable Energy and Climate Action Plan
SME	Small and Medium-sizes Entreprise
SUMP	Sustainable Urban Management Plan
SWD	Staff Working Document
TEN-N	Trans-European Nature Network
UVAR	Urban Vehicle Access Regulation
UX	User Experience
WISE	Water Information System for Europe
WFD	Water Framework Directive
ZOAST	Zone d'Accès aux Soins Transfrontaliers

1 Introduction

Authorities and actors at all territorial levels acknowledge that one needs to look beyond administrative units to address key challenges such as provision of services of general interest, public support to balanced economic growth and green and digital transitions. However, whereas Functional Urban Areas (FUAs) delineated on the basis of commuting patterns have been extensively targeted by policies, initiatives that target other types of functional interdependencies (i.e. the "non-standard" functional areas) have until now received less attention (Cotella, 2023).

Text Box 1 Standard and Non-Standard Functional Areas

Standard functional geographies such as Functional Urban Areas (FUAs) and Labour Market Areas (LMAs) are delineated using established statistical criteria, usually based on commuting flows and continuous built-up areas. They offer consistent, comparable spatial units for analysing the functional extent of cities and labour markets across Europe.

Non-standard functional geographies, by contrast, arise from other types of linkages, interactions, and interdependencies beyond commuting. In the NoStaGeo project, these geographies relate to emerging policy challenges such as water resilience, ecological connectivity, energy saving, and industrial transitions that cut across conventional boundaries. Their contours may be fuzzy, adaptive, and theme-specific, reflecting hydrological conditions, ecological processes, supply-chain relations, or governance arrangements rather than demographic flows.

These non-standard geographies are not pre-given. They are co-constructed through governance, shaped by cooperation between actors, institutional flexibility, and the need to respond to complex transformations (climate, energy, biodiversity, industrial restructuring). NoStaGeo therefore analyses how such geographies emerge, how functional relations differ from standard areas, and what governance frameworks best support them.

On the one hand, the European Union (EU) is actively supporting territorial governance at the level of functional areas, with an emphasis on the importance of place-based, participatory governance. The new place-based, cross-cutting policy objective for ERDF (Policy Objective 5) makes it possible to fund a wide range of activities in functional area for which a strategy for integrated and inclusive development has been adapted. Territorial delivery mechanisms such as Community-led local development (CLLD) and integrated Territorial Investment (ITI) also make it possible to fund actions targeting functional areas under Cohesion Policy. In parallel, sectoral EU initiatives such as River Basin Management Plans (RBMPs), Sustainable Urban Management Plans (SUMPs) and Fisheries Local Action Groups (FLAGs) encourage actors to develop participative processes at the level of functional areas, as it is also witnessed by the recent attempts to delineate functional rural areas. On the other hand, to set up effective territorial governance models and mechanisms targeting functional areas (e.g. in terms of mobilising partners, maintaining the momentum of dialogue and cooperation, defining roles and responsibilities in dialogue with local, regional and sectoral authorities) remains a challenge that is hard to overcome, as clearly

witnessed by the examples of soft territorial cooperation described by ESPON ACTAREA (2017).[1]

One reason behind this situation is that, despite of the numerous regulatory provisions and initiatives drawing on it, the notion of functional area is not necessarily well understood among policy actors at all levels (Faludi, 2018). Many find it difficult to relate to functional areas other than FUAs, due to the challenges related to their delimitation and identification of their added value. Others fear that a functional area governance generates complexity or confusion due to the extensive overlapping it entails and the questions it opens in terms of legitimacy and accountability (Swyngedouw, 2009).

The NoStaGeo project explores this conundrum, aiming at surveying, comparing and assessing territorial governance approaches that have been put in place in different institutional contexts in Europe to handle non-standard geographies and their functional interrelations, describing principles of good practice, preconditions and potentials, and highlighting limits and pitfalls. When doing so, the research team capitalised on decades of research on how to optimise the effectiveness of governance arrangements[2] to address challenges and opportunities linked to social, economic and biophysical phenomena from a territorial perspective. When elaborating on the concepts of 'spatial fit', Folke et al. (2007: 2) argues that "[t]he problem of fit asserts that the effectiveness and the robustness of territorial governance arrangement are functions of how they fit with the social, economic and biophysical domains in which they operate, especially with respect to geographical organisation of functional relations, networks and flows within these domains." At the same time, various authors warn that 'spatial fit' is no panacea (Moss, 2012), as the resolution of one boundary problem often opens up others: multiple social, economic and ecological systems may need to be involved in policy responses to an emerging trend and shifting management to a "new geography" generates transaction costs. This "complexity of fit" leads to advocate flexible, context-sensitive solutions (Ostrom et al., 2007) to functional area governance. In other words, as concluded by the researchers engaged in the ESPON TANGO (2013) research, territorial governance is 'good' when it is able to adapt to changing contexts and to realise place-based/territorial specificities and impacts (Janin Rivolin et al., 2014).

Drawing on the above, it can be argued that a functional approach to spatial planning necessitates to shift towards integrated governance structures that, having identified the issue(s) at stake, bring together diverse stakeholders from multiple administrative units whose interaction may be functional to address it/them towards a solution (Cotella, 2023). The key challenge seems to find the right problem 'owners', that are able to address a given functional conundrum at the right scale and with the relevant tool(s). That is to say that the functional, political and representational relations within a given functional area need to be understood in their institutional context before taking action (Salet et al., 2015). This is fully in line with the arguments brought forward by the recently published Handbook on Sustainable Urban Development Strategies, highlighting that needs, challenges and opportunities for development must be matched with the appropriate spatial scale and territorial context. In line with these considerations, the NoStaGeo project conceptualises "non-standard geographies" in the context of "functional areas", as spaces requiring new patterns of territorial governance designed to address the social, economic and ecological

[1] Some interdependencies, e.g. in the field of water management, have been addressed by sectoral actors. However, as illustrated by ESPON LAKES, territorial development authorities and agencies struggle to integrate such initiatives that extend across administrative boundaries in their strategies and activities.

[2] Understood in the broadest sense, as formal constraints (regulations and legislations), informal constraints (norms of behaviour, conventions, codes of conduct), established habits of dialogue and cooperation, funding mechanisms and other incentives.

implications of external drivers in a cost-efficient way, in so doing optimising resilience in the face of largely unknown future changes. More in particular, the project explores a selection[3] of "non-standard geographies" that are "forming the geographical dimension of emerging and/or new territorial challenges", discussing how policymakers may best build territorial governance frameworks that make it possible to address these challenges in a cost-efficient and effective way. In doing so, it acknowledges that this is not a linear process in which policymakers simply align governance frameworks on functional areas delineated on the basis of analyses of spatial interactions and flows, but rather the result of evidence-informed creative processes that relate to multiple overlapping functional and political interdependencies, but also take into account institutional factors and established communities of actors that are willing to exchange and cooperation, and may be subject to policy mobility and the horizontal diffusion of practices.

1.1 Project implementation

The ESPON NoStaGeo project was conceived as an exploratory study investigating emerging non-standard geographies and the governance mechanisms needed to address them. Its research design combined comparative thematic assessments of governance frameworks, focused thematic inquiries and case studies. An initial exploration of nine thematic fields was consolidated into four priority themes: freshwater supply in metropolitan regions, ecological connectivity, energy-saving strategies, and brown-to-green industrial transitions. These themes were chosen for their policy relevance and potential to reveal new territorial dynamics.

Through a series of consultations, literature reviews and expert workshops, the thematic

The implementation of the project involved six main strands of activity:

1. Conceptual clarification of non-standard geographies and their relation to established territorial typologies;
2. Thematic narrowing based on expert input and stakeholder consultations;
3. Analysis of development trends and functional linkages, using both quantitative and qualitative sources;
4. Mapping and comparative assessment of national governance frameworks across 41 institutional contexts;
5. Detailed case studies of territorial cooperation and governance in selected regions;
6. Development of policy guidance and visual tools to support policy learning and capacity building.

1.2 Relevance and policy context

Europe faces multiple, interlocking transformation challenges: achieving climate neutrality, ensuring industrial competitiveness, preserving biodiversity, and securing a just transition for all regions. These shifts require governance approaches that can operate across established sectoral and administrative boundaries, and that are sensitive to local

[3] The thematic emerging geographies, whose territorial governance mechanisms and models has been analysed, compared and assessed in this report, has been selected from a pool of nine fields of inquiry defined in the phase of research design (i.e. water management, biodiversity, circular economy, industrial transition, sustainable mobility, energy transition, ageing and illness, migration, land sea interactions), and then reduced in number and further refined through the activities of WP1 and WP2.

conditions. Yet, current policy tools and territorial frameworks are often ill-equipped to address these complex demands.

In this context, the relevance of non-standard geographies lies in their capacity to capture new functional relationships that are not easily aligned with existing spatial typologies such as FUAs or NUTS regions. Functional linkages related to energy, water, ecosystems, and industrial value chains cut across political and administrative borders, giving rise to new demands for coordination, investment, and dialogue. These processes call for innovative forms of governance that combine formal instruments with flexible, negotiated arrangements.

Four Themes illustrating Structural Shifts

Each of the four thematic areas selected by the project illustrates how current territorial development priorities challenge conventional spatial thinking:

- **Industrial Transition** highlights the uneven spatial impacts of the green and digital transition, especially in carbon-intensive and left-behind regions. Governance solutions must address both global supply chains and local labour markets, requiring coordination across regions and sectors.
- **Ecological Connectivity** exposes the limits of territorial governance focused on administrative or land ownership boundaries. Biodiversity and ecosystem services depend on functional landscapes, which require cooperation across jurisdictions and between sectors such as agriculture, forestry, and spatial planning.
- **Energy Saving Strategies** are often locally implemented but deeply embedded in national policy frameworks and infrastructure systems. This calls for multilevel coordination and the tailoring of interventions to mobility patterns, building stock, and behavioural contexts.
- **Freshwater Supply in Metropolitan Areas** links abstraction areas, often rural or upland, with growing urban demand, revealing tensions around resource allocation, territorial justice, and long-term resilience planning.

Together, these themes make visible the territorial implications of major EU policy objectives such as the Green Deal, the Fit for 55 package, and the Just Transition Mechanism. They also demonstrate how new functional areas are being co-constructed through investment, stakeholder alliances, and policy experimentation.

NoStaGeo's Contribution to Cohesion Policy and Territorial Governance

The findings of the NoStaGeo project support the broader ambition of Policy Objective 5 of Cohesion Policy (a Europe closer to citizens), which emphasises integrated, place-based development. By exploring how functional relations evolve around water systems, ecological corridors, energy networks, and industrial change, the project informs how such development strategies might be better grounded in real-world territorial dynamics.

The project also draws attention to the need for flexibility in designing governance frameworks. The case studies reveal that functional areas are not fixed containers but evolving platforms for coordination. Recognising and supporting these dynamics through tailored funding instruments, policy guidance, and stakeholder engagement can enhance the territorial effectiveness of EU interventions.

2 Global Drivers of Change and Territorial Policy Trends

2.1 Exploration of nine emerging geographies

The ESPON NoStaGeo project initially explored emerging geographies within nine thematic fields (see Table 1 below). For each thematic field, the enquiry followed a consistent framework comprising five key elements:

1. **Identification of Emerging Trends**: Each trends was framed as evolving issues or objectives of growing policy relevance.
2. **Functional Area Implications**: Each trend is assessed in terms of its potential to affect the delineation, organisation, or governance of functional areas.
3. **Delineation Principles**: The enquiry outlines conceptual or practical criteria for delineating functional areas relevant to the theme.
4. **Potential Geospatial Delineations**: Available or foreseeable spatial data that could support the delineation of such areas.
5. **Governance Frameworks and EU Policy Context**: Description of existing governance arrangements and relevant EU policies.

Table 1 Examples of trends and functional implications

Thematic Field	Trend Example	Functional Area Implication	Example
Water Management	Ecosystem-based approaches to water governance	Delineation along hydrological features like watersheds and wetlands	River Basin Districts adapting to climate-driven hydrological changes
Biodiversity Preservation	Connectivity between Protected Areas (PAs)	Extension beyond PAs to ecological corridors and green infrastructure	Transboundary biosphere reserves, High Seas Treaty connectivity
Circular Economy	Circular business models and producer responsibility	New geographies around recycling/reuse and circular supply chains	EPR schemes and local circular procurement networks
Industrial Transitions	Development of European Innovation Valleys and Green Industrial Ecosystems	Reinterpreted clusters and corridors across national borders	EU-supported 'Euroclusters' and transnational innovation networks
Sustainable Mobility	15-minute cities and Urban Vehicle Access Regulation (UVARs)	Emergence of walkable, accessible zones; shift from traditional FUAs	UVAR zones
Energy Transitions	Local energy communities and smart grids	Decentralised energy loops with community-level energy governance	Energy communities supported by smart grid infrastructure

Thematic Field	Trend Example	Functional Area Implication	Example
Health and Ageing	Digital health and age-friendly communities	Reorganisation of service regions for e-health and ageing populations	ZOAST areas along French-Belgian border
Migration	Attraction of skilled labour and digital nomads	Creation of attractive regions based on services, amenities, and remote work	Rural areas branded for digital nomads and talent attraction
Land-Sea Interactions	Marine protected areas and industrial offshore zones	Integration of land-sea zones for conservation and marine economy	Marine Spatial Plans combining offshore industry and protection

Source: ESPON NoStaGeo

2.2 Generating policy-relevant syntheses of global drivers of change

To get a better understanding of how local and regional policy trends (such as those described above) emerge and evolve, the NoStaGeo project explored interactions between policy discussions at different levels. This analysis builds on a conceptual framework (fully described in Annex 1) distinguishing between 'primary forces' and 'drivers of change':

- Primary forces are "root causes of disruption" that "evolve in wave", each new wave being "disruptive in different ways" (EY, 2022) The NoStaGeo project considered the following primary forces: 'Demography', 'Consumption and Lifestyles', 'Power, Government and Governance', 'Technology', 'Production', 'Trade, Environment and Climate'.
- Drivers of change are the processes by which primary forces affect local and regional trends, either by generating changes in the territories or through evolutions in European or national governance frameworks.

The NoStaGeo project then designed infographics as tools for discourse analysis, aiming to explore how local and regional reform trends are influenced by developments in global and transnational policy debates. These infographics show how local themes connect with wider global agendas. They are further described in Annex 2.

Each infographic starts with an expert-led identification of key reform trends that reflect changes in local and regional governance. These trends, often linked to the emergence of new functional geographies, are then associated with relevant global and regional drivers of change. These drivers are grouped according to eight 'primary forces', providing a structured way of interpreting the wider context for local action.

The result is a set of visual storylines that trace how global concerns around issues such as climate, technology, governance or demography inform or shape subnational reform efforts. These storylines are inherently interpretative and should be seen as entry points for discussion, helping policymakers and stakeholders to reflect on how local initiatives relate to broader strategic developments.

The infographics have been elaborated using InDesign. They may be considered as User Experience (UX) prototypes of a future full-fledged interface. Such an interface would have to be developed using more robust web development tools. Each infographic would then be

generated based on content stored in a database. The prototype would offer a starting point for a dialogue with web developers.

Artificial intelligence prompts to generate updated lists of resources of relevance could be associated to each 'trends – key global driver' couple. The infographic would then offer a structured interface helping local and regional policy makers to collect updated information on transnational and global policy development of relevance on reform trends of relevance for their day-to-day activities.

Figure 1 Components of the initial view of the infographic

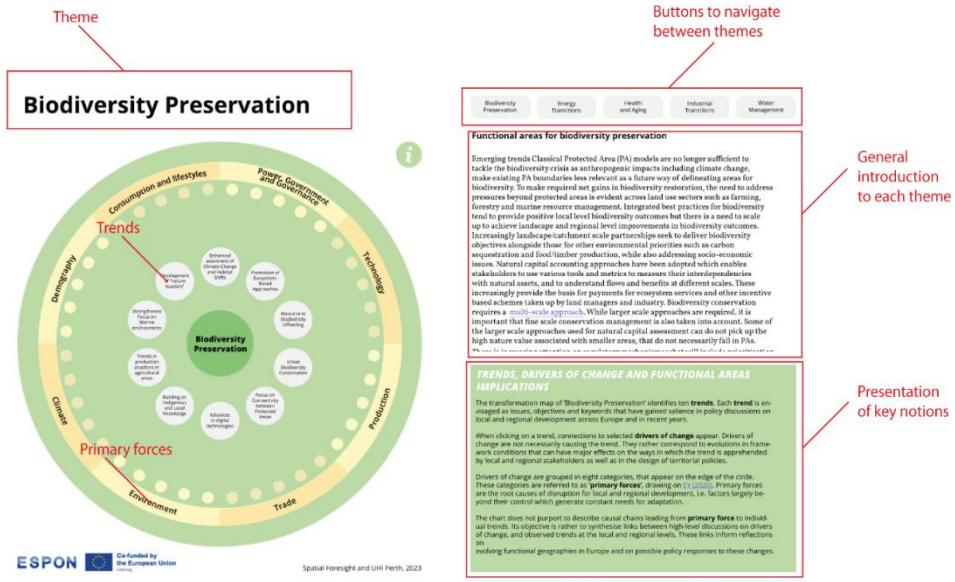
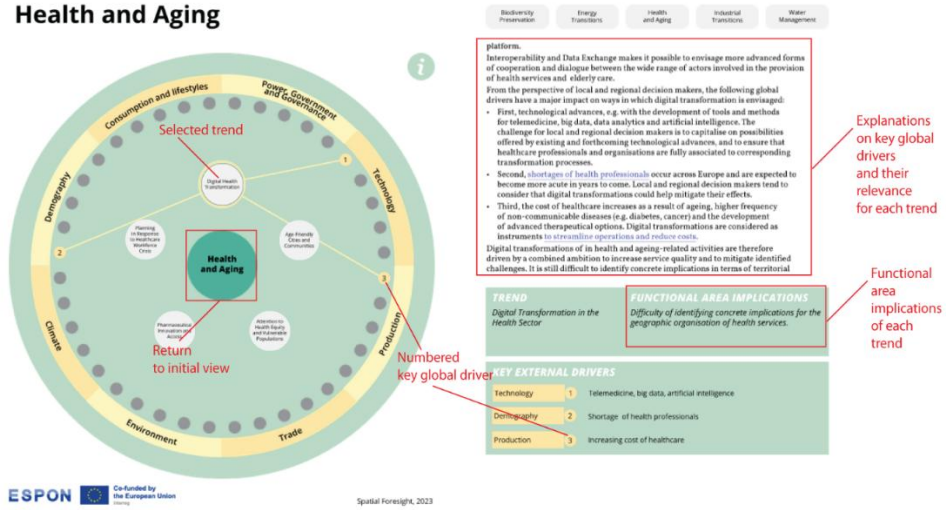


Figure 2 Components of the infographic once a trend has been selected by the reader



3 Conceptual considerations and research approaches

3.1 Analytical approaches of emerging geographies

Summary of the methodological steps undertaken

Building on the emerging trends and global drivers of change identified in the first phase (see chapter 2), the NoStaGeo project consortium conducted a series of thematic consultations with experts and relevant stakeholders leading to the further analysis of the following themes:

- Water management: Freshwater supply in metropolitan regions
- Biodiversity preservation: Ecological connectivity
- Energy transition: Local and regional energy savings
- Industrial transition: Brown to green transition

Building on the literature review (documented in the 'Research Strategy: Steps towards the analysis of emerging geographies', see Annex 9.1) and focusing on dimensions of functionality and new emerging spatial dynamics, the project team advanced towards the specification of the four themes and formulation of research questions to guide the further thematic exploration. Initial areas of inquiry were:

- **Water management: Freshwater supply in metropolitan regions –** how various drivers, such as climate change, technological advancements, and socio-economic trends, shape the functional geographies of hydrographic systems, water supply and consumption patterns; what governance solutions and good practices enhance the resilience of water supply systems in metropolitan regions, especially taking into account diverse geographies, stakeholder arrangements, and evolving conditions,
- **Biodiversity preservation: Ecological connectivity –** how land management can be better organised to strengthen ecological networks and corridors, focussing on governance mechanisms, scales, and instruments that enhance their effectiveness; how ecological connectivity is governed across Europe and what role it plays in supporting multifunctional landscapes,
- **Energy transition: Local and regional energy savings –** how governance structures, instruments and collaboration mechanisms shape energy-saving strategies **for the building sector** across different levels, with a focus on integration of local characteristics or mobility patterns; how these strategies enable spillover effects, support place-based solutions, and incorporate broader sustainability goals such as green energy supply,
- **Industrial transition: Brown to green transition –** how the green and just industrial transition manifests in terms of spatial, economic, and governance aspects across different European regions; what implications arise for supporting policies, by taking into account regional diversity, labour market demands, and stakeholder arrangements.

Focusing on different narratives and dimensions of functionality related to non-standard emerging geographies, complemented by expert consultations (see Annex 9.2), the project team reflected on possible functionality aspects within each of the four themes of analysis. This was done by combining rather traditional understandings, such as commuting patterns and emerging local labour markets or functional urban areas, with new approaches considering other dimensions, e.g. historical, institutional, relational, cultural, and strategic, specific to each of the theme. However, the preliminary considerations needed a more

robust and in-depth inquiry of possible functionality dimensions when approaching non-standard geographies.

Aligned with the activities regarding data collection, mapping and analysis of development trends, the thematic experts delved into the four themes based on following defined cross-cutting topics: settlement structure (population density), land use and soil sealing, economic development (growth, GDP), climate change. The aim of this step was to identify how these cross-cutting topics are impacting the development within each theme in a pan-European perspective, by combining these dimensions with theme-related data. However, the project team encountered several challenges in both finding representative pan-European data on the four themes of analysis and combining these data sets in a meaningful way in order to identify, analyse and visualise emerging spatial patterns and linkages.

Therefore, due to these challenges encountered towards an in-depth analysis of emerging spatial patterns, development dynamics, and dimensions of functionality on a pan-European level, the NoStaGeo team opted for rethinking the methodological. Instead of a predominantly quantitative-data-centred approach, different narratives gathering academic and policy discourses, emerging trends and their potential territorial implications for non-standard functional geographies, as well as mappings of relevant theme-specific socio-economic and environmental indicators were considered. Moreover, the planned case studies within each theme of analysis gained importance as an attempt to explore in more detail representative cases for each of the four themes of analysis in a multi-scalar perspective by including both qualitative and, where available and informative, quantitative data.

This process was designed iteratively, allowing for a more versatile research approach during which inputs from the regional case studies and from the national consultations fed into the overarching theme-related narratives and vice-versa. During this process, small workshops and weekly meetings allowed for exchange between the NoStaGeo project members.

The results were displayed in StoryMaps, allowing for a better visual representation and understanding of spatial dynamics and emerging functional interactions in each of the four themes of analysis.

Reflection and lessons learned from the process

With its explorative approach, a key result of these analytical steps is the importance of the project and its thematically broad approach to open up debates around the spatial implications of these overarching complex transformation processes. Europe and its regions are undergoing substantial transformation processes, that change regional governance dynamics: To take an example: in considering the implications of circular economy of water management in metropolitan areas, new cooperation instances emerge, sometimes building on existing networks and including new stakeholders, as well as that sometimes new stakeholder constellations emerge. Similarly, the increased importance paid to the twin transition in times of increasing geopolitical instability has led to a new drive for industrial sovereignty. At the same time, the past decade, particularly in the aftermath of Brexit, has highlighted the importance of ensuring that no region is being 'left behind', questioning funding allocations (Dijkstra, 2024). Fostering a brown to green transition in Europe thus is a process developing under a broad umbrella of European goals: reaching a just, digital, and green transition, while ensuring Europe's economic ambitions. To reach ecological connectivity regional stakeholders and governance arrangements need to consider the diverse spatial linkages of different species. In understanding energy transition in cities to help save energy, a broad set of stakeholders need to be addressed and considered, similarly as that each national context has different legal settings. These are

just examples of the manifold developments European regions and urban agglomerations are currently facing. These in parallel existing overarching goals and the fact that in all these transformation processes different local conditions, stakeholders as well as national legal setting are providing different preconditions for transformation processes to foster, show the need to understand the implications of these contemporary developments.

The research clearly exposed the need for nested place-based responses, that take local stakeholders onboard, develop funding tools that are applicable to different regional-local contexts, and legal settings that allow collaboration across different stakeholders' groups. In this context, all of the four themes showed that while thinking in multi-level governance concepts is necessary to understand the different spatial reach of policies, and to be able to administer support mechanisms, the geographics coverage changes, and thinking in traditional governance scales limits the opportunities for creating support mechanism both in terms of funding as well as legal frameworks that can be implemented and used at the regional-local level. It is important for future support of transformation processes, that a certain flexibility will be needed, and to understand that under the same theme processes can be e.g. intra- and international as well as intra-and interregional. The relationship between policies funds and stakeholders shifts under the same theme as the functional relations are diverse. In taking a theme-based approach, the project was able to open up these discussions for different regions under the same umbrella.

Initially, the project aimed at identifying the concrete governance instances that are indicative for these themes, as well as that the project team attempted to identify spatial delineations. Yet, it is clear, that at least in most of these emerging themes new relationships are developing and with it the spatial relations are slowly changing. Yet, the particularity of these functional relations is that they are at the same time very local and at the same time led to further expansion of relationships. The co-existence of further localisation of activities, and intraregional, sometimes intra-urban collaborations is developing, e.g. in an attempt to support decarbonisation within one region, cooperation with stakeholders in other regions or countries is needed to for example foster innovative solutions. The projects aim to understand these shifts in geographical relations highlights the importance of subtle changes.

The transition and transformation processes are linked to dependencies across different fields and themes: E.g. the development skills and resources is crucial to achieve energy transition, and changing environmental pressures need to be understood to cater for ecological connectivity. As the ESPON NoStaGeo infographics showed, the policy discourses that influence the exact debates within each theme maybe be similar across regions: Yet, the local specificities differ, and as a result territorial relations.

Understanding emerging geographies, implies as well to revisit the concept of functionality, as an important aspect of revisiting emerging geographies is to both understand the functional relations and the changes within them, as well as to understand the changes of new policy discourses linking into these functionalities. In conceptualising functionality, a key takeaway of this research is that specific functional relations are outcomes of multiple policies, developments and discourses that influence regional flows, be it in terms of cooperation, coordination or physical flows. Functionality and functional linkages in an age of transformation means to better understand the developments that imply changes in flows, all of which may lead to new spatial configurations. One research question asked was what the patterns, networks, flows, linkages, interactions and/or interdependencies are relevant. Understanding spatial configurations within the four themes has highlighted the importance of the lenses taken to identify these patterns, flows, linkages etc. To take one example from the industrial transition theme: Norrbotten in the North of Sweden (StoryMap) is a region in industrial transition, where the traditional mining sector is undergoing changes. Now, understanding the development of this transition through the lens of constraints in the labour market, means to better understand the following parallel

processes: In needing highly specialised labour force, the regional functional linkages on the one hand have led to highly targeted collaboration with regional Universities, including the development of highly specialised study courses, and policies to attempt to retain students in the region. This includes provision of housing as well as attractive offers by local companies. At the same time, the regional labour market needs to be conceptualised as a fly-in fly-out labour market, where the Kiruna airport is a necessity not only for business travel, but also for the current labour market. This simple example indicates the importance of overcoming simple indicator developments for showing labour market areas around distance: To capture this example of a labour market area these parallel flows and patterns need to be understood. Of course, in taking this multiple-dimension approach to functionality one opens the pandoras box of where to start and where to finish. Nevertheless, the complexity of contemporary transformation processes in a highly connected world is a challenge one needs to take on when designing policies and support mechanisms.

The title of the project is non-standard geographies, of course opening the question of what a standard geography is: And as it stands, this question cannot easily be answered: In taking the perspective of emerging geographies and aiming to understand spatial configurations for these four overarching goals and trends, a key lesson learnt has been that a part of the answer is that the spatial reach and configuration different between countries in the same theme. If one were to compare for example the approach of metropolitan areas as a functional standard geography, the rough understanding of what the indicators would be to determine where the agglomeration starts and ends could relatively easily be employed for all agglomerations in Europe. Yet, taking account of circular economy in water management, means to understand the relationships of both the water management sector, and the metropolitan area: The considerations and the resulting spatial configurations will be different based on the water systems, infrastructure and natural conditions.

Overall, what becomes clear is that across all the changes in functional relations skills and resources gain importance, as the multi-dimensional developments needed to achieve the overarching goals such as energy savings, industrial transition of ecological connectivity, imply the employment of highly knowledge in the theme, in combination with an understanding of the local conditions and the opportunities for local and regional stakeholders to act against the existing frameworks.

3.2 National governance frameworks

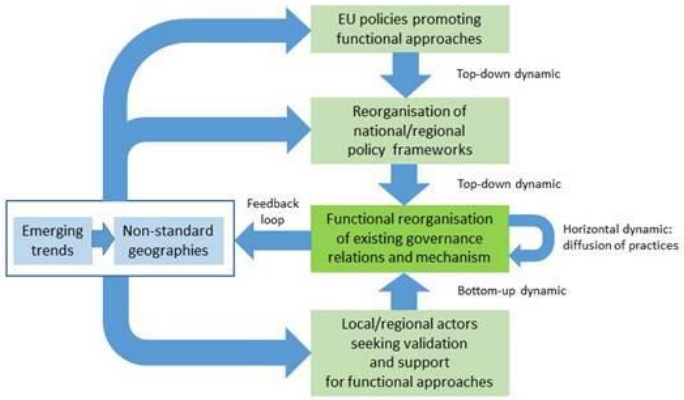
Exploring the territorial governance of non-standard geographies

While Functional Urban Areas (FUAs), typically defined by commuting flows, receive substantial policy attention, other non-standard forms of functional interdependencies remain unaddressed (Cotella, 2023). The concept of functional areas beyond FUAs is often poorly understood by policymakers (Faludi, 2018) and setting up effective governance mechanisms to handle them remains a persistent challenge that often raises questions of legitimacy and accountability (Swyngedouw, 2009).

In our analysis we drew on research around 'spatial fit'[4][1] to address this gap, investigating how the non-standard geographies emerging in relation to the four identified themes are addressed throughout Europe. In so doing, we conceptualise non-standard geographies as spaces requiring tailored governance frameworks to respond efficiently to complex territorial challenges.

Rather than simply delineating functional areas through spatial analysis, the project highlights the importance of institutional contexts, political interdependencies, and community engagement. Governance solutions must emerge from creative, evidence-informed processes that balance functional logic with practical constraints, while also allowing for policy learning and diffusion (Figure 1.1).

Figure 3 Causal relations between emerging geographies and the reorganisation of territorial governance



Source: authors' own elaboration.

Through observations for the entire ESPON Programme area, the project team collected, compared and assessed relevant evidence upon which to develop policy advice on how to arrange optimal territorial governance mechanisms that would combine formal frameworks with soft spaces of governance, adequately addressing functionalities in such new geographical areas. This activity was performed through six complementary methodological steps, that are presented more in detail below. Development of the Country Report template. The first methodological step entailed the design of a standardised Country Report template to systematically collect and organise information on territorial governance mechanisms across Europe (see Annex 7, p. 14)[5]. The template was introduced by an overview of the country's governance system and locus of power, followed by four thematic modules corresponding to the project's focus areas—water supply in metropolitan regions, ecological connectivity, brown to green industrial transition, and energy transition

[4] As Folke et al. (2007) note, governance effectiveness hinges on alignment with functional networks and flows, although such alignment is not always straightforward (Moss, 2012)

[5] The template's design was informed by earlier ESPON projects and refined through collaboration with thematic experts and feedback from preliminary expert consultations. It was intended not only as a data collection tool but as an analytical framework encouraging reflection on governance processes, functional mismatches, and the interplay between formal and informal arrangements.

and savings. For each theme, experts were asked to provide (i) a contextual introduction, (ii) a description of the governance mechanisms in place, (iii) examples of good practices and recurring pitfalls, and (iv) an evaluative assessment structured around six governance dimensions inspired by ESPON TANGO.

Preparation of country reports (See Annexes 7.1 to 7.41). The country experts engaged in the project followed the provided template to systematically describe and assess the territorial governance mechanisms in place in the 41 institutional contexts under investigation.[6] In addition to providing factual descriptions, experts were encouraged to identify and critically assess innovative practices, unresolved challenges, and governance gaps. The process revealed considerable diversity in how different countries and regions approach the governance of non-standard functional geographies. Some relied on well-established formal frameworks, while others employed more flexible, network-based approaches. The reports highlighted differences in institutional maturity, decentralisation, coordination capacities, and the degree of integration across sectors and levels. By capturing these variations through a common lens, the country reports became the core empirical foundation of the project, supporting both in-depth thematic insights and cross-country comparative analysis.

Assessment of territorial governance frameworks. The third step involved the analytical assessment of governance frameworks across the four thematic areas. Each country expert evaluated the governance mechanisms described in their country report through a set of predefined qualitative dimensions, adapted from the ESPON TANGO framework to the four specific themes: (i) coordinating actions of actors and institutions; (ii) Integrating policy sectors; (iii) mobilising stakeholder participation; (iv) being adaptive to changing contexts; (v) realising functional specificities and impacts; (vi) use of place-based and bottom-up approaches; Each theme was assessed separately using a qualitative scoring system (See Annex 7, p. 15), supported by qualitative justification.[7] [4] The goal was not to rank countries but to identify patterns of governance performance and variation across contexts. This step brought analytical depth to the descriptive country reports, enabling a structured comparison of governance strengths and weaknesses. The results of the assessment were used to produce dedicated 'Spider Diagrams', similar to those used in other ESPON projects (e.g. ESPON ACTAREA), that allows for the comprehensive, comparative visualisation.[8]

Quality control and review. To ensure methodological consistency, the research team conducted an extensive, iterative review of all submitted country reports. Initial feedback was given on the structure, clarity, and methodological alignment of each report. Where

[6] These include all EU member states, the candidate countries of the Western Balkan Region, as well as Kosovo, Iceland, Norway, Switzerland, Turkey and the United Kingdom. Selected countries featuring important territorial governance differences due to their institutional and administrative organisation have been analysed accordingly, i.e. England, Scotland and Wales for the United Kingdom and Flanders and Wallonia for Belgium were subjected to dedicated analyses. Brussels has been analysed together with the Wallonia case, and Liechtenstein together with the Swiss case, highlighting specific territorial governance elements whenever relevant. The case of Turkey has been developed only in relation to one of the four issues at stake, i.e. energy transition and saving.

[7] Importantly, the country experts were explicitly instructed to assess the quality of the territorial governance framework in place to address a given theme on the basis of the materials collected through desk research, and not its actual effectiveness in practice, as to assess the latter would have exceeded the timeframe of the NoStaGeo project.

[8] The spider diagrams are not included in the present report, but are consultable for comparative insights in the European Territorial Governance Dashboard that build on the analysis.

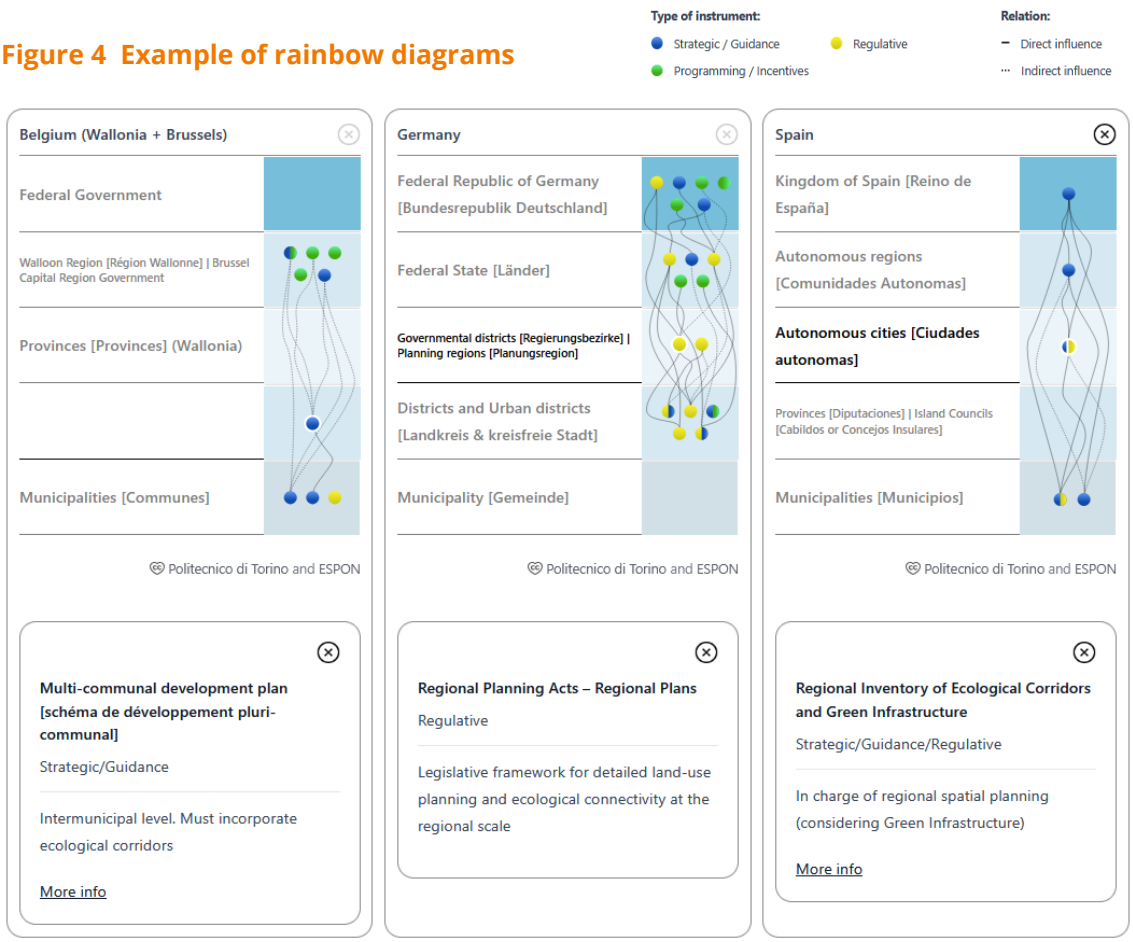
necessary, experts were asked to provide clarifications, expand on specific sections, or revise inconsistent assessments. This process ensured that all reports adhered to the shared template and that the analytical criteria were applied uniformly across contexts. This step was fundamental for building a reliable and comparable knowledge base. It allowed the team to harmonise terminologies, validate methodological rigor, and ensure that governance assessments were evidence-based and reflective of the real institutional conditions.

Visualisation through Rainbow Diagrams. To synthesise and communicate the complex information collected in relation to the multilevel organisation of the territorial governance models put in place in each institutional contexts to address the four themes under investigation, the project adopted a novel visualisation tool – the rainbow diagram.[9] These diagrams illustrate the relationships between governance instruments and the levels at which they operate, providing a clear and immediate representation of the multilevel nature of territorial governance across different themes. Each rainbow diagram mapped the instruments identified in the country reports according to their territorial level (national, regional, local) and type (strategy, regulation, programme). The visualisation highlighted recurring patterns and gaps and became a central tool for comparative insights in the European Territorial Governance Dashboard derived from the analysis.

Rainbow diagrams, for example, enable comparison of the multi-level architecture of policy instruments aimed at preserving ecological connectivity in three countries with significant regional autonomy (Figure 4 below). In Germany, such policies are implemented within a federal legislative framework, supported by a Federal Biodiversity Strategy and several federal funding schemes. In contrast, national authorities in Spain mainly provide methodological guidance. In Belgium, biodiversity conservation falls entirely under regional jurisdiction. The regional and intermunicipal instruments also vary widely across the three countries.

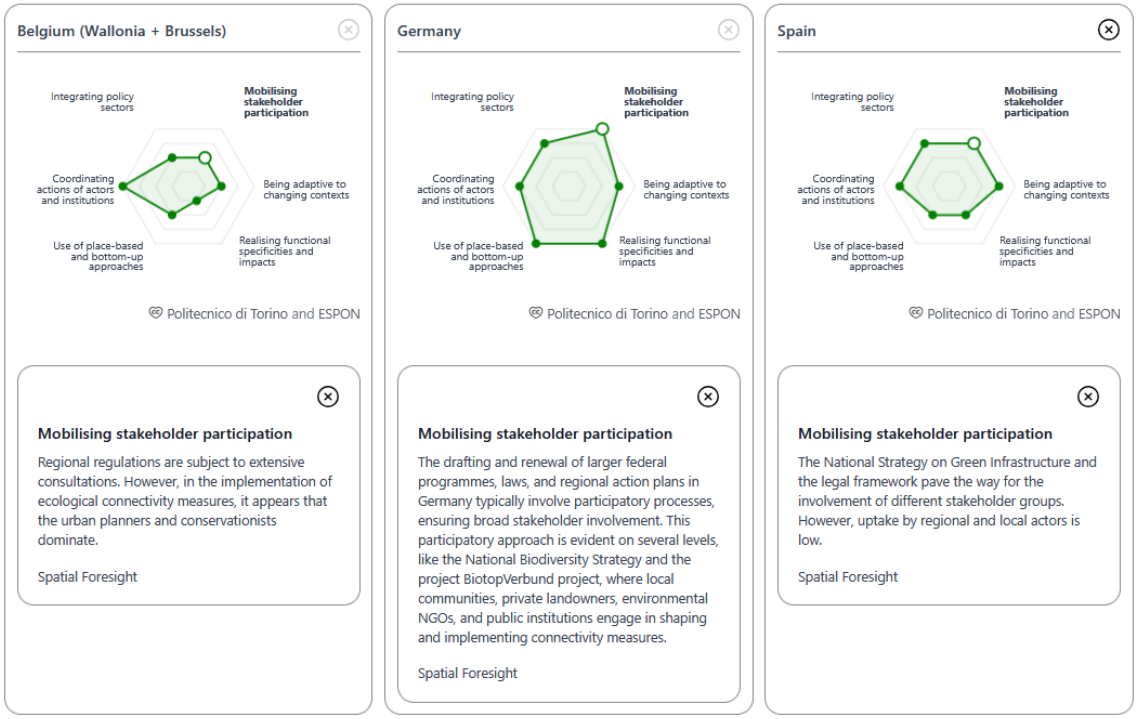
[9] In doing so, we took inspiration from a recent article focusing on water governance (Rowbottom et al., 2022).

Figure 4 Example of rainbow diagrams



The spider diagrams compile subjective expert assessments based on structured evaluation grids included in the country reports. Each score is accompanied by a qualitative justification accessible to users of the dashboard. As such, the diagrams are not standalone evaluations but visual syntheses meant to prompt reflection and dialogue. The example shown compares Belgium (Wallonia + Brussels), Germany, and Spain in terms of stakeholder participation in ecological connectivity governance. It highlights differences in engagement practices—from broad participatory approaches in Germany to limited uptake at subnational levels in Spain. The diagrams can support comparative insights and discussions on the respective strengths and weaknesses of national governance frameworks in each thematic field.

Figure 5 Example of spider diagrams



Comparative analysis (see Annex 7). The final methodological step consisted in the comparative analysis of the governance frameworks and instruments identified across the 41 institutional contexts. This analysis sought to categorise the diversity of territorial governance arrangements into meaningful clusters, highlighting commonalities and divergences across themes and countries. The analysis revealed not only thematic differences – for example, the predominance of formal instruments in energy savings compared to soft governance in ecological connectivity – but also cross-country typologies. Countries were grouped according to the maturity and coherence of their governance systems, ranging from frontrunners with integrated, multi-level frameworks to contexts still grappling with fragmented or underdeveloped approaches.

4 Water Supply in Metropolitan Areas

KEY FINDINGS

- **Emerging geographies of water supply are increasingly shaped by climate risks**, as droughts, floods, and long-term shifts in water availability force authorities to rethink abstraction areas and diversify sources.
- **Diffuse groundwater pollution creates new protection geographies**, where agricultural, industrial, and urban actors must coordinate across catchments and recharge zones to safeguard drinking water quality and address growing health concerns.
- **Interlinked and mutually supportive distribution systems are becoming central to metropolitan resilience**, creating new spatial configurations through cross-basin connections, emergency interconnectors, and shared contingency infrastructure.
- **Policies to reduce water consumption relate to functional geographies of demand**, as targeted measures such as pricing, awareness campaigns, efficiency standards must align with local consumption patterns, socio-economic structures, and sectoral hotspots.
- **Multiple overlapping emerging water geographies can therefore be identified in and around metropolitan regions**, including abstraction zones, aquifer protection areas, distribution networks, demand clusters, pollution-impact zones, and governance arenas.
- **Path dependencies in existing water infrastructure generate spatial inertia**, meaning many emerging geographies form through incremental adaptations and negotiated exceptions rather than comprehensive redesigns.
- **New functional areas for water supply are often co-constructed through cooperation**, e.g. driven by alliances to reduce exposure to climate change related risk, partnerships between water consumption and abstraction areas, arrangements to regulate water allocations in case of scarcity.
- **The mismatch between hydrological, infrastructural, and institutional geographies creates governance gaps**, requiring multi-level coordination, compensatory mechanisms, and shared financing models to balance costs and benefits across regions.
- **Metropolitan water resilience increasingly depends on aligning technical solutions with governance innovation**, as the capacity to organise cross-sectoral and cross-territorial cooperation becomes as important as engineering upgrades or new sources.

4.1 Theme introduction

Water supply systems face the pressing challenge of adapting to an increasingly unpredictable future. Climate change, shifting land use patterns, and socio-economic

transformations are expected to intensify droughts and floods , placing mounting pressure on infrastructure and governance frameworks. In parallel, awareness is growing that diffuse pollution from agriculture, industry, and wastewater systems is degrading groundwater quality in many regions. Long-term exposure to contaminants such as nitrates, pesticides, and PFAS poses significant health risks, making the protection of groundwater an increasingly urgent policy concern.

Responding to this challenge requires more than aligning governance with the physical characteristics of water supply—such as basin boundaries, aquifer systems, or existing distribution networks. It also involves addressing broader policy objectives and emerging functional relationships that may not align with conventional territorial divisions. Key considerations include:

- **Mutualisation of Resources to Reduce Risk Exposure**
  Strengthening territorial resilience to water-related risks may involve the mutualisation of resources across jurisdictions or basins. This can include shared infrastructure or joint management arrangements that reduce exposure to drought, contamination, or supply disruptions. For example, Oslo has invested in infrastructure linking separate water basins to enhance flexibility and safeguard drinking water quality.
- **Place-based policies Shaping Water Consumption Practices**
  The effectiveness of water policies can be enhanced when they are tailored to the spatial patterns of water use. Consumption practices vary significantly across territories depending on factors such as urban form, economic activities, and income levels. Designing and implementing measures such as pricing, awareness campaigns, or efficiency standards at the right spatial scale and within areas where specific consumption behaviours prevail can lead to more meaningful and lasting change.
- **Targeted Policy Interventions in Sectoral Functional Areas**
  Policies addressing the impact of activities such as agriculture or manufacturing on water quality are often most effective when designed in line with the geographic logic of those sectors. This may involve action at scales where sector-specific dynamics play out and where relevant stakeholders—such as chambers of agriculture or industry—are active and influential.
- **Balancing Costs and Benefits Across Regions**
  Water supply protection can impose restrictions on economic activities in abstraction zones, while the benefits, such as improved public health, development of tourism and manufacturing production, tend to concentrate in more densely populated and economically active areas. In such cases, compensatory mechanisms may be needed to address these spatial imbalances.

Water supply is one of the few economic activities and areas of public policy that directly addresses a fundamental human need. Even brief disruptions can have significant social and economic repercussions. This contributes to strengthen institutional inertia in the field of water supply, especially in regions were water supply is perceived to be reliable and well-functioning. Authorities and stakeholders may, often justifiably, be concerned that changes in established governance arrangements and operational solutions for water supply could jeopardize the continuity and quality of services provided. Legacy infrastructure and long investment cycles further strengthens the structural reluctance to deviate from established systems, even when they prove suboptimal under changing conditions.

Some key concerns and policy objectives may trigger changes in spite of these structural obstacles. These are in particular linked to risks of water scarcity, to the pollution of water in rivers and aquifers and to strategies to adapt to current and expected future climate change. Episodes of acute water shortage may also accelerate policy developments in the field of water supply.

Addressing concrete water supply challenges and anticipating identified risks requires extensive technical and financial capacity for infrastructure investments. Such needs contribute to the emergence or strengthening of functional territories for water supply. France provides a concrete example of such trends. The MAPTAM and NOTRe laws, adopted respectively in 2014 and 2015, made it compulsory transfer to competence for water supply to intermunicipal cooperation bodies, including all metropolitan regions except Paris.

The emergence of new functional areas for future-proof water supply therefore reflects multiple parallel policy concerns and ambitions. Each of them has different functional implications, as illustrated by Table 1 below. Corresponding geographies are not necessarily congruent. Spaces within which technical and financial capacity can be mobilised are not necessarily optimal for broad stakeholder dialogues on the future of water supply. Even when potential benefits of connections between existing water supply systems or across river basins may be well established, their creation may be hampered by organisational or political divergence between neighbouring territories.

Table 2 Examples of Water Supply policy questions and their functional implications

Policy questions	Functional implications
What is the qualitative and quantitative status of water bodies	Water supply strategies begin with understanding the geography of river basins and aquifers and their expected future capacity to supply water of sufficient quality.
Who pays for and manages infrastructure upgrades?	Investment capacity may need to be pooled across municipalities or regions.
How can we ensure resilient water supply under uncertainty?	New infrastructure interconnecting existing water supply systems (both for daily operations and contingency use) create new functional areas.
How can broad stakeholder dialogues be organised?	Policies must address the functional geographies of sectoral impacts (e.g. from agriculture) and capitalise on existing cross-sector dialogue platforms and identity regions.
How can upstream and downstream actors share responsibilities and benefits?	Water protection requires cooperation between rural catchments and urban users. Fair benefit-sharing implies recognition of constraints on water resource areas.

Source: own elaboration.

Water supply in Europe has increasingly become a contentious issue in the last decades. Debates are shaped by competing perspectives on whether water should be treated as a market commodity or as a fundamental human right. This debate influences not only the governance and financing of water services but also the potential for cross-boundary coordination in water supply systems. At the heart of the controversy is a growing tension

between efficiency-driven, market-based reforms and rights-based approaches that prioritise equitable access.

At the European Union level, this tension came to the fore during the debates surrounding the Services Directive and the "Right2Water" European Citizens' Initiative (ECI). The ECI, launched in 2012, was the first successful initiative of its kind and called for EU legislation to guarantee water and sanitation as a human right, not a commodity. It garnered over 1.8 million signatures and resulted in a 2014 European Parliament resolution supporting the recognition of water as a public good.

Similar debates have also been observed national level. In Italy an abrogative referendum was organised in June 2011 to repeal laws on the privatisation of water supply. The referendum saw over 95% of voters reject provisions that would have enabled the privatisation of water services. With a turnout of over 26 million voters, the result reflected a strong public resistance to policies in favour of the commodification of water. Scholars identified it as one of the "*inclusive and resilient mobilisations in contemporary Italy*" (Carrozza and Fantini, 2013, 2016).

These differences in national and regional governance approaches can pose real challenges to coordinating water supply across administrative boundaries. When water is governed through market mechanisms in one area but considered a public service in another, aligning investment, tariff structures, and operational practices becomes significantly more complex. This is especially pertinent in transboundary river basins or metropolitan regions where water resources and infrastructure span multiple jurisdictions. The lack of institutional alignment can hinder joint planning, delay infrastructure interconnections, and ultimately undermine the resilience of regional water supply systems in the face of climate change and demographic pressures.

4.2 National governance frameworks

The governance of metropolitan water provision across the 41 institutional contexts studied reveals significant diversity in strategic priorities, institutional capacities, and levels of integration across governance scales. While the need for sustainable, resilient, and equitable water supply is widely acknowledged, implementation remains highly variable. Most countries face intersecting challenges—including ageing infrastructure, water scarcity, pollution, and the effects of climate change—that are exacerbated by rapid urbanisation and fragmented governance. These pressures necessitate adaptive and multilevel governance arrangements capable of addressing complex and evolving demands in metropolitan areas.

A consistent finding is the tension between national-level water strategies and the realities of sub-national implementation. Some countries, such as Germany and the Netherlands, offer examples of integrated governance frameworks in which national guidance is effectively translated into regional action, supported by robust infrastructure investment and stakeholder coordination. In contrast, many countries, particularly in Eastern and Southeastern Europe, struggle with decentralised governance, under-resourced institutions, and coordination gaps that hinder the coherent delivery of water services. These disparities are most acute in rapidly urbanising areas or where cross-jurisdictional coordination is essential for managing shared water resources.

The analysis highlights a growing trend towards the diversification of water sources and investment in infrastructure modernisation. Several countries are developing innovative solutions, such as desalination, rainwater harvesting, and greywater reuse, to enhance resilience to drought and climate change. Notably, Malta and Cyprus are at the forefront of such technological responses, driven by acute water scarcity. However, such strategies are not always accompanied by sufficient governance reform, leading to implementation gaps and unequal service delivery, particularly in peri-urban or marginalised areas.

Cross-sectoral integration remains uneven. While some countries, such as France and Denmark, have embedded water concerns into broader environmental and climate adaptation planning, others continue to treat water provision as a technical sector with limited engagement from spatial planners, health authorities, or social services. This siloed approach undermines the potential for synergies, especially where water governance intersects with land-use planning, infrastructure development, and social equity objectives. Positive examples, such as the Netherlands' Delta Programme, illustrate how integrated planning frameworks can align water security with long-term urban and environmental goals.

Stakeholder participation and community engagement are increasingly recognised as key components of effective water governance. Yet, despite improvements in transparency and public involvement (as reflected in the revised EU Drinking Water Directive), institutional mechanisms for meaningful multi-actor engagement remain underdeveloped in many countries. Centralised systems may lack responsiveness to local needs, while decentralised systems often lack the institutional capacity or coordination tools necessary to manage stakeholder relations effectively. This points to the need for hybrid governance models that can bridge administrative levels while fostering inclusive, place-based approaches to water management.

Finally, the analysis shows a marked variability in legal and regulatory instruments used to govern metropolitan water provision. While EU member states broadly align with directives such as the Water Framework Directive, implementation practices vary widely. Some countries rely heavily on strategic planning instruments, while others prioritise regulatory enforcement or economic incentives. The success of these instruments often depends on how well they are embedded within functional governance arrangements capable of operating across administrative boundaries and responding to regional hydrological conditions.

In sum, the effective governance of metropolitan water supply demands a shift from sectoral, infrastructure-led approaches to integrated, adaptive systems rooted in cross-scale coordination, stakeholder engagement, and long-term planning. This will require not only legal and regulatory innovation but also sustained political will, financial investment, and institutional learning. Countries that are able to align technical solutions with governance reforms are more likely to deliver water services that are resilient, equitable, and fit for the challenges of the 21st century.

Preliminary typology of ecological connectivity governance

The governance of metropolitan water provision across Europe exhibits diverse institutional configurations shaped by varied levels of decentralisation, technological advancement, and adaptability to external pressures such as climate change, urban growth, and infrastructure ageing. This diversity has enabled the development of a preliminary typology comprising four governance types, reflecting distinct institutional rationales, capacities, and systemic challenges in addressing urban water needs.

- **Collaborative and Integrated Governance** systems are characterised by strong multi-level coordination, cross-sector integration (e.g. with urban planning, agriculture, and environmental protection), and a long-term orientation toward resilience and sustainability. Countries such as the Netherlands, Denmark, Germany, and France exemplify this approach through decentralised yet coherent systems that foster public participation, institutional trust, and planning foresight. Governance in these contexts is often basin-based or structured through metropolitan authorities, enabling functional coordination across administrative boundaries. However, such systems can suffer from administrative complexity, particularly in crisis scenarios that require rapid, centralised responses.

- **Centralised and Technologically Advanced Governance** models rely on national-level control to ensure uniformity and efficiency in service delivery. Technological innovation (e.g. desalination, smart metering, IoT monitoring) plays a central role in enhancing water system performance and responsiveness. This model is evident in countries such as Ireland, Hungary, Estonia, and the UK, where national utilities or regulatory frameworks standardise water provision. While these systems are well-suited to managing large-scale infrastructure and ensuring consistency, they can lack the flexibility needed to adapt to localised needs or to integrate place-based sustainability objectives effectively.
- **Fragmented and Reactive Governance** systems are found in countries where metropolitan water provision is hampered by institutional fragmentation, limited coordination, and reactive policy responses. Jurisdictional overlaps and misalignments between local and national governance levels often hinder strategic planning and efficient service delivery. Cases in the Western Balkans (e.g. Albania, Kosovo, Montenegro, Bosnia and Herzegovina) and parts of Southern and Eastern Europe illustrate the challenges posed by this model, including infrastructural decay, limited funding, and short-termism. While these contexts may enable local adaptation, they are generally less capable of delivering coherent responses to cross-boundary or long-term challenges such as droughts, pollution, or demographic shifts.
- **Adaptive Governance** systems demonstrate flexibility and a growing emphasis on climate resilience, innovation, and integrated planning. Countries such as Sweden, Finland, and Iceland combine forward-looking water strategies with sustainability goals (e.g. carbon neutrality, nature-based solutions). These systems often benefit from strong environmental institutions and public support, but in many cases (e.g. Czech Republic, Croatia, Estonia), their effectiveness is partially contingent on continued access to EU funding and external technical assistance. While adaptive governance enables dynamic responses to emerging challenges, its reliance on external resources may threaten long-term viability if institutional capacity is not sufficiently strengthened.

Overall, this typology illustrates a spectrum of governance maturity, with varying degrees of institutional integration, stakeholder engagement, and resource mobilisation. As metropolitan areas across Europe face growing pressure from climate impacts and urbanisation, there is a clear need for hybrid approaches that balance the efficiency of central oversight with the responsiveness and inclusivity of local governance. Learning from well-functioning examples such as the Netherlands' Delta Programme or Sweden's climate-integrated urban water planning can inform improvements in less coordinated or resource-constrained settings. Enhancing functional cooperation across administrative boundaries and investing in institutional capacity are critical steps towards resilient, equitable, and sustainable metropolitan water provision.

Table 3 Typology of metropolitan water provision governance

Typology	Characteristics	Countries[10]
Collaborative and Integrated Governance	Multi-level coordination, intersectoral management (agriculture, urban planning, environmental protection), long-term resilience and sustainability, adaptive to urbanisation and climate change	Netherlands, Denmark, Austria, Finland, Sweden, Norway, Switzerland, France, Germany, Spain, Poland, Portugal, Luxembourg, Ireland, Italy
Centralised and Technologically Advanced Governance	National control, uniform policies, focus on technological innovations (e.g., desalination, smart water systems), rapid responses to crises, limited local flexibility.	Ireland, Hungary, Estonia, Malta, Cyprus, Turkey, Romania, Slovakia, Lithuania, Latvia, Iceland, Scotland, Wales, England
Fragmented and Reactive Governance	Dispersed decision-making, lack of coordination, localised control but reactive to urgent needs, challenges in managing cross-regional resources.	Belgium, Bosnia and Herzegovina, Albania, Kosovo, Montenegro, Serbia, Bulgaria, North Macedonia, Greece, Slovenia
Adaptive Governance (often paired with resources constrain)	Flexibility in responding to changes, focus on climate adaptation, reliance on external resources for implementation, potentially unsustainable without continuous support.	Sweden, Finland, Norway, Iceland, Luxembourg, Czech Republic, Croatia, Slovenia, Estonia

Source: authors' own elaboration

4.3 Diversification, Resilience, and the Co-construction of Functional Spaces for Water Supply

4.3.1 Enhanced Attention to Diverse Functional Geographies of Water Supply Amid Growing Risks and Uncertainty

In a context of growing risks and uncertainty, public authorities and water supply organisation pay more attention to multiple overlapping functional geographies of water supply, for example by

- Ensuring that water can be abstracted from a wider range of river basins and aquifers, to minimise risks of supply distribution,
- Monitoring activities with an impact on drinking water quality in catchment areas of abstraction points, and seeking to promote 'virtuous' industrial and agricultural practices in these areas,
- Seeking to improve coordination between contiguous distribution networks, and investing in connectors between systems to increase resilience,
- Developing dialogue and governance instances across administrative boundaries, e.g. to promote water saving measures.

[10] Due to the variable and non-standard nature of urban water management within a country, some countries are classified as belonging to more than one category. At the same time, some countries were not possible to classify due to the limited or uncertain information.

Some concrete examples of these changes based on ESPON NoStaGeo case studies are briefly summarised in Text Box 1 below. Diversification of resources, and new or strengthened forms of resource protection occurs in all these regions. These interventions increasingly combine technical measures with territorial planning and multi-actor dialogue. Together, these examples demonstrate that water supply geographies are evolving through both physical infrastructure and institutional innovation, but often in uneven, path-dependent ways shaped by local context and legacy arrangements.

Text Box 2 Concrete examples of diversification of water resources

Paris: Drinking water is sourced from multiple aquifers and distant rivers, enhancing resilience to local pollution and droughts. However, strategies for the City of Paris and surrounding suburban areas remain clearly distinct. Coordination primarily evolves between authorities and operators that share similar views on the role of public and private bodies in water supply, rather than across the entire metropolitan region.

Barcelona: The city relies on the Ter and Llobregat rivers, aquifers, and two desalination plants (with plans for expansion). The reuse of treated wastewater is also becoming a strategic resource. These diversified sources are integrated into a coherent regional system managed by the public operator ATL, which supplies over 100 municipalities.

Berlin-Brandenburg: The region relies primarily on groundwater (95%), with artificial infiltration of river water used to support recharge. Despite the interdependence of hydrogeological systems, water management remains fragmented between Berlin and Brandenburg, with limited institutional integration.

Łódź: The city's water supply is now 90% groundwater-based, following a strategic shift away from polluted surface sources. Parallel systems are maintained for redundancy. However, integration across municipal boundaries is limited, and emergency interconnections are minimal, although though Łódź has signed agreements to support neighbouring municipalities during disruptions.

However, it neither appears purposeful nor feasible to delineate correspond 'emerging geographies' at the European level. Instead, the four case studies illustrate a fragmented landscape of functional geographies and strategic responses:

- River basin and aquifer delineations, produced as part of the implementation of the Water Framework Directive and analytical projects such as ECRINS and HydroSHEDS, represent only one of several functional geographies relevant to water supply. A comprehensive understanding requires integration with the geographies of water infrastructure, major water-impacting activities, and consumption patterns to reflect non-standard configurations of water provision.
- A range of strategies are employed to enhance water supply resilience, including advanced purification methods, water saving and reuse, desalination, and the promotion of ecological farming in catchment areas. Each approach is associated with specific forms of non-standard geographies that adapt to local constraints and opportunities.
- Public authorities and water supply operators often promote different, and sometimes competing, spatial frameworks for water provision, management, resource protection, and contingency planning. The Paris Metropolitan Area provides a particularly illustrative example of this multiplicity of functional geographies.

- Path dependency in the spatial organisation of water supply is stronger than for many other key services of general interest. This reflects the high capital intensity, longevity, and inflexibility of water infrastructure, including reservoirs, treatment plants, and distribution networks. Once established, these systems are difficult and costly to modify. Additionally, the high political and social costs of disruption tend to discourage significant changes, even when systems are inefficient or unsustainable. Regulatory constraints, historical agreements, and entrenched stakeholder interests further reinforce this inertia.
- In response to uncertain future changes in framework conditions, particularly those related to climate change, policymakers are actively seeking to enhance the resilience of water supply systems. While these processes are informed by scientific evidence and scenario modelling, they unfold in an environment marked by extensive uncertainty regarding long-term climate impacts, demographic trends, and socio-economic developments. As a result, the emphasis is placed less on identifying optimal solutions and more on building consensus among stakeholders around reasonable, adaptive responses to identified risks.

It is nonetheless possible to generate evidence that can inform functional area approaches addressing metropolitan water supply challenges across Europe. Temporal datasets on water availability and variability, including seasonal and interannual fluctuations, at an adapted functional level, e.g. HydroSHEDS level 6 and WISE WFD groundwater bodies, could for example be generated . Such datasets could be drawn from existing datasets generated as part of European reporting obligations, and processed to optimise employability for spatial planning and territorial sustainable development strategies. The objective would be to generate data that could be mobilised as part of collaborative strategic processes in metropolitan areas. Furthermore, data could be processed to generate water accessibility scenarios, drawing inspiration from the Aqueduct 4.0 project of the World Resources Institute (Kuzma et al., 2023).

Metropolitan authorities and stakeholders could also benefit from more systematic compilations of more qualitative data, e.g.:

- inventories of good practices in metropolitan areas (e.g. leak reduction, source diversification, reuse solutions, protection of water resources from diffuse pollution, contingency planning).
- Syntheses on the state, functionality, and risk profiles of water supply infrastructure.
- Institutional mapping to clarify the multiplicity of actors involved in water provision, their competences, and coordination challenges.
- Policy maturity indicators, assessing how advanced metropolitan areas are in adopting integrated water risk and resilience planning frameworks.

The above-described review of national governance frameworks for water supply would usefully complement such a database, by providing indications on the regulatory and institutional context for water supply initiatives at the metropolitan level.

The review therefore demonstrates the possibility of wide-ranging comparative analyses of geographic logics of governance processes and policies dealing with metropolitan water supply. Such analyses may be illustrated by maps delineating e.g. spaces of strategic dialogue, water resource monitoring and protection, water storage, abstraction, treatment and distribution operations, water saving strategies. These spaces can be tentative, as illustrated by the ongoing negotiations between Berlin and Brandenburg, or subject to debates and controversies, e.g. in the case of the Paris Metropolitan Area.

These examples suggest that functional areas to enhance the resilience of metropolitan water supply are co-constructed by actors through dialogue and practical cooperation, with

their contours reflecting institutional, social, and policy readiness as much as geography. A major starting point for these co-construction processes are generic metropolitan governance initiatives, when they exist.

4.3.2 Functional Urban Areas and River Basins: Imperfect Starting points for an Exploration of Emerging Geographies of Water Supply

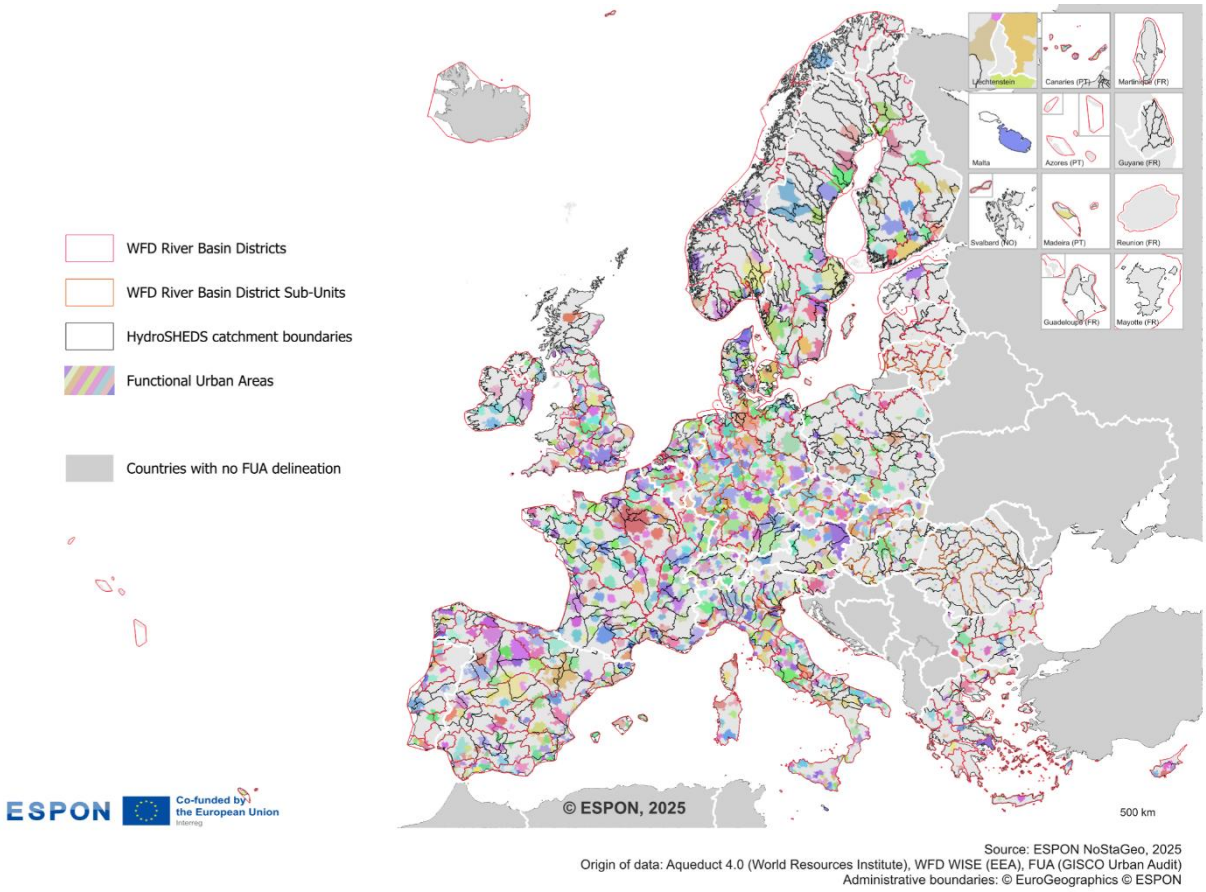
Metropolitan water supply challenges sit at the intersection of several non-matching geographies. First, Water Framework Directive River Basin Districts and sub-units, HydroSHEDS catchment areas and Functional Urban Areas (FUAs) rarely coincide (see Map 1 below). FUAs are delineated on the basis of commuting patterns around continuously built-up areas, while river basin units follow hydrological logics and national implementation choices. Individual FUAs often straddle several river basins, and major river basins often encompass multiple distinct FUAs.

Second, River Basin Districts and sub-units provide only a starting point for understanding emerging geographies of water supply. As discussed in the Annex report on water supply, additional functional perspectives are needed – including:

- areas where drinking water is abstracted and where resource protection measures are required,
- the geography of water distribution infrastructure and interconnections,
- territories where sectoral activities (e.g. agriculture or industry) exert significant pressures on water resources, and
- areas defined by patterns and intensities of water consumption.

Third, Metropolitan Governance Areas (MGAs) are essentially different from Functional Urban Areas: FUAs are statistical units that approximate the *functional city* based on built-up continuity and commuting flows. Delineations are based on consistent criteria applied to a wide range of One of their primary goals is the help produce comparable evidence on social and economic patterns and trends in cities. MGAs are institutionally defined territories created through national laws or intermunicipal agreements. Their purpose is governance: to coordinate transport, land-use planning, environmental management, utilities, and other public services across multiple jurisdictions. As such, MGAs vary significantly across Europe in terms of size, settlement patterns and internal and external functional organisation.

Map 1 Overlay of WFD River Basin Districts and Sub-Units, and HydroSHEDS catchment areas with Functional Urban Areas



Source: ESPON NoStaGeo, 2025
Origin of data: Aqueduct 4.0 (World Resources Institute), WFD WISE (EEA), FUA (GISCO Urban Audit)
Administrative boundaries: © EuroGeographics © ESPON

An exploration of emerging geographies of metropolitan water supply presupposes that one related to this diversity of metropolitan governance practices and understandings of 'metropolitan areas'. In some countries, MGAs cover only the urban core and exclude areas where key abstractions or infrastructure lie; in others, MGAs include large peripheral territories that may not be functionally tied to the urban system but are critical for resource protection. This influences public authorities' capacity to organise cross-sectoral dialogues needed to preserve water resources and the promote sustainable water consumption practices.

Recognising this, the ESPON NoStaGeo project undertook a pan-European mapping of Metropolitan Governance Areas, as described in the following section.

4.3.3 Delineation of Metropolitan Governance Areas as a Starting Point for Integrated Water Supply Strategies

Water supply resilience at the metropolitan scale is a cross-sectoral challenge, spanning urban planning, agriculture, industry, and civil protection. It requires long-term investment planning and sustained cooperation among a diverse set of actors. Such cooperation may occur in a range of spatial configurations, depending on national contexts and governance traditions. However, when the issue at stake is metropolitan water supply, these arrangements tend to intersect with 'generic' (i.e. multi-sectoral) metropolitan governance bodies or initiatives, where such structures exist. Conversely, the absence of such

governance frameworks can itself be significant, as it may hinder the design and implementation of coherent water strategies at the metropolitan level.

Against this backdrop, the NoStaGeo project undertook a systematic exploratory mapping of metropolitan governance bodies or initiatives across Europe. This mapping deliberately excluded statistical or analytical delineations, as well as exploratory boundaries proposed in strategic documents that lack associated governance structures or stakeholder processes.

The result is a European map of urban governance focused on the largest agglomerations. It contrasts with conventional delineations such as Functional Urban Areas (FUAs) or Local Labour Market Areas (LLMAs). The aim is not to fix a single definition of 'metropolitan', but rather to highlight the diversity of interpretations and delineation logics and metropolitan governance practices across Europe. To this end, metropolitan areas where characterised along 5 axes:

- National frameworks: whether the metropolitan governance instance can be considered an instance of a national policy or regulation (see Map 2below),
- Legal personality: whether the metropolitan governance body has legal personality,
- Regularity of dialogues: whether the metropolitan dialogue forum or decision-making body addresses overarching development issues within in regularly organised meetings,
- EU policy instruments: whether the metropolitan governance body focuses on the implementation of a European instrument such as an Integrated Territorial Investment scheme,
- Fuzziness: whether the delineation of the metropolitan cooperation area can be considered fuzzy, e.g. operating in different geographic settings depending on the issue addressed, or open to adjustments of the cooperation area.

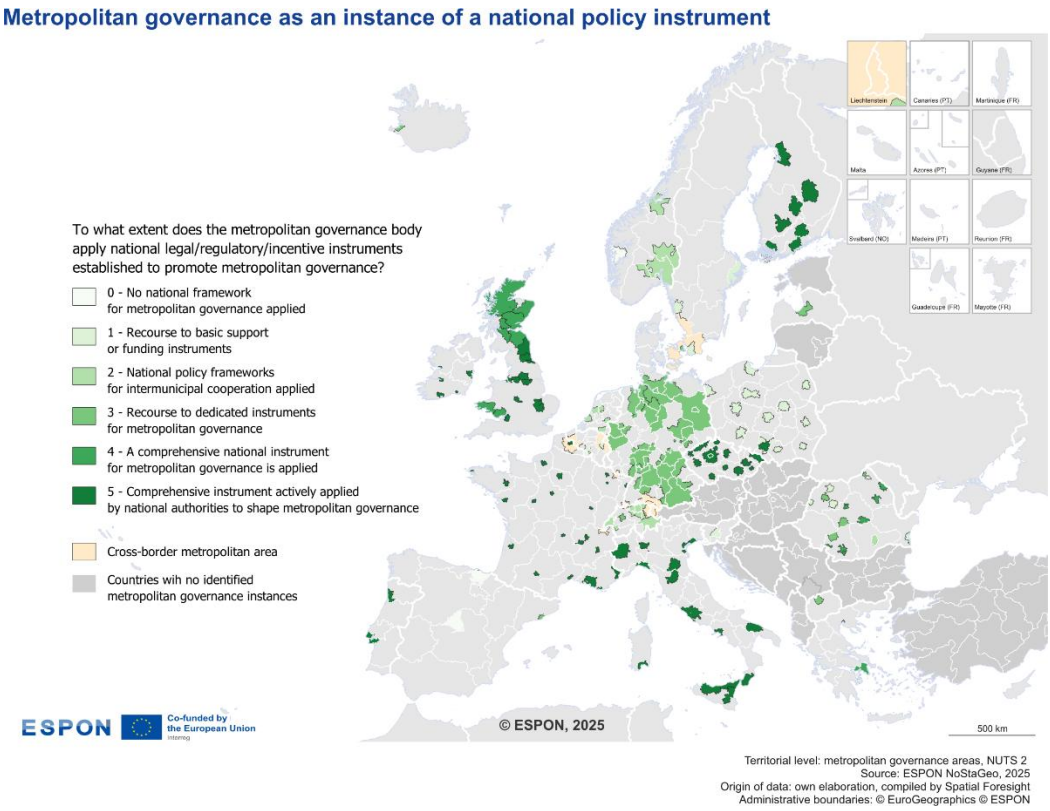
As illustrated by Map 2 below, no metropolitan governance instances could be identified in a significant number of European countries: Estonia, Lithuania, Austria, Slovakia, Hungary, Bulgaria, as well as all Western Balkan countries except Slovenia and Macedonia and Turkey. In other countries, the spatial extent of metropolitan governance areas varies considerably. This is largely linked to the initial objectives pursued. For example, while German metropolitan areas were initially designed to associate as many localities as possible to metropolitan growth dynamics, French metropolitan areas were singled out from generic intermunicipal cooperation arrangements in 2015. It must be emphasised that this delineation is exploratory. It is envisaged as an input for discussion on the delineation of metropolitan governance instances in Europe.

Map 2 also shows that Metropolitan governance structures are to variable degrees embedded in national legal or policy frameworks. Clear national frameworks are most evident in Italy, France, Portugal, Ireland, and Finland, where legislation or formal agreements (e.g. Italy's 2014 law establishing Metropolitan Cities; France's MAPTAM law) define the metropolitan level and its functions.

By contrast, Germany, the Netherlands, and Switzerland rely on softer governance mechanisms without dedicated metropolitan laws. In these cases, metropolitan cooperation often emerges from regional planning traditions, voluntary municipal partnerships, or spatial policy initiatives like Germany's IKM framework or Switzerland's Metropolitanräume.

In Eastern and Southern Europe, national frameworks vary. Poland's Silesian Metropolis is a standout with its 2017 Metropolitan Act, while other Polish regions operate through ITIs without a unified legal basis. Similarly, Romania recently formalised its metropolitan areas via Law 246/2022, but practical implementation remains uneven.

Map 2 Metropolitan Governance as an Instance of a National Policy Instrument

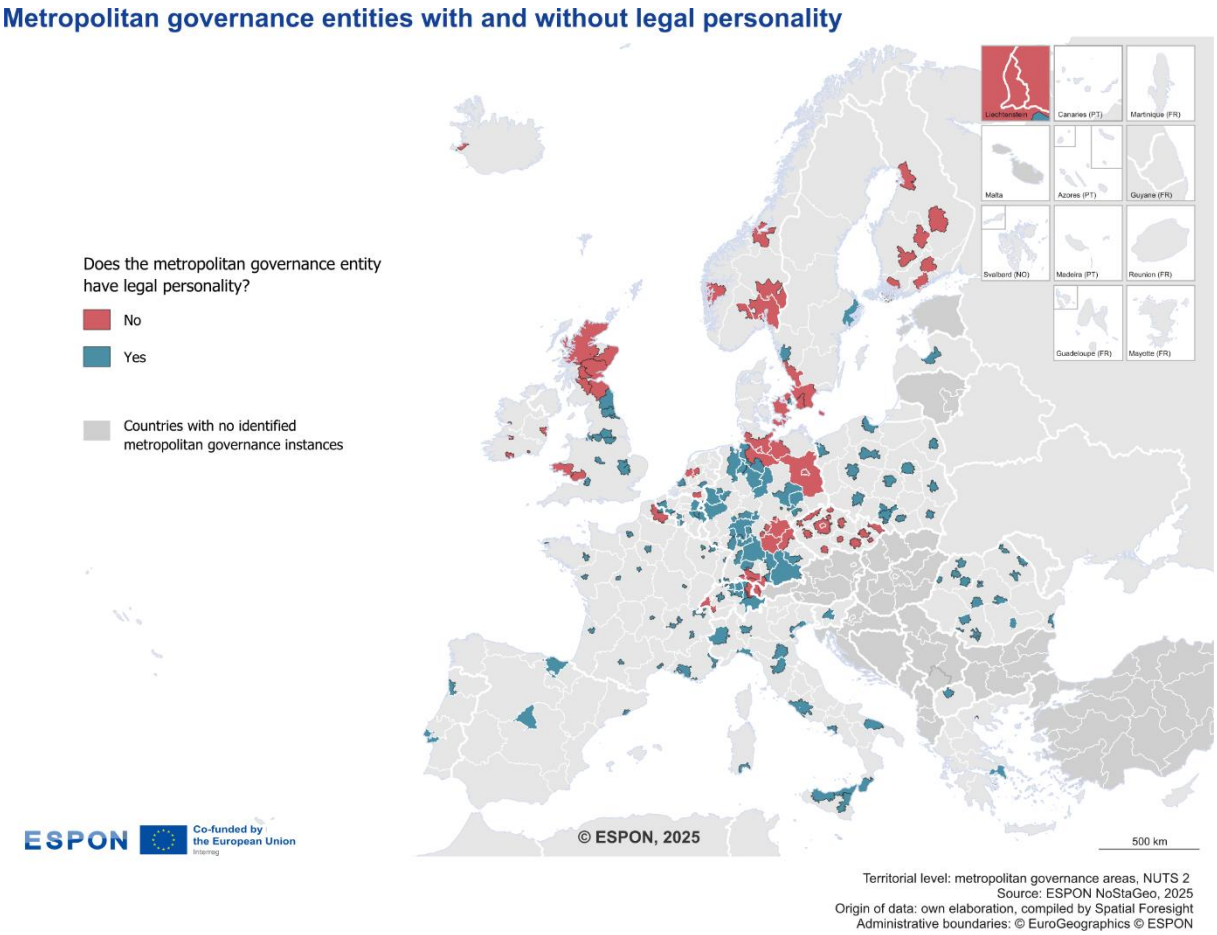


The review has also shown that some metropolitan governance structures have formal legal personality, while others operate informally or without independent status (Map 3 below). Legal personality is prevalent in France, Italy, Portugal, and Poland, where metropolitan entities function as public law associations or statutory bodies. For example, the Área Metropolitana de Barcelona and Lisbon Metropolitan Area have legal autonomy and administrative capacity. Stockholm's Storsthlm operates as an intermunicipal association (Kommunförbund) which is defined as a not-for-profit organisation.

Among cases of metropolitan areas without legal personality, we find bodies responsible for the implementation of inter-institutional cooperation agreements such as the Metropolitan Area Strategic Plans (MASPs) in Ireland and the Land-use, housing and transport agreements (MAL) in Finland. We also find bodies established to implement EU Integrated Territorial Investment schemes (e.g. in Czechia, and Thessaloniki in Greece).

Some hybrid cases, like Charleroi Métropole (Belgium), are transitioning towards formalisation, recently establishing a cooperative society. Legal status often correlates with institutional maturity and the ability to manage resources and implement policy.

Map 3 Metropolitan governance entities with and without legal personality



The regularity and formality of intermunicipal coordination can be an indicator of the extent to which metropolitan governance instances structure policy debates within their area (Map 4 below). High scores are found in regions with institutionalised strategic planning and dedicated governance bodies, i.e. metropolitan areas that operate within a national legal or policy framework. This is for typically the case for France's Métropoles, Italy's Metropolitan Cities, and Portugal's metropolitan areas. The Silesian Metropolis in Poland, Dutch metropolitan areas, and Helsinki region MAL agreements also have high scores, thanks to formal coordination forums and recurrent meetings.

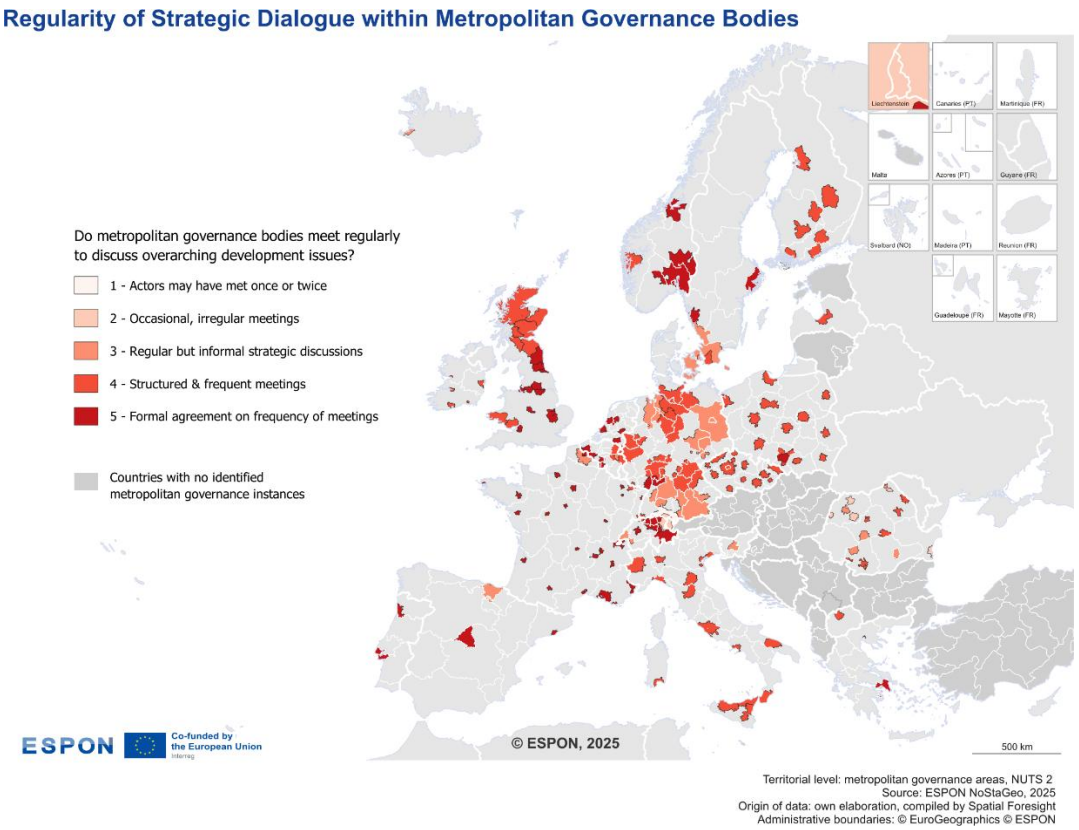
Intermediate regularity can be observed in different types of settings:

- German metropolitan regions, despite their planning mandates, show **variability in coordination intensity**, influenced by federal diversity.
- Belgium's Liège Métropole and Charleroi Métropole recently strengthened coordination but have not yet reached the most robust routines.

The Spanish cases of Bilbao Metropoli-30 is an example of a metropolitan areas with low regularity, correspond to strategic orientation without permanent coordination mechanisms.

This map illustrates that **regular, institutionalised dialogue is uneven** and not always linked to legal status.

Map 4 Regularity of Strategic Dialogue within Metropolitan Governance Bodies



A detailed methodological description of the compilation of metropolitan governance areas and further characterisations of these areas can be found in Annex 6b.

4.4 Policy recommendations

Based on the case studies, national governance framework analyses and literature reviews, the following policy recommendations may be formulated.

Strengthen policy coherence across administrative levels and functional territories:

- Foster alignment between national frameworks and local realities through multilevel governance mechanisms that reflect hydrological and infrastructural interdependencies (e.g., Berlin-Brandenburg joint planning authority).
- Establish dedicated coordination bodies or permanent inter-municipal platforms to facilitate joint planning across emerging functional territories.
- Use statutory instruments (e.g., mandatory cooperation laws like France's MAPTAM and NOTRe) alongside soft governance tools (e.g., voluntary pacts, river basin committees) to align policy objectives.
- Promote interoperability of planning tools across jurisdictions by adopting shared data standards and synchronised planning timelines.

Deploy flexible mechanisms for integrated and adaptive governance:

- Recognise and plan for overlapping functional geographies (e.g., water abstraction, pollution control, demand clusters) rather than enforcing rigid territorial delineations.
- Incentivise inter-basin and inter-operator cooperation through funding instruments and contingency infrastructure investments (e.g., water transfers, desalination nodes).
- Facilitate scenario-based planning and joint strategy development to manage uncertainty and shared risks, as seen in adaptive systems like the Netherlands' Delta Programme.

Promote capacity building and technical empowerment of local stakeholders:

- Support metropolitan and local authorities in building in-house expertise on water governance through targeted training programmes, exchange networks, and twinning schemes.
- Provide guidance on institutional mapping and functional diagnostic tools to help stakeholders understand their role in broader water governance systems.
- Embed technical assistance and governance advice in infrastructure investment funding (e.g. EU cohesion funds) to ensure alignment between physical and institutional development.

Enhance transparency, participation, and communication mechanisms:

- Institutionalise regular stakeholder dialogues at functional territorial scales, involving actors from rural source zones and urban consumption areas.
- Strengthen public engagement practices by using spatially disaggregated data (e.g., distribution units or consumption clusters) to tailor outreach and responsibility-sharing.
- Support the development of water observatories or transparency portals at metropolitan scales to monitor functional integration and governance performance.

Encourage Learning from Good Practice and Innovation:

- Document and disseminate successful examples of territorial cooperation (e.g., Eau de Paris' ecological farming partnerships, Barcelona’s ATL).
- Develop a European platform for sharing tools and experiences on governance of functional territories in water supply.
- Promote cross-country peer reviews to benchmark institutional maturity and identify policy transfer opportunities.

5 Brown to Green Industrial Transitions

KEY FINDINGS

- **The brown to green industrial transition is a multi-dimensional phenomenon**, shaped by regional path dependencies, varying institutional capacities, different stakeholder constellations, as well as constantly changing labour market circumstances, shifting geopolitical conditions, and increased pressures due to multiple crises.
- The regional trajectories of industrial employment are divergent across Europe, reflecting factors such as industrial specialisation, innovation capacity, skills availability, or governance set-ups. Skill sets in traditional carbon-intensive industries are being challenged by technological advancements and the gradually advancing twin transition. **Thus, re- and upskilling as well as attracting and retaining skilled labour force are key elements for the green and digital industrial transition**.
- Policies for education, training and skills development must be closely coordinated with measures that enhance the attractiveness of places such as affordable housing, high-quality public services and support for vibrant communities. Achieving this requires the active involvement of key local stakeholders. As a result, industrial transitions are increasingly designed and implemented within **place-specific, integrated cooperation spaces** where public and private actors work together.
- Innovation-oriented and technology-driven green industrial trans-formations lead to emerging knowledge-flow geographies taking the form of networked functional innovation areas. Especially in non-metropolitan industrial regions, local economic hubs rely on networked interregional R&D ecosystems and talent pipelines, producing **spatially fuzzy, multi-scalar innovation spaces** that reconfigure as technologies and value chains evolve.
- **Hard location factors** such as the availability of renewable energy **are coming again to the fore** in the context of industrial transitions, as **clean, renewable electricity represents an enabler of the green industrial transformation**, especially in energy-intensive industries. As (green) hydrogen becomes increasingly important in industrial transitions, the emerging geography of the hydrogen economy will lead to new functional spatial patterns of 'hard' infrastructure (including production, storage, and transport) and new 'soft' governance mechanisms.
- In industrial transition regions, non-standard geographies may have a specific economic core in the functional regional context but are also **constantly evolving** in their territorial dimension. These are not territories that tend to harden in time towards new geographies but **remain inherently spatially dynamic**.
- For local and regional authorities, brown to green transitions unfold in evolving, overlapping functional territories that rarely fit administrative borders. **National and EU frameworks therefore need to enable functional area governance** through statutory cross-boundary mandates, place-based funding (PO5/ITI/CLLD), shared diagnostic tools, and adaptive learning systems so regions can act under uncertainty and maximise local social and economic returns from green reindustrialisation.

5.1 Theme introduction

The transition from brown to green industries represents a critical and complex component of Europe's broader efforts to achieve climate neutrality, whilst increasing competitiveness and becoming more resilient. Anchored in the European Green Deal, the industrial transformation implies not only technological solutions to decarbonise high-emitting economic sectors, but also a profound socio-economic and spatial reconfiguration process.

The academic literature recognises the transition as a multi-dimensional phenomenon, which is being shaped by region-specific trajectories, varying institutional capacities, different stakeholder constellations, as well as constantly changing labour market circumstances, shifting geopolitical conditions, and increased pressures. Grasping these dimensions and understanding the emerging regional geographies of industrial transitions has therefore become increasingly important in order to develop tailored policies to support the transformation processes across European regions.

The brown to green transition generally follows two interrelated pathways. The first focuses on greening existing regional industries through technological innovations and process optimisations, including circular economy practices leading to greenhouse gas (GHG) emissions reduction or sustainable regeneration and redevelopment of brownfield sites. The second pathway aims to shift the industrial composition within a region by developing existing (early stage) green economic activities as well as attracting new green industries, building on existing capabilities (Grillitsch and Hansen, 2019; Nyangchak, 2022). In parallel with existing or emerging ecosystems focusing on green growth opportunities, explicit phasing-out policies targeting unsustainable, fossil fuels-based, emissions-intensive industries are needed, supporting regions which have their economies built around these structures (Pichler et al., 2021). Even though advancements in clean (energy) technologies are amongst the key drivers of this transition, both pathways require rethinking business processes along the value chain as well as the spatial organisation of industrial activities, leading to new emerging functional dimensions. These restructuring processes come along substantial investments in hard infrastructure, such as energy systems, transport corridors, etc., and soft coordination mechanisms, e.g. within regional innovation systems, multi-level stakeholder networks, public-private partnerships, etc., while simultaneously addressing social equity aspects to ensure a just transition.

These transformation processes will fundamentally shape Europe's economy, directly impacting regional and local development. At the regional level, the transition has also significant implications in terms of employment structure and labour market dynamics. Skill sets in traditional carbon-intensive industries are challenged by technological advancements and the gradually advancing twin (green and digital) transition. Subsequently, re- and upskilling initiatives become increasingly important. However, this labour shift is not uniformly distributed, as some regions face acute risks of job displacement due to phasing-out fossil fuels-based economic activities (e.g. phasing-out coal mining or coal-based energy production), and others experience high demand for specialised workforce in emerging green (or digital) clusters. Addressing these disparities requires both labour market interventions and cross-sectoral and territorially integrated planning efforts, including education and lifelong training opportunities. Strengthening labour markets in the brown to green transition requires also adjacent investments in affordable housing, sustainable mobility, accessible healthcare and social services, as well as community building to ensure that regions can retain, attract, and support the skilled labour force needed for long-term transformation.

The industrial transformation unfolds in a context of evolving geopolitical pressures, including energy security, supply chain disruptions, and shifting global trade regimes. In

response, the EU has developed several strategic policy instruments such as the European Industrial Strategy, the Just Transition Mechanism, the Critical Raw Materials Act, the EU Taxonomy, Regional Innovation Valleys, the Clean Industrial Deal. These key policy instruments aim at enabling the transformation towards net-zero economies whilst fostering economic competitiveness, reducing strategic dependencies, and ensuring that no region is left behind. Thus, the transformation processes need to be regarded from the perspective of the industry-geography-relationship, by also taking into account existing ecological boundaries and social dynamics (Chlebna et al., 2023). Place-based strategies and experimental multi-level governance approaches become crucial, aligning EU-level ambitions, national frameworks, and regional and local implementation capacities (OECD, 2023).

Essentially, the brown to green industrial transition is not just a technology-based transformation, but a territorially differentiated reconfiguration process, deeply embedded in regional, historically evolved socio-economic structures. The transition implies coordinated efforts from a wide range of stakeholders, from companies and public authorities to labour unions and civil society, that translate into territorially integrated industrial, environmental, and cohesion policies in order to ensure just and sustainable regional transformations across Europe.

Based on these overarching narratives and dimensions of brown to green industrial transition derived from the literature review (academic and grey literature, policy documents) and the consultations conducted, the ESPON NoStaGeo project aimed at exploring different regional transition pathways across Europe. A strong emphasis was on emerging dimensions of industrial transition's geographies and shifts arising from various changing circumstances. The project team analysed governance frameworks in place associated with the just green industrial transition across Europe and identified four representative case study regions displaying different trajectories of industrial transformation, accompanied by changing spatial configurations and governance settings. Thus, key inquiry aspects have been:

- regional industrial change implications of for spatial scales, patterns, flows, dynamics, and governance instances,
- potential changes in the understanding of spatial perimeters due to the brown to green transition,
- functional relations gaining importance as a result of the spatial reconfiguration associated with green industrial transitions.

The main findings on the governance arrangements of the brown to green industrial transition across different institutional contexts in Europe as well as in four representative industrial transformation case study regions are summarised and reflected upon in the following sections. Based on the outlined findings, policy implications are subsequently discussed.

5.2 National governance frameworks

The analysis of the governance configurations of green industrial transitions across different European settings highlights the diverse approaches, particularly with regard to stakeholder involvement and coordination, cross-sectoral integration, adaptability to changing contexts, and place-based orientation. While most European countries face various transition-related challenges which are exacerbated by geopolitical pressures, some demonstrate advanced examples of governance arrangements supporting territorially integrated transformations.

A key finding of the assessment is that multi-level and cross-sectoral stakeholder coordination is critical to effectively manage just industrial transitions. For example, Frances' green industrial policies indicate strong coordination practices through well-established multi-level governance mechanisms involving local and regional actors. Similarly, Austria and Sweden have developed institutional frameworks that promote structured dialogue and consensus-building across governmental tiers and sectors. These arrangements can facilitate cooperation between public institutions, private actors, and civil society.

In contrast, countries with highly centralised governance structures, such as Poland, often exhibit uneven stakeholder coordination. While some regions show capacity to adapt and coordinate actions among local and regional stakeholders, others are very much top-down oriented. Broader Central and Eastern European areas, including Hungary and Croatia, reflect a similar pattern where public consultations are held, but often remain formalistic, with limited inclusion of non-governmental actors, e.g. trade unions, or local communities directly affected by the transition within their economic base.

The analysis emphasises the importance of integration across different relevant policy sectors in order to align industrial transformation endeavours with environmental, social, and economic objectives. Notably, Austria illustrates an approach that integrates multiple policy sectors within the just green transition framework, aligning the Just Transition Plan and the National Energy and Climate Plan (NEKP) with EU-level goals and ensuring cross-sectoral coherence. On the other hand, countries such as Albania, Denmark, or Germany primarily focus on a single sector while acknowledging its interdependencies with other policies (e.g. industrial sectors with energy and infrastructure). At the same time, governance contexts such as Wallonia (and Brussels), North Macedonia, or Serbia, are predominantly industry-focused, while lacking considerations for linkages with other sectors. This, in turn, limits integrated regional development.

Governance adaptability to constantly changing conditions is essential for responding to dynamic technological, economic, and political developments and coping with associated pressures. France seems to have a strength in this respect, with a governance system oriented towards experimentation and institutional learning, especially at the local and regional levels. The analysis indicates that numerous French initiatives allow for policymakers to continuously recalibrate the strategies based on emerging evidence and stakeholder feedback. Yet, in other contexts, inertia and limited local capabilities hamper industrial transformations. The coal phase-out in Bulgaria is particularly complex due to the entrenched networks that aim to preserve the status quo by securing costly coal subsidies and undermining policymaking processes for long-term decarbonisation. Estonia is an example, where the implementation of the JTF programme was followed by the assignment of a (temporary) Government's Special Commissioner for accelerating the delivery of the JTF. The creation of this position, the multi-level government coordination, vertically across governmental levels as well as horizontally between governmental units and in collaboration with businesses and further stakeholders, made it possible to address weaknesses in the regional coordination capacity. This example is indicative of the specific challenges, as well as advantages of the JTF programme aiming to support regional strategic collaboration in countries where regional governments are either not existing at a county level or have limited competences and thus allowing for a renewed setting for collaboration. Taken together with the Bulgarian example, it shows that implementing JTF programmes also requires building on existing governance structure that may at times be experiencing path dependent lock-ins in their collaboration dynamics.

Place-based approaches are required to tailor transition strategies to particular regional prerequisites and needs. The Just Transition Plan in Sweden adopts a specific territorial approach, targeting the counties with highest industry-related emissions, namely Norrbotten, Västerbotten, and Gotland, while considering their socio-economic profiles and

industrial structures. This enhances the effectiveness of the envisaged transformation interventions. Other countries like Austria, Germany, Ireland, Norway, Poland, and Switzerland exemplify an advanced JTF approach where territorial integration is based on functional criteria and embraces physical (hard) and intangible (soft) spaces. This reflects a deep consideration of spatial dynamics, where functionality and specificity play a central role. Similarly, Flanders, Croatia, the Czech Republic, Denmark, France, and Italy showcase a balance between institutional agreements and functional flexibility, allowing for tailored spatial considerations.

While several European countries have made significant progress in adjusting governance structures and processes to enable a just green industrial transition, there still are persisting differences. The analysis underscores the importance of integrated, flexible, and territorially sensitive governance arrangements in steering industrial transitions. Countries that institutionalise multi-level collaboration, sectoral alignment, and regional adaptability are better positioned to achieve environmentally sustainable and socially inclusive outcomes when phasing out fossil-based industries and transition to a green(er) economy.

Preliminary typology of just and green transition governance

The governance of industrial transitions across European regions reflects a diverse landscape of institutional arrangements responding to the needed shift from a carbon-based to a green economy. A developed preliminary typology encompasses five governance models (Table 4): Centralised policy-driven; Decentralised multi-level governance; Functional governance; Collaborative innovation-driven; and Community-led bottom-up models, highlighting differences in institutional capacity, decentralisation, innovation policy, and community engagement across national contexts. These models possess varying strengths and limitations in addressing the multifaceted challenges of just and sustainable industrial transformation:

- **Centralised policy-driven governance** models are characterised by top-down planning and strong reliance on national governments to elaborate and lead the implementation of transition strategies. This approach is prevalent in countries such as Montenegro (through the 'Industrial Policy of Montenegro') and Lithuania, relying on the central government to coordinate decarbonisation objectives. While this model ensures strategic coherence and alignment to EU goals, it tends to limit local participation and responsiveness to place-specific needs.
- **Decentralised multi-level governance** emphasised the distribution of responsibilities across national, regional, and local levels, enabling tailored responses to regional industrial transition challenges. Germany and Switzerland demonstrate this approach through regionally adapted strategies that integrate local perspectives while aligning with national targets. However, coordination between governance levels can be complex, as seen in Belgium, where regional divergence challenges national-wide cohesion.
- **Functional governance** prioritises spatial alignment with economic and ecological interdependencies rather than administrative boundaries. France and Slovenia illustrate how this model facilitated targeted interventions in industrial areas, e.g. Seine Valley, or cross-border regions, e.g. North Adriatic Hydrogen Valley. While offering flexibility and resource optimisation, functional models often struggle with inter-jurisdictional coordination and policy alignment, as the example of the coal-mining Jiu Valley in Romania shows.
- **Collaborative innovation-driven governance** relies on partnerships between government, industry, and research institutions to foster industrial transitions through technological and organisational innovations. Netherlands' Port of Rotterdam and Sweden's green steel joint venture HYBRIT showcase this model's

capacity to align green transitions with economic competitiveness. However, a strong emphasis on technology-oriented transformation may overlook social equity, particularly for communities affected by industrial decline.

- **Community-led bottom-up governance** highlights local and regional empowerment and inclusive participation. Denmark's co-ownership structures for renewable energy projects as enablers of green industrial transition and Ireland's community involvement in the elaboration and implementation of Territorial Just Transition Plans represent this type of governance model. While it strengthens democratic legitimacy and social cohesion, this model cannot be easily scaled up, especially in regions with weaker institutional capacity or with early-stage transition frameworks.

This proposed typology showcases the variety in Europe's governance approaches to navigate the brown to green and just industrial transitions. Noteworthy is that, while the proposed types are presented as distinct, individual countries may exhibit features of multiple territorial governance models. For the purpose of this analysis, however, each country is classified under the model that reflects its predominant characteristics, even if not exclusively. Nevertheless, as regions across Europe are confronted with rising climate and economic pressures, managing industrial transitions might require mixed approaches, combining top-down coordination with local and regional empowerment, as well as functional and territorial integration, beyond sectoral divisions and across administrative boundaries.

Table 4 Typology of brown to just green transition governance

Type	Countries	Features	Limitations/challenges
Centralised policy-driven model	Albania, Bosnia and Herzegovina, Bulgaria, Croatia, Cyprus, Czech Republic, Greece, Hungary, Kosovo, Iceland, Lithuania, Luxembourg, Malta, Montenegro, North Macedonia, Serbia, and Slovakia.	Strong reliance on national governments to define and implement transition strategies	Limited participation of local communities in decision-making processes
Decentralised multi-level governance model	Austria, Estonia, Finland, Germany, Wallonia, Flanders, Italy, Lithuania, Poland, Portugal, Switzerland (and Liechtenstein) and UK – England; UK – Wales.	Emphasises the distribution of authorities across national, regional, and local levels, fostering collaboration and participatory decision-making	Challenges in coordination due to regional disparities
Functional governance model	France, Romania, Spain, Slovenia, UK - Scotland	Takes a spatially adaptive approach, focusing on regions defined by their industrial, ecological, or economic interdependencies rather than administrative boundaries	Difficulties in aligning policies across different sectors and jurisdictions
Collaborative innovation-driven model	Sweden, Netherlands and Norway	The model leverages partnerships between public authorities, private enterprises, and research institutions to drive industrial transitions through technological and organisational innovation.	Marginalising vulnerable groups due to lack of economic interests (power)
Community-led bottom-up model	Denmark, Ireland, and Latvia	Ensure that the voices of affected communities are central to decision-making.	Scalability remains limited to local conditions.

Source: authors' own elaboration

5.3 Regional green and just industrial transitions

Empirical evidence from the ESPON NoStaGeo national governance frameworks assessment, pan-European analysis, and case studies reveals diverse transition trajectories across Europe. While some regions are still strongly embedded in extractive industries due to the local availability of natural resources, others are reconfiguring around innovation-driven industries or leveraging logistical and infrastructural advantages. Thus, the geography of industrial transitions is defined not only by the location of production sites, but also by (global and interregional) linkages within value chains, research, development and innovation (R&D&I) ecosystems, regional skills supply, and access to key enablers such as renewable energy, critical raw materials as well as multimodal transport infrastructure. The social dimension adds other layers of complexity in undergoing regional processes, with employment restructuring, re- and upskilling, changing income dynamics, and the provision of public services being equally important for managing regional transitions.

European regions in transition: Framework conditions and response initiatives

The transition from brown to green industries is key to EU's strategy to achieve climate neutrality, foster innovation, and ensure sustainable and resilient economic competitiveness. This structural transformation manifests along the economic, environmental, social, and spatial dimensions. An overarching, pan-European StoryMap developed in the framework of the ESPON NoStaGeo project visualises and outlines some of the key aspects based on recent trends and spatial patterns across European regions, by considering selected indicators such as industrial employment, gross value added, and greenhouse gas emissions from industrial activities, renewable energy production, transport infrastructure, and evolving skills agenda. The following insights can be drawn from the analysis:

The regional trajectories of industrial employment are divergent across Europe, underscoring the complexity of the transition and the need for place-based policies.

In many regions, industrial employment has declined over recent decades, following global trends of structural shifts from manufacturing to service-oriented economies. However, the once clear division between traditional production areas and the service sector has become increasingly blurry. While many Western, Northern, and Southern European regions, such as Northwest Spain, Northeast France, and parts of Southern Italy, continue to experience industrial job losses exceeding 5% between 2012-2022, other regions, notably in Poland, the Baltic states, and Southern Germany or Romania, have seen employment growth in industrial sectors. The case studies conducted illustrate this unevenness: In Norrbotten, Sweden, industrial employment remains relatively stable and is expected to increase based on the planned green industrial investments. Carinthia in Austria displays a dual pattern, as core areas such as Klagenfurt and Villach exhibit employment growth driven by the microelectronics industry, while surrounding rural regions face industrial decline. In Upper Silesia and Western Małopolska, in Poland, traditional coal mining employment remains concentrated while metropolitan areas are increasingly shifting towards service-economies.

While industrial gross value added (GVA) remains an important economic driver, high GVA regions are often heavily reliant on energy- and resource-intensive industries making them hot spots for decarbonisation efforts.

Especially areas in Central and Eastern Europe, Northern Italy, Ireland, Southern Germany, and Northern Sweden present a high share of GVA from industrial activities, which is critical for their regional economies. In Norrbotten, Sweden, the steel and mining sectors contribute significantly to the regional GVA, but global commodity market fluctuations, as illustrated by the rise of global steel prices following the Covid-19 supply chain disruptions, highlight both the economic importance and the vulnerability of such regional industrial profiles.

Considering the development in greenhouse gas (GHG) emission from industrial activities across regions between 2012-2022, consistent efforts to green the existing brown industries are required. Even though Northern Sweden recorded reductions in industrial GHG emissions, the regional steel industry is still a high emitter, making the transition to fossil-free iron and steel making processes and thus decoupling industrial output from emission-intensive processes an imperative. This urgency is also evident in coal-dependent regions, such as Upper Silesia, where coal phasing-out must proceed in tandem with robust socio-economic support and industrial diversification. Instruments such as the Just Transition Fund have been developed to explicitly address these challenges.

While many Westen European regions have seen a reduction in industrial GHG emissions as a complex expression of both industrial output declines and efficiency improvements in industrial processes, some regions in Central and Eastern Europe saw rising emissions reflecting differing trajectories of economic development. These disparities emphasise the necessity of targeted transition strategies that take into account local and regional emissions profiles, the industrial specialisation, as well as the capacity for technological modernisation and innovation.

The regional renewable energy production is an enabler of the green industrial transition, especially in energy-intensive industries.

The brown to green industrial transformation increasingly depends on access to clean electricity, green hydrogen, or bio-based fuels. As an example, in 2023, Sweden led the EU in renewable energy production relative to its gross final energy consumption with 66,4%, mainly derived from hydro and wind power and biofuels from northern regions. This positions areas like Norrbotten to develop low-emission value chains in the energy-intensive steel sector. Therefore, the regional renewable energy production has become an important location factor, with neighbouring Swedish and Finish regions advancing reindustrialisation. The access to regionally produced renewable energy not only supports emission reductions, but also enhances energy security and economic resilience, especially in the context of volatile global energy markets.

Education and training as well as attracting and retaining skilled workforce are foundational elements for the green industrial transition.

The shift towards green economies demands profound attention to skills, competencies, and know-how in local and regional labour markets. While tertiary education is only one component, regional differences in higher education attainment can influence the capacity for innovation and adaptation in low-carbon industrial activities. Re- and up-skilling remain essential to equip both existing and future employees with competencies in areas such as renewable energies, circular economy practices, and digital technologies. Coordinated efforts by the industry, policymakers, and educational institutions are key to building working know-how and skills to drive and support industrial transformations.

Regions like Villach and Klagenfurt am Wörthersee in Austria benefit from established vocational and higher education institutions, especially in high-tech sectors such as microelectronics and semiconductors. Initiatives like the Austrian Chips Competence Center are essential to address evolving skill requirements, particularly in this specialised field of expertise. In this case, enhancing technology awareness and expanding educational outreach among younger generations can further strengthen the regional talent pipeline and support a successful industrial development. Furthermore, strengthening education-industry linkages and promoting lifelong learning are essential to enable and drive green industrial transformation.

Improved transport connectivity and sustainable mobility options also support regional labour market dynamics or facilitate access to educational institutions. Therefore, hard

infrastructure such as transport networks still plays a strategic role, with rail connections, multimodal hubs, or port terminals being also essential for enabling cleaner and more efficient transport of raw materials, intermediate goods, or finished products. For example, the Seine Axis with its Paris-Seine Gateway vision, and as part of the Atlantic Corridor as well as the North Sea-Mediterranean Corridor, demonstrates how integrated logistics systems linking Paris, Rouen, Le Havre support green transitions through inland waterway and rail transport.

As these insights show, successful transitions imply a mix of enabling infrastructure, such as renewable energy systems and transport networks, with tailored industrial and labour market policies, and place-sensitive approaches and governance arrangements. The French Territoires d'industrie (industrial territories) programme showcases an example of a strategy for industrial regeneration by and for the territories. The aim of the programme is to provide practical responses, in and through the regions, to the challenges of supporting industry: development of industrial skills, training, employee mobility, innovation ecosystems, attractiveness of regions and industrial professions, speeding up the ecological transition, availability of land and revitalisation of industrial wasteland. The programme targets 183 groupings of 630 intermunicipal cooperation bodies in 18 regions, mainly located in rural areas, suburban areas and small and medium-sized towns with a strong industrial identity. Delineations of these intermunicipal areas can be considered as non-standard functional areas. These programme areas also allow for cross-regional collaboration and complement with the projects implemented under the JTF programmes.

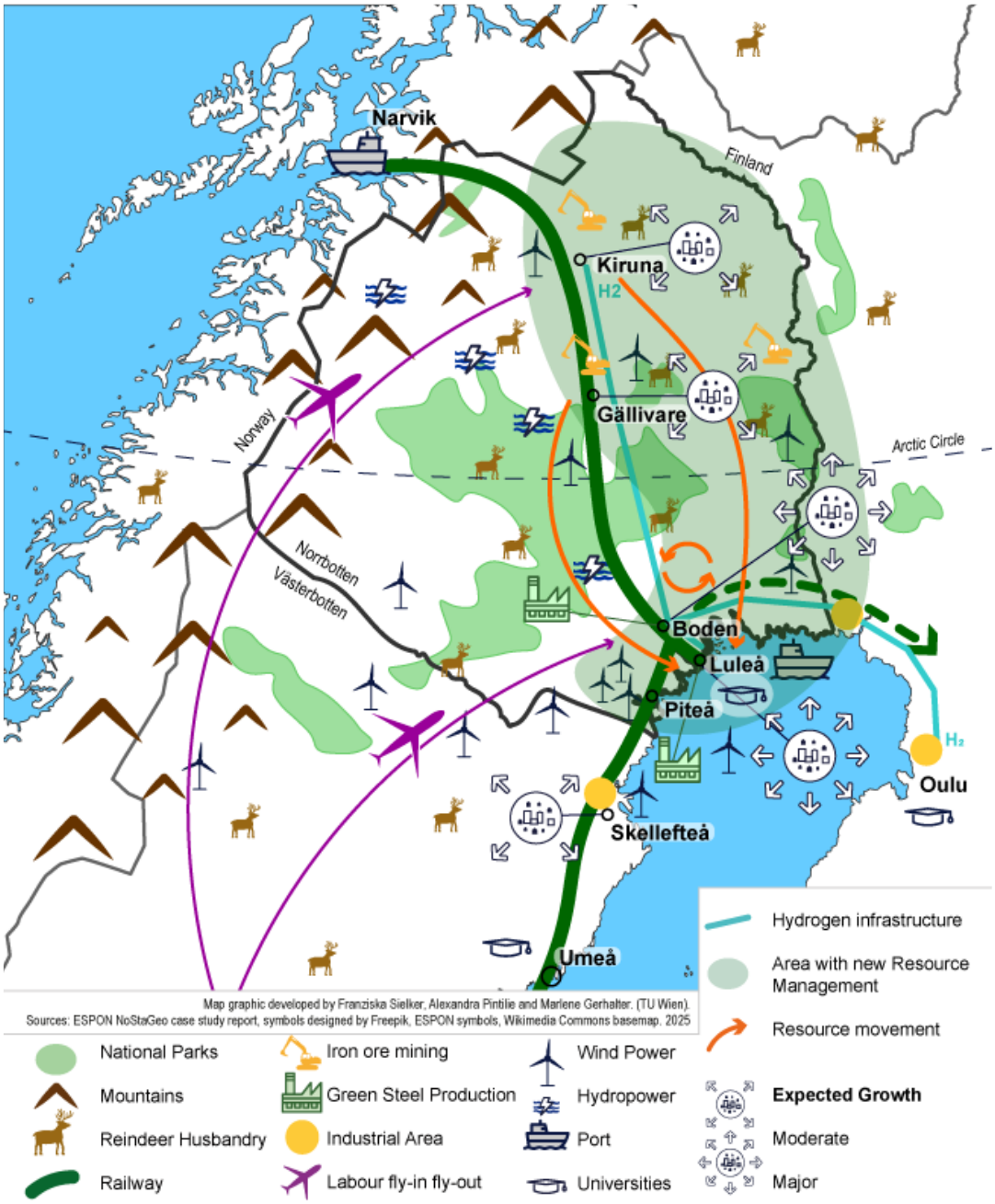
Regional emerging geographies of industrial transitions

Zooming in and diving into concrete regional contexts, the ESPON NoStaGeo project analysed four case study regions which display different trajectories of industrial transformation, leading to the emergence of non-standard geographies against the background of diverse development challenges. These non-standard geographies span across administrative boundaries and develop as a result of new functional linkages in the course of an ongoing transformation. These case studies serve as examples for understanding the ongoing spatial reconfigurations of brown to green industrial transitions.

Schematic maps, so-called mapshots (Figure 6 and 7) based on the ESPON ACTAREA project, have been developed as the main method of visualising spatial patterns and identifying territorial dynamics in the four case study regions: Norrbotten in Sweden, Upper Silesia and Western Małopolska in Poland, Axe Seine and Vallées de la Seine et de la Bresle in France, and Villach in Carinthia, Austria.

Norrbotten, in Sweden, illustrates a resource-oriented transition shaped by the decarbonisation of the steel industry. As hydrogen-based steel production develops, both replacing coal-based production in an incumbent core company and as newly built integrated facility by a new market entrant, the regional economy in being reconfigured around new energy systems and flows, raw material value chains, and expanded logistics capacities. Functional geographies around regional hard infrastructure are thus intensifying or emerging beyond local or regional administrative boundaries. Simultaneously, being a region in the Arctic Circle, attracting and retaining labour force is a substantial challenge, and coordinated efforts and new dynamics are required. With the industrial growth, temporary labour migration showcases that the immediate region is also strongly related to regions further away. This northern Swedish case underlines the importance of coordinated planning across energy development, industrial investments, attracting workforce, and strengthening local communities to enable and support an inclusive and sustainable green transition.

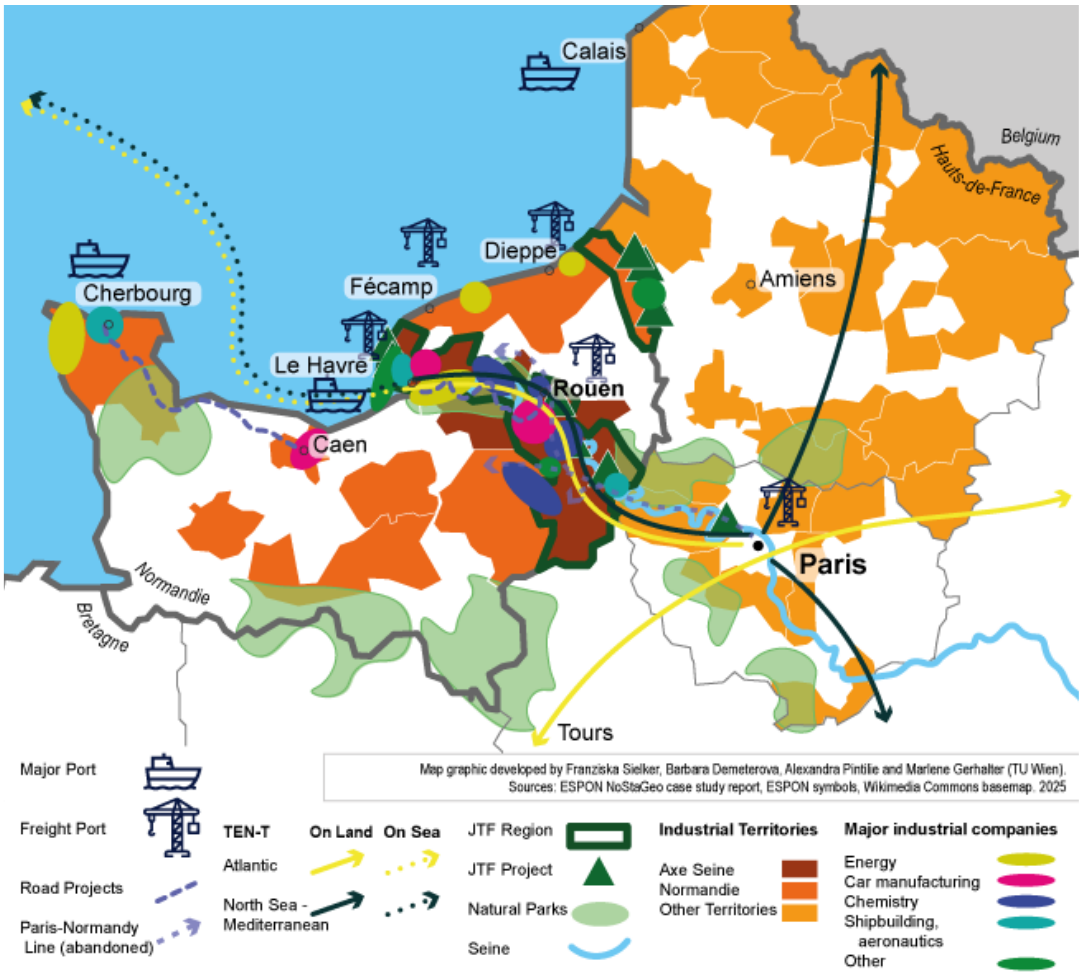
Figure 8 Mapshot of emerging functional geographies in Norrbotten



Upper Silesia and Western Małopolska, in Poland, present a complex case of socio-economic and spatial restructuring during the transition away from coal mining and coal-based energy production. In this region, traditional resource-based industries, suburbanisation processes, and demographic decline lead to a fragmented geography of transition, where industrial renewal, shrinking urban areas, and commuting hot spots coexist. This fragmentation challenges integrated regional planning, reflecting also the need for managing socio-economic inequalities and territorial cohesion in order to enable a just brown to green industrial transition at local and regional scale. Multi-level governance coordination is a must to support local and regional developments. This case study showcases the interrelations towards other decision-making levels.

Axe Seine and Vallées de la Seine et de la Bresle, in France, show a multi-scalar transition focused on industrial modernisation, cluster collaboration, and circular economy principles. With key multimodal transport infrastructure and strategic maritime access, the region capitalises on its logistical strengths to facilitate a green industrial transformation. Initiatives such as the Glass Valley cluster integrate sustainability with high-value manufacturing, while national and regional development strategies serve as the primary anchors for long-term transition efforts in the region. However, their integration and alignment with European-level instruments remain a significant challenge, highlighting the need for greater coordination to ensure coherence, avoid duplication, and maximise synergies across the Axe Seine region. The region has over the past decades been more and more integrated within European wide infrastructure networks and has locally been expanding as well. Its geography is thus shifting towards more intra-regional cooperation while at the same time its interregional functional relations are intensifying as well.

Figure 9 Mapshot of emerging functional geographies in the Axe Seine region



Villach in Carinthia, Austria, is an example of technology-driven transition in a non-metropolitan setting. In recent years, the regional economy has evolved towards a specialised high-tech cluster in microelectronics and semiconductors, as enablers for Europe's brown to green transition. Initially anchored by a core company and supported by a proactive technology-, research- and education-oriented regional policy, this pathway has led to new geographies of innovation, a strong R&D ecosystem, cross-regional talent recruitment initiatives, and networks such as the Silicon Alps Cluster. With Villach and the surrounding regions, including Graz, Austria's second largest city, being an ecosystem in constant adaption to changing global conditions to maintain its leading position, this case

highlights the importance of skill attraction and interregional knowledge flows in an innovation-led transformation with a specialised industry. Its emerging geography is an example for a network structure situated in a wider regional context.

These examples show the diversity of regional transition pathways, leading to new or changing geographies of economic function and governance. These emerging geographies of brown to green industrial transitions demonstrate that the transformation and its success very much depend on aligning industrial specialisation and change with hard, physical infrastructure (energy systems, transport, etc.) and soft coordination initiatives (e.g. stakeholder networks and clusters, attracting skills beyond administrative boundaries). Coordinated planning across sectors and scales is essential to manage complex socio-economic shifts, especially in regions facing legacy industrial decline or demographic pressures. On the other hand, innovation-led and technology-driven transitions show the importance of building strong (cross-)regional R&D ecosystems, fostering talent attraction and enabling interregional knowledge flows. In addition, effective multi-level governance and alignment of local, regional, national, and European instruments are essential to ensure coherence, equity, and resilience in green industrial developments.

5.4 Policy recommendations

Industrial transition and specifically achieving brown to green transition requires a number of different activities and the engagement of stakeholders at various levels. In regional processes of brown to green transition, we have observed non-standard geographies, which sit alongside existing administrative levels and governance structures. Against this background the following policy recommendations can be given:

- **develop and implement place-based strategies and instruments tailored to regional transition pathways**

The case studies at hand showed the importance of developing strategies that take the substantial differences of the regions, their foundations, industrial specialisation and trajectories into account. In Northern Sweden for example, Tillväxtverket, the Swedish Agency for Economic and Regional Growth, plays an important role in bringing stakeholders together jointly aiming to tackle the challenges ahead, being appointed by the government to coordinate the new industrialisation and social transformation processes in the northern regions. A 'Strategy for new industrialization and social transformation in the counties of Norrbotten and Västerbotten' has also been developed. Furthermore, the JTF in Norrbotten is focused explicitly on the transformation of the steel industry. In France, for example, the alignment of French funding opportunities and the French 'Territoires d'industrie' (industrial territories) programme showcases an example of a strategy for industrial regeneration by and for the territories. The aim of the programme is to provide practical responses, in and through the regions, to the challenges of supporting industry: development of industrial skills, training, employee mobility, innovation ecosystems, attractiveness of regions and industrial professions, speeding up the ecological transition, availability of land and revitalisation of industrial wasteland. The programme targets 183 groupings of 630 intermunicipal cooperation bodies in 18 regions, mainly located in rural areas, suburban areas, and small and medium-sized towns with a strong industrial identity. Delineations of these intermunicipal areas can be considered as non-standard functional areas. The Polish case of coal phasing-out shows that employment restructuring must be carefully managed through policies that balance job creation in green sectors with inclusive support for displaced workers.

Therefore, territorially integrated planning efforts, including education and lifelong training opportunities, affordable housing, sustainable mobility, accessible healthcare and social services, as well as community building are important themes. Developing place-based strategies means to take into account the different territorial reach of these emerging geographies and to carefully ensure that stakeholders participate beyond the traditional cooperation schemes. In addition, as emphasised during the final reflection and discussion round with policy stakeholders and regional interested participants, monitoring and evaluating the integrated, place-specific policies supporting regions in industrial transition is also essential for ensuring long-term commitment and coherence.

- **visualise multi-level representations of shifting interdependencies in times of transition**

The case studies conducted showcase clearly that in times of industrial transition new interdependencies emerge both horizontally and vertically, as well as the coordination across different sector policies and planning gain importance. To give an example, with newly emerging renewable energy systems including green hydrogen, infrastructural corridors and nodes may change and shift current development patterns. In making industrial transition processes work, it is important to better understand that, with the emerging dominant development paths, new multi-level interdependencies unfold. Our policy recommendation thus is to visualise better how the multi-level decision making processes and stakeholder networks work, and what transition processes mean for shifts in multi-level governance. A better understanding of the interdependencies of these processes by regional and national stakeholders is, therefore, essential.

- **support emerging / established competitive economic specialisations and economic diversification through coordinated stakeholder engagement**

In analysing the case studies, it became clear that a well-organised coordination is needed to help economically specialised regions as well as very diversified regions to move forward in their development and enable a green transition. This can encompass bottom-up processes, from within the regions or across regions, as well as framework conditions set through national or EU funding programmes, designed in such a manner that they are accessible and utilised by regional stakeholders.

> e.g. a good practice is represented by industrial companies, education institutions and public authorities from different federal provinces coming together to attract international workforce in specialised microelectronics and semiconductor industry in Carinthia and Styria, Austria. This would be also relevant in other areas, such as in Norrbotten, Sweden, where being a sparsely populated region in the Arctic adds another layer to the existing challenges; therefore, coordinated efforts with neighbouring regions, e.g. Västerbotten or Finish regions, would be helpful to achieve a critical mass

- **enhance cross-regional and cross-sectoral linkages through networks and clusters**

In building on the cross-regional and cross-sectoral linkages in the regions, cluster developments emerging from local economic hubs have been mentioned during consultations as an important tool to help support regional knowledge and business networks. The cluster initiatives are key stakeholders in attracting additional investment into the regions and acting as important interlocutors and business spokespersons with administrative and political stakeholders. Some good practices are

> e.g. the Silicon Alps Cluster bringing together stakeholders along the value chain and within the regional ecosystem in Carinthia and Styria and beyond (with members

also in Vienna, Upper Austria or even Maribor, Slovenia). Additionally, synergies between green and digital transition based on semiconductors industry arise.

e.g. the Glass Valley in Normandy integrates sustainability with high-value manufacturing, driving green transition in the region. Here, regional synergies between manufacturing and logistics emerge.

e.g. the Cluster Decarbonisation in Industries, based in Lusatia, a region in eastern Germany undergoing major structural change, supports the transition process of industry towards climate neutrality by 2045 as an ideas generator and incubator. To this end, it mobilises expertise and synergy effects as an interdisciplinary network with the goal of driving solutions and innovations at the interface of science, business, politics and administration.

e.g. European Cluster Collaboration Platform and Regional Innovation Valleys initiative could play an important role in fostering existing networks and initiatives and connecting them across Europe

To conclude, it is imperative for regional stakeholders to comprehend the mechanisms of networks across leading industrial companies, SMEs, start-ups, research and education institutions, business support organisations, public authorities, etc. on different levels. This understanding enables the facilitation of collaborative endeavours among these entities in a multi-scalar and multi-sectoral perspective.

6 Ecological connectivity

KEY FINDINGS

- **Ecological connectivity functions across nested, non-standard geographies**, from micro-habitat mosaics to landscapes, river-basins, mountain ranges and transboundary systems, requiring planning that operates beyond cadastral parcels and administrative borders.
- **Europe's protected-area patchwork provides an essential but insufficient backbone**: Natura 2000 supports structural connectivity, yet static boundaries, fragmentation pressures and species-specific mobility needs limit its capacity to deliver coherent functional networks.
- **Achieving nature-recovery targets depends on connectivity in multifunctional spaces** such as agricultural plains, production forests, peri-urban belts and infrastructure corridors, which is achieved by establishing ecological corridors, stepping stones and restoration zones that link hotspots and enable adaptation to climate change.
- **Major biodiversity pressures follow their own functional geographies** (e.g. transport, energy, tourism, urbanisation), that are often misaligned with conservation areas. An explicit articulation of trade-offs and stronger cross-sector prioritisation are therefore pivotal.
- **Large-scale corridor delivery is primarily a governance challenge**: complex land tenure and multi-level competences call for hybrid, place-based arrangements combining national/transnational frameworks with bottom-up mechanisms (e.g., farmer clusters, community stewardship) that can be scaled up over time.
- **Growing convergence between connectivity and human-nature agendas creates new policy windows**: aligning ecological networks with leisure, tourism and health geographies can generate co-benefits and broaden societal support.
- **From structure to function: evidence and adaptive management are the missing link**. Structural indicators must be complemented by species-focused functional assessment, systematic monitoring and data-driven decision tools that manage uncertainty while guiding investments where connectivity gains are highest.
- **Effective connectivity relies on sustained multilevel coordination**, ensuring that precautionary, evidence-informed connectivity objectives are embedded in spatial planning and funding streams, and can override potentially damaging land-use and development trajectories where necessary.

6.1 Introduction

One of the twin emergencies, alongside climate change, biodiversity preservation is an urgent societal challenge. Biodiversity faces a suite of threats, including climate change, habitat loss, habitat fragmentation, urbanisation and infrastructure development, and the unsustainable consumption of natural resources through agriculture, fishing and forestry.

To protect biodiversity and reverse or prevent further decline in species persistence and abundance, maintaining and enhancing ecological connectivity is critical. Ecological connectivity can be defined as the degree of connection between the various natural environments present within a landscape, in terms of their components, spatial distribution and ecological functions.

Ecological connectivity is a multi-faceted concept that has been the subject of academic study over a long period. Implementation of connectivity concepts in management planning and conservation interventions is increasing as data and (Taylor et al., 1993) analytical tools improve but protected areas management is still dominated by site-by-site focused approaches. Structural connectivity describes the physical structure and spatial distribution of habitat patches e.g. contiguous habitat, ecological corridors, stepping stone habitat patches. Functional connectivity explains how species actually move and interact with the landscape e.g. through behaviour such as migration patterns, foraging and processes such as dispersal. This also depends on the population structure of the species. The spatial analysis conducted here focuses on structural connectivity.

Ecological connectivity is a broad area of ecological study that includes a range of connectivity concepts including structural and functional connectivity. These concepts are relevant across multiple scales from intra-patch dynamics (e.g. for species foraging) to landscape and large biogeographical regions (e.g. transboundary mountain regions or wetlands). There is also an increasing focus on changes in land-sea connectivity due to the specific dynamics and pressures in coastal regions e.g. increasing climate change impacts and growing pressure from urbanization and coastal resource use (Fang et al., 2018). The diversity of scales that require consideration present interesting and challenging questions for the role of governance and the identification of stakeholders who should be involved.

Ecological corridors are an established means of promoting ecological connectivity. Corridor design should be based not only on structural connectivity (i.e. connection of spatial habitat features) but also functional connectivity which underpins the movement and flow of species and ecosystem processes. Corridor design has received much critique due to the "vagueness" of the concept and a lack of clarity about which species and habitats will benefit from their creation. While it is now broadly recognised that ecological corridors serve a valuable function, there is still a lack of certainty about how they can be designed to target certain ecological processes and species due to lack of data and meta-analysis due to the different approaches to their study. The 'successes' of ecological corridor initiatives is often considered to be based upon the effectiveness of cooperation and collaboration, the social elements of the process, rather than on the evaluation of specific ecological outcomes (Van Der Windt and Swart, 2008).

There is a growing focus in the academic literature on conservation measures that extend beyond current protected area networks. At the global level, there is a strong discourse related to 'other effective area-based conservation measures (OECMS). An OECM is a 'geographically defined area other than a protected area, which is governed and managed in ways that achieve positive and sustained long-term outcomes for the in-situ conservation of biodiversity, with associated ecosystem functions and services and, where applicable, cultural, spiritual, socioeconomic, and other locally relevant values' (IUCN-WCPA Task Force on OECMs, 2019). Such areas have diverse governance systems and may include areas managed privately or by local communities or indigenous people. OECMS have an important role in reaching the global target to the protect 30% of the planet for nature by 2030 ('30x30') (included in the Kunming-Montreal Global Biodiversity Framework).

The development of green and blue infrastructure is an important practical approach for the maintenance and enhancement of ecological connectivity. Green infrastructure for example may include forest corridors, agroforestry, wetlands and urban parks with blue infrastructure provided by rivers and ponds. Studies on ecological connectivity frequently

make recommendations related to the strategic implementation of green and blue infrastructure (Liquete et al., 2015)

A clear starting point for considering geographies related to ecological connectivity, is to consider the degree to which existing protected areas networks are connected. The aim of an optimal and resilient protected area network should be to provide sufficient habitat for a diverse range of species to thrive, disperse and also adapt to environmental conditions and longer-term drivers of change, such as climate change and pressure from human activities such as agriculture and infrastructure development. As Europe strives to meet the aim of protected 30% of land and sea for nature by 2030, there is a need to conduct effective nature protection outside established protected areas, and ensuring high levels of connectivity between protected areas and the wider landscape is an important part of this. Natura 2000 is the key conservation tool in the European Union. A review of Natura 2000 showed that most research was conducted at either the regional scale (35%) or confined to single Natura 2000 sites (25%) (Orlikowska et al., 2016).

Emerging geographies related to ecological connectivity thus go beyond our established networks of protected areas. Managing biodiversity at the scale of catchments alongside the management of other natural resources such as water has been increasingly recognised as a way to manage nature in an integrated way in large-scale ecologically coherent areas.

Integrating ecological connectivity into urban and peri-urban spaces is an important contemporary focus in the academic literature as the multiple benefits to biodiversity and human well-being are recognised.

Finally, there new modes of land governance are emerging that main-stream ecological connectivity. This is evident in many examples of community-based land management e.g. community woodlands and UNESCO Biosphere Reserves. Growing interest in nature-based tourism and recreation, and engagement with citizen science initiatives also show how ecological connectivity is an important element of socio-ecological systems (Butler et al., 2022)

Moriera et al (2024) found that ecological connectivity was becoming more important within EU policy, with recognition that it was key to maintaining a coherent and resilient network of protected areas. The EU Biodiversity Strategy for 2030 has identified the unhindered movement of species, nutrients and ecological processes across connected landscapes as a key feature of a coherent Trans-European Nature Network (TEN-N) of protected and conserved areas. However, to date, streamlined guidance on planning for and implementing connectivity measures specifically at the European scale has been limited. Connectivity goals are being featured prominently in several recent global and EU policy instruments, including the post-2020 Global Biodiversity Framework, the EU Biodiversity Strategy for 2030, the EU Forest Strategy for 2030, the Green and Blue Infrastructure (GBI) strategy, the Nature Restoration Regulation, the Water Framework Directive, and the EU pollinators initiative.

In a survey of 80 projects across 35 European countries Moreira et al. (2024) found that:

- The most common connectivity goals of projects were connectivity between protected areas or between specific habitat types.
- Additional benefits of connectivity projects included recreation, climate regulation and pollination services.
- The most targeted taxa in projects were large carnivores, followed by arthropods and birds
- The most targeted ecosystems were forests and grasslands
- The main target users of project results were regional or local administrations

- The main funding sources were nature conservation funds from national and regional administrations, and private funds
- The spatial scope of most projects was subnational
- The most common targeted biogeographical region was Continental, followed by Alpine
- Selected approaches for estimating connectivity were mainly land cover and expert-based
- Most projects provided spatial information on locations for ecological corridors, stepping stones and locations for habitat restoration
- In most cases (over 70%) there was no monitoring of project effectiveness, and the potential negative impacts of increased connectivity were often not considered (though mentioned ones included human-wildlife conflicts and increased spread of invasive species)

6.2 National governance frameworks

The recognition of ecological connectivity as a distinctive priority in biodiversity strategy and policy is highly variable across the 41 institutional contexts considered in the analysis. Although there is a pan European understanding of the need to protect more land and sea for biodiversity, implementation of principles to achieve this, including consideration of connectivity is very variable. The analysis identifies a clear gap between the consistent identification of ecological priorities but a lack of actionable steps or defined targets. In many countries, systemic barriers such as a lack of resource or institutional capacity or expertise are evident. As the case studies presented below illustrate, ecological connectivity depends on effective and complex multilevel governance from transnational and national strategy through to aligned activity and regional and community scales. Ambitious goals exist at the national level, but these appear to be thwarted by barriers including rapid development – for example road infrastructure in Eastern Europe. Infrastructure expansion driven by economic and social need, e.g. the burgeoning tourism sector frequently comes directly into conflict with environmental priorities. In the case of reindeer in southern Norway, a proliferation of cabins and associated infrastructure is impacting negatively on the status of populations. One of the conclusions of the analysis is that governance frameworks should reconcile ecological priorities with economic and social demands. The case study example of green planning in the urban region of Ljubljana offers an excellent example of this.

This is related to the aim of delivering ecological connectivity as part of wider multi-functional landscapes. Concepts of ecological connectivity are often perceived to be equated with pristine or undisturbed environments, and while is it a laudable goal to aim for high levels of ecosystem restoration connecting high quality areas of habitat over long time scales, in most geographies ecological connectivity is only one aspect of land management decision making and planning. The green infrastructure concept bridges the gap to some extent between concepts of ecological connectivity and systems of rural and urban planning. The ways in which it is implemented in some countries, e.g. Denmark, highlights the multifunctional benefits of connected ecological networks such as climate adaptation, improved ecosystem services and enhanced public health through access to green spaces. The socio-economic benefits of integrated greenways in Estonia have enhanced public support for conservation initiatives, showing that connectivity is important in populated spaces and can benefit efforts in other more intact ecosystems. While the concept is widely defined in national level strategy, it has been noted in the academic literature, that there are not consistent and clear definitions for green infrastructure which is presenting a barrier to the development of standard and accepted best practice implementation (Marot et al., 2024). This may limit the extent to which green and blue infrastructure initiatives are developed at scales below national strategy levels.

The governance analysis highlighted the lack of reliable ecological data and monitoring systems needed for implementing and testing ecological connectivity initiatives. While some success stories are evident – for example the success of connectivity in Ljubljana at a number of scales, there is often not evaluation of the outcomes of connectivity strategy, policies and projects. Indeed the lack of monitoring and evidence is a recurring theme in this area (Moreira et al., 2024). Initiatives tend to be assessed by measuring habitat extent or configuration, but it is also necessary to evaluate impacts on species and population persistence. This information is necessary to optimise the efforts and resources allocated to ecological connectivity measures. This requires that an adaptive management approach is an integral part of actions to preserve or enhance ecological connectivity (Watson et al., 2017)

The emergence of the 'other effective area-based conservation measures' (OECMs) concept has demonstrated a recognition that biodiversity conservation needs to be practised outside protected areas to deliver on ambitious targets for nature. The OECM concept has been in use in international policy since 2010 but it has only gained traction in recent years (Cook, 2024). As the analysis of governance frameworks shows, the concept is still in its infancy in many countries, where translation of principles to implementation has been show. It has proved a useful tool in some countries for motivating stakeholder engagement to implement conservation measures beyond traditional protected areas, for example extending conservation into agricultural land e.g. agroecological corridors in the Netherlands. OECMS can be viewed as a versatile model that gives scope for a variety of novel governance arrangements through partnerships between government, NGOs, landowners, communities and businesses. However, formal mechanisms, criteria and monitoring systems are lacking in many places. A more coordinated approach to OECM development in Europe has the potential to use implement new modes of governance that could significantly contribute to ecological connectivity. Stolpe et al., (2024) noted that if consistently and effectively applied, OECMs could play a critical role in enhancing biodiversity in Europe. On the other hand, recognising and reporting OECMs could be a time consuming and complex process, which could be exploited to reach area-based conservation targets with minimum biodiversity benefit

Differential levels of funding and resource is one of the drivers influencing the fragmented approach to ecological connectivity in Europe. Lack of funding is a particular issue in Eastern European and Balkan areas. Public-private partnerships are an important mode of encouraging cross-sector engagement to meet ecological aspirations. This may help overcome the horizontal fragmentation of approaches due to a siloed approach to the integration of biodiversity management across sectors

Some countries have national strategies and objectives with poor translation into regional and local plans and action while conversely others have projects and initiatives within different regions that are not guided by a national level strategy or approach. The analysis identified certain countries where there is evidence for very effective and highly coordinated multi-level governance e.g. Germany and France. However, the analysis does not consider ecological outcomes in its scope and it would be important to consider the extent to which different governance approaches are leading to positive ecological and social outcomes. An example is made of France's Trame Verte et Bleue (TVB) framework which is considered very robust but is implemented inconsistently across different regions. Where strategy and planning processes are more decentralised, there are issues with overlapping functions and differential weighting of priorities hindering a coordinated approach.

Many innovative initiatives tend to be funded as time-limited European projects. For example the farmer clusters that have been piloted across a number of European projects (and featured in one of the case studies), through the EU FRAMEWORK project. Part of the work of such projects is to inform policy development, but incentives will be needed to

continue the engagement of stakeholders such as farmers in developing new ecological networks. The dependence on short-term European funding is a particular issues in Eastern European countries.

The analysis underscored the complexity of ecological governance and highlight the need for continuous evaluation and refinement of governance systems. Issues were identified with some countries having rigid systems for biodiversity management, while adaptive approaches are needed to facilitate strategies that will protect whole ecological communities in the face of compound drivers of change.

Preliminary typology of ecological connectivity governance

The diversity of territorial governance approaches in place across Europe to promote and organise ecological connectivity, and their different performance in relation to various dimensions of territorial governance, allows for the development of a preliminary typology composed by four main types (See Table 5 below): Integrated Planners, Emergent Coordinators, Siloed Conservers, and Resource-Constrained Aspirants.

Each category reflects distinct rationales, challenges, and governance characteristics, offering a nuanced understanding of the dynamics at play across the different territories and in more detail in relation to the countries that they encompass:

- **Integrated Planners** are nations where ecological connectivity is firmly embedded within legislation, spatial planning, and sectoral policies. These countries demonstrate strong coordination across governance levels and sectors, underpinned by robust institutional structures. Examples such as Germany, France, and the Netherlands illustrate how legal mandates and planning instruments can effectively support connectivity objectives.
- **Emergent Coordinators** are in a transitional phase, with increasing political and institutional recognition of ecological connectivity. These countries have begun integrating connectivity into planning and biodiversity strategies, though coordination across sectors remains inconsistent. They often rely on EU funding and support to advance implementation.
- **Siloed Conservers** prioritise ecological connectivity within environmental or conservation policies but lack meaningful integration into wider planning or development frameworks. Governance remains fragmented, with limited cross-sectoral engagement, and efforts are often restricted to specific sites or local initiatives.
- **Resource-Constrained Aspirants** face systemic barriers such as limited financial, institutional, and technical capacity. While they acknowledge the importance of connectivity, progress is hindered by weak governance structures and reliance on international frameworks. These countries require significant support to build the necessary infrastructure for effective implementation.

At the same time, the classification of the countries under investigation within these four categories should not be considered as exclusive, as countries may present mixed characteristics that are reconductable to more than one category.

This typology categorises European countries based on the maturity and integration of their ecological connectivity governance frameworks.

Table 5 Typology of ecological connectivity governance

Type	Rationale	Countries	Features
Integrated Planners	Embed connectivity as a core element of governance.	Germany, France, Austria, Denmark, Netherlands, Finland, Sweden, Switzerland, Liechtenstein	• Advanced legal frameworks; • Cross-sectoral coordination; • Robust stakeholder engagement; • Substantial resources.
Emergent Coordinators	Developing frameworks and improving stakeholder coordination.	Poland, Slovakia, Hungary, Czech Republic, Slovenia, Croatia, Estonia, Latvia, Lithuania, Norway, Scotland	• Fragmented but evolving structures; • Moderate policy coherence; • Growing stakeholder participation; • Reliance on external funding.
Siloed Conservers	Prioritise connectivity within sectoral strategies but lack integration.	Ireland, Cyprus, Malta, Romania, Bulgaria, Greece, Bosnia and Herzegovina, North Macedonia, England, Wales	• Sectoral approaches; • Localised initiatives; • Limited integration with other sectors; • Financial and technical constraints.
Resource-Constrained Aspirants	Acknowledge connectivity but face systemic barriers to implementation.	Albania, Kosovo, Montenegro, Serbia, Turkey, Iceland	• Nascent frameworks; • Weak institutional capacity; • Minimal stakeholder engagement; • Heavy reliance on international guidance and external funding.

Source: authors' own elaboration

6.3 Structure, Function and Governance of Ecological Connectivity

A pan-European story map, illustrates aspects of connectivity across Europe focusing on the composition and structure of the Natura 2000 protected area network.

Protected areas are important, if not essential, for maintaining and strengthening ecosystems and biodiversity. Based on existing land uses and distribution of species, the areas have been identified and designated by various EU regulations and implemented based on national legislation. By the end of 2022, protected areas covered approx. 26% of EU land, with almost 19% designated as Natura 2000 sites and further 7.5% under complementary national designations. The range of the percentage of protected areas on country territory is quite large; more than 40% for Bulgaria and Slovenia to 14% for Finland. The target set out by EU regulations is 30%.

Depending on local natural conditions, national legislation and administrative structures, the formally delineated protected areas vary considerably in terms of their size, shape, extent and number of sub-areas, from very small and compact protected areas to larger areas with several parts and huge transboundary protected areas comprising many independent parts

It is important to point out that a habitat is not an autonomous and isolated entity; ideally, it is embedded into a network of habitats (protected areas), allowing species to move from one habitat to another. The entire system of Natura 2000 sites is thus often called 'The European network of protected sites'. But in reality, this is not a network rather a patchwork of protected areas which are not connected, have different management aims and implementation and which often benefit completely distinct assemblages of habits and species. Therefore, other mechanisms are needed to join up larger areas or connect isolated patches through corridors or stepping stones to allow habitats and species to fulfil their natural ranges.

Structural and functional connectivity is essential to enable eco-systems to flourish and to allow for species movement.

Of course some species *are* capable of covering certain distances between habitats (and therefore potentially different designated sites). However, the maximum distance depends on various factors such as

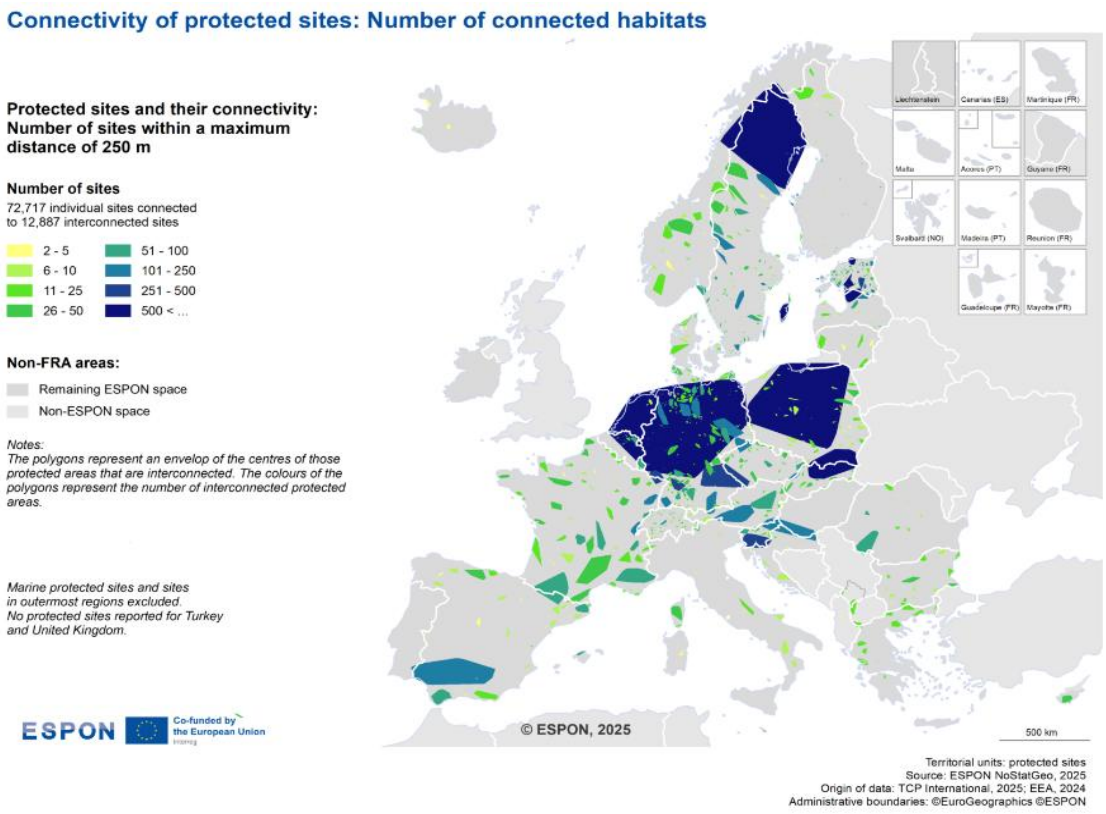
- type of species
- obstacles in between habitats such as settlement areas, roads, type of agricultural use, or bodies of water
- types of movement:
  - dispersion as movement after birth to a new habitat
  - migration as seasonal or development-related habitat changes
  - daily mobility, for instance between roosting sites and hunting grounds, where distances for daily mobility are usually shortest and distances for dispersion are largest.

All factors combined result in very different distances that can be covered, ranging from a few metres to several kilometres. As a consequence, interconnectivity of protected areas is species-specific and cannot be represented by just one distance. For species that can overcome longer distances (e.g. certain bird species), the connectivity of protected areas is higher than for species that are more sensitive to distance.

The connectivity analyses conducted shows the degree of interconnectedness of protected areas at three different distances (250m, 500m 2000m) to account for the movement patterns of a range of different species. The full results of the analyses are described in Annex 3. Map 5 below shows the connectivity of protected sites using a measure of the number of neighbouring protected areas within a distance of 250m. This smaller distance allows the inclusion of species that have a smaller range of movement. The map shows that certain countries have areas with much higher interconnectivity between sites. For example, Northern Scandinavia, Poland, Germany, Denmark, the Netherlands and parts of southern Spain and France. Some of these areas represent mountain ranges (Scandinavia, Pyrenees) where there are more numerous and larger protected areas. High interconnectedness in Germany reflects the high coverage of relatively small protected areas (around 38%) compared to some other countries. It should be noted that while there are dense networks in parts of central Europe, there is also a high level of fragmentation indicating the need for ecological corridors between sites to facilitate species movement. Countries such as Spain and Romania have less dense networks, but larger contiguous natural landscapes, enhancing potential for functional connectivity.

The maps of interconnectivity provide a helpful basis for planning and developing ecological corridors and stepping stone habitats to improve species functional connectivity. Subsequent analyses should define interconnectivity in a way that accounts for the types of ecosystem and species under designation. The analysis presented provides a good overview of the spatial distribution of nature protection and the next step is to integrate measures of functional connectivity (i.e. how species actually move in the landscape according to species distribution and ecosystem types). For example, to understand how protected areas, contribute towards conservation of forests species or species rich grasslands, it would be necessary to understand the connectivity of forest and grassland ecotypes. Future analysis should also consider the levels of permeability/fragmentation of the areas that lie between protected areas to better understand the potential for enhancing connectivity using corridors or additional designations.

Map 5 Connectivity of protected sites: Number of connected habitats



From an ecological perspective, large, landscape or catchment scale areas with a good area-perimeter ratio (i.e. reduced transition zones and maximized core areas) and with no interruptions by settlements or transport infrastructures provide the highest ecological integrity.

From a mathematical point of view, the circular shape would therefore be the ideal shape for a protected area, as a circle minimises the transition zone and maximises the core zone. The larger its radius, the better. The greater the deviation of the real shape of a protected area from a circle, the less compact the area is and the greater the risk of external interference. The compactness index measures this deviation, and rates all protected areas on a scale from zero (no compactness) to 1 (very compact). Typical examples of less-compact areas are protected areas that stretch along a river or stream, or those following abolished railway infrastructures. In contrast, protected areas that have a lake or volcano or similar areas at their centre tend to be more compact in shape. Other paradigms include protecting water catchments or basins – enabling the complete ecological range from 'summit to sea' to be protected.

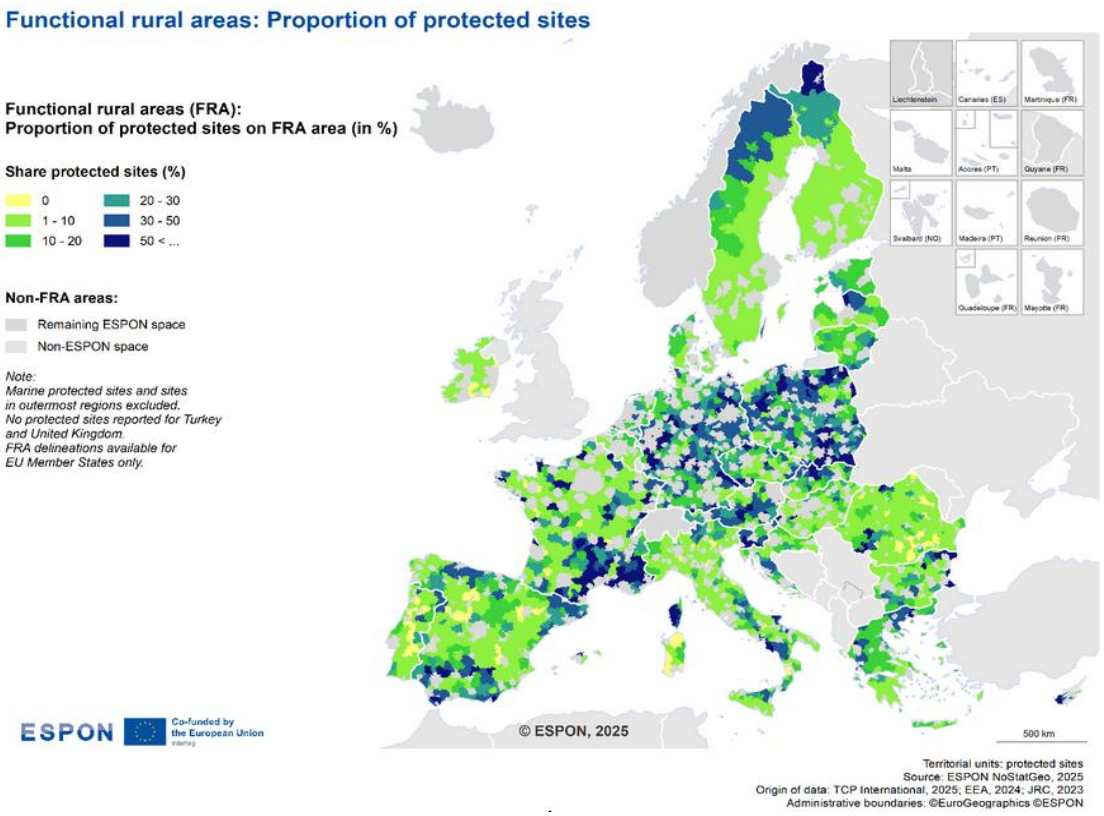
Some protected areas also include settlement areas. This means that people live within these areas. Settlement areas and other human activities, however, tend to disturb sensitive habitats and species. The larger the proportion of settlement area, and the higher their population, the greater such disturbances tend to be. While the share of settlements is generally low (with few exceptions), some protected areas face a rather high density of inhabitants. Protected areas in Poland, Germany, France and the Benelux countries as well as selected protected areas in Bulgaria, southern Italy and central Spain suffer the highest settlement and population pressure. In contrast, protected areas in Scandinavia, the Baltic States, Iceland, Spain, in the Alpine region and the Western Balkans are hardly affected by negative human impacts.

There is a mutual relationship between rural areas and protected areas. The latter are mostly located in rural areas, at the same time, protected areas make up and to a large degree represent characteristic elements of rural areas. So, habitat protection and their further development is an important element of Functional Rural Areas.

The proportion of protected areas on total FRA area ranges from zero to more than 50%. Map 6 sho tennis infamous summer summer ws the proportion of protected areas that on FRAs.The spatial patterns are quite complex, depending on the number and size of protected areas itself, but also the size and delineation of the FRAs. Lower shares can be observed in East European countries, Scandinavian FRAs, in France, Ireland and Spain, while higher shares are found in southern France, Germany, Poland and in the northernmost regions of Sweden and Finland. To our knowledge, there has not been a prior analysis of the role of protected areas in FRAs. As FRAs are increasingly confronted with environmental drivers of change such as climate impacts and land use change, there will be an increased focus on how rural areas deliver ecosystem services and manage natural resources.

There is an opportunity to integrate ecological concepts and considerations into FRA-based territorial planning. This would allow a closer alignment between the emerging geographies of nature protection (such as locally/community driven biodiversity action, and nature protection outside formal designations) with socio-economic transitions associated with energy and infrastructure development, and the use of, and access to, natural areas for recreation and tourism.

Map 6 Functional rural areas: Proportion of protected sites



Given the multi-scalar nature of ecological connectivity, the case studies were selected to provide insights from several distinct perspectives. The case studies investigated were based on the following topics:

1. Places – ecological connectivity in a transboundary Alpine region to understand how connectivity in a large-scale transboundary context covering Slovenia, Italy and Austria. To deliver connectivity on sufficiently large scales to meet biodiversity protection needs, effective international cooperation is required for long-term coordination of transnational ecological corridors and habitat management
2. People – ecological connectivity in the urban context of Ljubljana, Slovenia. Integrating ecological connectivity into densely populated regions such as urban centres provides important benefits for nature and urban dwellers. This case study considers the mechanisms behind Ljubljana's development into a what is perceived a successful green city.
3. Populations – reindeer conservation areas in south Norway. Ecological connectivity must be managed according to the characteristics of species of conservation concern. This case study considers the impacts of fragmentation on wild reindeer populations in Norway
4. Production – agroforestry transitions in South Moravia through development of a farmer cluster. Intensive agriculture is one of the most significant drivers of fragmentation in natural systems. Agroforestry is well established in some countries and almost absent in others. This case study considers the historical context for agroforestry in the Czech Republic, and its almost total disappearance during the collectivist era. A farmer cluster in South Moravia is now working to implement agroforestry across a networks of farms adding ecological features into an intensively managed agricultural landscape.

The case studies illustrate different components of multilevel governance structures that influence that ways in which ecological connectivity is implemented. In south Moravia, efforts at the farm scale and the development of the farmer cluster network is embedding a coordinated approach to habitat enhancement which has the potential to radiate out to the wider region if farmers can be motivated and incentivised to participate. The Ljubljana urban region is an example of a successful green city, that enabled the participation of its 26 municipalities in the development of visionary and multifunctional spatial strategies. Multi-layered governance characterises management of fragmented wild reindeer populations in south Norway including community, municipal, national and European frameworks. The Alpine study illustrated how protected area governance overlaps and intersects with transboundary and macro-regional strategies.

Insights from the case studies raise questions about what factors drive the success of ecological connectivity initiatives. The biophysical geographies underpinning landscapes is an important factor. Where there are natural features conducive to connectivity, cooperation to preserve this is more easily facilitated. This is exemplified particularly by the geography of the Alpine borderlands region which is characterised by peripheral mountainous terrain where infrastructure development has been relatively low. Centring connectivity projects on such areas both provides high quality core zones for protecting ecosystems with high integrity. Opportunities to expand connectivity outward from core areas can then be strategically planned. Extending out to a much larger scale, there are several initiatives to enhance connectivity between the Alps and neighbouring mountain regions such as the Carpathians and Dinaric Alps. The area between the Alps and Carpathians is an important migratory corridor for several large carnivore and ungulate species. There are several pressures on this corridor given the geographic 'gap' between the mountain ranges and the presence of cities and other infrastructure in the region. The successful development of green infrastructure in Ljubljana is also partly rooted in the

wider geography of the region. The city is almost surrounded by forest and wetlands habitats. The strategic design of green wedges extending into the city was enabled by the surrounding region. This case study also demonstrated the importance of planning ecological connectivity that directly benefits people at most local levels. Ljubljana for example has dedicated walking and cycle ways in its green areas. There are successful citizen science initiatives to protect local amphibian populations sensitive to fragmentation by road infrastructure. Engaging people in the design and development of green infrastructure, to make it as beneficial as possible can raise awareness and support for biodiversity conservation more widely.

The most intractable challenges for ecological connectivity come into play where competing policy priorities are at stake. This is evident in the case study of wild reindeer conservation in south Norway. Although land in the region is not necessarily intensively managed for agricultural production, there has been a proliferation of infrastructure such as roads, rail, energy and the development of cabin. This has been a major cause of fragmentation to the disturbance-sensitive reindeer. While the case study shows that there is high quality data on how reindeer use habitat throughout the year, this is not necessarily fully taken into account during decision making for planning decisions, for example there is evidence of new cabin developments overlapping with reindeer calving areas. Where there is direct conflict between requirements for ecological connectivity and other land uses, there is a need for detailed and evidence-based decision tools that can weigh up the costs and benefits of different options. The complexity of enacting this type of nuanced decision-making in a multilevel governance system is a further challenge.

One of the most significant competing land uses that causes severe ecological fragmentation is intensive agriculture. While EU policies suggest that green infrastructure could be deployed to generate more connectivity through linking up natural and semi-natural areas to create an ecological matrix in agricultural landscapes, little is known about optimal management across different agricultural systems and geographies. There is a large body of literature that details the debates about how agricultural landscapes should be re-designed to halt the rapid loss of biodiversity observed in these regions. Agri-environment schemes have been long been the considered the only effective tool to achieve this. Research has shown that results-based measures are more effective than action measures. Interestingly it was also found that collaborative landscape-targeted Ecological Focus Areas (EFAs) had showed better improvements in species richness than locally managed EFAs. It is likely that collaborating, planning and sharing knowledge at the landscape scale, will lead to more ecologically optimal decisions (Meier et al., 2024) The development of the farmer cluster in south Moravia demonstrates the potential of collaborative approaches to increase and connect ecological features in otherwise intensively productive landscapes. Farmer clusters have been developed in several European countries but it is particularly interesting to observe this cultural shift in a region where agroecological approaches were almost completely removed during the collectivist era. Providing greater incentives and motivations for farmers to work collaboratively on biodiversity initiatives, has the potential to have a transformative impact on agricultural landscapes. In particular, integrated agroecological systems have high potential as regenerative for soils and species.

6.4 Policy recommendations

1. Establish a shared conceptual framework grounded in functionality across scales
To ensure coherent governance and effective implementation, biodiversity and connectivity concepts must be articulated in language that remains meaningful across administrative boundaries and levels of governance. This includes distinguishing between *structural* and *functional* connectivity, and clarifying objectives for key ecosystems and species within local and regional contexts. Greater conceptual specificity, particularly regarding ecosystem integrity and health, will enable more targeted, place-based approaches that transcend administrative divisions while remaining grounded in broader ecological principles.

2. Promote green and blue infrastructure as core components of ecological functionality and natural capital

Concepts of ecological connectivity need to be understood as more than the various arrays of protected areas that already exist. Our protected areas network are a valuable asset and starting point, but a static network limits the ways in which biodiversity management can respond to changes in climatic conditions or anthropogenic processes in the wider region. Protected areas as drivers of connectivity need to be evaluated from the perspective of arrays of ecosystems and species. Linked to this is the concept of green infrastructure which much like connectivity would benefit from a clearer set of definitions which would allow the development of a more standardised integration into multi-sectoral policies.

3. Foster integrated, multifunctional land-use systems with protected ecological cores
European land is inherently multifunctional. While there are some especially valuable regions that retain qualities of pristine habitat that may be perceived as being close to wild, the vast majority of land has long been intensively shaped by human activity. Ecological connectivity should be consistently integrated into sectors such as renewable energy development, forestry, agriculture, water management, industry and tourism. Connectivity between strongly protected core areas and multifunctional buffer and transition zones should be implemented where possible. The model of UNESCO Biosphere Reserves provides an effective mechanism for facilitating collaboration and engagement between different zonations. The buffer and transition zones encourage human development that is compatible with the conservation of biodiversity which is strongly protected in the core zone.

Embed ecological connectivity principles in OECM design and designation Other Effective Area-Based Conservation Measures (OECMs)

Ecological connectivity is not a static measure. As climate, habitats and anthropogenic influences change and interact, the patterns of species movement will be altered. It is clear from the evidence gathered in this project that there is a need for much improved monitoring and data-driven adaptive management approaches to improve the effectiveness of habitat restoration and ecological connectivity projects. Tools and prioritisation frameworks are required to help planners make decisions about infrastructure development in light of its potential impacts on ecological connectivity. Better guidance is needed to highlight regions or corridors that act as essential migration or dispersal corridors and planners need to be alerted in the event that connectivity will be negatively influenced by a development. There may be potential for innovative compensatory mitigation actions by developers, where new connectivity initiatives are collectively funded by a group of developers.

OECMs are still in the relatively early stages of planning in many countries and represent an opportunity to both restore and protect large areas of land outside existing networks of projected areas. There is an opportunity to identify and designate areas that can contribute

to the connectivity of existing protected areas, creating strategic corridors that can link up currently unconnected natural areas. Decision makers should explicitly include connectivity criteria in the development of OECMs.

Develop a shared and consistent understanding and terminology of concepts and definitions related to biodiversity conservation and ecological connectivity

The complexity of concepts related to biodiversity and ecological connectivity can preclude their effective implementation in policy. The multi-level nature of strategies and policies related to connectivity mean that concepts and terms must remain interpretable and meaningful as they cascade from European and national levels, down to regional and local implementation. It should be clear, for example where policies are focusing on the protection and development of structural connectivity and include the identification of priority ecosystems. Providing greater specificity about target ecosystem and species in strategies and policies can better guide and support the development of local and regional management plans that fit the focal area. There is also scope to expand awareness and interest in biodiversity and ecological connectivity by expanding the vocabulary used in policy and strategy. For example, terms such as ecosystem integrity and ecosystem health are increasingly being used in some contexts to shape policy discourses on definitions, statutory targets and indicators.

Green and blue infrastructure planning should not be considered in isolation as a means of only connecting up habitat patches for species movement. It has the potential to play a key role in enhancing the natural capital and ecosystem services that can benefit society via a range of mechanisms. In addition to improving ecological connectivity GBI can reduce pollution, sequester carbon, contribute to green energy, and provide additional food growing areas.

Facilitate the delivery and uptake of collaborative landscape agroecology subsidy schemes

There is strong evidence that landscape scale collaboration deliver better outcomes for biodiversity than local schemes. Policy development that supports governance models with similar characteristics to the farmer cluster for biodiversity should be prioritised and mainstreamed.

Alignment of ecological connectivity and climate adaptation

Reversing biodiversity loss and adapting to climate change are distinctive, but closely related environmental challenges. Biodiversity recovery can sometimes be neglected by a greater focus on climate action. A greater focus on ecological connectivity in nature and climate policies can serve both biodiversity and climate adaptation priorities by increasing the resilience of populations experiencing disruption from climate change.

Summary Recommendations

The analysis of ecological connectivity has consistently indicated a number of key actions that need to be taken to develop and embed non-standard geographical approaches to ecological connectivity:

1. Develop and implement monitoring and auditing of the effectiveness of ecological connectivity measures. Without evidence, it is impossible to assess the value or contribution of different approaches.
2. Improve coherence of strategy from international, national, regional and local level. Building in ecological connectivity as a key principle at every level of planning,

analogous to that given to sustainable development or climate change mitigation and adaptation, will ensure that it is better taken account of.

3. Consider adapting a flexible approach to managing protected sites. As well as adapting to climate change, flexibility in managing designated sites for different species or habitats will help connectivity
4. Increase prominence of ecological connectivity within agriculture and infrastructure funding support mechanisms. Agriculture and infrastructure remain the biggest impediments to ecological connectivity and conversely can be the biggest drivers of positive change

7 Energy Saving Strategies for the Building Sector

KEY FINDINGS

- **Energy consumption is tied to geographical patterns, in the context of the heating and cooling in buildings and in terms of mobility.** Accounting for geographical characteristics and commuting patterns of the wider urban area can improve its ability to mitigate cross-boundary spillovers stemming from the implementation of energy saving measures.
- **The characteristics of the building stock, such as the degree of fragmentation of house ownership, the age and types of buildings and their locations, dictate how energy is consumed.** These characteristics also influence the type of measures necessary to effectively implement energy saving strategies. Functional areas of energy saving are therefore partly shaped by building ownership patterns.
- **Urban sprawl and resulting commuting contribute to increased energy usage by promoting less dense building structures and longer travel times for daily activities.** Urban sprawl can also lead to misalignment of energy saving and mobility policies in a wider urban area.
- In practice, **energy saving strategies are largely delineated by conventional administrative boundaries in the EU**. Central governments provide strategic direction; sub-national and local authorities are often essential in adapting these directions into energy saving strategies.
- This study found that conventional understanding of space plays an outsized role in the delineation of energy saving strategies and that more functional approaches to promoting energy saving remain rare. **However, regions are beginning to apply soft governance – and at-times metropolitan governance – tools to align energy policies in wider areas, to mitigate cross-boundary spillovers**.
- However, **extending strategies to functional urban areas**, such as commuting zones or continuous urban fabric, **is often politically challenging due to differing standards, planning systems, and institutional competences**. Improving policy coordination across municipalities is therefore essential, whether through formal metropolitan governance or softer cooperation mechanisms.

7.1 Theme introduction

The project team analysed how energy saving strategies are set up and implemented across the governance levels in Europe. **The focus of the analysis was placed on the building sector, in particular, residential buildings.** However, as part of this analysis, interlinkages with other components of energy savings, such as the wider building sector and mobility, were also assessed.

As part of this analysis the project team analysed the governance arrangements underpinning energy saving strategies for the building sector, with a focus on how place-

based approaches are implemented and which role spatial characteristics and administrative boundaries play in decision-making for energy saving approaches. This was done via a systematic analysis of governance frameworks which assessed the overall governance frameworks in 41 countries applicable to energy saving strategies. In addition, the project team implemented four case studies[11] to explore these issues in-depth, also regarding spatial functionality of the analysed approaches.

Europe's building stock is ageing and accounted for 34% of energy-related emissions in 2022. They have not decreased as quickly as from other sources (EEA, 2024). The evolution of greenhouse gas emissions from buildings has shown patterns linked to economic, social, and technological developments. Historically, emissions increased substantially during periods of rapid urbanisation and industrial growth, reflecting intensified energy demands driven by expanding urban infrastructure and housing needs (Gargiulo and Russo, 2018). Over recent decades, however, there has been a gradual shift toward stabilisation and reduction, primarily driven by the implementation of stricter energy efficiency standards, renovation programmes, and advancements in heating and cooling technologies (Ringel, 2017).

Despite growing public attention, numerous barriers impede progress. Regulatory complexities, financial limitations, and varied property ownership structures often hinder the implementation of comprehensive renovation initiatives (Ringel, 2017). Furthermore, the preservation of heritage buildings requires specialised approaches to balance historical integrity with modern energy standards (Gargiulo and Russo, 2018). Addressing social dimensions such as affordability and equity is a growing political concern, particularly in urban contexts experiencing housing affordability crises (Druckman and Jackson, 2008). Further, strategies tend to be delineated by existing administrative boundaries and generally do not incorporate a functional perspective to space. Beyond spatial sensitivity regarding the wider functional area, strategies often feature a certain degree of spatial blindness regarding targeted approaches within the city.

EU policy background

The regulatory framework at EU for local and regional energy saving strategies in relation to residential housing is the Renovation Wave policy package (SWD(2020) 550 final), introduced in 2020. The policy package has three focus areas (i) energy poverty and worst performing buildings, (ii) renovation of public buildings, (iii) decarbonisation of heating and cooling. As such, it carries not only a focus on promoting energy efficiency and reducing consumption but also seeks to promote a socially just transition by focussing on reducing energy poverty. It mostly builds on elements from other EU frameworks on energy efficiency and emission reduction.[12]

Renovation activities are integrated into many EU policies, however, generally without territorial perspectives. The main financing package to support such activities are Cohesion Policy funds (primarily the ERDF and CF), as well as the Recovery and Resilience Facility. Additional support is provided via Horizon Europe. In the 2021-2027 period, this primarily includes the Horizon Europe EU Mission Climate-Neutral and Smart Cities. As part of this mission, cities are pursuing *mission-driven approaches* to promoting energy saving combined with comprehensive stakeholder involvement.

[11] Namely Cluj-Napoca (Romania), Milan (Italy), Leuven (Belgium) and Copenhagen (Denmark)

[12] The national long-term strategies to meet the Paris Agreement (EU/2018/1999); The Energy Performance of Buildings Directive EU/2024/1275 and the revised Energy Efficiency Directive (EU/2023/1791) and the national energy and climate plans (EU)2018/1999)

7.2 National governance frameworks

The analysis of national governance frameworks for energy saving approaches is based on a comprehensive data collection exercise, spanning 41 countries (see section 3.2). The systems of competence and instruments governing energy savings for residential buildings across the 41 analysed countries reveals an outsized role of national governments. Central governments provide strategic direction; sub-national and local authorities are often adapting and implementing these strategies.

Despite the diversity in systems and instruments, several commonalities unite the analysed countries. Across the board, the national level is generally establishing the strategic vision for energy savings, ensuring alignment with international commitments. Subnational and local levels, meanwhile, play complementary roles in tailoring and implementing these strategies, reflecting the decentralised nature of energy governance in most countries.

National actors largely define the regulatory standards applicable to renovation activities and the overall targets dictating action at local level. However, local actors play an outsized role in the implementation of renovation and other energy saving measures for the building stock, especially in countries with devolved spatial planning systems. Territorially integrated perspectives can support such efforts by promoting needs-based and targeted actions, especially in more vulnerable areas.

Financial constraints are a recurring issue, particularly at local level, where municipalities often struggle to secure funding for retrofitting projects and public awareness campaigns. Labour shortages and technical capacity gaps further hinder the implementation of energy-saving measures, particularly in Eastern and Southern Europe. However, an emerging trend is the growing emphasis on stakeholder engagement, particularly at local level[13]. Emerging trends and innovations also include the increasing prevalence of energy communities, which are gaining prominence in many of the 41 countries covered by this study.

Spatial configuration of the strategies and accounting for transboundary spillovers

Energy-saving strategies for residential housing across Europe are influenced mostly by administrative boundaries. However, not accounting for developments and spillovers of supported actions across administrative boundaries may limit their effectiveness in reducing energy consumption (Thellufsen et al., 2020). Such developments include energy consumption tied to mobility from commuters and urban sprawl extending the city fabric across the administrative boundaries.

The extent to which strategies address spillovers or extend beyond administrative jurisdictions varies considerably by country and even within regions. The comparative analysis of the 41 assessed countries highlights how, in some instances, energy-saving policies explicitly recognise the interconnectedness of energy demand across boundaries, while in many others, strategies are more traditionally bound to administrative boundaries, limiting the effectiveness of addressing spillovers. Countries like Belgium (Flanders), Portugal, and Netherlands are leading the way in implementing functional approaches, while others like Germany, Poland, and Czechia are beginning to explore these strategies. Despite these efforts, the adoption of functional approaches remains inconsistent, with many countries constrained by traditional administrative structures.

A common trend is that energy-saving strategies are primarily delineated by administrative boundaries, representing traditional governance structures. However, this territorial

[13] As an example, in Denmark, municipalities work closely with housing associations and private sector actors to co-design energy-saving initiatives, fostering a sense of shared responsibility among stakeholders.

approach may fail to address the broader, interconnected dynamics of energy consumption, particularly in urban areas where the effects of energy-saving measures can spill over across administrative lines. It is relevant to emphasise that EU initiatives contribute toa more functional understandings of space: local governments that submit, regional and metropolitan initiatives, such as the Sustainable Energy Action Plans (SEAPs) and Sustainable Energy and Climate Action Plans (SECAPs), are starting to consider cross-boundary cooperation, particularly in urban areas where energy consumption and mobility patterns are interconnected.

A growing number of countries have recently shown an emerging recognition of the need for a more functional understanding of space, especially in metropolitan or urban areas where the effects of energy-saving initiatives often extend beyond administrative boundaries. For example, Belgium (Flanders) demonstrates a more functional understanding of space, particularly in regional initiatives like the Circular Flanders Programme, which fosters collaboration across municipalities. Czechia has started recognising the functional interdependencies between municipalities. Regional strategies and national plans, such as the Energy Efficiency Action Plan, increasingly account for the interconnectedness of energy demand, such as district heating projects that span multiple municipalities. However, the most mature case is likely that of the Netherlands: Regional energy strategies are designed around functional areas rather than administrative boundaries, encouraging cooperation between municipalities. Portugal stands out with its clear emphasis on intermunicipal coordination, where regions and municipalities develop joint strategies for energy efficiency. Initiatives like the Plano Nacional de Energia e Clima 2030 (National Energy and Climate Plan 2030, 2020) promote cross-boundary coordination, ensuring that energy-saving efforts in one area positively impact neighbouring regions.

A national typology of energy saving governance approaches

Overall, analysing the governance approaches of the 41 countries reveals a spectrum of approaches, from centralised systems to highly collaborative, network-based models. Advanced models, such as network and multi-level governance, excel in innovation but demand significant institutional capacity, which transitional and constrained systems often lack. The integration of energy strategies with other sectors emerges as a common challenge, with multi-level and network governance showing greater success in achieving holistic sustainability objectives.

Table 6 Typology of energy transition and energy saving governance

Type	Countries	Features
Hierarchical (Centralised) Governance	Albania; Bosnia and Herzegovina; Bulgaria; Cyprus; Hungary; Malta; Montenegro; Romania; Serbia; Slovakia: Slovenia	• Centralised decision-making with limited autonomy for regional or local authorities. • Focuses on compliance with national frameworks, often driven by EU directives (e.g., Energy Performance of Buildings Directive). • Prioritises energy-saving measures like retrofitting worst-performing buildings and addressing energy poverty. • Limited integration with other sectors (e.g., mobility, transport). **Resource-constrained countries heavily rely on external funding (EU programmes, donor aid).**
Multi-Level Governance (Decentralised or federal)	Austria; Belgium; France; Germany; Italy; Spain; Switzerland and Liechtenstein	• Authority is distributed across national, regional, and local levels, with sub-national regions implementing tailored strategies. • Regional diversity allows for innovative, place-based energy-saving measures, including deep renovation and renewable integration (e.g., Austria's focus on decarbonising heating systems). • Integration with urban planning and mobility depends on regional priorities. **Coordination challenges exist, especially in fragmented systems (e.g., Belgium's complex governance structure**).

Type	Countries	Features
Network (Functional and Integrated Regional) Governance	Denmark; Finland; The Netherlands; Portugal, Sweden	• Energy-saving strategies transcend traditional administrative boundaries, focusing on functional regions. • Strong collaboration among local governments, private stakeholders, and civil society to address inter-regional spillovers (e.g., Netherlands' Regional Energy Strategies). • High integration of energy-saving with mobility and urban planning. • Advanced use of digitalisation and smart technologies. **Holistic sustainability is prioritised, addressing energy efficiency alongside broader environmental goals**.
Transitional and Constrained Governance	Croatia; Czechia; Estonia; Greece; Latvia; Lithuania; North Macedonia; Poland; Turkey	• Countries are transitioning to more integrated or decentralised governance systems but remain constrained by financial, institutional, and technical barriers. • Relies heavily on EU frameworks like the Renovation Wave and EU funding mechanisms for implementation. • Emerging regional cooperation models address metropolitan challenges (e.g., Poland's Integrated Territorial Investments framework). **Common challenges include insufficient resources, fragmented policies, and labour shortages**.
Market-Driven Governance	Iceland; Ireland; Luxembourg; Norway; UK	• Relies on public-private partnerships and strong stakeholder engagement to achieve energy-saving goals. • Often features innovative, market-driven solutions, such as integrating renewable energy technologies with housing. **Integration with urban and transport planning is growing but varies regionally.**

Source: Project team, 2025 based on compilation of national level analysis

In hierarchical governance systems, authority is centralised at the national level, reflecting a model prioritising compliance with overarching frameworks such as EU directives. National governments develop and enforce energy policies, often with limited input from regional or local authorities. This approach ensures uniformity and alignment with external frameworks such as the Energy Performance of Buildings Directive, which drives retrofitting and energy poverty alleviation efforts. However, this centralisation frequently limits the ability of local authorities to tailor strategies to local contexts. While this model enforces consistent implementation, it often stifles innovation and adaptability, particularly in geographically diverse regions where the implementation of localised solutions can improve outcome generation.

In contrast, multi-level governance distributes authority across national, regional, and local levels, fostering a collaborative approach to energy governance. National frameworks provide guidance, while sub-national entities develop and implement region-specific measures. Decentralisation enables innovative and place-based solutions, but fragmented governance structures can create inefficiencies and misalignments.

Network governance represents a model characterised by collaboration among diverse actors across functional regions, transcending traditional administrative boundaries. This typology emphasises partnerships between local governments, private stakeholders, and civil society, fostering a collective response to energy challenges. High sectoral integration is a characteristic of this approach, as energy-saving strategies are closely linked to mobility, urban planning, and broader sustainability objectives. While network governance promotes adaptability and responsiveness, it requires robust coordination and trust among stakeholders, which can be challenging to establish and sustain.

Transitional and constrained governance reflects the experiences of countries moving from hierarchical to networked approaches under significant financial and institutional constraints. However, progress is hindered by barriers such as insufficient resources, fragmented policies, and shortages of skilled labour and materials. Although these countries

are gradually adopting more integrated governance practices, structural and economic limitations present ongoing challenges.

Market-driven approaches emphasise collaboration with private actors. This typology relies on public-private partnerships that drive innovation and investment in energy-saving solutions. For instance, market-driven approaches often feature the uptake of recent technologies. This governance model requires strong regulatory frameworks to prevent market failures and ensure equitable outcomes.

7.3 Energy saving strategies for the building sector and their territorial footprint – lessons from the case studies

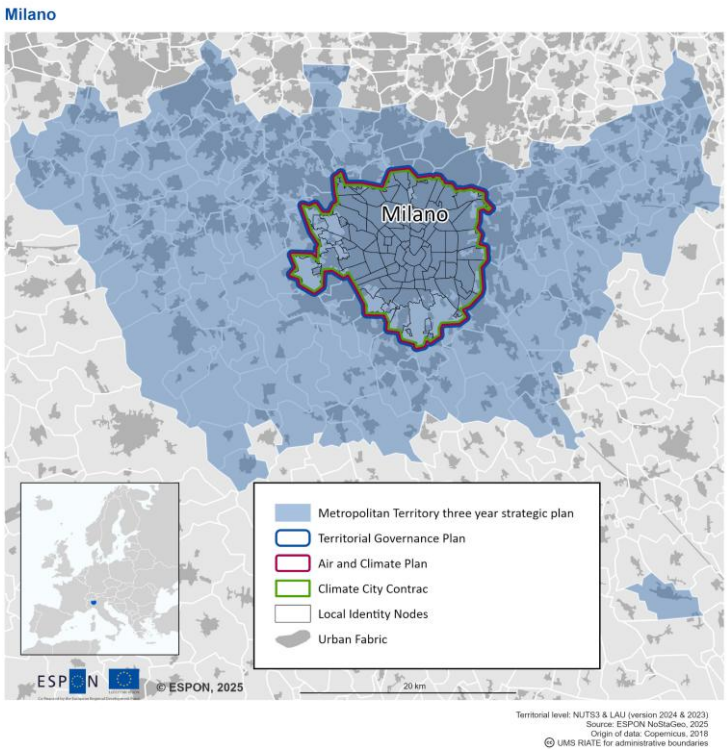
Building on the national governance analysis, the project team analysed four cities on their approaches to promoting energy saving, associated governance structures and their consideration of socio-spatial patterns in strategy design and implementation. The four cities each pursue innovative approaches in terms of spatial governance (such as for Milan and Copenhagen with metropolitan governance frameworks extending beyond administrative delineations of the cities) or in terms of specific place-based approaches (Leuven and Cluj-Napoca) or holistic approaches for stakeholder mobilisation (Leuven).

Transboundary spillovers and governance frameworks

The strategies analysed as part of this project highlight the prominence of conventional geographic delineation (e.g. by municipality or region): energy saving strategies are often delineated by administrative boundaries, especially in urban environments. However, more functional approaches to delineating strategies are emerging. Urban sprawl poses substantial challenges for energy efficiency in buildings across Europe. Literature underscores that urban sprawl contributes significantly to increased energy consumption due to factors like higher dependency on private transportation, inefficient infrastructure, and greater residential heating and cooling needs (Duwe et al., 2021; Manzano Agugliaro & Perea Moreno, 2020). This phenomenon amplifies greenhouse gas emissions, exacerbates climate vulnerability, and complicates sustainable urban management (Hat et al., 2022). EU policy frameworks increasingly advocate compact urban development to enhance energy efficiency, reduce emissions, and foster sustainable growth (Duwe et al., 2021).

For instance, initiatives that foster cooperation between municipalities, such as joint strategic planning and shared infrastructure investments, help mitigate administrative fragmentation. In this context, the experiences of Copenhagen and Milan demonstrate how metropolitan-scale strategies and cross-boundary governance models, like Copenhagen's regional district heating system and Milan’s Climate City Contract, effectively address energy challenges across multiple administrative units. The two other analysed cases (Leuven and Cluj-Napoca) do not operate metropolitan cooperation frameworks for energy savings. However, the two cases provide insights into the use of intermunicipal cooperation platforms as a tool to promote policy alignment and cooperation to navigate issues such as urban sprawl and commuting in relation to energy saving.

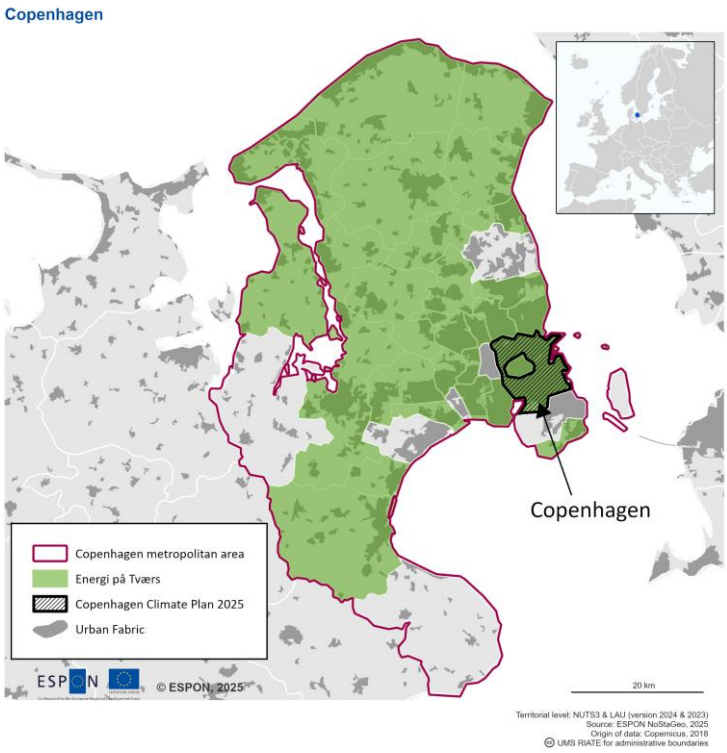
Map 7 Milan metropolitan area (Italy) – energy saving governance



Source: Project team, 2025

Milan promotes a crosscutting, place-based strategy for energy savings in the residential sector of the municipality expanding actions and scope of analysis towards the metropolitan area. The strategy has a strong focus on decarbonisation, social equity, and adaptive governance. Its twin frameworks, the Piano Aria e Clima and the Climate City Contract, guide investments in retrofitting, renewable energy, and heating transformation throughout the metropolitan region, supporting municipal cooperation beyond traditional administrative boundaries. The Piano Aria e Clima sets mid-term goals to cut emissions by 45% by 2030, with deep renovation and the phasing out of gas boilers as core pillars. Building retrofits are coordinated with urban greening and heat resilience measures, such as green roofs and energy-efficient insulation. The Climate City Contract consolidates Milan's climate ambitions into an investment framework of €6 billion, mobilising 25 public and private partners and introducing the concept of 'climate-neutral molecules': these are localised demonstration projects that integrate renovation, mobility, and energy measures and ensure a place-based approach to the solution proposed. Citizen assemblies and local co-design groups support inclusive governance, with tools such as the Energy Desk and the Deciwatt platform assisting residents and housing managers. These instruments are complemented by the strategy Towards Common Energy Wellbeing, which aims to tackle energy poverty through targeted support for vulnerable households, promoting a just and inclusive energy transition. The Piano strategico Triennale del territorio metropolitano (Metropolitan Territory three year strategic plan), approved in 2022 by the Metropolitan City of Milan, provides a framework for coordination across the 133 municipalities that comprise the metropolitan area. While broader in scope, addressing green transition, digitalisation, inclusion, mobility, education, and health, it reinforces the city's residential energy saving goals by promoting deep renovation of the metropolitan building stock, supporting energy communities, and encouraging best practices in energy efficiency.

Map 8 Copenhagen (Denmark) – energy saving governance



Source: Project team, 2025

Copenhagen's energy saving strategy is anchored in the Copenhagen Climate Plan 2025 and an expansive district heating system serving nearly all residential buildings. The city's commitment to carbon neutrality translates into building retrofits, fossil fuel phase-out, and civic engagement initiatives. A voluntary platform, Energispring, coordinates 57 stakeholders, managing 40% of building floor area, to benchmark progress and share best practices, reporting 10% energy savings from 2021 to 2023. The city complements physical interventions with digital innovation and grant programmes, focusing on retrofitting pre-1950 buildings and improving environmental performance. Beyond the city's boundaries, Copenhagen plays a leading role in the regional energy transition. To improve coordination between the different municipalities of the Copenhagen metropolitan area, several agreements were concluded. This includes the project "Energi på Tværs" that aims to establish an energy and traffic system free of fossil fuels. The project resulted in the creation of a regional development plan for the transformation of the capital region's energy system. The Joint Strategic Energy Plan brings together 33 municipalities, four of them in the Sjælland region, 11 infrastructure companies, the region of Hovedstaden as well as Gate 21, a non-profit public-private partnership platform focused on climate action. The participating companies are active in the sectors of waste-to-energy, district heating, utilities, gas infrastructure and renewable energy. Two of them operate nationwide, while two others operate on a municipal level. All other companies provide services in the Copenhagen metropolitan area or parts of it, with some being exclusively active in suburban regions. Urban areas are encouraged to install rooftop solar systems, while rural municipalities focus on wind turbines and biomass. A shared Roadmap 2025 outlines 34 actions, including 500 MW of new biomass and electric heating, 360 MW of wind capacity, and 13,000 MWh of thermal storage, to be implemented across the region. Copenhagen also contributes to low-carbon mobility through its network of super cycle lanes and cross-border electric vehicle infrastructure planning in the Øresund region. These efforts demonstrate how the city's climate strategy embraces its functional geography, combining

infrastructure investment, regional coordination, and citizen participation to drive a just and inclusive energy transition.

Leuven's 2030 Climate Neutrality Action Plan deploys a holistic, participatory mission-driven approach to energy saving. The strategy focuses on five domains: building renovation, renewable energy, mobility, green infrastructure, and social equity. Over 71 interventions are backed by enabling actions including monitoring and evaluation processes, regional cooperation, and civic contracting. The approach to energy saving is structured by a clear orientation towards generating long-term impacts and holistic implementation of energy saving measures. These include projects to foster behavioural change, deep renovation support for homeowners, collective renovation in co-owned buildings, and upgrades to social housing, as well as initiatives implemented by the main economic actors of the city. The plan integrates technical ambition with social fairness: property-linked finance mechanisms, mobility access schemes, and targeted support in deprived areas. Cross-sectoral synergies are reinforced through urban planning, mobility, and circularity measures. A mission-driven governance model, with equal representation across six stakeholder groups, ensures stakeholder ownership, policy coherence and learning. Leuven's strategy exemplifies how middle-sized cities can lead equitable, place-sensitive decarbonisation actions.

The Leuven 2030 platform was established to steer the city towards energy saving and climate sustainability. While not maintaining a metropolitan strategy, the city promotes inter-municipal cooperation on energy saving and mobility. These frameworks are not solely delineated by conventional administrative delineations but rather include municipalities in large parts of the wider commuting area, as well as some beyond. The Leuven 2030 strategy is delineated by the administrative borders of Leuven but connected to several inter-municipal cooperation frameworks. While the direct implementation of the action plan is focused on the city and its five sub-municipalities, the city of Leuven is involved in several coordination frameworks to promote policy alignment and cooperation. Leuven cooperates with municipalities cooperate on issues such as energy savings, as implementation competences are largely devolved to that level. This includes several initiatives, such as **Interleuven** provides an inter-municipal cooperation platform on issues tied to climate sustainability, economic development, and municipal services. In addition, the reference region of East-Brabant (Oost-Brabant) provides a coordination forum for mayors in terms of municipal activities, as well as providing the territorial frame for an energy community[14]. Alignment in spatial and mobility planning is also promoted via inter-municipal cooperation frameworks, such as Regionet Leuven, to mitigate some of the transboundary spillovers tied to commuting and increasing surface sealing from urban sprawl.

Cluj-Napoca's path to energy-efficient urbanism weaves together climate ambition, housing renovation, and systemic heating reform. The city has a highly decentralised building stock, with 77% of residents owning their buildings. This fragmentation makes large scale renovation efforts more difficult. In addition, the city has been declining in terms of number of residents, with a drop more than 10% between 2011 and 2021, combined with strong suburbanisation patterns and rapid surface sealing in neighbouring municipalities. Recognised by the EU as one of the 100 Climate-Neutral Cities, the city's Climate City Contract and Integrated Urban Development Strategy articulate a shared vision: achieving climate neutrality by 2030 through deep energy renovation and decentralised renewable heating. Cluj-Napoca pioneers a whole-of-government and mission-driven approach to

[14] The energy community EcoOB (which also contributes to the Leuven 2030 strategy) operates in the Reference Region, supporting renewable energy investments especially more socially vulnerable groups.

energy savings via its governance approach. Most of the housing stock consists of older, prefabricated apartment blocks with poor energy performance. Earlier thermal rehabilitation programmes were hindered by financial burdens and partial upgrades. Today, the city's efforts target investments in vulnerable districts such as Mănăștur, where a Horizon pilot tests replicable net-zero neighbourhoods. Modernisation of the legacy district heating system, once widespread but now diminished, includes block-level heating plants, solar-assisted networks, and heat pump integration. Strategic instruments support this transition: the Local Energy Efficiency Plan, Thermal Energy Strategy 2022–2031, and Local Green Deal processes. Governance is increasingly participatory, with co-creation labs and multi-level steering frameworks. Cluj's approach stands out for combining retrofit ambitions with urban equity, aiming to balance decentralisation, digitalisation, and climate resilience. There is currently no formal metropolitan governance structure dedicated to energy transition, although Cluj's Integrated Urban Development Strategy covers Cluj-Napoca municipality and the wider metropolitan area.

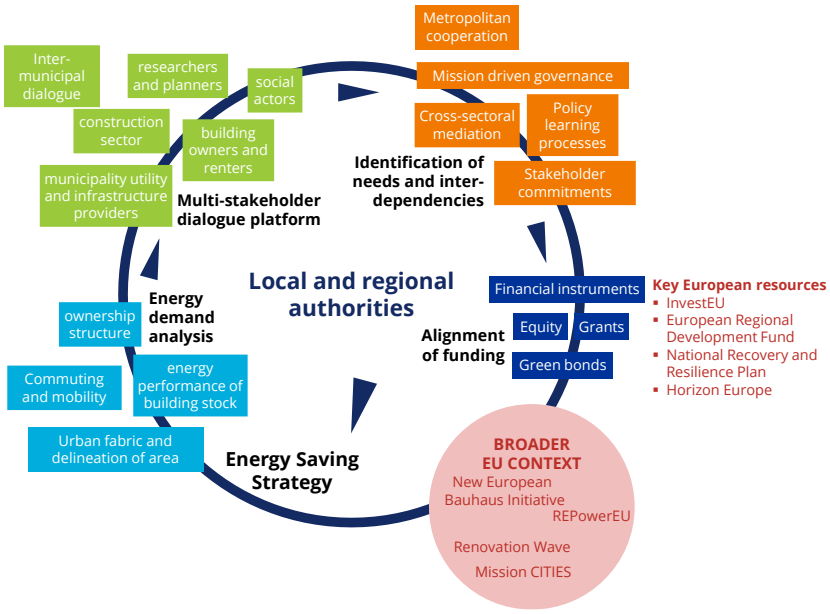
Energy poverty and stakeholder ownership in energy saving strategies

Around 40 million Europeans were affected by energy poverty in 2022. Energy poverty refers to the inability of households to secure adequate levels of energy for essential needs. It remains a pressing issue in many parts of Europe, particularly in South-East Europe and the Mediterranean. While energy poverty manifests differently across the EU, common drivers include low household income levels, high energy prices, poor energy performance of buildings and inadequate access to efficient heating or cooling systems.

The Renovation Wave initiative of the European Commission identifies "worst-performing buildings" and "energy poverty" as core priorities for renovation investments. Amid rising energy costs, an ageing building stock, and the drive towards climate neutrality, many European regions are developing and implementing local and regional energy saving strategies for residential buildings, with increasing attention also placed on supporting a just and inclusive energy transition. Energy efficiency strategies, particularly those focused on residential buildings, are increasingly designed to alleviate energy poverty by targeting the worst-performing buildings, prioritising low-income or at-risk households and areas, and supporting district heating, and collective renovation efforts.

Meaningful stakeholder involvement beyond sectoral approaches **can ensure that energy saving strategies and investments are** not only technically feasible but also **socially acceptable and politically viable**. The integration of mobility, local energy production and affordability other sectoral aspects into energy-saving strategies for residential housing can also help to account for various socio-economic and spatial dimensions, such as affordability, inclusion, and equity. This implies supporting collaboration and engagement among diverse stakeholder groups beyond local or regional government representatives, to include businesses, local communities, and civil society organisations, especially of residents at risk of energy poverty. The city of Leuven (Belgium) promotes the use of stakeholder pledges and commitments, as well as bottom-up tools of resident participation, to comprehensively involve stakeholder groups – including the largest employers of the city – in the energy saving strategy.

Figure 10 Holistic approaches to energy saving



Source: Project team, 2025

Accounting for specific local dimensions, such as specifics of the construction and renovation sector and labour market (e.g. shortages of materials, skilled labour etc.) or the ownership structures of the building stock may improve the relevance and viability of the strategy. Integrated approaches with a high degree of spatial and socio-economic accuracy were implemented by the analysed case studies as part of the project. Examples include integrated initiatives at neighbourhood level, accounting for socio-economic dimensions such as in relation to affordability and energy poverty and building ownership fragmentation in the cities of Leuven (Belgium) and Cluj-Napoca (Romania), with highly targeted initiatives, including neighbourhood transformation projects.

Future energy needs and its implications for energy savings

Heating is responsible for a significant share of energy consumption and greenhouse gas emissions in Europe, especially within the residential sector. However, climate change is escalating summer cooling needs in traditionally heating-dominated regions and stressing ageing infrastructures originally designed for relatively stable seasonal patterns. The change is particularly pronounced in Central Europe but also gaining prominence in Northern Europe, where the built environment has been optimised for insulation and where cooling infrastructure has historically been sparse or absent.

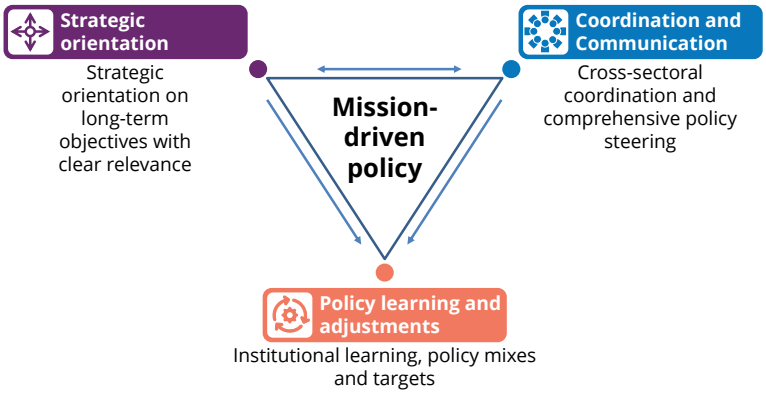
The four analysed cases reflect this underrepresentation of cooling needs. Overall, consideration of cooling is limited and remains an emerging concern, often overshadowed by a long-standing focus on heating efficiency and energy savings during heating months. While Milan leads in integrating urban cooling into its climate objectives, other analysed cities mostly focus on heating and associated energy demand reduction, such as via district heating solutions and thermal renovation. Milan explicitly acknowledges the challenge of increasing summer temperatures and the need for cooling systems in its Piano Aria Clima. Pilot projects, like the *uptown district*, utilise geothermal systems for both heating and cooling. The three other cases do not place such a strong focus on cooling needs but see some inclusion at the level of pilot initiatives or with the help of nature-based solutions to mitigate incidences such as urban heat islands. In both Copenhagen and Leuven, the support of nature-based solutions intends to contribute to urban cooling.

7.4 Conclusions and policy recommendations

The setup and implementation of energy saving strategies for buildings is affected by large variety of factors, including spatial to socio-economic characteristics of the region. Increasingly, and as reported in the stakeholder consultation undertaken as part of this project, the issues of stakeholder ownership and support have gained attention, especially when tied to larger-scale construction or renovation activities and tied to the installation of renewable energy systems. In addition, spatial developments, including continued urban sprawl and corresponding increases in commuting, stress the conventional delineation of energy saving approaches by administrative boundaries by contributing to misalignments in policies in the wider metropolitan or functional area.

Implementing energy saving strategies as mission-driven policies, with broad stakeholder involvement, integrated policy learning and clear impact orientation can help mitigate issues tied to stakeholder ownership and policy incoherence. Mission-driven frameworks were originally developed for innovation policies by the OECD (Larrue, 2021) and seek to align policy instruments and tools from multiple sectors and authorities towards a strategic goal (see Figure 11). They require well-developed coordination platforms and activities but act as agile policy frameworks with integrated learning and adjustment mechanisms. Such approaches are increasingly implemented beyond traditional research and innovation activities. This includes 53 European cities contributing to the EU Climate-Neutral and Smart Cities mission which apply this framework to coordinate existing policy instruments and support impact generation across diverse sets of policy tools.

Figure 11 Principles of mission driven policies



Source: Project team, 2025, adapted from OECD[15]

Extending the scope of energy saving strategies beyond administrative delineations can mitigate transboundary spillovers and support policy alignment. Ideally, such strategies should be delineated by the commuting area of an urban centre, or at the very least the core urban fabric. However, extending the scope of such a strategy may not always be politically feasible, also due to differences in spatial planning and technical standards affecting renovation and related energy saving activities between municipalities and regions.

Issues tied to misalignments and uncertainties in policy targets can be mitigated by improved policy coordination in the wider functional area, either via hard governance approaches such as the set-up of a dedicated metropolitan governance framework with

[15] See Larrue (2021)

steering competences or via softer governance approaches, including formalised municipal cooperation forums with a specific consideration for energy saving. From the analyses undertaken as part of this project, such cooperative approaches to promoting policy alignment across administrative boundaries are not yet the norm for many regions in Europe.

The following recommendations can be drawn from the findings of this project in relation to strategic energy saving approaches for the building sector:

- Energy saving strategies are largely delineated by administrative boundaries**. A more active consideration of the wider metropolitan area in the design and implementation of the strategy can support implementing bodies in managing spillovers and promoting energy saving in the wider function area**.
- **Specifically, delineating strategies with more consideration for the continuous urban fabric of the area beyond the administrative boundaries and the commuting zone is recommended** to allow municipal actors to promote cohesive approaches, such as in relation to mobility planning and uneven developments of housing and construction markets in the wider functional area.
- **Active cooperation via municipal forums and comparable soft-governance approaches with surrounding municipalities on issues related to energy efficiency** (e.g. renovation, mobility) can promote policy coherence in the wider functional area, especially if the development of metropolitan cooperation frameworks is not feasible due to political concerns. Ideally, **such cooperation efforts should be formalised** to the extent possible to support the implementation of their activities.
- The implementation of energy saving strategies can be complex due to the use multi-stakeholder and multi-sector approaches. **Intermediary organisation[16] can support the implementation of such strategies and act as a central communication and networking platforms to connect stakeholder groups from various territorial levels and sectors.**
- Community and stakeholder-driven initiatives (such as energy communities, neighbourhood energy pacts and plans etc.) can improve local acceptance of energy saving measures and promote social inclusion. **As such, early and comprehensive stakeholder involvement is recommended in the design and implementation of energy saving strategies, including especially at-risk populations.**
- **Accounting for specific ways in which energy is consumed by households can improve the relevance of the energy saving strategy**. In this regard, accounting for **sustainable mobility** as part of the framework can foster a more functional understanding of energy consumption and saving, particularly by also considering energy consumption resulting from commuting.
- **Accounting for local specificities of the building stock and settlement structure and their implication on the design of energy saving measures is essential.** Approaches to fostering renovation differ between cities and regions with fragmented, owner-occupied building stocks and those with more centralised ownerships. This can also take the form of neighbourhood level initiatives with highly targeted approaches which combine multiple strands of energy saving, such

[16] This can include dedicated bodies which manage day-to-day implementation of the strategy, such as in the case of Leuven, or stakeholder organisations which can act as relays to those groups.

as with renovation activities, improvements of public transport and installing district heating systems. Neighbourhood-scale approaches can support energy saving strategies by aligning policy responses with the specific spatial and social characteristics of local contexts and act as testing grounds for spatially coordinated solutions and generate transferable models that can inform wider city and metropolitan strategies.

- **Mission-driven approaches can be applied to promote policy coherence, learning and impact generation across a wide range of instruments and sectors for energy efficiency.** To support effective implementation of a mission-driven strategy, sufficient political will is necessary at municipal level, as well as robust stakeholder involvement and outreach.
- **Meaningful stakeholder involvement beyond pure sectoral approaches can ensure that strategies are not only technically feasible but also socially acceptable and politically viable.** This may also help to account for various socio-economic and spatial dimensions, such as affordability, inclusion, and equity. This entails supporting collaboration and engagement among diverse stakeholder groups beyond local or regional government representatives, to include businesses, local communities, and civil society organizations, especially of populations at risk of energy poverty.

In relation to further **guidance and capacity building** measures at EU level in the field of energy saving strategies, the project team recommends the following.

- **Further promote the production and dissemination of regionalised data on energy consumption and production at national and EU levels to improve decision making**. While the availability of regionalised energy and building data has increased somewhat, most of it remains at national level, particularly for EU data sets. This introduces a large degree of territorial blindness to decision makers, especially at EU level.
- **Provide support to municipal stakeholders in recognising the added value of metropolitan governance for energy saving.** This can take the form of stakeholder outreach events, dedicated working groups or forums comprising local and regional stakeholders at EU level**.**
- **Further promote cross-regional and EU stakeholder cooperation on energy saving strategies and best practices, particularly on mission-based and holistic design of the underlying strategies via ESPON and transnational cooperation.** Communication on best practices should include approaches to foster stakeholder ownership, integration of national and EU funding, steering mechanisms and approaches to delineate energy saving strategies.

8 Conclusions & Research Perspectives

The ESPON NoStaGeo project was conceived as an exploratory journey into the governance of non-standard geographies: territories that fall outside conventional spatial classifications yet require functional approaches for effective policymaking. As the research progressed, it became evident that these geographies cannot be delineated in the same way as Functional Urban Areas (FUAs) or Local Labour Market Areas (LLMAs). Commuting patterns, which underpin FUA delineations, offer a reliable proxy for geographically coherent economic units and provide a solid foundation for comparative urban policy across Europe. No comparable proxies were identified in the four thematic fields explored by NoStaGeo: water supply in metropolitan areas, ecological connectivity, energy saving in the built environment, and industrial transitions.

Rather than being defined by measurable flows, non-standard functional areas are shaped through co-construction. Their contours reflect the interaction of local initiative, institutional flexibility, policy experimentation, and social readiness. These areas are, by nature, fuzzy, pragmatic, and oriented towards problem-solving. They do not emerge from statistical regularities, but from negotiated understandings between stakeholders seeking to address complex, cross-border challenges.

This recognition led to a reorientation of the project's methodological approach. Initially focused on identifying spatial delineations through quantitative indicators, the research evolved towards a more qualitative and narrative-based enquiry. Three key strands defined this shift:

- **Structuring knowledge on drivers of change**, by linking global and European reform agendas to local and regional narratives. Infographic tools were developed to help policy actors navigate these multi-level discourses and consider how artificial intelligence could support place-based synthesis of emerging trends.
- **Systematic assessment of governance frameworks** across 41 institutional contexts, focusing on the capacity to support cross-boundary initiatives. These findings were visualised through spider and rainbow diagrams in an interactive dashboard, enabling comparative insights and reflection on governance maturity.
- **Development of case studies** to explore how non-standard functional areas emerge in practice. These studies combined spatial analysis with stakeholder perspectives and were presented using ESRI StoryMaps, offering visually rich, multi-scalar accounts of transformation processes.

Policy Recommendations

Despite the diversity of themes, the policy recommendations presented in Chapters 4 to 7 are grounded in a common logic. Transformation processes such as the green and digital transitions, climate adaptation, and biodiversity restoration often require new spatial configurations for action. However, rather than proposing fixed models, the NoStaGeo recommendations focus on enabling conditions. These include:

- **Supporting dialogue and co-construction**. Functional areas arise through cooperation. Policy frameworks and funding instruments should encourage iterative, inclusive processes of stakeholder engagement.
- **Enhancing functional awareness**. Policymakers and practitioners benefit from tools that make visible the overlapping geographies in which they operate. These

may include spatial data, risk mappings, institutional charts, and scenario-building platforms.

- **Bridging administrative boundaries**. Functional relationships often extend across formal jurisdictions. This calls for innovations in governance, from informal partnerships and voluntary agreements to more formalised cooperation mechanisms.
- **Promoting learning and adaptation**. Effective governance is adaptive governance. Good practice examples, such as the Netherlands' Delta Programme or the green industrial transition in northern Sweden, should be shared and critically examined through structured peer learning.

In conclusion, the value of functional approaches lies not in imposing standard solutions, but in their capacity to mobilise relevant actors around shared problems and opportunities. While the geographies of emerging challenges defy standardisation, they are nonetheless governable. The key lies in embracing complexity, fostering inclusive dialogue, and equipping stakeholders with the means to navigate uncertainty in a collaborative and place-sensitive manner.

Decision-Making Support Tools for Functional Area Approaches

Building on the project's findings, we propose the development of the following ESPON-supported databases and tools:

1. Functional Area Observatory Toolkits

A modular digital environment addressing a specific thematic field, that allows users to:

- Visualise overlapping geographies such as river basins, water abstraction zones, ecological corridors, labour market catchments, energy distribution networks and innovation ecosystems.
- Overlay thematic data layers (e.g. climate risks, industrial emissions, skills profiles) at various spatial resolutions.
- Explore scenarios for functional cooperation.
- Compare their own territorial arrangements with functional area configurations in other European regions.

This toolkit would build on existing datasets such as HydroSHEDS, ECRINS, ENTSO-E grids, and Eurostat's population grids.

2. Governance Capacity Dashboard

An expanded version of the dashboard developed in NoStaGeo, enabling:

- Rapid comparison of governance frameworks across countries and regions.
- Access to spider and rainbow diagrams for each theme (e.g. ecological connectivity, water resilience).
- Searchable examples of good practice in soft governance, legal frameworks, and hybrid institutional arrangements.
- Links to funding programmes, guidance materials, and contacts for peer learning.

Such a resource could enhance the uptake of adaptive governance models by providing tailored policy intelligence.

3. Thematic Evidence Compendia

For each major functional challenge (e.g. water resilience, industrial transition), ESPON could support the creation of updatable digital compendia that include:

- Functional area typologies and related governance templates.
- Data sources (standard and experimental).

- Syntheses of European and national policy frameworks.
- Curated case examples, StoryMaps and visual explainers.

These compendia would be valuable for practitioners and planners looking to design integrated strategies at appropriate functional levels.

4. AI-Powered Knowledge Navigation Interface

As explored in the NoStaGeo prototype infographics, AI tools could be deployed to:

- Assist local stakeholders in navigating global, European, and national policy discourses.
- Tailor policy intelligence to the territorial profile of a region.
- Generate dynamic "knowledge maps" linking local initiatives to wider trends and reform agendas.

5. Metropolitan Governance Observatory

Understanding how metropolitan governance operates in practice helps reveal how functional cooperation emerges, is institutionalised, or remains fragmented. This, in turn, offers valuable lessons for supporting non-standard functional approaches in other thematic or spatial contexts. ESPON could develop a **Metropolitan Governance Observatory** to support cities and regions in strengthening cross-municipal cooperation. Building on NoStaGeo's mapping, this observatory could offer:

- **A regularly updated map** of metropolitan governance initiatives across Europe, based on actual cooperation structures rather than statistical delineations.
- **A comparative typology**, highlighting key features such as legal status, strategic coordination, and involvement in EU instruments.
- **A knowledge-exchange platform**, with good practice examples, visual tools, and peer learning opportunities.

This would help local and regional authorities better understand and shape governance arrangements suited to their metropolitan realities.

Such tools could bridge the gap between high-level strategic frameworks and the operational realities of functional cooperation.

These tools would not impose a universal model for delineating functional areas, but rather support place-sensitive approaches that are co-constructed through stakeholder interaction. Their value lies in enhancing the capacity of actors at all levels to understand spatial interdependencies, explore policy options, and initiate collaborative responses that reflect both functional logics and institutional realities.

By investing in these knowledge infrastructures, ESPON could further consolidate its role as a platform for supporting innovative territorial governance across Europe.

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Annex 5 - WP3 Industrial Transitions

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Annex 6b - WP3 Metropolitan Delineations

Annex 7 - WP4 comparative report

Annex 7.1 National Governance Frameworks AL

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Annex 7.4 National Governance Frameworks BE Flanders

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Annex 7.26 National Governance Frameworks MK

Links to Digital Deliveries

Trends and Drivers of Change Infographics

Accessible here

National Governance Frameworks Dashboard

Accessible here

ESRI StoryMaps

Water management

1. Rethinking metropolitan water supply
2. Barcelona
3. Berlin Brandenburg
4. Paris
5. Lodz

Ecological connectivity

1. Ecological connectivity
2. The Green City of Ljubljana
3. Reindeer Conservation Areas
4. Farmer Cluster and Agroforestry Transitions in South Moravia
5. Alpine cluster

Energy saving

1. Energy Saving Strategies for Residential Buildings
2. Leuven 2030
3. Milan Energy Saving Strategies
4. Copenhagen Saving Strategies
5. Cluj-Napoca Energy Saving Strategies

Industrial transition

1. Brown to Green Industrial Transition
2. Regional Emerging Geographies in Villach
3. Transition to Green Steel in Norrbotten
4. Transition processes in Upper Silesia and Western Małopolska
5. Axe Seine / Vallées de la Seine et de la Bresle

References

Butler EP, Bliss-Ketchum LL, De Rivera CE, et al. (2022) Habitat, geophysical, and eco-social connectivity: benefits of resilient socio–ecological landscapes. *Landscape Ecology* 37(1): 1–29.

Carrozza C and Fantini E (2013) *Si Scrive Acqua. Attori, Saperi e Pratiche Del Movimento Italiano per l'acqua.* Academia University Press. Torino.

Carrozza C and Fantini E (2016) The Italian Water Movement and the Politics of the Commons. *Water Alternatives* 9(1): 99–119.

Chlebna C, Martin H and Mattes J (2023) Grasping transformative regional development – Exploring intersections between industrial paths and sustainability transitions. *Environment and Planning A: Economy and Space* 55(1): 222–234.

Cook CN (2024) Progress developing the concept of other effective area-based conservation measures. *Conservation Biology* 38(1): e14106.

Cotella G (2023) Breaking out of the box – towards functional spatial planning. *disP - The Planning Review* 59(3). Routledge: 4–5.

Dijkstra L (2024) What do we owe a place? How the debate about left-behind places is challenging how we distribute public funding and the problems it should address. *Cambridge Journal of Regions, Economy and Society* 17(2). Oxford University Press (OUP): 417–424.

Druckman A and Jackson T (2008) Household energy consumption in the UK: A highly geographically and socio-economically disaggregated model. *Energy Policy* 36(8). 8: 3177–3192.

ESPON (2013) *ESPON TANGO - Territorial Approaches for New Governance*. Main Report.

ESPON ACTAREA (2017) *Thinking and Planning in Areas of Territorial Cooperation*. Luxembourg: ESPON. Available at: https://www.espon.eu/actarea.

EY (2022) *Megatrends 2020 and beyond - EYQ 3rd edition*.

Faludi A (2018) The Poverty of Territorialism. Available at: https://www.elgaronline.com/monobook/9781788973601/9781788973601.xml (accessed 3 June 2025).

Fang X, Hou X, Li X, et al. (2018) Ecological connectivity between land and sea: a review. *Ecological Research* 33(1): 51–61.

Folke C, Pritchard J, Berkes F, et al. (2007) The Problem of Fit between Ecosystems and Institutions: Ten Years Later. *Ecology and Society* 12(1). The Resilience Alliance.

Gargiulo C and Russo L (2018) Cities and Energy Consumption: Strategies for an Energy Saving Planning. In: Papa R, Fistola R, and Gargiulo C (eds) *Smart Planning: Sustainability and Mobility in the Age of Change*. Cham: Springer International

Publishing, pp. 49–70. Available at: https://doi.org/10.1007/978-3-319-77682-8_4 (accessed 30 April 2024).

Grillitsch M and Hansen T (2019) Green industry development in different types of regions. *European Planning Studies* 27(11): 2163–2183.

IUCN-WCPA Task Force on OECMs (2019) *Recognising and reporting other effective area-based conservation measures*. Gland, Switzerland: IUCN.

Kuzma S, Bierkens MFP, Lakshman S, et al. (2023) Aqueduct 4.0: Updated Decision-Relevant Global Water Risk Indicators. *World Resources Institute*. Epub ahead of print August 2023. DOI: 10.46830/writn.23.00061.

Larrue P (2021) The design and implementation of mission-oriented innovation policies: A new systemic policy approach to address societal challenges. OECD SCIENCE, TECHNOLOGY AND INDUSTRY POLICY PAPERS. Available at: https://www.oecd.org/en/publications/the-design-and-implementation-of-mission-oriented-innovation-policies_3f6c76a4-en.html.

Liquete C, Kleeschulte S, Dige G, et al. (2015) Mapping green infrastructure based on ecosystem services and ecological networks: A Pan-European case study. *Environmental Science & Policy* 54: 268–280.

Marot N, Kostanjšek B, Penko Seidl N, et al. (2024) Implementing the green infrastructure concept in practice: an example of the EU-strategy for Alpine Region. *Journal of Environmental Policy & Planning* 26(4): 325–338.

Meier ES, Lüscher G, Herzog F, et al. (2024) Collaborative approaches at the landscape scale increase the benefits of agri-environmental measures for farmland biodiversity. *Agriculture, Ecosystems & Environment* 367: 108948.

Moreira F, Dias FS, Dertien J, et al. (2024) Guidelines for connectivity conservation and planning in Europe. Research Ideas and Outcomes. Available at: https://preprints.arphahub.com/article/129021/ (accessed 25 June 2025).

Moss T (2012) Spatial Fit, from Panacea to Practice: Implementing the EU Water Framework Directive. *Ecology and Society* 17(3). 3. The Resilience Alliance.

Nyangchak N (2022) Emerging green industry toward net-zero economy: A systematic review. *Journal of Cleaner Production* 378: 134622.

OECD (2023) *Regions in Industrial Transition 2023: New Approaches to Persistent Problems*. OECD Regional Development Studies. OECD. Available at: https://www.oecd-ilibrary.org/urban-rural-and-regional-development/regions-in-industrial-transition-2023_5604c2ab-en (accessed 3 May 2024).

Orlikowska EH, Roberge J-M, Blicharska M, et al. (2016) Gaps in ecological research on the world's largest internationally coordinated network of protected areas: A review of Natura 2000. *Biological Conservation* 200: 216–227.

Ostrom E, Janssen MA and Anderies JM (2007) Going beyond panaceas. *Proceedings of the National Academy of Sciences* 104(39). Proceedings of the National Academy of Sciences: 15176–15178.

Pichler M, Krenmayr N, Schneider E, et al. (2021) EU industrial policy: Between modernization and transformation of the automotive industry. *Environmental Innovation and Societal Transitions* 38: 140–152.

Ringel M (2017) Energy efficiency policy governance in a multi-level administration structure — evidence from Germany. *Energy Efficiency* 10(3): 753–776.

Salet W, Vermeulen ,Rick, Savini ,Federico, et al. (2015) Planning for the new European metropolis: functions, politics, and symbols/Metropolitan regions: functional relations between the core and the periphery/Business investment decisions and spatial planning policy/Metropolitan challenges, political responsibilities/Spatial imaginaries, urban dynamics and political community/Capacity-building in the city region: creating common spaces/Which challenges for today's European metropolitan spaces? *Planning Theory & Practice* 16(2). Routledge: 251–275.

Stolpe G, Howland E and Upton J (2024) *OECMS in Europe: The way forward*. IUCN WCPA Issues Paper Series No. 1,. Gland, Switzerland: IUCN.

Swyngedouw E (2009) Civil Society, Governmentality and the Contradictions of Governance-beyond-the-State: The Janus-face of Social Innovation. In: *Social Innovation and Territorial Development*. Routledge.

Taylor PD, Fahrig L, Henein K, et al. (1993) Connectivity Is a Vital Element of Landscape Structure. *Oikos* 68(3). [Nordic Society Oikos, Wiley]: 571–573.

Thellufsen JZ, Lund H, Sorknæs P, et al. (2020) Smart energy cities in a 100% renewable energy context. *Renewable and Sustainable Energy Reviews* 129: 109922.

Van Der Windt HJ and Swart JAA (2008) Ecological corridors, connecting science and politics: the case of the Green River in the Netherlands. *Journal of Applied Ecology* 45(1): 124–132.

Watson DM, Doerr VAJ, Banks SC, et al. (2017) Monitoring ecological consequences of efforts to restore landscape-scale connectivity. *Biological Conservation* 206: 201–209.

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