

Vat photo-polymerization 3D printing of gradient scaffolds for osteochondral tissue regeneration

Original

Vat photo-polymerization 3D printing of gradient scaffolds for osteochondral tissue regeneration / Corrado, F.; Di Maio, L.; Palmero, P.; Coppola, B.; Abbas, Z.; La Gatta, A.; Schiraldi, C.; Scarfato, P.. - In: ACTA BIOMATERIALIA. - ISSN 1742-7061. - 200:(2025), pp. 67-86. [10.1016/j.actbio.2025.05.042]

Availability:

This version is available at: 11583/3006787 since: 2026-01-21T14:39:49Z

Publisher:

Elsevier

Published

DOI:10.1016/j.actbio.2025.05.042

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RESEARCH ARTICLE OPEN ACCESS

What Role for Cities in the EU Green Deal? Analysis of Policy Framework, Interlinkages and Contribution to the 2030 Agenda

Matteo Trane^{1,2}  | Steve Borchardt³  | Luisa Marelli¹ | Alice Siragusa⁴  | Riccardo Pollo² | Patrizia Lombardi²

¹European Commission, Joint Research Centre (JRC), Ispra, Italy | ²Interuniversity Department of Regional and Urban Studies and Planning (DIST), Politecnico di Torino, Turin, Italy | ³Department of Agricultural and Food Sciences, Università degli Studi di Bologna, Bologna, Italy | ⁴United Nations ESCAP—The Economic and Social Commission for Asia and the Pacific, Bangkok, Thailand

Correspondence: Matteo Trane (matteo.trane@ec.europa.eu) | Luisa Marelli (luisa.marelli@ec.europa.eu)

Received: 4 September 2024 | **Revised:** 24 February 2025 | **Accepted:** 25 February 2025

Funding: This work was supported by the Joint Research Centre.

Keywords: EU cities | European Green Deal | SDG interlinkages | sustainable development goals | urban green transition | urban policies

ABSTRACT

Urban environments are at the forefront of the European Union (EU) climate ambitions as envisaged by the European Green Deal (EGD). Cities are also central to delivering most of the 2030 Agenda Sustainable Development Goals (SDGs). However, EU cities face severe implementation challenges in operationalising the EGD and SDGs. This research aims to support EU cities in implementing the EGD by providing a coherent framework, aligning green transition policies with the SDG targets and indicators. The framework may support policy coherence and ambition alignment among governance levels. Specifically, the research identified 22 SDG targets matched to 76 EGD policy targets requiring implementation at the urban level, with SDGs 7, 13 and 15 being the most addressed. Furthermore, the application of the framework allows for informing SDG interlinkage assessment among policy targets also at the urban level, acknowledging potential caution areas, especially when implementing EGD targets directly linked to SDGs 7, 13, 6 and 9. Major implications include (i) the opportunity to align local development programmes with identified overarching priorities, unlocking the 2030 Agenda's potential to inform policy-making at the urban level, and (ii) the need to properly address trade-offs when implementing EGD policies to exploit EU cities' potential towards the EU green transition.

1 | Introduction

The European Union (EU) has strengthened its global leadership in combating global warming by adopting the *European Green Deal* (EGD) on 1 December 2019. Framed under the Paris Agreement, the EGD set the pathway for the EU to become the first climate-neutral continent by 2050 (European Commission 2019). A milestone towards climate neutrality, which implies a mid-term reduction target of -55% in greenhouse gas (GHG) emissions by 2030 with respect to 1990 levels, was established by the first-ever 'European Climate

Law' (European Union 2021) and the *Fit for 55* initiative by the European Commission (2021b), requiring (i) emission cuts and new standards in most of the emitting sectors, such as aviation, maritime and road transport; (ii) a renewed Emission Trading System (ETS); (iii) methane emission reduction in the energy system; and others. In addition, a recently endorsed aspirational target requires cutting GHG emissions by 90% as of 2040 (European Commission 2024a), putting the EU on a path towards climate neutrality by 2050. As such, the EGD policies and related targets (EGD-Ts) are designed to assist in renewing production and consumption patterns

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via cleaner processes and energy use optimisation while promoting EU economic growth. Besides, the EGD sets forth the EU's commitment to the United Nation's (UN) 2030 Agenda (European Parliament 2020). Being the headline priority established by President Von der Leyen's (2019) 2019–2024 political guidelines, the EGD addresses most of the 17 Sustainable Development goals (SDGs) and related 169 targets (SDG-Ts) (Papa and Sachs 2021).

Assessing interlinkages among targets is crucial to enhance positive relationships among them, minimise trade-offs and smooth the implementation process to deliver the green transition (Fronza et al. 2023; Moallemi et al. 2022). In these terms, several sustainable finance pieces of legislation (e.g., the new 'Taxonomy Regulation') (EU 2020) highlight that the EGD has introduced the principle of Do Not Significant Harm (DNSH). The DNSH seeks to eliminate or minimise possible trade-offs between economic growth and the environment by establishing that sustainable economic activities must not cause more harm to the environment than the benefits they bring, with specific reference to climate change mitigation and adaptation, protection of water and marine resources, circular economy, pollution, environment and biodiversity. In addition, the new Renewable Energy Directive (RED) introduced recitals to manage trade-offs between the material use of biomass and its use for bioenergy production. Such examples acknowledge the importance of undertaking a holistic and cross-sectoral approach to achieve the EGD's energy, climate and environmental objectives (Papa and Sachs 2021). The SDGs, which are interlinked and indivisible by nature (UN 2018), could assist policy-making to ensure greater policy coherence (Fronza et al. 2023; Papa and Sachs 2021) at all governance levels (Committee of the Regions [CoR] 2024) for supporting the implementation of EGD (Trane et al. 2023).

By focusing on the urban level of policy implementation and with the aim of providing actionable knowledge for EU cities struggling with operationalising both the EGD and SDGs, this paper explores how EU cities might contribute to the implementation of EGD-Ts while supporting the achievement of SDG-Ts. Outputs provided can be utilised to communicate and engage with stakeholders, guide decision-making and facilitate co-learning (Matti and Rissola 2022). Furthermore, this research aims at fostering a systemic approach to local-level policy-making through the lens of SDG interlinkages, informing EU cities' stakeholders about possible trade-offs and leverage entry points. The results consist of a coherent framework, matching EGD-Ts involving EU cities to the proxy SDG-Ts while highlighting potential interlinkages among them. The implications are manifold. First, a full set of policy targets is made available to EU cities, providing a blueprint for action to implement the green transition coherently. Second, the matching of the EGD-Ts with the SDG-Ts unites the two frameworks into a novel one, promoting coherence among them while acknowledging potential caution areas to consider for smoother implementation. Third, the matching implies the identification of overarching SDG priorities for EU cities implementing the 2030 Agenda, to understand 'where to begin' (Breu et al. 2021; Trane et al. 2023) out of 169 UN targets. Fourth, trade-offs potentially exist among policies, and, despite being often overlooked, should be considered when implementing the EGD locally.

This paper aims at answering the following research questions (RQs):

- i. What is the EGD policy framework involving cities for implementation, and what are the systemic relationships with the SDG targets?
- ii. What synergies and trade-offs might exist among the priority SDG targets for EU cities when implementing the EGD policies?

Having briefly introduced the scope of the paper in this section, Section 2 explores the policy mix and governance contexts, as well as research and implementation gaps that motivate this research. The methodology, consisting of three major stages, is described in Section 3, whereas Section 4, complemented by the [Supporting Information](#), presents the outputs of each stage and the framework developed. In Section 5, results are critically analysed and implications highlighted, with a view to (policy) interlinkages analysis. Section 5 opens up to future research development.

2 | Background

2.1 | Policy Context

Cities are key enablers of climate objectives and testbeds for new ways of working and living (Genta et al. 2022). Indeed, EU cities take up only 4% of the continental land area but they are home to 75% of citizens. Furthermore, cities account for more than 70% of CO₂ emissions globally (IEA 2021). Several EGD policies identify cities as active parts of the green transition (CoR 2024). Besides, urban environments are at the core of the '100 Climate-neutral and smart cities by 2030' EU Mission (Ulpiani et al. 2023) and the 'New European Bauhaus' initiative (European Commission 2021a), which aims to transform urban environments according to the 'beautiful, sustainable, together' principle (European Commission 2021c). These responsibilities place local and regional authorities (LRAs) at the forefront of EU climate and environmental strategies, as already strengthened with the introduction of the Covenant of Mayors (CoM) in 2008 by the EC. The CoM is the initiative addressing climate change with the highest number of signatories (Crocì et al. 2021), resulting in formal contracts between city governments and the EC by which cities voluntarily (Crocì 2005) commit to specific emission reduction targets and sustainable energy policies (Pūķis et al. 2023). The CoM has gained over 12,000 signatures since 2008 and assists local authorities in implementing sustainable energy policies (Pūķis et al. 2023).

The new *Better Regulation* agenda, a tool aiming to foster evidence-based, more transparent and inclusive law-making in the EU, further ensures that all legislative proposals (LPs) contribute to the SDGs to boost policy coherence (European Commission 2023). The EU as a continent presented its first-ever SDG Voluntary Review at the High-Level Political Forum in 2023 (EU 2023), highlighting progress towards the goals by linking them with sectoral targets, many of which come from the EGD policies.

Being decisive for achieving most of the EGD-Ts (CoR 2023b; Negreiros and Falconer 2021), cities are also central for

delivering the SDG-Ts. It has been acknowledged that 65% of the 169 SDG-Ts will not be reached globally without the active engagement of cities (OECD 2019). To facilitate SDG mainstreaming at the sub-national level, the Joint Research Centre (JRC) of the European Commission has published the *Handbook for SDG Voluntary Local Review* (Siragusa et al. 2022), providing a blueprint for cities implementing the SDGs via 72 indicators for measuring progress at the local level.

The achievement of climate neutrality, as conceived by the ‘Climate Law’, requires an inclusive and accessible process across all dimensions of multilevel governance. This approach involves engaging national, regional and local administrations alongside social partners, academic institutions, the business sector, citizens and civil society, promoting synergy between governance levels by integrating both top-down and bottom-up strategies (Pūķis et al. 2023). The concept of ‘multilevel governance’ is linked to a new model of global sustainability governance, emphasising the local level of policy-making and implementation and cross-sectoral economic development (Jänicke and Quitzow 2017). The EU itself is frequently regarded as a prototype of multilevel governance due to the way its policies are crafted (Dobracev et al. 2021). In line with the principle of subsidiarity, higher-level administrations are expected to handle matters only if lower-level administrations cannot do so effectively (Monni and Raes 2008). The distribution of rights and responsibilities between EU Member States (MSs) and their subnational entities is determined by each country’s national competence, resulting in variations in the division of roles among MSs (Pūķis et al. 2023).

As highlighted, implementing the EGD-Ts contributes to operationalising the SDG-Ts in the EU. In this perspective, setting a clearer connection between the EGD-Ts (policy targets) and SDG-Ts (pursued on a voluntary basis) might favour the mainstreaming of the 2030 Agenda while boosting policy coherence among governance levels (Trane et al. 2023).

The governance of urban green transition eventually requires new environmental planning processes that make explicit connections between local urban challenges and broader global, national and regional macro-development goals (Frantzeskaki et al. 2018; Newman 1999; Scott 2001; Trane et al. 2024). In parallel, a growing body of literature has highlighted how priority setting is crucial for implementing the SDGs (Asadikia et al. 2021; Breu et al. 2021; Trane et al. 2023), resource allocation (Daniels 2016) and policy-making also at the sub-national level (Brattström and Hellström 2019; Nygaard and Hansen 2020; Pignatelli et al. 2023). The coherence and systems thinking of policies are considered major factors in this process. Therefore, cities should identify local priorities, aligning them with the EGD ambitions while contributing to the global goals of the 2030 Agenda (ICLEI 2024), addressing potential caution areas in the implementation process.

2.2 | Implementation Gaps

A recent report has highlighted several emerging implementation gaps to be addressed in all EGD policy domains (Marelli et al. 2025). At the sub-national level, key consultative bodies

of the EU, such as the CoR (2023a, 2024) and the Economic and Social Committee (Official Journal of the European Union 2020), have raised concerns about the insufficient involvement of social partners and subnational authorities in the policy-making process for the EGD. The lack of effective mechanisms for multilevel governance is seen as a significant obstacle to the EGD’s implementation (CoR 2024). In turn, stakeholders have indicated that the local and regional execution of the EGD has been inadequate to date (European Commission 2024c). An unprecedentedly high number of policy targets, a rapidly evolving policy framework also responding to a changing geopolitical context (Matti et al. 2023) and resource and skill availability issues at MS and LRA levels (European Commission 2024c; Ulpiani and Veters 2023) hamper the green transition and policy implementation in EU cities. In this regard, the *State of Regions and Cities* report (CoR 2023b) called for a consistent framework for local sustainable development that aligns with global climate and sustainability agendas, as well as increased simplification, transparency and better communication in the definition of the objectives to be achieved by EU LRAs. In turn, cities should contribute to the green transition—as envisaged by the EGD—by delivering on ambitions on which they might have specific competences (e.g., building renovation) or can provide support (e.g., ‘Planting 3 billion trees by 2030’ from the Biodiversity Strategy) (European Commission 2020).

Regarding SDG implementation gaps, it is undoubted that EU cities are becoming increasingly committed to and familiar with the 2030 Agenda (CoR 2023b; Siragusa et al. 2022; UNDP 2023). As such, the SDGs might constitute valuable support for shaping coherent local sustainable development programmes (Biermann et al. 2022; Trane et al. 2024). However, operationalising the SDGs remains significantly challenging, also given the inherent complexity of the framework (Leal Filho et al. 2018; Breu et al. 2021). Furthermore, translating the broad aspirations of the SDGs into effective actionable place-based knowledge (Bianchi et al. 2024) for cities and concrete development plans at the local level requires considering the intricate web of interactions among the 169 targets (Breu et al. 2021). Analysing the systemic relevance of priority targets can ease this process (Allen, Metternicht, and Wiedmann 2018; Breu et al. 2021; Weitz et al. 2018) while providing EU cities with clear guidance on what to implement first to support EGD policies.

2.3 | Research Gaps

As recalled, the complexity and uncertainty (Frantzeskaki 2022; Loorbach 2022) of the (green) transition process requires addressing synergies and trade-offs among goals and policy targets, taking into account the specificities of local contexts (Borchardt et al. 2022). Abdullah (2021) studied the contribution by EU cities to the energy and mobility transition. Gisotti and Tarsi (2023) developed a new method to assess how regional plans align with the EGD objectives in the metropolitan area of Florence. Buckley et al. (2021) presented how Urban Building Energy Modelling can support the EGD, whereas Testi et al. (2023) designed an analytical framework to support the implementation of local policies contributing to the EGD. Jordová and Brůhová-Foltýnová (2021) addressed the implementation of Sustainable

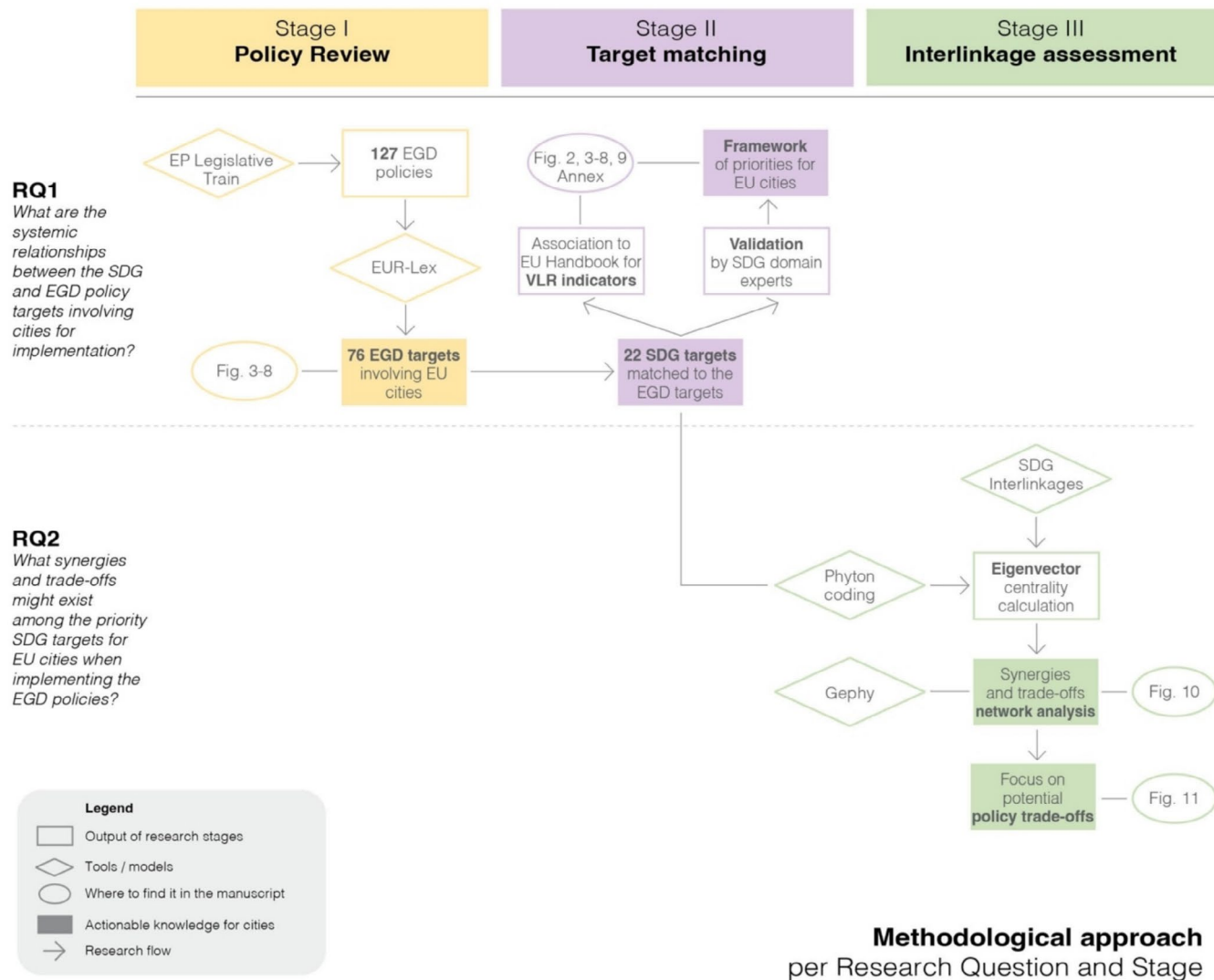


FIGURE 1 | Research flow: Methodological approach per research question and stage, with related output, models and tools employed. Author's elaboration.

Urban Mobility Plans in Czech cities. Cerutti et al. (2021) highlighted the role of universities in addressing societal and environmental challenges, training and engaging local communities to succeed in the EGD. Rivas et al. (2021) highlighted the drivers fostering greater ambitions by EU cities with respect to GHG emission reduction. Maya-Drysdale et al. (2020) assessed ambitious local energy vision strategies in support of the EGD.

Despite several calls for providing cities with practical guidance and knowledge (CoR 2023a, 2023b; ICLEI, 2024), no actionable support has been provided to EU cities to fulfill the policy implementation gap while fostering a systemic approach to the SDGs and EGD to the best of our knowledge. In light of the new European Commission work programme 2024–2029, which will provide resources to deliver the EGD implementation also locally (Von der Leyen 2024), there arises a timely opportunity to critically reflect on the role of cities towards the EU green transition by providing them with concrete actionable knowledge to foster PC and system thinking in the realm of a multilevel governance system.

3 | Materials and Methods

The methodological approach underpinning this paper comprises a range of methods and tools employed in three different stages: policy review, target matching and interlinkage assessment. The approach, with intermediate outputs and where to find them in the paper, is synthesised in Figure 1.

3.1 | Policy Review

EGD policies have been reviewed via the Legislative Train Schedule website by the European Parliament (2024), which shows legislative elements that form the major part of the EU institutions' work programme and related status of implementation. The LPs considered for this analysis include Communications, Proposals for Directives, Proposals for Regulations, Directives and Regulations. It should be noted that communications may include 'policy evaluations, commentary or explanations of action programmes or brief outlines on future policies or arrangements

concerning details of current policy' (EU Monitor 2024) and are not binding LPs. However, communications often anticipate targets envisioned by the EC and are then included in Proposals for Directives or Regulations by the EC, then entering the process of *trialogue*¹ with the European Council and the Parliament. As such, progress towards targets from communications can be formally monitored² and transposed into binding policy documents³ later on. For this reason and to provide a comprehensive picture⁴, targets from communications are included in this study. With the same approach, formal proposals for directives or regulations by the EC have been considered, as they are not legally binding but have entered or are about to enter the *trialogue* process (with, in some cases, an agreement already reached) (Marelli et al. 2025).

As of July 2024, 166 legislative proposals are labelled under the EGD in the 'Legislative Train' website. They are classified under 'Announced', 'Tabled', 'Blocked', 'Close to adoption', 'Adopted/Completed' and 'Withdrawn'.⁵ For this analysis, we only considered 'Announced', 'Tabled', 'Close to adoption' and 'Adopted/Completed' LPs, resulting in 127 LPs. It should be noted that, for proposals already adopted and transposed into binding directives or regulations, only the adopted documents have been considered for this study to avoid double counting or considering outdated targets. Information about the legislative process was updated in December 2024.

The text of the 127 LPs was accessed via Eur-LEX (EU 2024), which grants access to EU law. Documents were reviewed to identify quantifiable targets set under the EGD (from 2019 to 2024), that is, targets defining a specific value (numerical or semantic) to be reached by a specific timeline (e.g., 'Three billion trees to be planted by 2030'). Targets extracted were collected in a spreadsheet via Microsoft Excel. They were organised according to seven thematic areas (TAs). These TAs derive from the original [Supporting Information](#) to the Communication on the EGD (European Commission 2019) and regard: '1. Climate ambition' (TA1), '2. Clean, affordable and secure energy' (TA2), '3. Industrial strategy for a clean and circular economy' (TA3), '4. Sustainable and Smart Mobility' (TA4), '5. Greening the Common Agricultural Policy/Farm to Fork strategy' (TA5), '6. Preserving and Protecting Biodiversity' (TA6) and '7. Towards a zero-pollution ambition for a toxic-free environment' (TA7).

Once all quantifiable EGD-Ts were extracted, targets requiring EU cities to act for their implementation were isolated.

3.2 | Matching

Establishing an interface between the EGD-Ts and SDG-Ts aims to foster policy coherence for sustainable development at the local level of policy-making and implementation. Furthermore, the analysis is conducted at the target level, as recommended by Better Regulation and previous scholars (Borchardt et al. 2020; Fronza et al. 2023; Trane et al. 2023). Finally, it allows for priority setting and exploring possible interlinkages among the EGD policies through the lens of the 2030 Agenda. The matching between the EGD-Ts and SDG-Ts by the authors was validated by expert colleagues with proven experience in the field, considering the best proxy UN targets for the association. In fact, although a single EGD-T might contribute to achieving multiple

SDG-Ts at the same time, the one-to-one association allows for better framing of the study on interlinkages.

The analysis on internal synergies and trade-offs was conducted using the SDG interlinkages tool developed by JRC. Capitalizing on a large database of SDG interlinkages that emerged from a comprehensive literature review (Fronza et al. 2023), the matched SDG-Ts were analyzed with respect to their interconnected nature to reveal possible synergies and trade-offs between them (and between relevant policies implicitly). From the more than 23,000 records of SDG interlinkages, only the target-level interlinkages were considered, stating a clear directionality of the effect (e.g., if SDG 2.3 on doubling agricultural productivity was found to hamper the achievement of 12.2 on the efficient management of natural resources) and the type of interlinkage (either synergy or trade-off).

3.3 | Interlinkage Assessment

To focus on the internal, systemic interactions, database records were only considered when relevant SDG-Ts were part of both the source and target of an interlinkage. The resulting selection of interlinkages constituted the basis for constructing two networks of interactions for both synergies and trade-offs individually. Since the above-mentioned database featured numerous reviewed publications that identified interlinkages between the same pairs of SDG-Ts, the type of network had to be a directed graph with multiple edges between the same nodes. To better account for the relative importance of ATs in the context of this paper, the outcomes of RQ1 were incorporated to calculate weights for the edges by assigning node weights based on the number of links between EGD-Ts and SDG-Ts and summing them up for the final edge weight. Visualisation of networks was done using Gephi software starting from *.csv files. Apart from general network properties to better grasp the structure of the network (number of nodes and edges, network density and transitivity), eigenvector centrality was calculated to identify central nodes in both networks as it better accounts for directionality and weighting of the connections compared to classic centrality measures like degree, closeness and betweenness centrality (Bonacich 2007). The calculation and setting of *.csv files were done via Python.

4 | Results

4.1 | The EGD Framework for Cities and Contribution to the SDGs

EGD-related quantifiable targets have been extracted from highlighted LPs, and 76 targets directly involving EU cities for their implementation have been isolated. These targets come from 31 LPs and belong to six TAs. Specifically, one target from the Biodiversity Strategy related to organic farming is in common with the Farm to Fork Strategy, which refers to TA5, but it has been incorporated into TA6. Considering the type of LPs from which targets were derived, around 54% of these targets (41) are currently not binding, that is, coming from communications (30 targets, 40% of the total) and proposals for directives or regulations (11 targets, 15% of the total) (Figure 2). One might expect that the final figure will change when proposals are converted

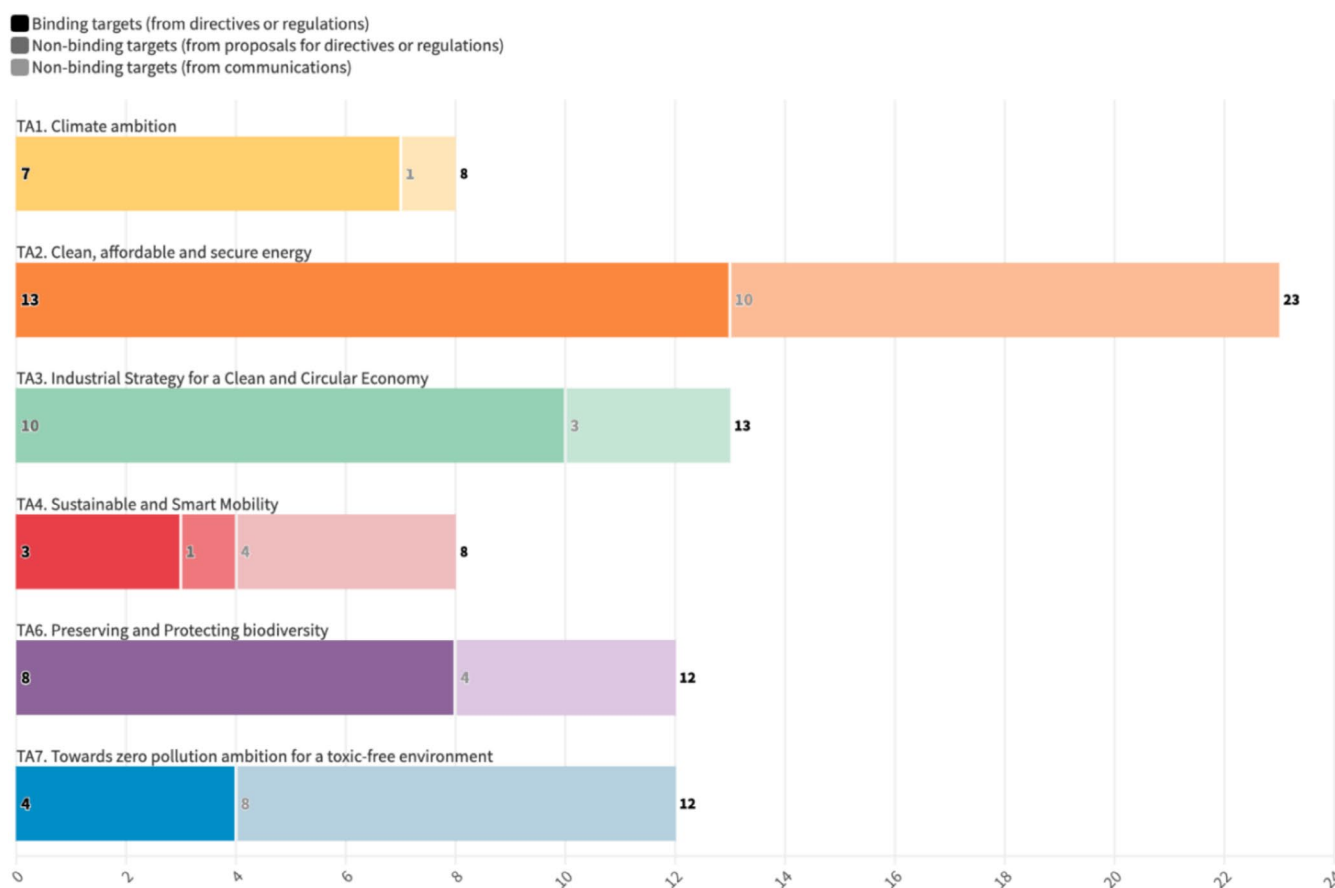


FIGURE 2 | Number and type of targets per Thematic Area. Authors' elaboration via Flourish (<https://app.flourish.studio/>).

into proper regulations and directives, making binding targets constitute 60% of the total.

Figure 3 presents a visual synthesis of the framework matching the EGD to the SDGs requiring cities to implement policy targets, considering policies and their type (if binding or not). Figures 4–9, separated by TA for readability, delve into EGD-Ts involving EU cities for their implementation. The figures also indicate the LPs from which targets were extracted, the type of targets (legally binding or non-legally binding), associated proxy SDGs at the target level and the expected timeline for their achievement.

Finally, Table S1 in Supporting Information highlights the corresponding potential indicators coming from the VLR Handbook (Siragusa et al. 2022), official UN-related indicators and potentially impacted EGD TAs. This could constitute a potential monitoring framework to support cities in mainstreaming the SDGs envisaged by the EGD policies coherently.

4.2 | Target Matching

Figures 4–9 highlight the matching between the EGD-Ts and SDG-Ts. The EGD-Ts involving cities might directly contribute to the achievement of 10 SDGs, namely SDG 2 ('End hunger, achieve food security and improved nutrition and promote sustainable agriculture'), SDG 3 ('Ensure healthy lives and promote well-being for all at all ages'), SDG 6 ('Ensure availability

and sustainable management of water and sanitation for all'), SDG 7 ('Ensure access to affordable, reliable, sustainable and modern energy for all'), SDG 9 ('Build resilient infrastructure, promote inclusive and sustainable industrialisation and foster innovation'), SDG 11 ('Make cities and human settlements inclusive, safe, resilient and sustainable'), SDG 12 ('Ensure sustainable consumption and production patterns'), SDG 13 ('Take urgent action to combat climate change and its impacts'), SDG 14 ('Conserve and sustainably use the oceans, seas and marine resources for sustainable development') and SDG 15 ('Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss') (UN 2015). It should be noted that, given the intertwined nature of the SDGs, the EGD policies support the achievement of other goals, but matching was made with the best proxy for coherence and to inform the interlinkages analysis.

Specifically, the EGD-Ts involving cities might directly contribute to the achievement of 22 SDG-Ts, as shown in Figure 10. TA7 (Towards Zero-Pollution Ambition for a toxic-free environment) addresses most of the SDGs involved, as it is expected to deliver on SDGs 3, 6, 11, 12 and 15, specifically 3.9, 6.1, 6.2, 6.3, 12.4, 11.6 and 11.1. TA1 (Climate ambition) addresses directly SDG 13.2 on the mainstreaming of climate change measures into policies. TA2 (Clean, affordable and secure energy) addresses three SDG-Ts, namely 13.2, 7.2 and 7.3. TA4 (Sustainable and Smart Mobility) addresses three targets, namely 3.6, 9.1 and 13.2. TA6

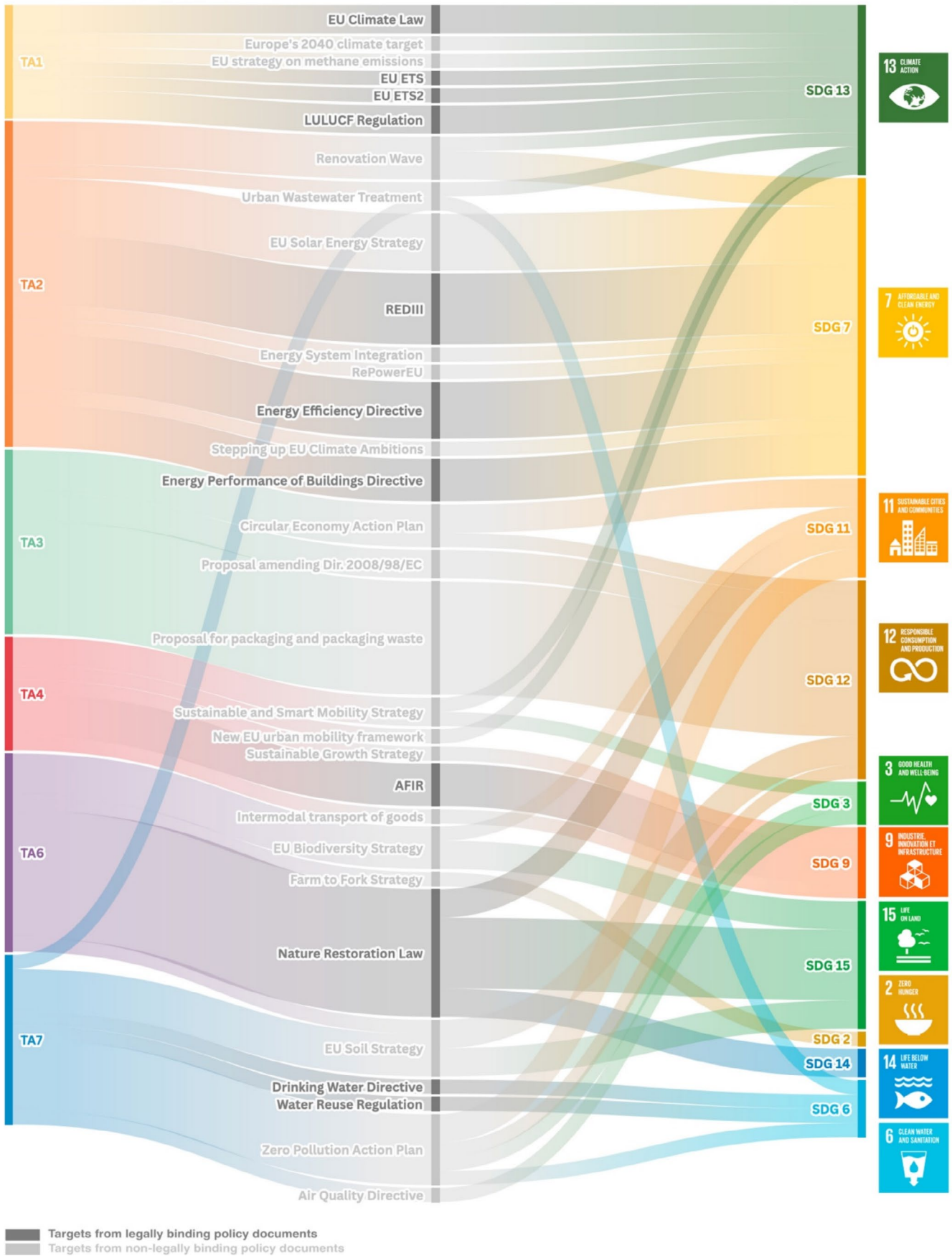


FIGURE 3 | EGD policy framework and contribution to the 2030 Agenda. Number of targets (76) per EGD Thematic Area (6) involving EU cities for implementation, related policy documents (31), type of policy documents (legally binding and non-legally binding, as of December 2024) and associated SDGs. Authors' elaboration via Flourish (<https://app.flourish.studio/>).

Climate Ambitions Targets		To reach by	Binding	Policy	Proxy SDG
GHG EMISSIONS	Reach climate neutrality in the EU	2050	X	European Climate Law	13.2
	Reach -90% GHG emissions in the EU with respect to 1990 levels	2040		Europe's 2040 Climate target	13.2
	Reach -55% GHG emissions in the EU with respect to 1990 levels	2030	X	European Climate Law	13.2
	Reduce methane emissions of 35% if compared to 2005 levels	2030	X	EU Strategy to reduce methane emissions	13.2
	Contribution of the buildings and road transport sectors of 43% emission reductions by 2030 compared to 2005 and of the additional sectors, a combined cost-efficient contribution of 42% emission reductions by 2030 compared to 2005	2030	X	EU Emission Trading System	13.2
	Increased national targets in line with an EU-wide reduction of 40% in the ESR sectors compared to 2005. Member States contribute to the overall EU reduction in 2030 with targets ranging from -10% to -50% below 2005 level (sectors: transport, buildings, agriculture and waste)	2030	X	EU Emission Trading System 2	13.2
GHG REMOVALS	Achieve an EU net GHG removal of 310 million tonnes CO ₂ equivalent per year for the land use, land use change and forestry (LULUCF) sector, by 2030, and Member State-specific targets for 2030 summing up to -42 MtCO ₂ e increase in LULUCF sink between 2016-2018 and 2030	2030	X	LULUCF Regulation	13.2
	From 2021 to 2025, each Member State shall ensure that GHG emissions from the sector do not exceed GHG removals, calculated as the sum of total emissions and total removals on its territory in all the land accounting categories. The accounting benchmark for the EU is ca. -229 MtCO ₂ e/year for 2021-2025	2025	X	LULUCF Regulation	13.2



FIGURE 4 | EGD targets, timeline, typology, policy and proxy SDG targets in TA1. Authors' elaboration.

(Preserving and Protecting Biodiversity) is expected to deliver on four SDGs and eight targets, namely 2.4, 11.7, 11.b, 14.2, 15.1, 15.2, 15.3 and 15.5.

Table S1 in Supporting Information presents the full name of these targets (UN 2015), the corresponding potential indicators coming from the European Handbook for VLR (Siragusa et al. 2022), official UN indicators and EGD TAs.

4.3 | Interlinkage Assessment

Based on the selected SDG-Ts and the selection criteria outlined, 463 'internal' interlinkages (i.e., among prioritised SDG-Ts matched to the EGD-Ts) were identified in the database—378 synergies (covering all 22 selected SDG-Ts) and 85 trade-offs (covering 19 out of 22 selected SDG-Ts). The resulting networks for synergies and trade-offs (Figure 11) differ with respect to their network density, where the larger network for synergies exhibits a high density (0.82), whereas the smaller network for trade-offs indicates only a moderate level of connectivity among the SDG-Ts (network density of 0.25).

When looking at the number of links with other SDG-Ts, targets 7.2 on expanding renewable energy, 6.3 on improving water quality and 13.2 on integrating climate change measures into national policy-making have a high number of interlinkages across both networks, based on SDG Interlinkages data. This might indicate a high level of connectivity on one hand, but also a certain degree of ambiguity as interlinkages might play out differently depending on their contexts (either positively or negatively).

To further integrate those interlinkages within a systemic perspective, eigenvector centrality was calculated for the nodes in both networks to account not only for the quantity of connections but also for their quality. For the network of synergies, 6.3 had the highest eigenvector centrality, followed by targets 7.2 and 13.2. In the network of trade-offs, targets 7.3, 7.2 and 15.5 constitute the nodes with the highest eigenvector centrality. Though these results indicate the targets with the highest relevance in the networks, they also highlight the possible context dependency when looking at SDG interlinkages.

5 | Discussion

The framework introduced with Figure 3, complemented by Supporting Information and Figures 4–9, is the major novelty element of this paper. It provides actionable knowledge to support cities in navigating the green transition as envisaged by the EGD and coherently with the SDGs. The analysis of interlinkages, potentially informing areas of caution and synergies for smoothing policy implementation at the local level, constitutes a first demonstration of the application of this framework, having further implications as an effect.

The original aspects introduced are manifold. First, (A) a comprehensive policy framework with quantifiable EGD-Ts affecting and driving local policy-making in the EU is made available for the first time (Figures 3 and 4–9, Table S1 in Supporting Information), aligning the EGD targets to SDGs and related indicators from the UN (2015) and the European Handbook for SDG VLRs. As a second element of novelty, (B) this paper delves into the SDG target level of analysis, moving beyond the usual goal-level approach

Clean, affordable and secure energy Targets		To reach by	Binding	Policy	Proxy SDG
GHG EMISSIONS	Reduce buildings' GHG emissions by 60%, by 2030 (compared to 2015), and reach climate neutrality by 2050	2030 2050		A Renovation Wave for Europe	13.2
	Reach energy neutrality in the wastewater treatment sector, with GHG emissions reduced by 4,86 million tonnes*	2040	X	Directive on Urban Wastewater Treatment	13.2
RENEWABLE ENERGY	Set up at least one renewables-based energy community in every municipality with a population higher than 10,000 inhabitants	2030		EU Solar Energy Strategy	7.2
	Bring online over 320 GW of solar photovoltaic by 2025 and 600 GW	2030		EU Solar Energy Strategy	7.2
	The energy demand to be covered by solar heat and geothermal should at least triple (currently rate at 1,5%)	2030		EU Solar Energy Strategy	7.2
	Install 45 GW per year of PV to reach the share of 45% of energy coming from renewables set out in the RePowerEU Plan	2030		EU Solar Energy Strategy	7.2
	The share of energy from renewable sources in the Union's gross final consumption of energy in 2030 is at least 42,5 %, aiming at 45%	2030	X	Renewable Energy Directive III	7.2
	Indicative target for innovative renewable energy technology of at least 5 % of newly installed renewable energy capacity	2030	X	Renewable Energy Directive III	7.2
	By 2025 achieve 43% of the total increase in the share of energy from renewable sources between that Member State's binding 2020 national target, and its contribution to the 2030 target of share of energy from renewable sources in gross final consumption of energy (65% by 2027)	2025 2027	X	Renewable Energy Directive III	7.2
	Indicative target of at least a 49% share of energy from renewable sources in the building sector in the Union's final energy consumption in buildings in 2030	2030	X	Renewable Energy Directive III	7.2
	By 2030, the share of renewable energy in the electricity mix should double to 55-60%, and projections show a share of around 84% by 2050. The remaining gap should be covered by other low-carbon options	2030 2050		An EU strategy for energy system integration	7.2
	Increase the share of renewable energy in that sector by at least 0,8% as an annual average calculated for the period 2021 to 2025 and by at least 1,1% as an annual average calculated for the period 2026 to 2030, starting from the share of renewable energy in the heating and cooling sector in 2020	2025 2030	X	Renewable Energy Directive III	7.2
ENERGY EFFICIENCY	Double the current deployment rate of individual heat pumps, resulting in cumulative 10 million units by 2027 and 30 million units by 2030	2027 2030		RePowerEU	7.3
	Member States shall ensure that the total final energy consumption of all public bodies combined is reduced by at least 1.9% each year, when compared to 2021	2030	X	Energy Efficiency Directive (2023/1791)	7.3
	Member States shall collectively ensure a reduction of energy consumption of at least 11.7% in 2030 compared to the projections of the 2020 EU Reference Scenario so that the Union's final energy consumption amounts to no more than 763 Mtoe	2030	X	Energy Efficiency Directive (2023/1791)	7.3
	Member States shall make efforts to collectively contribute to the indicative Union primary energy consumption target amounting to no more than 992.5 Mtoe in 2030	2030	X	Energy Efficiency Directive (2023/1791)	7.3
	Reduce buildings' final energy consumption by 14% compared to 2015	2030		Stepping up climate ambitions	7.3
	Reduce buildings' heating and cooling energy consumption by 18% compared to 2015	2030		A Renovation Wave for Europe	7.3
	At least 55% of the decrease of the average primary energy use is achieved through the renovation of the worst-performing buildings	2030	X	Energy Performance of Buildings Directive	7.3
RENEWABLE ENERGY	Member States shall ensure that the average primary energy use of the entire residential building stock decreases by at least 16% compared to 2020 by 2030; and by at least 20-22% compared to 2020 by 2035	2030 2035	X	Energy Performance of Buildings Directive	7.3
	Each Member State shall ensure that at least 3% of the total floor area of heated and/or cooled buildings (of buildings which have a total useful floor area of over 250 m ² and are not nearly-zero energy buildings) that are owned by public bodies is renovated each year to be transformed into at least nearly zero-energy buildings or zero-emission buildings in accordance with Article 9 of Directive 2010/31/EU	2030	X	Energy Efficiency Directive (2023/1791)	7.3
	At least double the annual energy renovation rate of residential and non-residential buildings by 2030 and foster deep energy renovations	2030 2030		A Renovation Wave for Europe	7.3
Member states will have to renovate 16% of worst-performing non-residential buildings by 2030 and, by 2033, the worst-performing 26% through minimum energy performance requirements	2033	X	Energy Performance of Buildings Directive	7.3	

*Proposal for a Directive, with an agreement already reached between co-legislators (August 2024)



FIGURE 5 | EGD targets, timeline, typology, policy and proxy SDG targets in TA2. Authors' elaboration.

(Trane et al. 2023) as promoted by the EU Better Regulation tool, to inform the SDG implementation process as well as the interlinkage assessment. As a third element of novelty, (C) the interlinkage assessment fosters a systems-thinking approach to EGD policy implementation and local policymaking. In fact, there is evidence that facing synergies might imply a smoother policy implementation and accelerating effect towards the achievement of the SDGs. Conversely, not addressing trade-offs slows down

policy implementation and SDG achievement, even in EU countries with the best rankings (Kostetckaia and Hametner 2022; Kuc-Czarnecka et al. 2023). The exercise on interlinkages is not intended to imply as a causal relationship, that is, it does not imply that the emerging synergies and trade-offs among targets necessarily and always exist. Interlinkages should be assessed given local specificities and involving stakeholders' perspectives (Fronza et al. 2023; Trane et al. 2023; Breu et al. 2021). However, the

Industrial Strategy for a clean and circular economy Targets		To reach by	Binding	Policy	Proxy SDG
MUNICIPAL WASTE	Halve the amount of residual (non-recycled) municipal waste	2030		Circular Economy Action Plan	11.6
	Reduce landfill to a maximum of 10% of municipal waste	2035		Circular Economy Action Plan	11.6
	Double the EU circular material use rate in the coming decade	2030		Circular Economy Action Plan	12.5
	Reduce the generation of food waste in processing and manufacturing by 10% in comparison to the amount generated in 2020	2030		Proposal amending Directive 2008/98/EC on waste	12.3
	Reduce the generation of food waste per capita, jointly in retail and other distribution of food, in restaurants and food services and in households, by 30 % in comparison to the amount generated in 2020	2030		Proposal amending mending Directive 2008/98/EC on waste	12.3
	Reduce packaging waste by 5% per Member State per capita compared to 2018 by 2030, 10% by 2035 and 15% by 2040*	2030 2040		Proposal for packaging and packaging waste	12.5
RECYCLING	Member States shall take measures to achieve a sustained reduction in the consumption of lightweight plastic carrier bags on their territory, i.e. the annual consumption does not exceed 40 lightweight plastic carrier bags per person, or the equivalent target in weight, by 31 December 2025 and in each year thereafter*	2025		Proposal for packaging and packaging waste	12.5
	Member States shall take the necessary measures to attain a recycling target of 50% of plastic by weight of plastic contained in packaging waste generated by 31 December 2025 and of 55% by 31 December 2030*	2025 2030		Proposal for packaging and packaging waste	12.5
	Member States shall take the necessary measures to attain a recycling target of 25% of wood by weight of wood contained in packaging waste generated by 31 December 2025 and of 30% by 31 December 2030*	2025 2030		Proposal for packaging and packaging waste	12.5
	Member States shall take the necessary measures to attain a recycling target of 70% of ferrous metals by weight of ferrous metals contained in packaging waste generated by 31 December 2025 and of 80% by 31 December 2030*	2025 2030		Proposal for packaging and packaging waste	12.5
	Member States shall take the necessary measures to attain a recycling target of 50% of aluminium by weight of aluminium contained in packaging waste generated by 31 December 2025 and of 60% by 31 December 2030*	2025 2030		Proposal for packaging and packaging waste	12.5
	Member States shall take the necessary measures to attain a recycling target of 70% of glass by weight of glass contained in packaging waste generated by 31 December 2025 and of 75% by 31 December 2030*	2025 2030		Proposal for packaging and packaging waste	12.5
	Member States shall take the necessary measures to attain a recycling target of 75% of paper and cardboard by weight of paper and cardboard contained in packaging waste generated by 31 December 2025 and of 85% by 31 December 2030*	2025 2030		Proposal for packaging and packaging waste	12.5

*Proposal for a Regulation, with an agreement already reached between co-legislators (August 2024)



FIGURE 6 | EGD targets, timeline, typology, policy and proxy SDG targets in TA3. Authors' elaboration.

purpose of this analysis is rather to inform about possible 'caution' areas when implementing the EGD policies and 2030 Agenda at the local level to inform policy-making.

5.1 | Policy Implications

As a first implication of (A), the framework introduced could inform cities' local development programmes by identifying overarching SDG target priorities to succeed in the green transition as envisaged by the EGD. In fact, applying the matching framework to local policy-making implies raising awareness of what priorities are in place for the EU in the environmental policy domain. In turn, aligning with those priorities might strengthen coherence among the EGD and the 2030 Agenda, promote policy and SDG mainstreaming, and also potentially result in better funding opportunities for EU cities (Local Alliance 2024). Ultimately, it can help close the highlighted EGD and SDG implementation gaps.

As a second implication of (A), certain trends and gaps in the policy landscape might emerge. From a quantitative point of view, TA2 on Clean, affordable and secure energy is the EGD area with the highest number of targets (23 out of 76) to which EU cities should contribute (Figure 3). Therefore, 30% of targets relate to SDG 7 on affordable and clean energy. However, it should be noted that certain policy domains (e.g., TA2 on energy and TA3 on circular economy with recycling targets) have more granular and numerous targets by design. This constitutes a statistical measure only, as it does not imply any consideration of expected impacts on the EU green transition pathway by certain TAs or policies. Besides, SDG 13.2 is also well addressed, notably by TA1 regarding Climate ambitions. SDG 12 on production and consumption patterns and SDG 11 on sustainable cities are also linked to a significant share of EGD-Ts in the waste management domain. It is worth noting that the role of cities in shifting towards circular processes and more sustainable consumption and production is delegated to waste recycling and collecting efficiency targets by the EGD. However,

Sustainable and Smart Mobility Targets		To reach by	Binding	Policy	Proxy SDG
GHG EMISSIONS	Cut the emissions of transport sector by 90%	2050		Sustainable and Smart Mobility Strategy	13.2
	Zero-emission in urban logistics	2030		The new EU urban mobility framework	13.2
HYDROGEN INFRASTR.	Member States shall ensure that, by 31 December 2030, at least one publicly accessible hydrogen refuelling station is deployed in each urban node*	2030	X	AFIR (Alternative Fuel Infrastructure Regulation)	9.1
ELECTRIC VEHICLE INFRASTRUCTURE	By 31 December 2030, in each urban node publicly accessible recharging points dedicated to heavy-duty electric vehicles with an aggregated power output of at least 1 800 kW are deployed, provided by recharging stations with an individual power output of at least 150 kW	2030	X	AFIR (Alternative Fuel Infrastructure Regulation)	9.1
	Build three million public electric charging points by 2030. Build one million public electric charging points by 2025**. 30 million zero-emission cars and 80.000 zero-emission lorries are expected in operation in EU roads by 2030***	2030		Annual Sustainable Growth Strategy 2021 / Sustainable and Smart Mobility Strategy	9.1
	Member States shall ensure that, at the end of each year, the following power output targets are met cumulatively: (a) for each light-duty battery electric vehicle registered in their territory, a total power output of at least 1.3 kW is provided through publicly accessible recharging stations; and (b) for each light-duty plug-in hybrid vehicle registered in their territory, a total power output of at least 0.80 kW is provided through publicly accessible recharging stations.	2030	X	AFIR (Alternative Fuel Infrastructure Regulation)	9.1
ROAD SAFETY	The death toll for all modes of transport in the EU will be close to zero ***	2030		Sustainable and Smart Mobility Strategy	3.6
INTER-MODALITY	Reduce the average door-to-door cost of combined transport operations by at least 10% within 7 years	2031		Proposal for a Directive to support framework for intermodal transport of goods	9.1

*This target supports the ambition of building 500 hydrogen stations by 2025 and 1.000 by 2030 expressed in the document "Annual Sustainable Growth Strategy 2021"
 ** This target is expressed in the document "Annual Sustainable Growth Strategy 2021".
 To support this ambition, the new Alternative Fuel Infrastructure Regulation requires power output targets (as reported in this table) and several targets regarding the availability of publicly accessible recharging points alongside the core and comprehensive TEN-T (Trans-European Transport Network). However, this targets would mostly regard national or regional infrastructural issues. For further details, please refer to the Regulation or visit <https://webgate.ec.europa.eu/tentec-maps/web/public/screen/home>
 *** These ambitions are expressed as "Milestones" under the Sustainable and Smart Mobility Strategy and are intended to "show the European transport system's path towards achieving our objectives of a sustainable, smart and resilient mobility, thereby indicating the necessary ambition for our future policies"



FIGURE 7 | EGD targets, timeline, typology, policy and proxy SDG targets in TA4. Authors' elaboration.

more action for the prevention of waste and a shift towards pro-environmental behaviours might be needed, with cultural and behavioural attitudes being the most common barriers to a circular economy in EU cities (Möslinger et al. 2023). Looking at TA4 and SDG 9, policy initiatives to promote travel demand reduction (e.g., via digitalisation, connected autonomous vehicles, mobility as a service and more active transport modes like cycling, etc.) could be further leveraged at the urban level to contribute to the -90% reduction in GHG emissions from transport by 2050 (ESABCC 2024; Intergovernmental Panel on Climate Change 2023). Targets (e.g., those from the new Alternative Fuel Infrastructure Regulation [AFIR]) focus on techno-infrastructure advances, which mostly pertain to regional scales for implementation (e.g., for the TEN-T network). Strong multilevel and inter-regional cooperation will be needed to close the implementation gap in these cases (CoR 2024). TA7 is linked to the widest range of SDGs. Specifically, the agreed Nature Restoration Law sets many targets to be implemented in cities (referred to as 'urban ecosystems') and regions, while many ambitions of the Biodiversity Strategy are supported by specific policies (e.g., the new Air Quality Directive) that set detailed requirements for EU cities and MSs. Also in these cases, inter-regional cooperation will be needed to cover the biodiversity

restoration and pollution domains to implement most of the EGD-Ts and SDG-Ts; therefore, targets do not only pertain to the urban level of implementation. Finally, TA5 on the EU food system does not have specific quantifiable targets directly involving cities. A target on organic farming has been included in this framework under TA6 to underline the potential role of urban agriculture towards a more sustainable food system, despite the fact that in 2010, around 14% of the global population was nourished by food grown in urban and peri-urban areas (Kriewald et al. 2019). There is evidence that urban agriculture can provide citizens with several benefits, being an effective strategy for boosting resilience in cities, supporting pro-environmental behaviour and shifting towards lower carbon diets (Puigdueta et al. 2021), even if its carbon footprint might be higher than conventional agriculture (Hawes et al. 2024).

As a third implication of (B), this exercise clarifies the mutual contribution of both frameworks to each other. In fact, there is growing evidence that implementing both the SDGs and the Paris Agreement, to which the EGD responds, can significantly boost both agendas and that considering interlinkages is needed for greater policy coherence (OECD 2024). Furthermore, it highlights the transformative power of the SDGs in supporting

Preserving and Protecting Biodiversity Targets		To reach by	Binding	Policy	Proxy SDG
HABITAT PROTECTION AND RESTORATION	Legally protect a minimum of 30% of the EU's land area	2030		EU Biodiversity Strategy	15.1
	Member States shall put in place [...] measures [...] to jointly cover, as a Union target, throughout the areas and ecosystems [...] defined in Art. 2, by 2030, at least 20% of land areas in need of restoration and, by 2050, all ecosystems in need of restoration	2030 2050	X	Nature Restoration Law	15.1, 14.2
	Member States shall put in place the restoration measures [...] to improve to good condition at least 30% of terrestrial, coastal and freshwater ecosystem areas by 2030 (60 % by 2040, 90% by 2050)*	2030 2040 2050	X	Nature Restoration Law / EU Biodiversity Strategy	15.1, 14.2
	Member States shall make an inventory of artificial barriers and remove them to connectivity of surface waters and, taking into account their socio-economic functions, identify the barriers that need to be removed to contribute to the achievement of the objective of restoring at least 25.000 km of rivers into free-flowing rivers*	2030	X	Nature Restoration Law / EU Biodiversity Strategy	15.1
URBAN GREENERY	By 2030, Member States shall ensure that there is no net loss in the total national area of urban green space, and of urban tree canopy cover in urban ecosystem areas. Member States may exclude from that total national area the urban ecosystem areas in which the share of urban green space in the urban centres and urban clusters exceeds 45% and the share of urban tree canopy cover therein exceeds 10%	2030	X	Nature Restoration Law	11.7
	Member States shall achieve thereafter an increasing trend in the total national area of urban green space, including through the integration of urban green space into buildings and infrastructure, in urban ecosystem areas [...]	from 2030	X	Nature Restoration Law	11.7
	Member States shall achieve, in each urban ecosystem area, determined in accordance with Article 14(4), an increasing trend of urban tree canopy cover, measured every six years after 31 December 2030, until the satisfactory level identified in accordance with Article 14(5) is reached.	from 2030	X	Nature Restoration Law	15.2
	Member States shall, by putting in place in a timely manner appropriate and effective measures, improve pollinator diversity and reverse the decline of pollinator populations at the latest by 2030 and thereafter achieve an increasing trend of pollinator populations, measured at least every six years from 2030*	2030	X	Nature Restoration Law / EU Biodiversity Strategy	15.5
	[...] Member States shall aim to contribute to the commitment of planting at least three billion additional trees by 2030 at Union level*	2030	X	Nature Restoration Law / EU Biodiversity Strategy	15.2
	Cities with at least 20.000 inhabitants have an ambitious Urban Greening Plan	2030		EU Biodiversity Strategy	11.b
ORGANIC FARMING	Increase organic farming with the aim to achieve at least 25% of total farmland under organic farming by 2030	2030		EU Biodiversity Strategy / Farm to Fork Strategy	2.4
SOIL	Reach no net land take	2030		EU Soil Strategy	15.3

*Targets originally proposed by the Biodiversity Strategy, then transposed into binding by the Nature Restoration Law










FIGURE 8 | EGD targets, timeline, typology, policy and proxy SDG targets in TA6. Authors' elaboration.

the green transition also at the sub-national level and system thinking in local policy-making. In this perspective, despite a limited policy influence so far (Biermann et al. 2022), the 2030 Agenda might constitute an 'interface' for dialogue between policymakers, stakeholders and domain experts, considering that it is a well-established framework also in local decision-making and favours the adoption of complexity as a core value (Fronza et al. 2023).

5.2 | Potential Applications

Overcoming 'silo approaches' and identifying interconnections when implementing the 2030 Agenda could reinforce policy coherence vertically (among governance levels) and horizontally (among policy domains). The application of the framework presented, which allows analysing the EGD through the lens of the

2030 Agenda, might facilitate the understanding of possible interactions among EGD policy areas also at the urban level.

In the case of the SDGs, synergies among targets might exist and are much more numerous than trade-offs (Figure 11). For instance, maximising urban forest carbon sinks under the Land Use, Land Use Change and Forestry (LULUCF) Regulation and Nature Restoration Law might contribute to mitigation efforts (EU Climate Law) while providing EU cities with important ecosystem services and co-benefits to citizens (Steenberg et al. 2023). Furthermore, it might support the achievement of other EGD-Ts, such as those related to air pollution removal (TA7), tree planting and land restoration (TA6) (Pollo and Trane 2021) as well as many other SDG-Ts beyond those isolated (Tosun and Leininger 2017). Demand reduction in the transport system could have several positive repercussions on health and the promotion of more pro-environmental

Towards Zero Pollution Ambition for a toxic-free environment Targets		To reach by	Binding	Policy	Proxy SDG
WATER QUALITY	Member States shall take the measures necessary to ensure that water intended for human consumption is wholesome and clean, by meeting several requirements related to micro-organisms and parasites which constitute a potential danger to human health and quality standards recalled in the Directive	from 2020	X	'Drinking Water Directive' (2020/2184)	6.1
	Encourage and facilitate water reuse by harmonised minimum water quality requirements for the safe reuse of treated urban wastewaters in agricultural irrigation. Further detail requirements are set for monitoring, risk management, transparency and permits on production and supply of reclaimed water for agricultural irrigation	from 2023	X	'Water Reuse Regulation' (2020/741)	6.3
	Improve and maintain access to sanitation for all, in particular for vulnerable and marginalised groups, by extended the secondary treatment of urban wastewater to all agglomerations with at least 1.000 population equivalent (p.e.) by 2035. In plants larger than 150.000 p.e., apply tertiary treatment, for the removal of nitrogen and phosphorus (by 2039), and quaternary treatment, for the removal of a broad spectrum of micropollutants (by 2045)**	2035 2039 2045	X	Directive on Urban Wastewater Treatment	6.2
	Improve water quality by reducing waste, plastic litter at sea by 50%	2030		Zero Pollution Action Plan	6.3
	Improve water quality by reducing microplastics released into the environment by 30%	2030		Zero Pollution Action Plan	12.4
AIR QUALITY	The Ambient Air Quality Directives set EU air quality standards for 12 air pollutants that Member States must not exceed: sulphur dioxide, nitrogen dioxide, nitrogen oxides, fine particulate matter, ozone, benzene, lead, carbon monoxide, arsenic, cadmium, nickel, and benzo(a)pyrene. The annual limit value for the main pollutant – fine particulate matter – will be cut by more than half with respect to previous Directive***.	from 2024	X	Directive on ambient air quality and cleaner air for Europe	11.6
	Improve air quality to reduce the number of premature deaths by air pollution by 55%	2030		Zero Pollution Action Plan	3.9
	Reduce by 25% the EU ecosystems where air pollution threatens biodiversity compared to 2005	2030		Zero Pollution Action Plan	11.6
NOISE	Reduce the share of people chronically disturbed by transport noise by 30% compared to 2017	2030		Zero Pollution Action Plan	11.1
SOIL QUALITY	Improve soil quality by reducing nutrient losses by 50%	2030		EU Soil Strategy	12.4
	Improve soil quality by reducing chemical pesticides' by 50%	2030		EU Soil Strategy	12.4
	Have all soils in healthy conditions	2050		EU Soil Strategy	15.3

* Proposal for a Directive, with an agreement already reached between co-legislators (August 2024)
 ** Detail requirements and intermediate time-steps apply. Please refer to the upcoming Directive.
 *** Proposal for a Directive, with an agreement already reached between co-legislators (August 2024). Detail limit values for pollutant concentration apply. Please refer to the upcoming Directive.



FIGURE 9 | EGD targets, timeline, typology, policy and proxy SDG targets in TA7. Authors' elaboration.

attitudes (ESABCC 2024; Kahlmeier et al. 2021; Meireles and Ribeiro 2020).

As a fourth implication of (C), the framework and network analysis based on the SDG Interlinkages Tool highlight potential trade-offs when implementing the EGD-Ts at the urban level. To test a potential application of the framework and having matched the EGD-Ts and SDG-Ts, Figure 12 illustrates what trade-offs might theoretically exist among policy targets to be implemented locally (Figure 11). It focuses on trade-offs due to manuscript length constraints and to highlight possible caution areas when implementing the EGD at the local level, often overlooked (Nilsson and Weitz 2019).

Figures 11 and 12 suggest that trade-offs might theoretically exist, especially among TA2 policies (Figure 4) and other TAs at the local level. For instance, trade-offs could potentially emerge from implementing locally SDG 7.2, addressed by the new RED III, against SDG 3.9 and 11.6 on air quality, linked to the Air Quality Directive and Zero Pollution Action Plan (ZPAP), as bioenergy and the incineration of waste might

increase air pollution (Blair et al. 2021). In addition, advancing SDG 7.2 implementation might potentially slow down SDG 11.6 and 12.5 on waste generation linked to the Circular Economy Action Plan (CEAP) and the Proposal on Packaging and Packaging waste, considering that, if waste is used for energy, there might be less incentive to improve recycling. As a potential trade-off, the one with SDG 13.2 might affect local climate mitigation efforts, specifically referring to the updated LULUCF Regulation (Figure 3). In fact, according to Blair et al. (2021), policies aimed at emission reduction in the energy sector may lead to land use change or increased emissions in another region or country, or competition for biomass between bioenergy and other bioproducts, highlighting the need to craft tailored solutions in an inter-regional cooperation set-up (CoR, 2024). SDG 15.1, 15.2, 15.5 and 14.1, relating to the Nature Restoration Law and Biodiversity Strategy (Figure 9), could be impacted by SDG 7.2 as well. In fact, if bioenergy production increases nutrient pollution and GHG emissions, rates of eutrophication and acidification might increase (Blair et al. 2021), while biomass could put pressure on protected areas and biodiversity (15.1). Furthermore,

increasing the global proportion of renewable energy could result in worse water quality (14.1) and biodiversity status (15.5) (Lyytimäki et al. 2021). Regarding SDG 7.3 addressed by the Energy Efficiency Directive, it might potentially counteract with SDG 6.3 (ZPAP), since a change in the energy mix driven by cities increasingly implementing renewable sources could potentially hamper water quality improvement (Alcamo 2019). Several trade-offs could emerge from targets linked to SDG 13.2 and the EU climate law, Sustainable and Smart Mobility Strategy (SSMS) and Renovation Wave. For instance, it could slow down the pathway towards the achievement of SDG 3.6 on road safety (SSMS) (Figure 7) if not accompanied by proper infrastructural and habit changes (Stevenson et al. 2021). In addition, it can obstruct SDG 11.6, addressed by the CEAP, as the production of energy from waste could incentivise and

monetise waste streams (Stevenson et al. 2021). Finally, it could hamper SDG 7, also addressed by the EU Solar Energy Strategy, as increased costs for energy might generate fuel poverty and disincentivise people from accessing energy (Stevenson et al. 2021). Looking at SDG 6 and related EGD policies, several targets could be impacted by implementing it improperly. In turn, it could be impacted by the AFIR (SDG 9.1) and ZPAP implementation (SDG 11.1). Specifically, SDG 6.2 (access to adequate sanitation) might counteract with SDG 6.3 addressed by the Urban Wastewater Treatment Directive (UWWTD), as low shares of wastewater treated can cause a higher water footprint (Milan 2017). Additionally, SDG 6.1 could impact SDG 15.1 and 14.1 (Nature Restoration Law), as access to safe and affordable drinking water for all in regions with water scarcity counteracts the conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems (Wang et al. 2022). In turn, the reactive nitrogen emissions from energy use in the transportation network (AFIR, SDG 9.1) may pollute water and counteract the improvement of water quality (SDG 6.3, SDG 6.1) and reduce marine pollution (SDG 14.1) (Wang et al. 2022).

These examples, as already stated, do not intend to infer causalities among policies and related targets, with interlinkages to be assessed case by case and taking into account local contexts. However, they exemplify how the SDGs might be used to strengthen policy coherence and implementation, as available knowledge might inform potential caution areas to consider when designing local implementation programmes aiming to deliver the EGD.

5.3 | Limitations

This extensive analysis faces several limitations. From a technical point of view, the centrality measures were built considering associations with the EGD targets (number of matchings, for the node size) and the number of interlinkages in the database behind the SDG Interlinkage tool of the JRC. As such, this is based on academic literature on interlinkages behind the 2030 Agenda and only counts the occurrence of

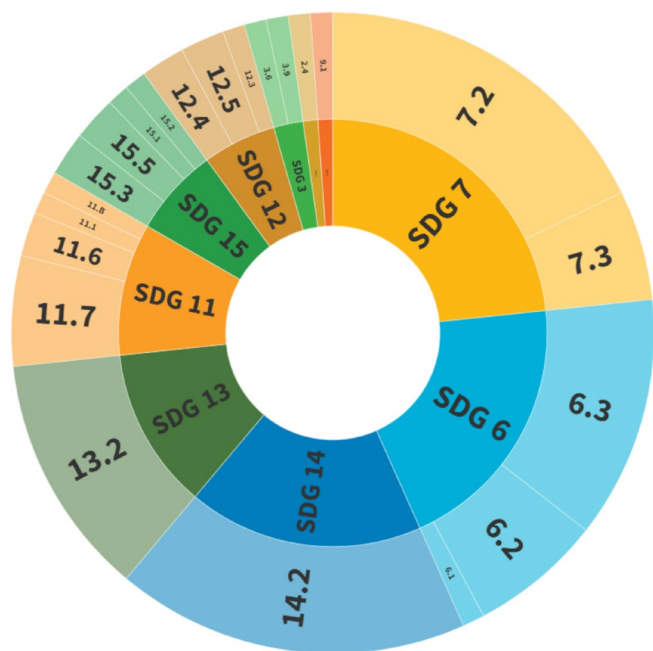


FIGURE 10 | SDG targets matched with EGD policy targets involving EU cities. Authors' elaboration via Flourish (<https://app.flourish.studio/>).

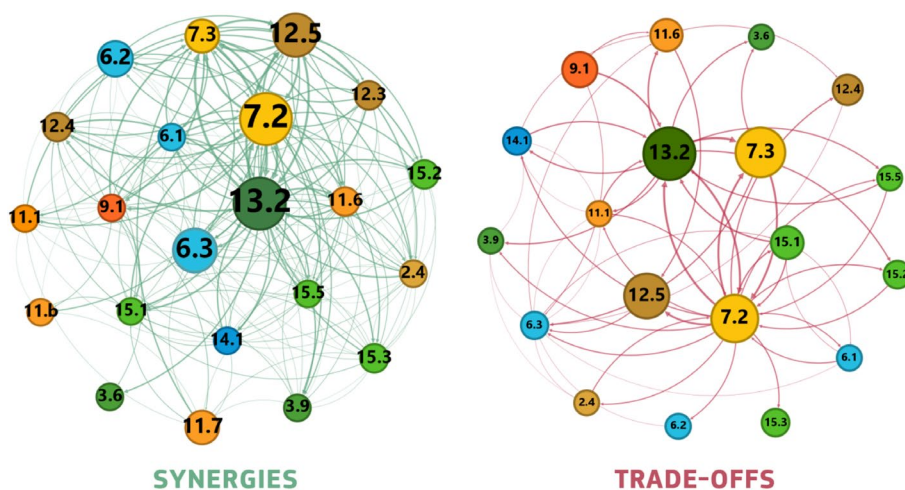


FIGURE 11 | Synergies and trade-offs networks among SDG targets matched to the EGD policy targets. Authors' elaboration via Gephi, based on the JRC SDG Interlinkages tool (www.knowsdgs.ec.europa.eu).

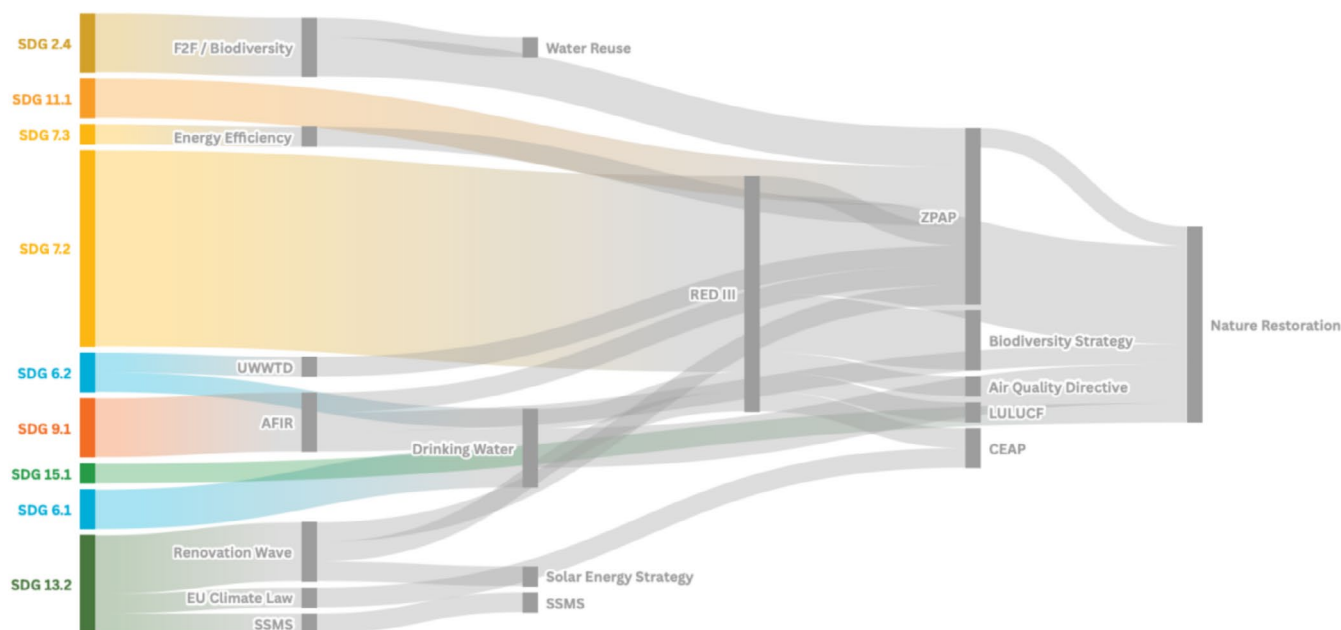


FIGURE 12 | Theoretical application case of the framework matching the EGD-Ts with the SDG-Ts, entirely based on the SDG Interlinkages tool, to exemplify trade-offs among policy targets at the local level of implementation. Authors' elaboration via Flourish (<https://app.flourish.studio/>).

interlinkages as studied by scholars in different geographic contexts.

However, this does not take into consideration the strength of specific links as highlighted in publications reviewed. For example, if a positive interlinkage between two SDG-Ts exists, as pointed out in a paper, the database of the SDG Interlinkages tool does not consider if this relationship is 'consistent', 'enabling', 'reinforcing' or 'indivisible' (Nilsson et al. 2016), since it goes beyond the scope of the tool. In this perspective, further considerations (i.e., assessing beneficial or detrimental relationships among targets) should be elaborated according to context specificities, stakeholders' perceptions and local priorities (Breu et al. 2021; Fronza et al. 2023; Trane et al. 2023). However, as stated, the purpose of the interlinkages analysis is to unveil complexity behind policies dealing with system transitions, highlighting a potential application of the matching framework to inform local policy-making. Any specific consideration should be assessed in specific urban contexts' realms.

Finally, although the database of SDG interlinkages utilised for this network analysis is the most exhaustive available to date, it should be noted that it might be skewed towards certain SDGs that might have been more frequently targeted by the reviewed publications, which can ultimately also affect the outcomes of the network analysis (examples of potential overrepresentation of SDGs in the database are SDG 7, 14 and 6) (Fronza et al. 2023).

6 | Conclusions

The results highlight that the EGD policies call for an active role of cities to contribute to the green transition in the EU, with a particular emphasis on the domains of clean, affordable and secure energy; climate ambition; circular economy (recycling);

and zero pollution ambition. Navigating the complexity of a fast-developing policy landscape and the SDGs might be highly challenging for cities, which often have limited resources, expertise, and a low degree of autonomy (CoR 2023b; Ulpiani and Vetter 2023). Therefore, this exercise responds to the need of EU cities to have concrete guidance in implementing EU policies (CoR 2023b; EC 2024a; 2024b, 2024c) with a novel framework matching the EGD to the SDGs at the target level.

Our findings have several implications, touching upon priority and monitoring process setting, the need for a systemic approach when implementing the EGD locally, reinforced policy coherence horizontally (among frameworks) and vertically (from the lowest to the highest level of governance in the EU), and policy gaps. EU cities should ensure alignment with EU ambitions; aligning policies, investments and citizen mobilisation for climate neutrality across governance levels and jurisdictions is fundamental to succeeding in the green transition (Ulpiani et al. 2023). The potential application of the framework presented can guide towards uncovering interlinkages among targets also at the local level, as specifically demonstrated in the case of trade-offs.

As a development of this research, the authors will consult local policymakers to focus on what structural challenges cities are facing in implementing specific policies, potential patterns emerging across the EU and bottlenecks to policy coherence. Moreover, future research could focus on what external interlinkages (i.e., with respect to other EU policies and additional SDGs impacted) could be envisaged while implementing these prioritised targets. Conversely, it could be interesting to understand to what extent VLRs produced by EU cities so far (Stamos et al. 2024) are prioritising the matched SDG targets. Finally, future research applying the framework presented could focus on assessing and quantifying interlinkages with ad hoc tools (Nilsson et al. 2016) and test it in specific local contexts.

Author Contributions

Matteo Trane: conceptualisation, data curation, formal analysis, investigation, methodology, software, visualisation, writing – original draft, writing – review and editing. **Steve Borchardt:** data curation, formal analysis, writing – original draft. **Luisa Marelli:** conceptualisation, methodology, supervision, writing – review and editing. **Alice Siragusa:** supervision, writing – review and editing. **Riccardo Pollo:** supervision, writing – review and editing. **Patrizia Lombardi:** supervision, writing – review and editing.

Acknowledgments

We would like to thank the reviewers for their constructive comments. We would also like to thank Cristian Matti (JRC) for his valuable feedback on the first version of this paper. Finally, we thank Giulia Barbero Vignola (JRC), Louisa Contipelli (formerly JRC) and Michele Maroni (consultant to JRC) for validating the target matching.

Endnotes

¹The trialogue process implies an informal negotiation involving representatives from the European Parliament, the Council of the European Union, and the EC. It aims to reach preliminary agreements on legislative proposals that the Parliament and the Council, as EU co-legislators, can accept and ratify through formal procedures (EU 2024).

²For instance, the Zero Pollution Action plan is the EC's strategy to monitor the health and pollution of the environment (EC 2022), whereas the Biodiversity Strategy (EC 2020) targets set are monitored in the JRC Biodiversity dashboard. Source: <https://dopa.jrc.ec.europa.eu/kcbd/dashboard/> (accessed on 31 January 2024).

³For instance, the target 'Three billion additional trees are planted in the EU' by the Biodiversity Strategy (EC 2020) became binding when recalled by the Nature Restoration Law (EU 2024).

⁴It should be noted that the food system reform EGD policy area has no quantifiable binding targets set (ESABCC 2024) nor LP tabled (EC 2023).

⁵According to the definitions on the website, 'Announced' LPs are initiatives expected from the EC that contribute to the implementation of the EC priorities. These either announce future legislative activity or are of major political importance. Once the Parliament has received a legislative proposal—or significant non-legislative initiative—from the EC, the file takes the status 'Tabled'. The status 'Close to adoption' applies when legislative procedure will be finalised shortly, with the European Parliament and Council having concluded negotiations (trialogue) and reached a provisional agreement on the text. Once a legislative proposal is formally adopted, the file moves to 'Adopted/Completed' status.

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Supporting Information

Additional supporting information can be found online in the Supporting Information section.