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PLANNING AS A TRANSFORMATIVE ACTION IN AN AGE OF PLANETARY CRISIS



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Referencing style

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Zero Net Land Take Policy Mapping: A Multi-Level Analysis in the Context of Italy and Emilia-Romagna

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Abstract

The Zero Net Land Take (ZNL) policy seeks to reconcile urban development and land conservation by 2050. This study reviews ZNL-related policies at the European, national, and regional levels, focusing on Emilia-Romagna region, Italy. Analysis of legal documents reveals that while strategic objectives are set at the European level, member states and regions implement ZNL with varying approaches, reflecting their governance and planning traditions on example of Emilia-Romagna region. This study underscores the importance of a coherent multi-level governance structure to achieve ZNL. Misalignments between national guidelines and regional or local practices create fragmentation, undermining cohesive policy action. Analyzing these gaps is crucial to advancing sustainable urban development aligned with ZNL goals.

Key words: ZNL, Land Consumption, Policy Mapping

Background and Rationale

Recent rapid urban expansion has led to extensive land consumption and ecological degradation. To balance growth with preservation, the EU has prioritized sustainable spatial planning, notably the Zero Net Land Take (ZNL) objective, which seeks to match land consumed for urban development with renaturalization of previously developed areas by 2050, ensuring no net increase in urbanized land (European Commission, 2021a; 2021b). ZNL's prominence in strategic frameworks reflects its connections to land conservation, climate adaptation, biodiversity protection, and ecosystem restoration. These strategies underscore that mitigating urban sprawl and soil sealing is vital for environmental sustainability, urban resilience, and climate adaptation.

There is a growing recognition of ZNL policies' importance across multiple governance levels - several EU member states have adopted policies aligned with ZNL, such as France's binding target for 2050 (République Française, 2021) and Flanders' 2040 target (Departement Omgeving, 2018), or Italian Regional Law No. 24/2017 (LR 24/2017), aiming to achieve ZNL by 2050; however significant challenges persist, that hinder the cohesive and wide implementation of ZNL across member states.

Local priorities, fiscal constraints and sectoral silos frequently dilute strategic intent (Idt et al., 2024; Decoville & Feltgen, 2023; Schatz et al., 2021). Fragmented competencies and limited inter-sectoral coordination further widen the gap between policy and practice (Gradinaru et al., 2023; Geneletti et al., 2017). Conceptual ambiguities allow divergent interpretations, while the absence of harmonised monitoring indicators hampers consistent tracking and accountability (Löbmann et al., 2022; Zoppi & Lai, 2014). Economic incentives for greenfield development often outweigh the long-term benefits of land neutrality, reducing local commitment to ZNL goals (Schatz et al., 2021). Finally, stakeholder participation remains sporadic, risking the exclusion of critical perspectives needed for equitable spatial planning (Lacoere & Leinfelder, 2023; Stankovics et al., 2020). ZNL balances fresh urban land uptake with renaturalisation or brownfield reuse so that total "consumed" land does not rise by 2050. Interpretations and implementation, however, vary widely among member states, revealing notable conceptual gaps between EU and national levels (Decoville & Feltgen, 2023; Schatz et al., 2021).

Additionally, a considerable conceptual ambiguity persists: European policies variously employ the terms No Net Land Take (NNLT) and Zero Net Land Take (ZNL), breeding unnecessary uncertainty. NNLT, used in EU frameworks (e.g., Resource Efficient Europe Roadmap 2011; Biodiversity Strategy 2020; Soil Strategy 2021), seems to emphasize prevention of new soil sealing, whereas the term ZNL appears to sanction development only if it's offset by de-sealing, ecological restoration, or brownfield reuse, projecting a looser, "balance-of-accounts" stance. Besides,

as highlighted by Elisabeth Marquard (Marquard et al., 2020), there are different copes of the discussed concepts and indicators in relation to different land use/land cover categories. There is significant conceptual ambiguity in the terms to describe land conversion processes: land consumption, land take, soil sealing, artificialization, etc. The primary objective of this study is to provide a comprehensive multi level analysis of ZNLT policy frameworks at the EU level, and their adoption, adaptation, and operationalization at national and regional scales (with Italy and Emilia-Romagna region as case studies). It seeks to identify persistent cross-level misalignments, institutional fragmentation, and operational challenges hindering ZNLT objectives local implementation. By analyzing policy adoption, the study seeks to clarify conceptual ambiguities in translating EU directives into effective land-management practices.

Methodology

This study adopts a multi phase qualitative policy mapping to identify, analyze, and evaluate ZNLT instruments and governance frameworks at European, national, and regional scales. The study employs a mixed methods policy mapping framework, integrating qualitative document analysis with quantitative network analytic metrics to interrogate the ZNLT governance architecture at supra , national, and subnational scales.

The case studies—Italy at national level and Emilia-Romagna at regional level—were chosen for their contrasting policy landscapes: Emilia-Romagna has proactively enacted a no-net-land-take law, whereas Italy as a whole remains without a unified ZNLT framework. This divergence provides an instructive lens through which to examine the complexities of multi-level governance, highlighting both the region’s innovative advances and the national-subnational coherence and enforcement challenges that arise in the absence of an overarching legal architecture.

In phase one of the study, policy documents were systematically collected that explicitly or implicitly linked to ZNLT thematic pillars. The search was built around the following topics: land take and soil sealing; urban regeneration, sustainable land management, and ecosystem restoration; and reuse of previously developed areas. Guided by a literature and policy review, the desktop search used official sources, legal databases, institutional reports, and spatial planning guidelines. The corpus of polices was enriched by involving expert consultation, database enrichment, and policy validation with sectoral representatives from Emilia-Romagna public administration,

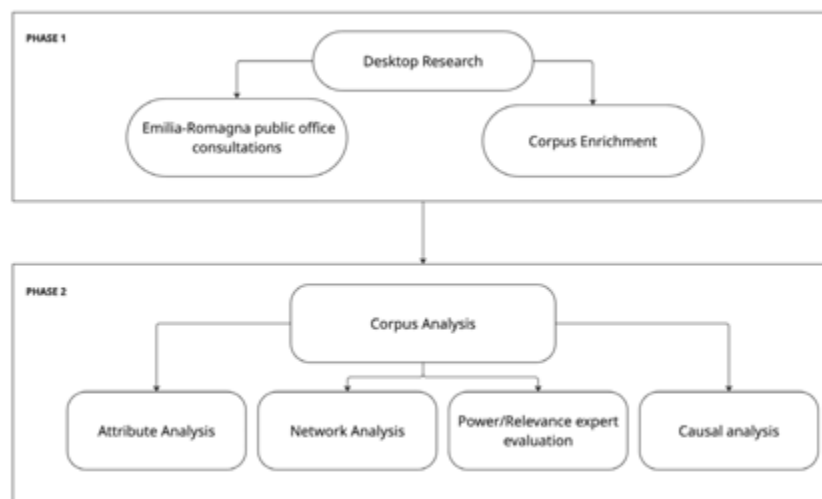


Figure 1. Methodological framework of the study, source: authors

An inclusion protocol ensured analytical rigor and relevance by requiring that documents be currently in force, and explicitly or implicitly related to at least one of the land take thematic.

The collected policies were then analyzed to assess their attributes, their linkages to other policies, their causal roles, and their relevance to local practices in Emilia-Romagna.

1. Comparative Framework and Analytical Lens

The review encompassed legally binding instruments, and non-binding strategic programmes, guidance documents, and implementation frameworks. Contextual analysis interrogated both external and internal analysis: exogenous policies attributes that affect wider governance environment and the policies' intrinsic characteristics.

To assess the governance environment, network analysis was applied to the assembled policy corpus. The principal links were grouped as following: subordinated implementation links (policies serving as subordinate components within broader frameworks), strategic execution links (policies translating high-level strategies into actionable goals without strict subordination), and operational links (policies providing financial, regulatory, or procedural mechanisms to implement other policies). Expert collaboration with Emilia-Romagna public administration further enriched and validated the findings. Based on Kristensen's (2004) framework, policy objectives were coded by entry date and DPSIR node (Drivers, Pressures, States, Impacts, Responses), revealing temporal gaps and concentrations that affect adaptive governance.

At the content analysis, policies were systematically compared across different dimensions:

1. Instrument Classification (Howlett, 2009; Belin et al., 2014): instruments were categorized as legal (binding), economic (incentives/disincentives), informational (guidance), or strategic (non-binding visions) to assess enforceability and leverage.

2. Thematic Clustering: Land Use and Soil Protection; Biodiversity and Ecosystem Restoration; Environmental Quality and Pollution Prevention; Sustainable Urban Development and Regeneration.

3. Land Conversion Scope Correspondence: Policies were grouped by targeted land conversion processes, using different terms from described in Marquard study (Marquard et al., 2020) - soil sealing, land take, land consumption, SDG 11.3.1 and also also fragmentation (division of habitats due to conversion).

Soil sealing: Permanent covering of land by impervious materials, impairing soil functions.

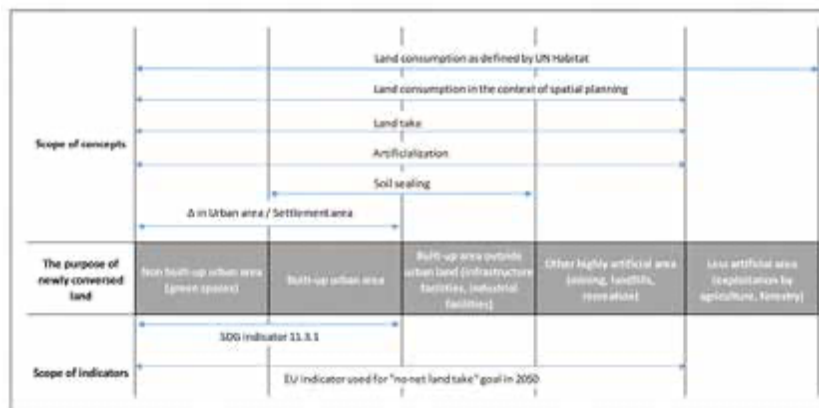


Figure 2. Scales of the concepts and indicators in relation to different land use/land cover categories, source: Marquard et al., 2020

Each policy's relevance and contribution to reusing abandoned land was jointly scored by researchers and Emilia-Romagna experts according to their relevance to local practices on ZNLT, ensuring analytical rigor and practice-oriented evaluation.

2. Defining the ZNLT Policy Corpus at European, National, and Regional Tiers

Following a desk review, the first 44 policy documents were identified. Subsequently, policy officers from the Emilia-Romagna administration recommended three additional texts. This corpus then served as the basis for a network-mapping analysis designed to visualise inter-document linkages and thematic overlaps (SocNetV tool).

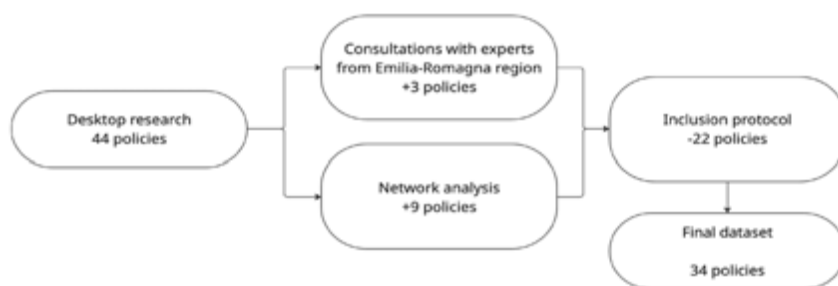


Figure 3. Policy mapping process, source: authors

Policies acted as nodes in networks, linked by references, legal hierarchies, or shared objectives, with their centrality indicating structural importance. Central hubs exhibit the highest degree, each spawning more than a dozen subordinate regulations and guidelines in the intermediate rings. Secondary hubs further translate these directives into territorially specific measures. In contrast, the sparsity of links in the upper right sector corresponds to under transposed objectives related to ecosystem service valuation, suggesting a gap between strategic intent and operational uptake. Overall, the topology confirms a “command and translate” hierarchy: supranational norms initiate the causal chain, national legislation refines scope and enforcement, and regional plans supply context dependent tools, yet the uneven distribution of subordinate ties highlights domains requiring additional transposition efforts to achieve full multi level alignment.

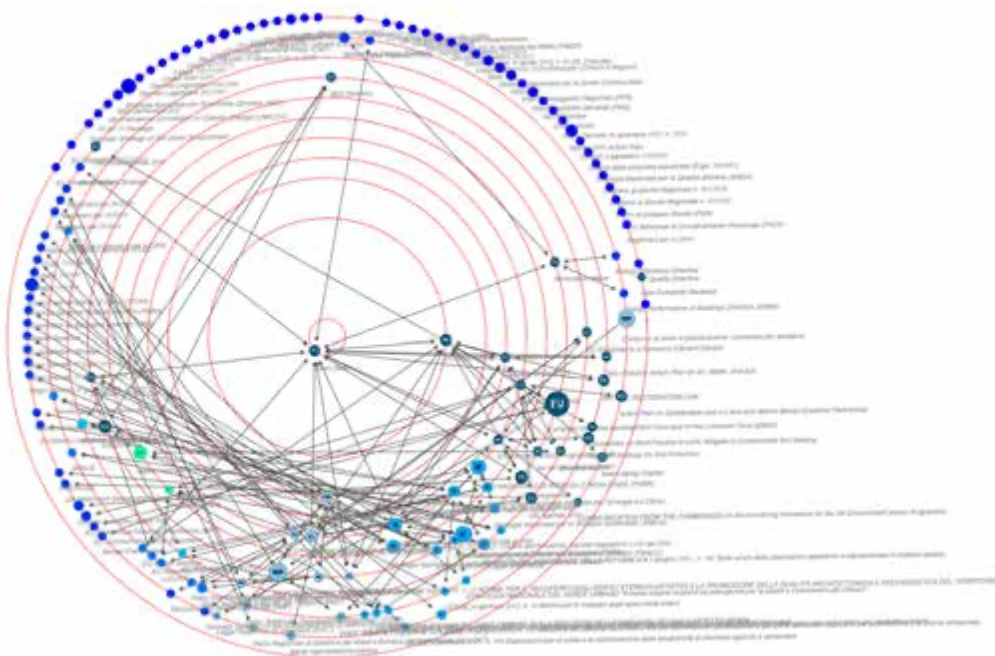


Figure 4. Policy network mapping, subordinated implementation links, source: authors (SocNetV tool)

The second radial graph shifts the lens from hierarchical subordination to horizontal connectivity, visualizing explicit cross references and shared implementation clauses that bind the corpus into a cohesive governance web. In this layout, a dense inner core of EU level strategies—including the European Green Deal, Biodiversity Strategy 2030, and Soil Thematic Strategy—functions as a multi policy “switchboard” with the highest betweenness centrality, channeling over one third of lateral edges. National framework laws (e.g., Italy’s Climate Law 2020

and the Circular Economy Action Plan) occupy mid rings, forming cross sector bridges that synchronize energy, land take, and restoration agendas. Outermost rings host specialized regulations—such as regional territorial plans and sectoral decrees—that derive operational guidance from multiple upstream sources, reflected in their high out degree but low reciprocity. A pronounced edge density along the southeast arc highlights an execution “cluster” where climate adaptation, brownfield redevelopment, and renewable energy mandates reinforce one another, indicating strong integrative capacity in those domains. In contrast, the sparse link field in the northwest quadrant signals thematic silos around ecosystem service valuation and social equity, showing these topics are weakly embedded in current execution chains. Overall, the topology reveals a governance architecture that is horizontally well connected for mitigation and circular economy objectives but remains fragmented for socio ecological valuation, pinpointing strategic areas where future policy knitting is needed.

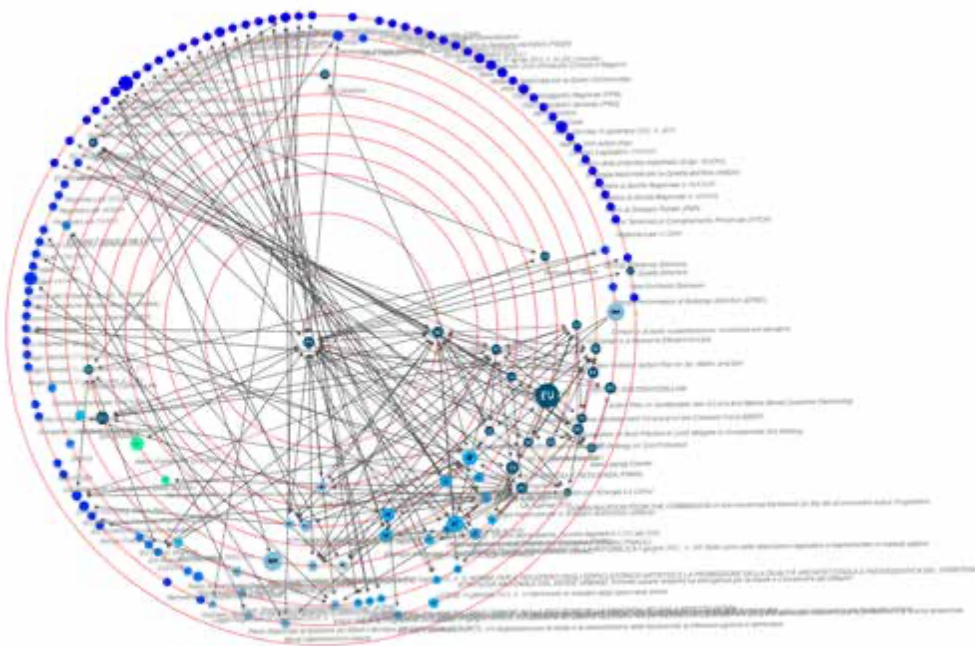


Figure 5. Policy network mapping, strategic execution links, source: authors (SocNetV tool)

The operational layer of the policy web comprises concrete instruments that translate strategic goals into codified procedures, monitoring schemes, or financing mechanisms. At the graph’s centre lies a single dominant hub—a regulation with top decile degree and highest betweenness—representing a cross cutting implementation framework serving as the procedural backbone for multiple thematic domains. From this hub radiates a dense fan of edges to mid tier policies forming an “execution cluster” in the south eastern arc; their moderate betweenness but high degree indicates they collect mandates from the central hub and redistribute them into sectoral toolkits without bridging to other clusters. Conversely, the north western quadrant contains smaller peripheral nodes with low degree and negligible betweenness, reflecting policy instruments operating largely in isolation and weakly institutionalized within mainstream operational machinery. Overall, the topology reveals a governance architecture dominated by a few procedural heavyweights, while several thematic areas lack robust linkages. Closing these gaps will require augmenting existing hubs’ mandates or establishing new bridging instruments to align operational execution with strategic ambition.

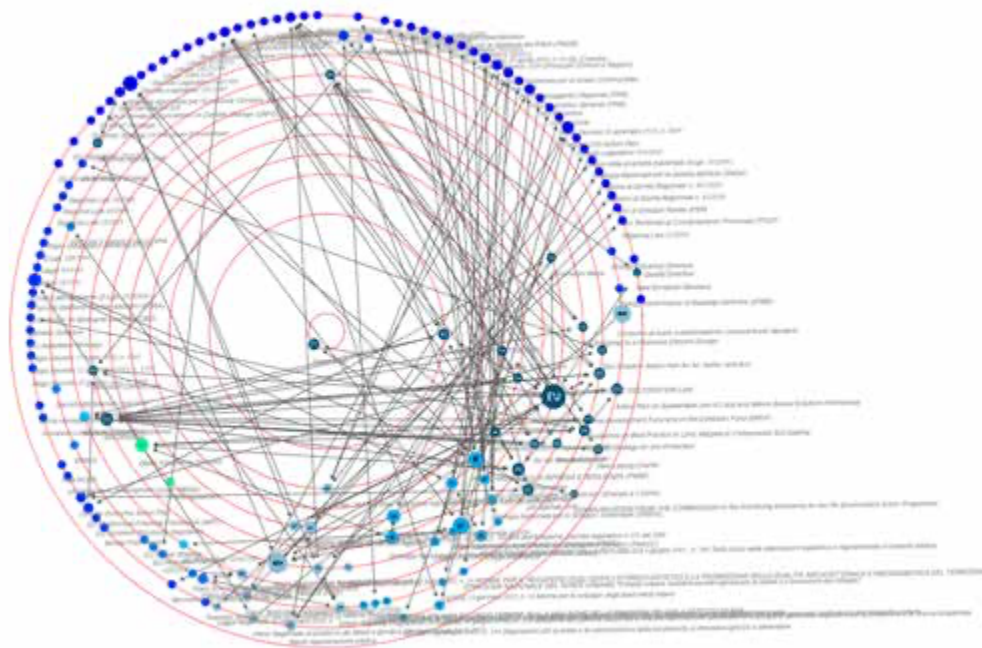


Figure 6. Policy network mapping, Operational execution links, source: authors (SocNetV tool)

The network analysis enabled the identification of prominent nodes both through visual inspection and quantitative centrality metrics (degree, betweenness, and eigenvector). High-scoring nodes that were not present in the initial corpus were flagged as omissions, resulting in the inclusion of nine additional policies. The full texts of 56 candidate policies were systematically reviewed to assess their fit to inclusion protocol and extract the necessary data. This screening process yielded a final dataset of 34 policies for all subsequent analyses (see Appendices).

3.1 ZNLT at the European Level

The concept of ZNLT has gradually evolved into a cornerstone of the European Union's environmental and spatial planning agenda. Anchored in the broader objectives of land degradation neutrality, biodiversity conservation, and sustainable urban development, the ZNLT goal aims to halt the net conversion of natural and agricultural land into artificial surfaces by 2050. The progression from soft strategic guidance (2006–2011) to operational planning (2020–2021) and finally to enforceable legal mandates (2024) represents a significant trajectory in EU land governance. Initially, the 2006 Thematic Strategy for Soil Protection set limits on soil sealing and promoted brownfield rehabilitation, introducing “limitation–mitigation–compensation” principles. The decisive milestone came with the EU Roadmap to a Resource Efficient Europe (European Commission, 2011), which introduced the 2050 ZNLT target. It also proposed the development of indicators (soil sealing and urban density) as tools for monitoring progress toward sustainable land use. Building upon this, in 2020, EU Biodiversity Strategy for 2030 emphasized land preservation for biodiversity, committing to restore 15 % of degraded land and mandating Urban Greening Plans. In 2021, EU Soil Strategy for 2030 reaffirmed ZNLT, recommending national soil management plans, land reuse incentives, and participatory governance, prioritizing degraded land and promoting land recycling rates above 70 %. Finally, in 2024 Nature Restoration Law introduced binding targets to prevent green urban area loss by 2030, expand green cover, and prioritize disused urban land for redevelopment, institutionalizing monitoring of urban tree canopy and habitat fragmentation. The law embedded the ZNLT concept within enforceable national restoration plans, marking a shift from strategy to obligation. It also institutionalized monitoring requirements on urban tree canopy, and habitat fragmentation, closing previous gaps in enforcement and transparency.

The analyzed final dataset includes 12 documents, functional typology of which reveals that strategic frameworks dominate: most texts set politically endorsed but non-binding objectives; three documents serve primarily as informational tools (providing monitoring guidance or methodological standards); and only the Nature Restoration Law constitutes a legally binding instrument, creating enforceable obligations. This distribution

forms an implementation pyramid, where a broad strategic apex funnels into a narrow base of binding regulations, potentially diluting enforcement consistency across the Union. Applying a categorical clustering to their policy objectives shows a predominant emphasis on land use and soil protection: of the twelve high-level instruments, five target land-use and soil protection, focus on biodiversity restoration, pollution prevention, urban regeneration, climate adaptation is less present, illustrating a strong corpus focus on soil governance.



Figure 7 (from left to right) Categorical clustering and functional typology of supranational dataset, source: authors

The content analysis highlights a significant presence of soil sealing and land take terms, which are addressed in ~75% policies. In contrast, broader socio-ecological concepts such as land consumption (UN-Habitat) and SDG 11.3.1 appear in only 25% and 17% of documents respectively, while Landscape fragmentation is cited in ~58%, mainly in biodiversity-focused instruments, but is mainly absent from soil or resource-efficiency strategies.



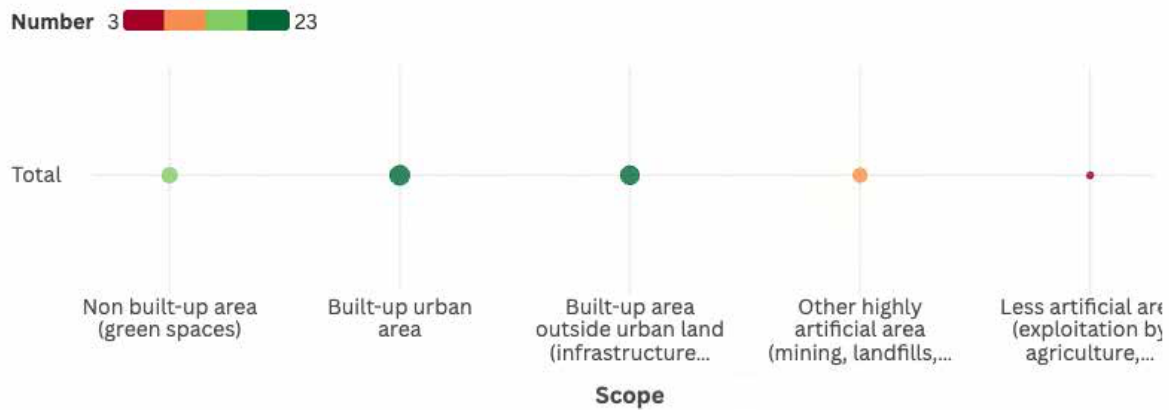


Figure 8: Terminology Trends (top) and Spatial Focus (bottom) in EU ZNLT Policies, source: authors

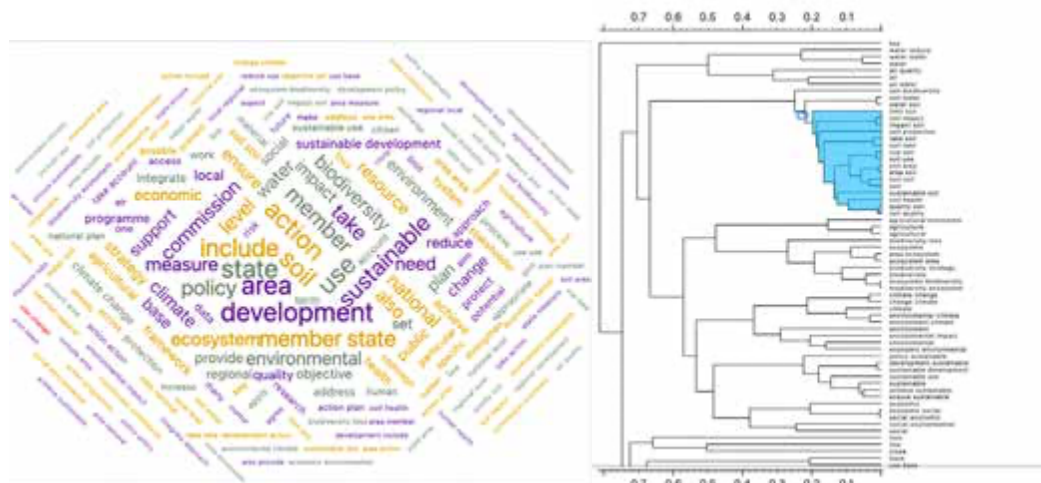


Figure 9. Machine learning text mining, supranational level, source: authors (Orange machine learning tool)

Tri-layer network analysis corroborates the textual findings by revealing stratified policy roles. Certain documents serve as normative hubs or “procedural spines” underpinning governance, i.e. EU Biodiversity Strategy functions as a hierarchical anchor, exhibiting high eigenvector centrality in both subordinated implementation (76.98 %) and strategic execution (94.48 %) layers, confirming its pivotal role in setting normative objectives across subordinate policies.



Figure 10. Policy network centrality analysis (supranational level), source: authors

In contrast, the Nature Restoration Law acts as an operational engine with the highest eigenvector centrality in the operational layer, translating strategic objectives into concrete procedures, monitoring requirements, and enforcement protocols. Between these poles lie strategic orchestrators, such as the EU Soil Strategy and Territorial Agenda 2030, which display elevated betweenness centrality in the strategic execution network, bridging high level goals with implementing acts. Foundational texts like the Thematic Strategy for Soil Protection and the EU Roadmap to a Resource Efficient Europe retain moderate degree centrality in subordinated implementation, anchoring early policy cascades.

Network analysis reveals that several high-centrality documents, though silent on land conversion, serve as critical connectors in governance. The EU Green Deal leads in eigenvector centrality for subordinated implementation and strategic execution (100%), and in subordinated betweenness ($\approx 9\%$), positioning it as the macro-framework for climate neutrality and the circular economy. The Floods Directive 2007 also emerges as a key vertical bridge linking soil and water governance. High strategic but low operational eigenvector centrality for UN Agenda 2030, the New Urban Agenda, and Territorial Agenda 2030 ($\geq 17\%$ – 42% vs. $< 6\%$) underscores their role as agenda setters rather than direct implementers.

Overall, the corpus exhibits a multi tiered topology: hierarchical anchors establish land take targets, strategic orchestrators integrate cross sectoral ambitions, and operational engines drive implementation, forming a resilient, though uneven, governance network.

3.2 ZNLT in Italy: National Framework

Over the last two decades Italy has moved from treating soil sealing as an indirect planning concern to recognising ZNLT as a core dimension of ecological transition. While a single framework statute is still absent, a review of national laws, strategies and investment plans reveals a cumulative layering of restrictions, incentives and monitoring duties that increasingly converge on the ZNLT logic.

The term *consumo di suolo* starts appearing in national policy documents only after 2010, while early 2000s statutes dealt with land take mainly through landscape- or contamination-related provisions. Earlier laws, such as Legge Urbanistica (Governo Italiano, 1942), addressed land take indirectly by mandating municipal master plans, promoting regeneration, and protecting green strips. Articles 13 and 20 directed growth toward degraded urban zones, mandating their redevelopment and allowing expropriation if owners failed to act. Article 18 empowered

municipalities to reclaim idle plots for public use, discouraging land speculation, while Article 25 protected private gardens and green strips, safeguarding permeable soil and urban vegetation. The Codice dell'Ambiente (D.Lgs. 152/2006) introduced precautionary and remediation principles for contaminated soils; Article 239 framed land degradation as an environmental liability, anchoring future anti-sealing debates (Governo Italiano, 2006). The policy narrative gained explicit soil-consumption language only after the EU Roadmap to a Resource-Efficient Europe fixed the 2050 ZNLT horizon. Domestically, a sequence of soft-law and targeted statutes began to translate that horizon.

In response to EU prompts, Italy made several attempts to approve a framework law to limit land take. The first, the "Catania" bill (2012), proposed capping agricultural land conversion caused by impermeabilization, urbanization, and non-agricultural construction (Naldi, 2012). The 2013 draft (Redazione Carteinregola, 2013) aimed to reduce soil consumption gradually, targeting zero by 2050 in line with European objectives. A 2014 proposal amending the Legge Urbanistica sought to encourage urban regeneration and discourage greenfield development to combat sprawl (ANSA, 2014). None of these drafts passed. In 2015, the Strategia Nazionale di Adattamento ai Cambiamenti Climatici (SNAC, 2015) identified soil sealing as a driver of hydrogeological risk and ecosystem fragmentation, linking climate adaptation with land take control (Ministero dell'Ambiente e della Sicurezza Energetica, 2015). In 2016, the comprehensive bill "Contenimento del consumo del suolo e riuso del suolo edificato" (Atto C. 2039-A) was approved by the Chamber of Deputies on 12 May 2016 and transmitted to the Senate as Atto Senato 2383 (Senato della Repubblica, 2016). However, it did not receive final Senate approval before the end of the XVII Legislature and thus did not become law.

Concurrently, Law 132/2016 (Istituzione del Sistema nazionale a rete per la protezione dell'ambiente e disciplina dell'Istituto superiore per la protezione e la ricerca ambientale) established a national network comprising ISPRA and regional/provincial environmental agencies, which issued guidelines and annual reports quantifying land take via soil-sealing (imperviousness) indicators (Senato della Repubblica, 2016). The Strategia Nazionale per lo Sviluppo Sostenibile (SNSvS) formally adopted SDG-aligned soil-sealing indicators and designated ISPRA as the national monitoring hub, inaugurating a coordinated data regime for land take (Ministero dell'Ambiente e della Sicurezza Energetica, 2017). The Piano Nazionale Integrato per l'Energia e il Clima (PNIEC) advanced a "zero-additional-soil" criterion for renewable-energy siting (Ministero dello Sviluppo Economico, 2019). After 2021, Italy's Piano Nazionale di Ripresa e Resilienza (Presidenza del Consiglio dei Ministri, 2021), and Ecological Transition Plan (PNTE) (Ministero della Transizione Ecologica, 2022), have linked ZNLT to brownfield reuse, restoration, and advanced targets to 2030. The Strategia Nazionale del Verde Urbano (Ministero della Transizione Ecologica, 2021) promoted de-sealing and urban nature-based solutions, while the Strategia Italiana di Lungo Termine (Ministero dell'Ambiente e della Sicurezza Energetica, 2021) recognized conflicts between renewable energy rollout and soil conservation, proposing degraded-land restoration as a mitigation measure.

In 2023, a bill on soil consumption and urban regeneration titled "Disposizioni per il contenimento del consumo di suolo e la rigenerazione urbana" (Atto Camera 1179) was introduced in Parliament but did not reach a vote before dissolution (Camera dei Deputati, 2023). It is now under examination by the VIII Commissione Ambiente of the Chamber of Deputies, with review having begun on 3 October 2023. The proposal aims to create a national framework for progressively reducing land consumption in line with the EU's goal of zero net land take by 2050. Italy has developed robust indicators to track progress on land take. The National System for Environmental Protection (SNPA) – comprising ISPRA and regional environmental agencies – monitors land consumption annually using satellite imagery and GIS data. Their flagship report "Consumo di suolo, dinamiche territoriali e servizi ecosistemici" provides detailed statistics by region and municipality (SNPA, 2024). These data are published openly and serve as a basis for policy adjustment.

The collected corpus of 12 policies is predominantly of soft power: only 25% are binding, supplying juridical backbone for urban development controls, tree-planting mandates and environmental monitoring, but precede or stand apart from the EU-driven sustainability agenda of the last decade. The other 75%, such as SNAC, PNIEC, and PNRR, are non-binding but strategic, reflecting a model that promotes coordination but risks fragmented implementation due to weak enforcement mechanisms. Thus, Italy's land-use regulation rests on a robust legal base for basic controls, while its post-2015 sustainability objectives rely primarily on aspirational instruments whose effectiveness depends on their integration into regional and municipal law. Thematic analysis shows that half of corpus belongs to "climate adaptation, resilience, and green infrastructure".

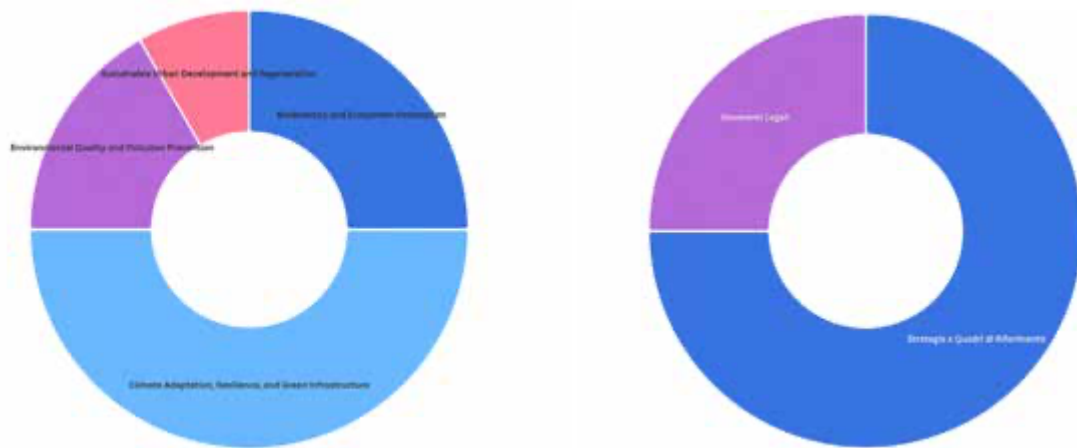


Figure 11 (from left to right) Categorical clustering and functional typology of national dataset, source: authors

In Italy is mainly used the term consumo di suolo, which according to ISPRA¹ refers to the transition from non-artificial to artificial cover, whether permanent (buildings, paved roads) or reversible (construction sites, ground-mounted PV, unpaved depots). Agricultural and forestry uses are excluded, as they retain biophysical cover; permeable greenspaces only count if the soil structure is irreversibly altered. ISPRA equates consumo di suolo with the EU's "land-take" indicator, while UN-Habitat's broader "land consumption" (SDG 11.3.1) includes intensive agriculture and cropland or forest expansion—highlighting ISPRA's narrower, sealing-focused approach. In this way, content analysis reveals land take, landscape fragmentation and soil sealing dominate Italian policy discourse, while "land consumption" and SDG 11.3.1 are less referenced.



1 <https://www.isprambiente.gov.it/it/attivita/suolo-e-territorio/suolo/il-consumo-di-suolo>

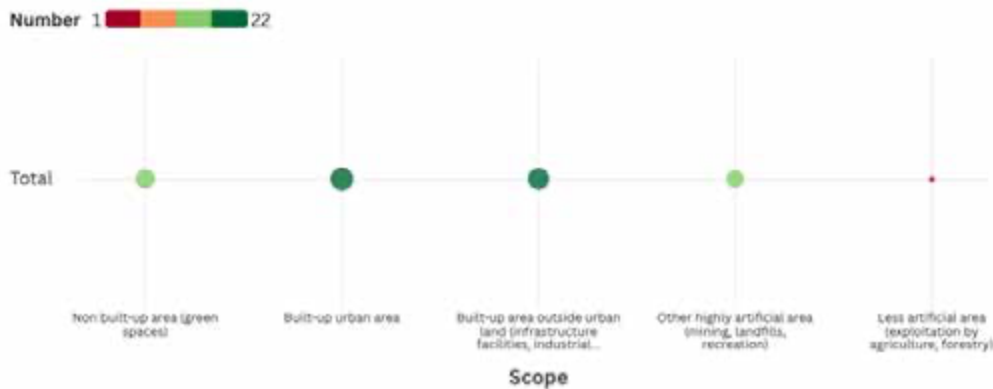


Figure 12: Terminology Trends (top) and Spatial Focus (bottom) in IT ZNLT Policies, source: authors

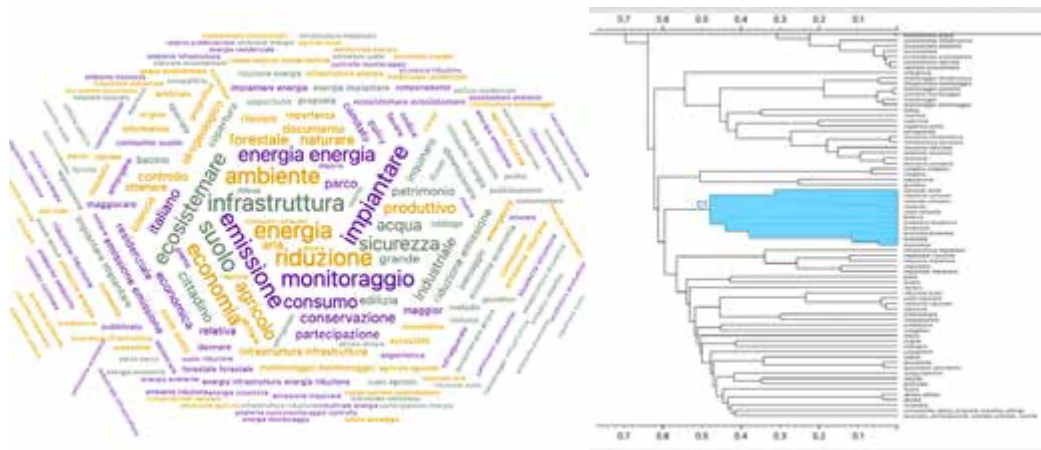


Figure 13. Machine learning text mining, national level, source: authors (Orange machine learning tool)

Network analysis reveals a stratified policy architecture. The SNSvS serves as a normative hub, with high eigenvector centrality in subordinated implementation (~9%) and strategic execution (~33%), unifying various statutes. The PNRR is the chief orchestrator, exhibiting the highest strategic-execution eigenvector (~53%) and high degree and betweenness. Operational engines like PNACC and SNAC show strong operational centrality (~3–4%) and betweenness, translating strategic objectives—such as sealing mitigation and flood-risk reduction—into local regulation and financing. Notably, several frequently cited statutes (D.Lgs. 42/2004, D.Lgs. 152/2006) occupy important procedural roles but lack explicit land-take clauses, creating “silent-but-central” gaps that undermine policy cohesion.

Policy	Identified Implementation Unit - Degree Centrality, N	Identified Implementation Unit - Resilience Centrality, N	Identified Implementation Unit - Accessibility Centrality, N	Strategic Element Unit - Degree Centrality, N	Strategic Element Unit - Resilience Centrality, N	Strategic Element Unit - Accessibility Centrality, N	Operational Unit Degree Centrality, N	Operational Unit Resilience Centrality, N	Operational Unit Accessibility Centrality, N
Strategia Nazionale per la Biodiversità al 2030	4.120	2.282	40.884	3.402	1.158	22.947	1.362	4.384	6.888
Piano Nazionale per la Transizione Ecologica (PNTE)	3.194	1.388	30.088	3.402	0.447	40.038	2.722	0.402	6.888
PIANO NAZIONALE DI RIPRESA E RESILIENZA (PNRR)	4.120	4.368	4.962	0.884	9.122	50.122	2.722	0.402	6.128
STRATEGIA NAZIONALE DEL VERDE URBANO "Foreste urbane resilienti ed eterogenee per la salute e il benessere dei cittadini" - 26	1.370	0.000	0.000	1.362	0.000	17.000	0.000	0.000	0.000
STRATEGIA NAZIONALE A LUNGO TERMINE SULLA RIDUZIONE DELLE EMISSIONI DEI GAS A EFFETTO SERRA - 33	1.370	0.000	0.000	0.000	0.000	12.348	0.000	0.000	0.000
PNIEC (Piano Nazionale Integrato per l'Energia e il Clima) - 19	1.420	1.370	0.000	1.362	0.000	18.238	0.722	0.000	0.000
Strategia Nazionale per lo Sviluppo Sostenibile (SNSvS) - 20	2.740	2.228	0.000	4.762	1.122	38.038	2.722	1.000	6.888
LEGGE 28 giugno 2018, n. 132 Istituzione del Sistema nazionale a rete per la protezione dell'ambiente e disciplina dell'Istituto superiore per la protezione e la ricerca ambientale - 29	0.000	0.000	0.000	0.000	0.000	0.000	1.362	0.000	0.000
Strategia Nazionale di Adattamento ai Cambiamenti Climatici (SNAC) - 21	1.420	2.688	2.702	0.722	0.702	0.000	1.362	4.000	1.702
LEGGE 14 gennaio 2013, n. 10 Norme per lo sviluppo degli spazi verdi urbani - 28	1.370	0.000	0.000	1.362	0.000	0.000	0.000	0.000	0.000
DECRETO DEL PRESIDENTE DELLA REPUBBLICA 6 giugno 2001, n. 380 Testo unico delle disposizioni legislative e regolamentari in materia edilizia - 23	0.000	0.128	0.000	0.000	0.000	0.000	1.362	0.122	0.000
Piano Nazionale di Adattamento ai Cambiamenti Climatici (PNACC) - 26	1.740	2.402	7.078	0.722	0.488	16.578	0.000	0.000	0.000

Figure 14. Policy network centrality analysis (national level, Italy), source: authors

This assessment indicates that Italy has advanced in embedding ZNLT principles, yet its policy architecture is still characterised by a mosaic of sector-specific measures and largely non-binding strategies rather than a single statutory backbone. Key statutes address land conversion peripherally, with climate-resilience strategies prevailing. The hub-and-spoke architecture depends heavily on multi-mission plans such as the PNRR, leaving gaps whereby absent soil-consumption clauses may permit indirect land take. Although the PNRR, PNIEC provide operational leverage and SNSvS, SNAC offer normative guidance, weak soft-hard integration might sustain fragmentation and regional inertia.

3.3 Regional Implementation: Emilia-Romagna Case Study

In the absence of a national land-take statute, regional governments took the lead in limiting land take, primarily using their planning powers. Emilia-Romagna's Piano Territoriale Regionale (PTR, Regione Emilia-Romagna, 2010), approved in 2010, provides the broad strategic framework for territorial development and coordination of local plans. By the time of its drafting in the 2000s, awareness of uncontrolled land consumption (consumo di suolo) was growing in Italy. The PTR embeds the principle of limiting land take as a key policy guideline. In fact, language echoed later in law can be traced to the planning ethos of that time – for example, treating land as a “bene comune e risorsa non rinnovabile” (common good and non-renewable resource) that must be preserved.

In 2013, a significant initial step was taken with the establishment of an interdepartmental working group, the “Valorization of Agricultural Areas and Containment of Land Consumption, that equipped with detailed knowledge of land consumption patterns and the status of rural territories, and proposed operational methodology that not only quantified existing soil consumption but also enabled a qualitative spatial analysis. Building on this foundation, Emilia-Romagna launched a pioneering soil consumption monitoring program culminating in the 2015 regional report (Consumo di suolo e pianificazione: conoscere per decidere, Regione Emilia-Romagna, 2015). A crucial conceptual advance was the precise definition of consumo di suolo: the irreversible conversion of agricultural, natural, or semi-natural areas into sealed or permanently artificialized surfaces (e.g., buildings, roads, industrial yards).

The set of land uses that lead to the loss of natural characteristics, resulting in an artificial surface whose purpose is not the production or harvesting of biomass. It was described as a dynamic process that alters the nature of the territory, moving from natural conditions to artificial conditions, of which impermeabilization represents the final stage. Importantly, the methodology excluded temporary or reversible uses and permeable green areas from the “consumed” category until conversion was made permanent.

The subsequent LR 24/2017, signaled a major shift toward achieving ZNLT by 2050 by capping new land take and prioritizing urban regeneration over greenfield development. The law restricts new construction to cases where all reuse or replacement options are exhausted and reinforces urban growth boundaries. Its provisions require that any new construction is permissible only after all feasible options for the reuse or replacement of existing buildings have been exhausted, effectively relegating greenfield expansion to a last-resort status. By reinforcing urban growth boundaries and explicitly demarcating built-up areas, the law curtails further encroachment on undeveloped land. The law limits new land take to a maximum of 3% of the urbanized land area (as of 1 January 2018) up to the year 2050. In practice, this functions as a “land take budget” for each municipality and the region as a whole. Importantly, LR 24/2017 defines “land take” in net terms, as the balance between newly urbanized areas minus any areas returned to natural state through de-sealing within urban boundaries.

Urban planning was restructured with the introduction of the Piano Urbanistico Generale (PUG), replacing prior municipal plans and emphasizing regeneration, with detailed zoning assigned to secondary instruments. Municipalities were required to adopt new PUGs by the end of 2020. By January 2025, dozens of new PUGs had been adopted or approved.

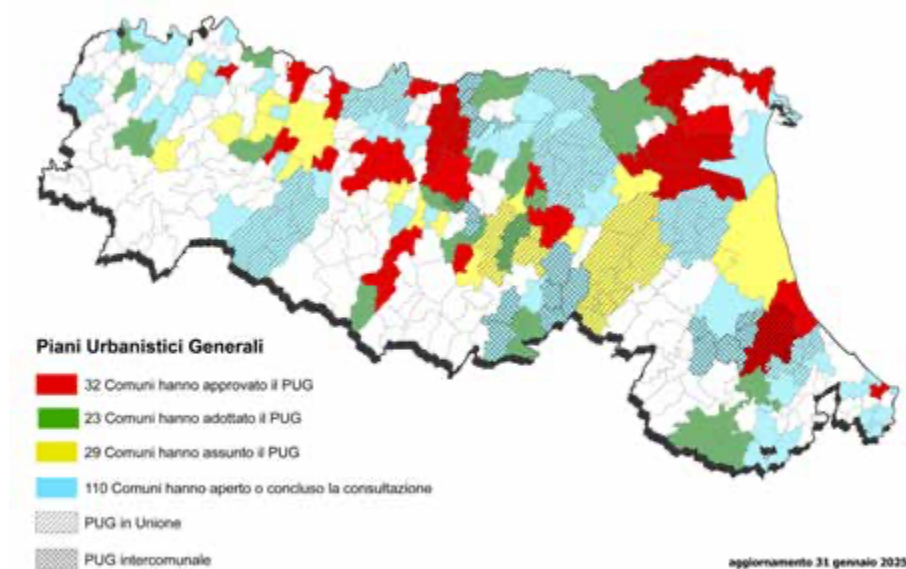


Figure 15. Level of PUG approval at municipal level, source: Emilia-Romagna region

Emilia-Romagna has established a multi-layered governance system to monitor and enforce its land take policies. Municipalities are obliged to submit digital data on any land transformations. Each January, the region compiles the previous year’s land take data and publishes the results. The region’s open data portal also provides shapefiles of the officially recognized urbanized territory per the new plans. The success of LR 24/2017 led to the integration of ZNLT principles into subsequent regional policies. The Regional Strategy for Agenda 2030 commits to ZNLT, aligning with SDGs 11 and 15 and the EU’s 2050 target, focusing on urban regeneration, brownfield restoration, and compliance with the 3% cap. The Piano Regionale di Gestione dei Rifiuti e Bonifica delle Aree Inquinare 2022–2027 prioritizes brownfield reuse for waste infrastructure, promoting regeneration in line with ZNLT goals. The ERDF Programme 2021–2027 incorporates land take reduction, using LR 24/2017 as a benchmark, funding urban transformation agendas that prioritize regeneration and reuse over greenfield development.

The functional typology and clustering of Emilia-Romagna's policy corpus reveal clear patterns in both legal force and thematic orientation. Binding instruments belong to Sustainable Urban Development and Regeneration and Land Use and Soil Protection clusters, respectively, reflecting their role as normative hubs that mandate redevelopment-first approaches and set soil consumption ceilings. In contrast, non binding strategies occupy the Climate Adaptation and Sustainable Urban Development clusters, serving primarily as high level vision documents that lack enforceable provisions. Economic instruments, explicitly target Sustainable Urban Development and Regeneration. Lastly, informational tools, epitomized by "Consumo di suolo e pianificazione: conoscere per decidere", are classified under Land Use and Soil Protection, furnishing data for evidence based decision making without direct regulatory authority.

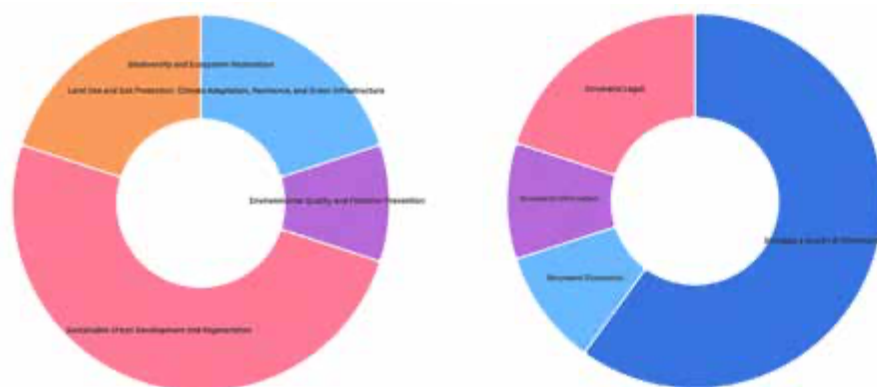


Figure 16 (from left to right) Categorical clustering and functional typology of regional dataset, source: authors

Across all ten documents, there are explicit provisions addressing land-take reduction. Although soil sealing appears in nearly all documents, its treatment differs markedly depending on the policy family. Land-take itself appears as a headline metric, signalling broad acceptance of this concept as the principal proxy for horizontal land conversion. However, only four instruments (e.g., L.R. 24/2017, PER 2030, the Regional Strategy for Agenda 2030, and PTPR) pair land-take with explicit restorative language such as de-sealing or ecological compensation. Equally significant is the limited uptake of the broader "land-consumption" concept as defined by UN-Habitat.



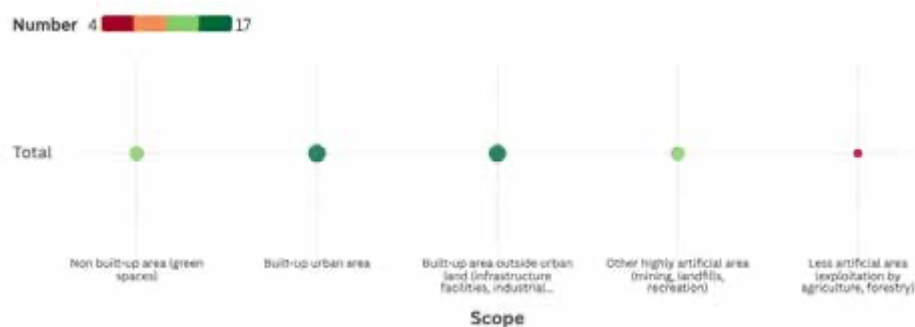


Figure 17: Terminology Trends (top) s and Spatial Focus (bottom) in ER ZNLT Policies, source: authors

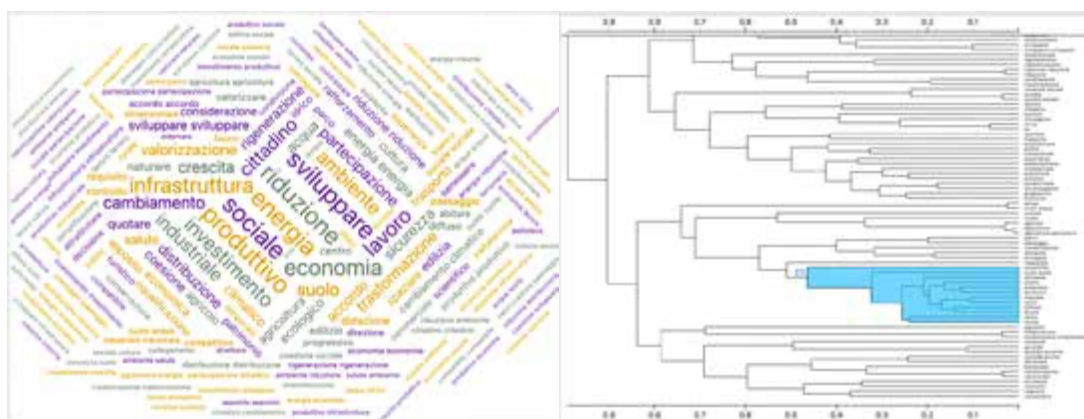


Figure 18. Machine learning text mining, regional level, source: authors (Orange machine learning tool)

Network-centrality metrics highlighted the following. The Regional Strategy for Agenda 2030 and LR 24/2017 show high betweenness and eigenvector centrality, acting as key orchestrators and hierarchical anchors that connect multiple policy tiers, even without directly addressing land consumption. In contrast, instruments like Bandi rigenerazione urbana and the Smart Specialisation Strategy suggest low centrality, indicating peripheral roles with limited integrative capacity. Secondary anchors, such as PRAP and Legge Regionale 16/2002, provide coordination but lack direct land conversion provisions, creating potential alignment gaps.



Figure 19. Policy network centrality analysis (regional level, Emilia-Romagna), source: authors

The analysis showcased institutional innovation and strong multi-level governance, embedding the ZNLT target through spatial analysis, monitoring, and land-take caps. However, gaps persist where non-binding fiscal tools lack explicit land-consumption metrics. The next policies revision (or the drafting) of peripheral to ZNLT, energy-transition or climate-adaptation policies, incorporating quantitative sealing thresholds (e.g., maximum km² of new impermeable surfaces), could enforce the net-gain logic that underpins ZNLT.

3.4 Cross-Level Analysis and Policy Gaps

In collaboration with Emilia-Romagna experts, the corpus was evaluated for relevance to the process of land take reduction and re-using abandoned or previously-used land in Emilia-Romagna. Combining scores with policies' legal bindingness, it allowed to map these scores onto a Power/Relevance matrix, where:

Key policies (High relevance and power) directly address land-take prevention or land-reuse through binding provisions (laws, directives, mandatory funding conditions). Rigorous execution and regular updating are essential, as gaps might pose immediate risks. Influential policies (high relevance, low power) provide technical guidance, strategic visions, or soft-law recommendations promoting ZNLT without binding force. Strengthening them requires converting these into binding obligations; until then, their impact relies on political will, peer pressure, and funding alignment. Contextual policies (low relevance, high power) are binding legal acts that have only secondary or indirect practical usefulness for the ZNLT processes. Often "sleeping giants," small amendments can produce major effects. Effective cross-sector coordination is needed to prevent these powerful instruments from unintentionally promoting new land take. Peripheral policies (low relevance, low power) – Soft-law or legacy documents that target adjacent sustainability objectives with minimal or no explicit focus on the regional ZNLT effort. They provide entry points to embed ZNLT terminology into wider policy contexts.

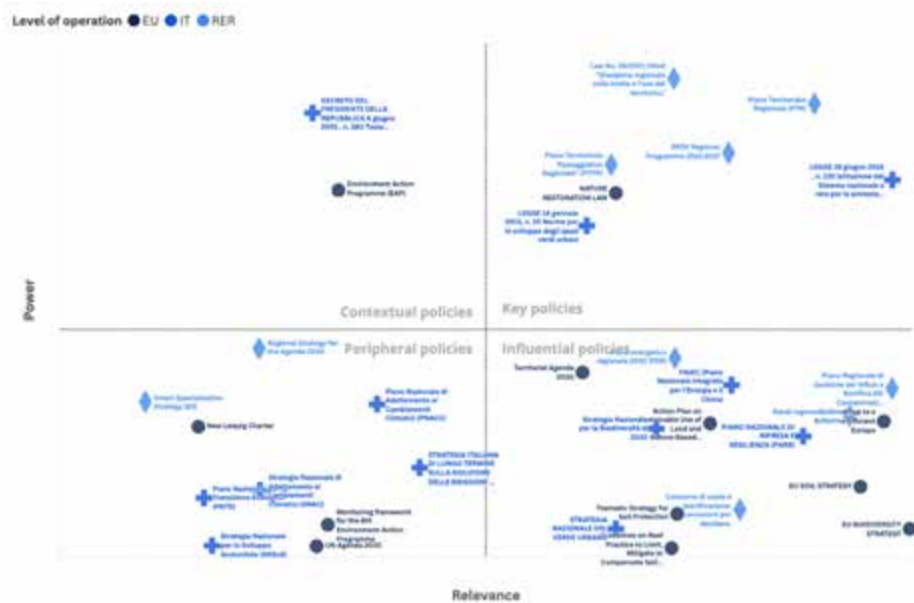
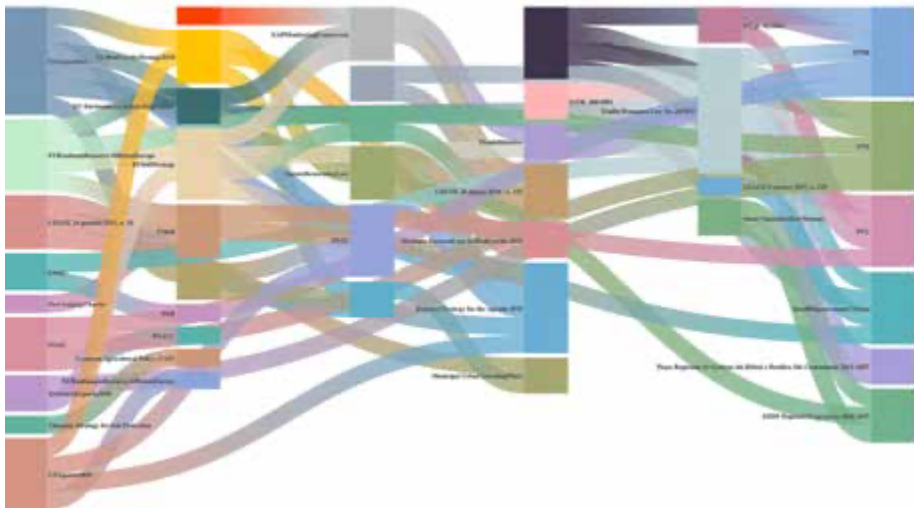


Figure 20. Policy Power/Relevance matrix, source: authors

The self-evaluation revealed that only 21% of the corpus emerged as Key policies, that practitioners regard as directly operational for achieving ZNLT (e.g. the EU Nature Restoration Law 2024; LR 24/2017; the ERDF 2021–2027 programme; and the PTR/PTPR tandem). The largest cluster (44%) falls in the Influential quadrant, where soft-law strategies and thematic action plans can be widely consulted but lack coercive force. Finally, 29 % were deemed Peripheral: overarching frameworks (i.e. UN Agenda 2030, National Ecological Transition Plan and Regional Smart Specialisation Strategy, etc), which provide little concrete leverage for practitioners. And only two high-power texts were rated as Contextual (6%)—notably 8th Environment Action Programme and the national Consolidated Building Code (DPR 380/2001).

Network-analysis and expert-evaluation results were consequently onto the DPSIR framework. DPSIR was recalibrated, categorizing objectives as Drivers, Pressures, States, Impacts, or Responses to construct a governance-oriented causal network. Policies containing multiple objectives were mapped according to their most relevant DPSIR categories, enabling accurate representation across different analytical nodes.



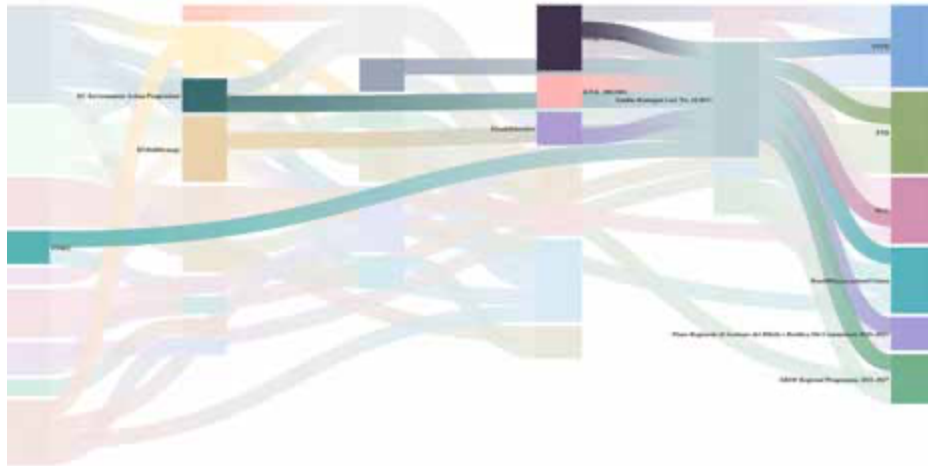


Figure 21. Sankey diagram (transition of policy objectives), source: authors

At the Driver level, agenda-setting strategies such as the European Green Deal, EU Biodiversity Strategy 2030, and EU Soil Strategy position land-take neutrality, ecosystem restoration, and soil health as central economic priorities. High strategic centrality scores reflect their ideational influence, but limited operational centrality signals persistent implementation barriers. Pressure policies, as Nature Restoration Law and LR 24/2017, translate strategic goals into enforceable quantitative limits. Urban regeneration incentives and brownfield prioritization in national and EU funding schemes further operationalize the “reuse before new take” hierarchy. State-focused instruments remain peripheral: few policies establish systematic monitoring of land condition or biophysical baselines. Notable exceptions are the 8th Environment Action Programme Monitoring Framework, Italy’s Law 132/2016, and Emilia-Romagna’s “Conoscere per decidere.” Their low centrality underscores a monitoring deficit, weakening adaptive management. Impact-oriented measures are more consistent, targeting ecosystem and social consequences of land conversion. The EU Biodiversity Strategy and adaptation policies promote connectivity, habitat restoration, and nature-based solutions to mitigate flood and heat risks. Urban green space mandates and financial instruments (PNRR, ERDF) support mitigation and compensation, though most objectives remain qualitative, diluting their regulatory effect. Responses comprise a stratified layer of operational instruments and funding mechanisms translating prior targets into practice. High-relevance statutes such as LR 24/2017 and regional ERDF programmes drive implementation via updated local plans and dedicated investments, while non-binding strategies maintain high strategic influence but limited coercive force. Institutional mechanisms, including the SNPA monitoring system, enhance enforcement capacity and policy learning.

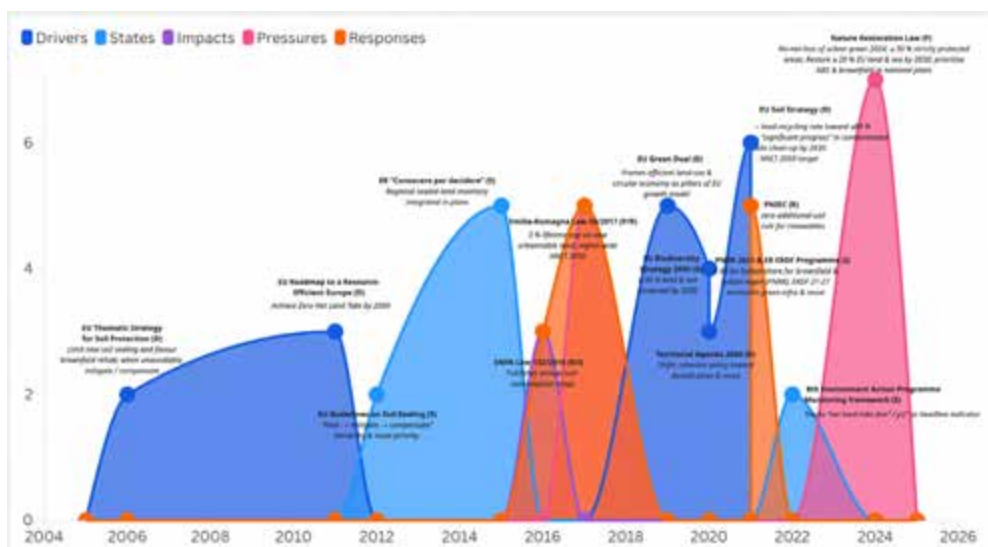


Figure 22. Sankey diagram (transition of policy objectives), source: authors

The longitudinal reconstruction of ZNLT corpus discloses a six-phase “policy stratigraphy” in Emilia-Romagna in which successive DPSIR nodes accrete rather than co-evolve. Early Driver texts—the EU Thematic Soil Strategy (2006) and the Resource-Efficient Roadmap (2011)—conferred a macro-narrative of circular growth and set a 2050 neutrality horizon, yet remained programmatic. Only after a distinct State layer (2012-15) had produced the first sealed-soil baselines did impact-mitigation pilots surface, linking annual soil-consumption reporting (SNPA, 2016) with modest urban-greening offsets. Hard Pressures arrived abruptly: LR 24/2017 imposed a 3 % lifetime land-take cap, while the 2024 EU Nature Restoration Law crystallised a 20 % ecosystem-repair mandate and an urban-green “no-net-loss” rule. An intervening consolidation wave (2019-21) re-embedded ZNLT within the Green Deal’s climate-neutrality calculus and paired it with restoration (30 % strict protection; 20 % degraded-land recovery), thereby recasting neutrality from a stand-alone limit into a limit-plus-repair paradigm.

Overlaying temporal and functional layers reveals systemic discontinuities. Drivers precede enforceable Pressures by 6-8 years, creating windows of political drift in which implementation relies on voluntary Response finance (PNRR, ERDF 2021-27). Monitoring capacity remains front-loaded and stagnant: after 2016 no major State instrument has been added, jeopardising the evidentiary basis for the 2050 neutrality claim. Conversely, rhetoric on ecological and social impacts proves catalytic, synchronising surges in mitigation funding with the 2016 and 2021 policy waves.

3. Conclusions and Recommendations

This study has demonstrated that ZNLT ambition is embedded within a richly textured but uneven multi-level governance architecture. Clear vertical alignment emerges through the top-down diffusion of EU objectives, such as no net land take and land degradation neutrality, explicitly reflected in national strategies. At the supranational level, flagship initiatives such Biodiversity Strategy 2030, and Soil Thematic Strategy serve as powerful “normative anchors,” diffusing the 2050 neutrality target through hierarchical subordination and strategic execution networks. Yet the translation of these objectives into binding national and regional instruments varies markedly: Italy’s national framework remains a patchwork of soft-law strategies and piecemeal statutes, while Emilia-Romagna has pioneered one of the most coherent subnational approaches with its LR 24/2017 cap and advanced de-sealing pilots. This divergence vividly illustrates how policy innovation at one tier can catalyze—or be held back by—gaps at another, highlighting the need for stronger vertical coherence.

The analysis revealed some potential governance imbalances. The land-use policy landscape functions as a multi-level governance system, where interactions among European, national, and regional policies reveal alignment, redundancy, and governance gaps. Strategic “Drivers” dominate the policy topology, whereas “monitoring baselines and some quantitative thresholds are under-represented, weakening adaptive feedback loops. Enforcement of pressure measures are unevenly applied: Emilia-Romagna’s 3 percent land-take budget exemplifies a clear cap, whereas national and EU funding programmes often offer only aspirational incentives. At the same time overlapping instruments might create administrative complexity and “strategy fatigue” unless well-integrated.

In summary, the linkages show a multi-level orchestration at work: when properly aligned (as in the case of the 2050 target cascading down to Emilia-Romagna’s law), governance becomes coherent and mutually reinforcing. Where levels are misaligned – such as a national policy vacuum – adaptive governance suffers, as lower-level efforts may lack broader support and higher-level goals remain aspirational. The network of policies is densely interconnected, but the strength of those connections (alignment vs. fragmentation) greatly influences outcomes on land-use sustainability.

As the draft Italian land-take law moves forward, lawmakers face a choice: keep the narrow, sealing-centred metric for regulatory simplicity, or broaden the definition toward full land consumption to capture agricultural encroachment and forestry conversion.

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Abbreviations

EAP	Environmental Action Programme
EU	European Union
FUA	Functional Urban Areas
ISPRA	Istituto Superiore per la Protezione e la Ricerca Ambientale
NNLT	No Net Land Take
PNIEC	Piano Nazionale Integrato per l'Energia e il Clima
PTR	Piano Territoriale Regionale
PUG	Piano Urbanistico Generale
RER	Emilia-Romagna Region
SDG	Sustainable Development Goals
SNAC	Strategia Nazionale di Adattamento ai Cambiamenti Climatici
SNSvS	Strategia Nazionale per lo Sviluppo Sostenibile
ZNLT	Zero Net Land Take

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Appendices

- [Corpus of analyzed policies](#)
- [Network Mapping](#)