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Key recommendations for cities committed to climate neutrality



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Cities are pivotal in the global quest for climate neutrality, yet implementation of climate actions often lags behind their ambitions. This Perspective distils practical recommendations to unlock the full potential of cities on their zero-emission journey. It focuses on comprehensive emissions accounting, innovative green finance, multilevel governance, co-creation, and integrated urban planning. These are key areas to bridge the ambition-implementation gap and advance a fair, inclusive climate transition.

Worldwide, cities are responsible for a large share of greenhouse gas (GHG) emissions (67–72% in 2020), with about 100 of the largest emitting cities accounting for nearly 18% of the global carbon footprint¹. An ascending trend in their commitment to climate mitigation strategies can be observed, notably in the most recent decade. More cities have engaged in emissions reduction efforts, have pledged to reduce emissions faster than previous years, and/or have established more ambitious targets than their regional or national counterpart² (by about an additional 37% by 2030, collectively)^{3,4}. Net-zero emissions targets have proliferated, spurred by dedicated initiatives like “Race to Zero” at the global level⁵ and the 100 Climate-Neutral and Smart Cities Mission in Europe (hereinafter Cities Mission)⁶. Cities growingly position themselves as trend-setters for their regions and countries by providing bold examples of ways forward to climate neutrality⁷, harnessing their proximity to places and people to materialise a just transition, and acting as innovation and experimentation hubs for new technologies, governance systems, financial instruments, and integrated multisectoral approaches^{8,9}. Despite this vast potential, a significant ambition-implementation gap persists between aspirational objectives and their practical execution, as evidenced when comparing stated targets with outcomes².

In a global study considering more than 3000 cities and 170 regions within G20 countries³, only 40% report sufficient data to assess progress toward their mitigation targets, out of which less than 40% are advancing as planned. Aggregating the same data at the national level, several European countries, such as Portugal, Ireland, Latvia, and Cyprus appear on track to meet over 75% of their climate targets; however, these successes often come with less ambitious goals. In contrast, cities and regions in China and Türkiye show little progress, and those in countries with high public engagement in climate issues, such as Canada, the UK, and Australia are reducing emissions by less than a quarter of their climate targets. Overall, only a small fraction of existing targets (7%) are in line with scenarios that limit global warming to 1.5 °C with no or limited overshoot³. In addition to

heterogeneous climate targets, there’s a global shortfall in action, with the current annual emissions reduction rate (1.6% per year) falling behind the necessary 2.7%, particularly in the Global South³. Overall, at present, most cities only partially achieve their mitigation goals^{10–13}. They have generally seen a 10–25% reduction in emissions over the past decade⁶ largely ascribable to energy efficiency and renewable energy policies, with reductions being more significant in wealthier, northern European cities⁶. Hence, the gap to climate neutrality (i.e., absolute- or net-zero GHG emissions) is wide. Exemplarily, for those subnational entities that expressed interest in the Cities Mission, reaching the goal of zero emissions by 2030 would require at least a quadruple effort in half the time, on average⁶.

Climate neutrality refers to a holistic and integrated state where all sectors, gases, and scopes are accounted for, and the balance of positive and negative emissions is demonstrated to be zero at the target year. It implies conceptual, methodological, and procedural differences from regular climate mitigation to enable holistic action and go beyond reduction targets or incremental emissions decreases. Cities on a journey to climate neutrality must wade through unprecedented complexity in climate action as multiple urban systems undergo systemic changes, characterised by nonlinear feedback loops, multiscalar interactions, and legacies - all of which are likely to occur asynchronously¹⁴. This complexity also unfolds as cities face multifaceted risks, such as securing adequate financial resources, adhering to precautionary and equal opportunities principles, and establishing the regulatory frameworks, governance structures, and stakeholder networks needed to enable systemic change^{15,16}. Navigating these challenges requires empowering cities, especially those from developing countries, to cultivate a longer-term perspective, self-enforcing power structures, transparent distribution of responsibilities and impacts, and contingency plans^{7,14}.

In this Perspective, we contend that the moment is ripe to empower cities, drawing key lessons from the experience of cities worldwide in climate action. Capitalising on the rapidly growing literature¹⁵ on urban climate

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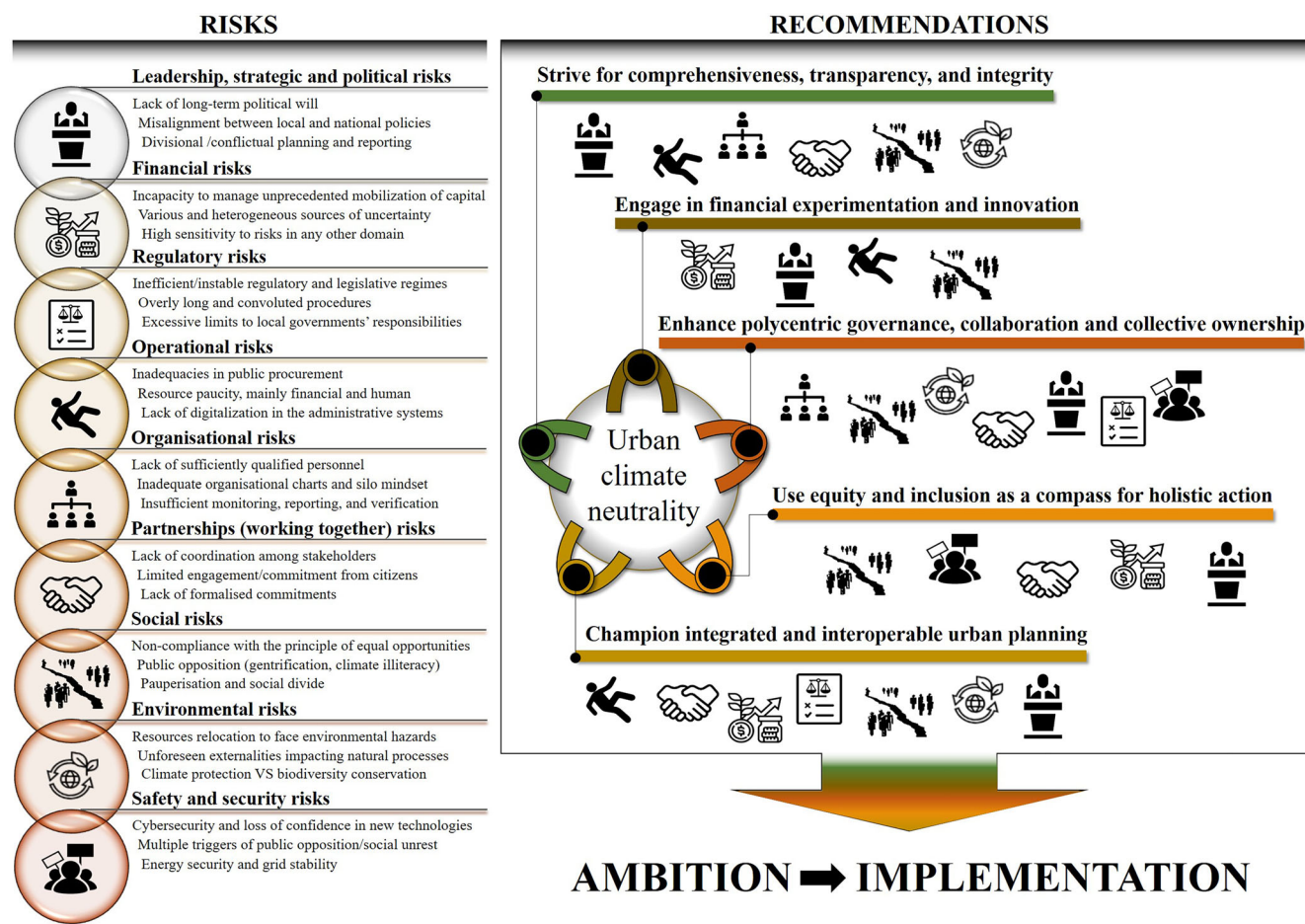


Fig. 1 | Risk mitigation through targeted recommendations in urban climate neutrality. Schematic overview of identified risks (represented by specific icons) to urban climate neutrality efforts, as mapped in Ulpiani and Vetter¹⁶. Each recommendation is associated with the icons of the risks it can address (with no specific ranking), illustrating the direct impact of strategic measures on mitigating specific

challenges within the urban climate action framework. It is important to note that the same actions may introduce new risks, such as increased cybersecurity vulnerabilities. This potential cyclic interaction between actions and emerging risks should be considered in the strategic planning process.

action, this Perspective proposes 5 practical recommendations to help cities unleash all their potential to meet their climate neutrality goals. These recommendations focus on multilevel governance and co-creation, green finance, citizen engagement, equity and justice, and digitalisation, inter alia. Simultaneously, they emphasise the critical role of transparency and integrity in target- and action-setting. We elaborate on dimensions that are especially salient from the standpoint of a real-world planner and aim to directly respond to the most common risks perceived by climate neutral-to-be cities, as illustrated in Fig. 1. Our recommendations are grounded in the experience of a large urban sample, comprising 13,000+ cities from the Global Covenant of Mayors, 362 cities from the Cities Mission, and the analysis of climate action plans from hundreds of cities worldwide including the Global South. As risks, needs, and opportunities may be city-specific, the recommendations and their possible interactions suggest successful processes towards climate neutrality that are necessary but not necessarily sufficient and whose prioritisation may be different on a case-by-case basis.

Strive for comprehensiveness, transparency, and integrity

Pursuing climate neutrality requires internalising a process of mapping and integrating emissions data and their sources, to compile comprehensive baseline and monitoring inventories. However, de-facto, urban greenhouse gas emissions inventories are often incomplete (i.e., lacking data across relevant sectors and gases)^{6,17} and/or outdated. Song et al.³ found that only 22% of almost 1500 local authorities globally had an emissions inventory

updated since 2020. This implies that emissions baselines may be unrepresentative of the status quo or even strongly biased by COVID-19 effects¹⁸.

To avoid underreporting (and, interconnectedly, undercommitment), cities require accounting methodologies adapted to their scale. Empowering their technical capabilities with dedicated personnel as well as access to high-quality data, including advanced sensor networks and earth observation, is essential to effectively measure and account for all emissions⁶. This is particularly relevant in the Global South³ and for Scope 3 emissions, which require extensive monitoring and innovative policies to accurately assess and manage the carbon footprint of urban activities and consumption patterns^{19–21}. To enhance accuracy and self-sufficiency in areas with inadequate monitoring, the rollout of data acquisition systems and remote sensing might be prioritised over indirect methods (such as downscaling from national data), where feasible. Furthermore, to facilitate the digital transition, the adoption of remotely controlled, intelligent monitoring systems and advanced big data platforms should be promoted.

Preferably, cities should insource the development of emissions inventories⁶. This is crucial for them to fully own the process and develop a robust territorial understanding of the origins of emissions in the local environment. Additionally, it helps identify which sources are more critical than others (useful for prioritisation) and understand why certain policies have been or will be more effective at reducing emissions (essential for evidence-based policy monitoring, assessment, and updating)¹⁷. Further, duly documenting approaches, assumptions, data sources, and possibly uncertainty is beneficial to sense-making and harmonisation across inventory years.

Box 1 | Residual emissions: integrity and credibility as core challenges

Effectively addressing residual emissions entails navigating the intricate tapestry of carbon sinks and carbon credits in a way that maximises transparency, environmental integrity, and co-benefits, all the while avoiding double counting¹⁰⁷. Just like national governments¹⁰⁸, cities envision focussing on natural carbon sinks (almost exclusively greening and forestation programmes) to compensate for substantial quantities of GHG emissions⁶. The co-benefits on ecosystem services are unquestionable, but the carbon sequestration potential comes with limitations and is prone to impermanence^{109–111}, especially on urban soil¹¹². To forge credible strategies, cities pursuing net-zero emissions should seek enhanced strategic support to manage residual emissions. Especially

where nature-based solutions are selected as the sole means of compensation, cities should focus on commonly overlooked indirect pathways for emissions reduction (for example, behaviour change interventions and sufficiency) that would reduce residual emissions¹¹³. Further, cities should critically leverage demand and technological interventions (including dietary changes) to substantially curtail emission levels in hard-to-abate sectors and reduce reliance on carbon dioxide removal solutions. Following this approach, scientific evidence corroborates the feasibility of climate neutrality within hard-to-abate sectors like industry, agriculture, buildings, and transport, using Paris Agreement compatible scenarios consistent with the 1.5 °C temperature goal²⁹.

To enhance accountability, once emissions data have been collected and processed, they should be transparently reported and communicated, along with the baseline assumptions and associated targets. Dedicated frameworks and tools exist for cities to streamline measurement and reporting procedures, such as the Common Reporting Framework (CRF) of the Global Covenant of Mayors for Climate and Energy, and the Community-Scale Greenhouse Gas Emission Inventories (GPC) by C40, both based on IPCC Guidelines. Such calculative infrastructures become the means of making net zero manageable and transparent and can be tailored to account for data limitations, such as those faced by cities in Africa²².

Accountability is imperative as climate neutrality targets seldom stipulate the attainment of absolute zero emissions within a specified timeline²³. Rather, cities commonly pursue net-zero targets with substantial residual emissions in the target year⁶.

There is common understanding that residual emissions need to be held at a minimum. Emissions reduction at source is always the priority (“mitigation first principle”²³) as only rapid near-term emission reductions are effective in reducing climate risks²⁴. Declaring emissions as residual can be a controversial matter. While compensation offers a means of balancing residual emissions via mechanisms such as carbon sinks and credits, a risk exists that governments may disguise expensive or politically inconvenient operations by categorising them as residual^{23,25}. This can create pressures for an oversized carbon removal infrastructure²⁶ with all associated concerns in terms of feasibility, sustainability, societal impacts, land footprint, food security, energy requirements, and availability/affordability^{27,28}. Transforming residual emissions in a legitimate instrument of climate action requires dedicated planning. The claims of necessity and possibility that underpin the very concept of residual emissions as “unfeasible” or “hard” to “abate” emissions are contingent on values, norms, and interests, where they should be based on science^{29,30}. Current assumptions should be challenged to foster societal debates on what constitutes unavoidable emissions, considering the unequal historical and distributional impacts of emission patterns, as well as power dynamics inherent in these discussions³¹.

Overall, to adhere to the integrity and transparency necessary to uphold the legitimacy of net-zero pledges, cities should clearly disclose the components of residual emissions and ensure they result from a dynamic and multidisciplinary analysis. A conceptual framework to guide this effort has been recently proposed²³, requiring cities to scrutinise emissions sources, solutions, and constraints in mitigation (sensitive to their role in the multilevel governance system). Cities should also design adequate compensation strategies (Box 1), while considering what this means for different societal groups.

Engage in financial experimentation and innovation

Recent empirical evidence suggests that green finance is the most effective financial strategy at reducing CO₂ emissions, with positive impacts demonstrated in the top ten economies that have historically supported it (i.e., Canada, Denmark, Hong Kong, Japan, New Zealand, Norway, Sweden,

Switzerland, the United Kingdom, and the United States)³². An analysis of panel data from 46 countries suggests that this positive effect has increased over time³³ and is observed transversally³⁴, including in the construction sector, with the highest intensity in emerging economies³⁵. This finding is crucial as several of these nations are currently experiencing rapid and steady population growth and urban expansion, with ensuing increases in GHG emissions.

Despite this, only a small elite of cities have estimated the capital requirements for funding and financing climate neutrality^{36,37}. Additionally, the methods employed to assess the size of the investment are commonly simplified, resulting in either disproportionately high capital needs or extremely low figures. There is still significant untapped potential for cities to deploy capital market opportunities for green climate financing or establish dedicated investor relations^{36,38}. Further, cities are either in the initial stages of or have limited experience in formulating investment strategies and/or lack a project pipeline. This suggests that, even in cases where financial resources may be available, cities face a competence gap hindering their ability to advance projects or effectively capitalise on available funding^{36,37}. Finally, very few cities consider the importance of creditworthiness and transparency in the use of proceeds as a pre-requisite to obtain financing in capital markets^{36,38}.

Government support and guarantees are relevant in building momentum and enabling early action by derisking projects³⁶; however, net-zero investments should be as future-proof as possible and resistant to political changes¹⁶. Therefore, many cities consider necessary to draw from self-owned capital while acknowledging that this would cover only a small share of the costs to transition to climate neutrality³⁶.

Alternatives for financing investments exist, yet cities still favour conventional financing mechanisms available at the local level (such as property taxes and issuing debt in capital markets to finance capital costs), while making little to no use of innovative financing instruments³⁶. This is particularly relevant to the digital transition, where crowding in private financing (whether in the form of public-private-partnerships, investments, or blended finance) and using innovation procurement appear to be a blind spot. Additionally, energy service companies, green bonds, public-private partnerships, and crowdfunding may be attractive to cities in the Global North³⁶ just like in the Global South^{39,40} and can be positive instruments of climate action when structured to genuinely address urban inequalities and foster socio-ecological transitions⁴¹. This is especially important as traditional funding sources often neglect social dimensions, such as gender aspects, intergenerational fairness, or poverty alleviation^{42,43}.

Further, cities can extend their investment power in various ways. Taking the energy sector as an example, cities can engage in joint commitments with e.g., energy suppliers, private district heating owners, building construction and rental companies⁴⁴. Moreover, energy performance contracting, revolving funds, rewarding systems, and re-distribution of revenues hold promise in the establishment of virtuous loops of investment³⁶ that make decarbonisation efforts cost-neutral in the long term

and promote social justice⁴⁵. For instance, the revenues of energy communities can feed into new projects, new jobs, and new services in circular mechanisms that help sustain the transformative momentum^{36,46,47}. Engaging stakeholders and the investor community helps estimate investment needs and identify financial products that match the risk profile of projects. This is particularly important due to the innovation in business models, the learning curve for investors, citizens and city managers, and the long-term investment horizon.

To increase momentum in the global transition to climate neutrality, more financial tools that support every stage of the process are needed, especially for cities that are just defining their long-term commitments or are facing significant capacity constraints, such as smaller local authorities^{36,48}. Sandboxes (controlled testing environments) may help to identify innovative financing mechanisms tailor-made for the needs of the cities and their stakeholder community⁴⁹. New toolkits and funding programmes are also on the horizon^{50,51}, yet for cities in developing countries, national financial development is crucial to temper the emissions augmenting roles of economic growth, energy use, foreign direct investment and trade openness by minimising credit costs, improving credit allocation, and making it easier to invest in green energy sources⁵². Financial innovation in such urban settings necessitates going beyond conventional sets of instruments (e.g., green bonds, carbon taxes), actors (e.g., real estate developers, private investors), and projects (e.g., large-scale infrastructure), to focus more on the deployment of decentralised, small-scale or community-led efforts, which better match the collective potential for a safe and just transition⁵³. The financial gap is also a matter of careful strategic design, factoring in the efficiency of different technologies and the role of high-tech versus low-tech, soft, or nature-based solutions (NBS) to minimise capital costs from the outset. However, securing financing for softer measures or NBS is a persistent barrier in climate action, highlighting the need for effective co-finance⁵⁴ and prudent but effective narratives around co-benefits.

Enhance polycentric governance, collaboration and collective ownership

Polycentric governance is essential for cities to address the complexity of achieving climate neutrality as it stimulates experimentation, local adaptation, and learning across scales^{55,56} while leading to more effective and equitable outcomes⁵⁷. Cities, as commons, represent shared resources - spaces and infrastructures that are open to all yet prone to congestion and rivalry. This requires rules and governance systems that ensure equitable and sustainable use⁵⁸. By enabling multiple, overlapping centres of decision-making across different scales, polycentric governance supports the design of flexible rules and equitable frameworks for resource sharing, ensuring that diverse needs are balanced while reducing emissions⁵⁶. It represents an opportunity to harness shared learnings and promote systemic change, allowing cities to address challenges such as resource scarcity, social inequities and climate resilience⁵⁹. As climate neutrality entails multidimensionality and cross-sectorality, experience-based, local-knowledge-rich, need-driven, and stakeholder-diverse approaches can help identify and anticipate trade-offs and spillover effects. This approach not only helps cities stay on track, but also meet their citizens' needs and empower their agency while gaining political consensus⁶⁰. In practice, this requires evolving governance structures that institutionalise climate action, foster participatory governance, and actively engage key stakeholders in decision-making processes⁶¹. Such approaches may need to be evaluated against time and cost overruns; however, they can enhance legitimacy and long-term effectiveness, particularly when addressing cross-sectoral spillovers and social equity dimensions of climate neutrality. Although often associated with democratic and multi-level governance, elements of polycentricity can also be observed in more centralised systems, where accountability and legitimacy tend to rely more on performance outcomes than on participatory deliberation.

As complex nodes within a web of interdependencies, cities can accelerate climate action through participation in inter-city networks^{62,63} and science-policy-practice (SPP) partnerships engaging citizens,

businesses, academia, and other levels of government^{40,64}. Exemplarily, collaborations to match ambition levels across co-located cities and companies could enhance the overall emissions reduction potential by almost 70%⁶⁵. SPPs can harness epistemic diversity and support an integrated urbanism⁶⁶, potentially catalysing transformative urban alliances - as observed to some extent in response to the Covid-19 pandemic⁶⁷ - circular business models, and industrial symbiosis⁶⁸. This sort of transdisciplinary interaction requires further reinforcement in the Global North and holds the potential for significant transformation in various Global South regions, where the need for enhanced support and cohesion among diverse governmental levels and stakeholders is critical⁴⁰. Further, given the lack of established models for extrapolating successful climate solutions and the unresolved challenges of generalisability and replicability, SPPs are indispensable to transfer and upscale climate action so as to accelerate the pace and reach of transformation⁶⁶.

The question is how to stimulate the "active interface" of collective intelligence and commitment. We argue that valuing climate neutrality as a whole, including its co-benefits such as improved air quality, improved resource access (e.g., transport, energy), public health, and green jobs⁶⁹, can play a key role. By measuring, monetising and making these co-benefits salient, cities can show how climate neutrality speaks to the needs and well-being of all citizens and stakeholders, especially in rapidly urbanising emerging economies⁷⁰. By showing how these co-benefits are currently being distributed and how they can be more equitably distributed, cities can garner more public support and make investments in climate action more accountable⁷¹. At the same time, integrating climate co-benefits into all municipal decisions and leveraging sector coupling and synergies can enhance the cohesion of actions and foster a shared commitment to climate goals⁷². Linguistic and cultural barriers, stereotypes, and biases should be explicitly addressed to prevent miscommunication and ensure all stakeholder groups are heard⁷³. Further, co-creating SMART (Specific, Measurable, Achievable, Realistic, and Time-bound) targets, actions, and key performance indicators (KPIs) can help keep climate neutral objectives accountable and in line with collective needs. This process strengthens the social contract by fostering community bonds. Further, setting intermediate targets for KPIs creates spaces to celebrate and communicate successes, which in turn would improve public acceptance and engagement.

Cities are encouraged to explore a variety of methods to engage citizens and stakeholders, as different groups and urban contexts have distinct needs^{74,75}. An efficient and meaningful citizen engagement strategy should include two elements: a clear objective and a defined role for citizens (co-creative, decisional, or consultative) along with the expected contribution. Further, cities should foster bottom-up initiatives and elicit citizens' preferences on engagement methods, which can introduce innovative perspectives into engagement strategies⁷⁶. A meaningful citizen engagement strategy must centre on collective deliberation, where citizens come together to reflect on shared challenges and co-create solutions⁷⁷. This process relies on empowering individuals with the information and competences they need to participate fully - whether to weigh the benefits of a green alternative or contribute to decisions that affect their communities. At the same time, the collective dimension must be nurtured through dialogue that encourages diverse perspectives and fosters mutual understanding. By making information accessible and relevant, cities can enable informed, reflective engagement, build trust, and strengthen social cohesion (Box 2). Conversely, a climate urbanism with little to no consideration of different groups' experiences risks perpetuating inequalities, compromising the socio-technical and financial viability of city-wide climate neutrality targets and potentially leading to exclusionary net-zero commitments. An intersectional approach that ensures the needs of vulnerable groups and minorities are duly considered is crucial^{78,79}, as these communities face disproportionate climate risk exposure, have limited influence over policy decisions, yet possess valuable local knowledge (e.g., indigenous communities)^{80,81}. Inclusive processes that go beyond consultation towards co-creation prevent social mistrust, polarisation, divide, and pauperisation while enhancing the effectiveness and legitimacy of climate actions (as

Box 2 | Local liaisons to foster reflection and collective deliberation

Some cities flag the importance of having local teams/offices, selecting representative local groups of stakeholders, or involving local activities as “climate translators” to build local democratic cooperation on the green transition¹¹⁴. This is particularly relevant in contexts of misinformation and mistrust, often exacerbated by political discontinuities in climate action. Engaging citizens in decision-making processes can restore the sense of collective efficacy, strengthen mutual trust and build social capital, all of which are essential for fostering a sense of collective ownership and shared responsibility. Cities can leverage external incentives, like rewards or gamification, as an entry point, as these mechanisms help replacing eco-anxiety with satisfaction and

gratification¹¹⁵ while tapping into the competitive spirit - particularly effective in motivating younger individuals. However, awakening individuals’ intrinsic motivations, norms and values citizens hold, such as a desire for environmental sustainability, social justice, or intergenerational responsibility, can create a deeper, longer-lasting commitment to climate action^{115,116}. Cities can, for example, use nudges and boosts to reconnect citizens with these intrinsic motives and to equip them with the core competencies needed for effective participation, such as deliberative skills¹¹⁷. This approach fosters a sense of collective efficacy, where citizens see their actions as integral to a broader, meaningful transformation¹¹⁷.

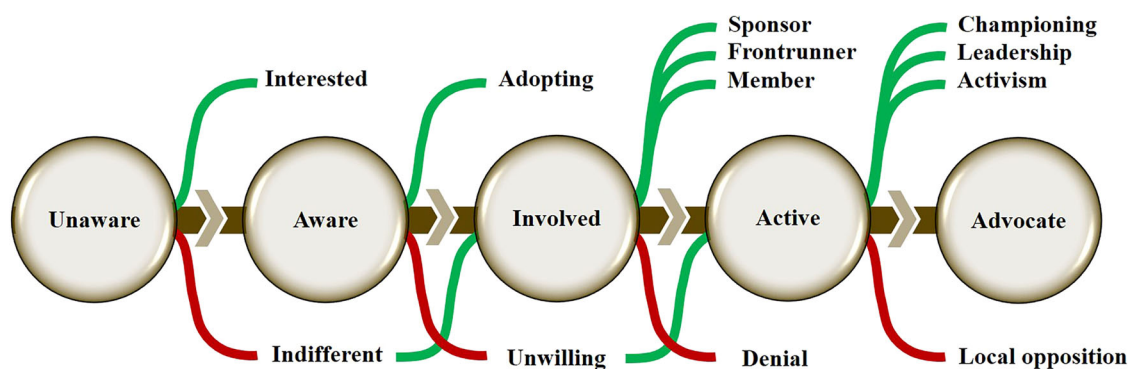


Fig. 2 | Representation of the non-linear climate citizenship awareness ladder, adapted with permission from the EU project GRETA¹⁰⁶. Green and red lines link to positive and negative outcomes, respectively. Green lines in the lower section

indicate transitions that may occur from a negative to a positive outcome that reroute citizens on a virtuous pathway towards advocacy.

Box 3 | Framework for justice-driven climate strategies

Interpreting climate problems and climate decisions as ethical and justice concerns with people at the centre can propel cities towards climate neutrality while advancing socio-environmental equity¹¹⁸. The climate justice framework, deeply rooted in normative theories and operationalised through recognitional, distributional, procedural, and intergenerational pillars, offers urban policymakers a rigorous approach to identify and rectify climate-related inequities¹¹⁹. Distributional justice aims to ensure the fair allocation of benefits and burdens of climate policies (e.g., retrofitting programmes for low-income households, or progressive carbon pricing that redistributes revenues to vulnerable groups). Recognitional justice addresses the unique vulnerabilities of

marginalised groups (e.g., funding for adaptive housing for disabled individuals, rent control paired with efficiency upgrades for tenants, or special support programmes for communities disproportionately affected by climate risks). Procedural justice calls for inclusive and transparent decision-making that amplifies marginalised voices (e.g., participatory urban planning for green infrastructure, citizen assemblies on climate actions, or targeted outreach to underrepresented groups). Finally, intergenerational justice can facilitate the long-term sustainability of today’s actions (e.g., embedding future impact assessments into climate policy, establishing youth councils to advise on climate strategies, or preserving urban commons for future generations).

evidenced, for instance, in the case of public space redevelopment⁸² and local heat decarbonisation⁸³.

Yet co-creation is not a silver bullet. Cities should be mindful, as engaging a diverse array of stakeholders in climate neutrality efforts can introduce risks, such as poor coordination, conflicting objectives, and organisational inefficiencies. These challenges can lead to operational paralysis, hinder accountability and ambition, and potentially exclude certain groups from the process, slowing down the pace of transformation and limiting inclusive participation¹⁶. Further, in stimulating societal participation, there is no straight line from unawareness and inaction to action and empowerment (see Fig. 2). Indifference, unwillingness, denial, and local opposition are just as easily triggered as positive levers such as interest, proactiveness, leadership, and activism⁸⁴. To build sustained positive

engagement, investing in an inclusive and evidence-based training programme about the climate-neutral transition, free from biased information, could be an effective option. Additionally, clear accountability mechanisms must be established to ensure transparency and trust.

Use equity and inclusion as a compass for holistic action

While the transition to climate neutrality brings many benefits, it may also induce negative consequences that often disproportionately affect the most vulnerable. This is why climate action cannot be implemented in a moral vacuum; equity and justice must guide every step of the process⁸⁵ (Box 3).

Neglecting climate justice in the pursuit of a climate-neutral future can undermine the transformative aspirations of this transition. It can

perpetuate extant social disparities or catalyse novel inequities. Addressing issues like *renoviction*, where tenants are displaced due to renovations for energy efficiency measures, or ensuring access to public transport, green corridors and energy-efficient solutions for vulnerable communities is imperative⁸⁶. Otherwise, the transition to climate neutrality risks becoming exclusive, benefiting only certain groups while leaving vulnerable communities behind⁸⁷. Further, social polarisation and poverty, in any form (including energy and transport poverty) will make it difficult to switch to new models and practices because of the inherent operational barrier and socially divisive potential and because it reduces spendable income¹⁶. Cities should thus integrate in their climate planning a systematic assessment of the distributional effects of climate policies to ensure that climate action benefits all, including socioeconomic, age, and gender groups, businesses of all sizes, and communities in wealthy and vulnerable situations alike. In addition, cities must recognise the specific needs of marginalised groups and of current and future generations to ensure that their voices are heard in decision-making processes⁸⁷. For instance, valuing the perspectives and role of youth in implementing solutions towards their climate neutrality targets, a hundred cities (such as the city of Hobart in Australia, the city of Despeñaderos in Argentina, Mykolaiv in Ukraine) have joined the Youth Climate Action Fund supported by Bloomberg Philanthropies and the World Organisation of United Cities and Local Governments (UCLG) through which actions designed by youth can be delivered⁸⁸.

Encouragingly, there is evidence that cities more engaged in climate change mitigation tend to better integrate the social justice dimension into their policies⁸⁹. However, significant variations exist due to geographical location and the relationship with higher governance levels, necessitating targeted support for capacity building and financial advisory services to enhance climate justice awareness⁸⁹. Equally interesting is that some cities targeting climate neutrality are prioritising interventions to improve the quality of life and the well-being of the most deprived first¹⁶. By focussing on the needs of the most vulnerable, these cities aim to mitigate, if not prevent, the risks of exacerbating injustices and pauperisation, while fostering social cohesion.

Champion integrated and interoperable urban planning

Cities should adopt comprehensive planning strategies that consider sectors (e.g., energy, transport, waste, water, agriculture, industry, land use), goals (e.g., GHG emissions reduction, climate adaptation, air quality, liveability, economic prosperity), and resources in a cohesive manner, embedding climate neutrality goals into existing and innovative planning tools and approaches and interweaving the threads of green finance, digitalisation, and circular economy^{90,91}. For instance, while pursuing buildings decarbonisation, cities should strive to maximise co-benefits and synergies (e.g., combining building energy retrofit with social housing initiatives, seismic resilience interventions and/or asbestos removal) and include the construction process and the life cycle of products in their quest for sustainability^{68,92}.

Spatial planning plays a crucial role in orchestrating integrated, multi-sectoral, and cross-scale actions that acknowledge the intricate relationships between policy domains, sectors, and challenges, thereby fostering a holistic and adaptive approach to climate neutrality^{93,94}. Further, integrated urban planning promotes land use efficiency (and can therefore save surrounding carbon sinks)⁹⁵ and enables territorial cohesion⁹⁶, which is essential for cities striving for climate neutrality⁷. By fostering an urban-rural balance, cities can value the strengths of both landscapes, such as the innovation and infrastructure of urban centres and the natural carbon sinks and agricultural practices of rural regions, while promoting a safe ratio in terms of surface permeability and sealing¹. This balance is critical for the equitable distribution of resources and opportunities, preventing the overburdening of urban systems and the neglect of rural communities. Further, integrating diverse territories in climate action plans encourages shared responsibility, synergies and maximises the potential for renewable energy use, waste reduction, and conservation efforts. Exemplarily, 78% of the photovoltaic, onshore wind and hydropower potential in Europe is rural⁹⁷. Accessing these resources while retaining local value and needs, for example through

the promotion of renewable energy communities, would allow rural areas to contribute and benefit from the energy transition while preserving their natural and agricultural assets. Further, as cities are open systems that depend on their hinterlands for imports and exports, urban-rural linkages constitute a means for cities to influence large upstream emissions and decarbonise their supply chains, while promoting a sustainable approach to waste, food, and water¹. Ultimately, a strong urban-rural partnership is a cornerstone of resilience, allowing cities to achieve climate neutrality while promoting regional development and quality of life for all inhabitants. Changes in land use efficiency is also about patterns of urban growth. A shift toward vertical development is being observed among a large sample of cities around the world, carrying important consequences for material and energy use⁹⁸. In addition, urban characteristics can provide different potentials for rain harvesting and can be planned together in an integrated manner⁹⁹.

By investing in integrated urban planning, cities can minimise the need for costly remedial measures that arise from haphazard or short-sighted development practices, thereby ensuring budget efficiency and correct allocation of resources. Further, an integrated approach promotes attention to co-benefits, which, as mentioned, are precious levers to stimulate the appetite of a wide range of investors and interested parties, while also helping citizens recognise meaningful improvements in their quality of life. Integrated planning and holistic assessments can be supported by open-source tools^{100,101}.

Digital and smart city solutions are a powerful instrument of integration in the pursuit of climate neutrality¹⁰². Despite urban entities increasingly acknowledging the strategic value of investments in digital twins, IoT, and open data platforms, the imperative of cultivating people-centric design and ensuring the infrastructural integrity of both the physical and cybernetic dimensions within the smart city ecosystem is often overlooked, along with the challenges of interoperability and data ownership¹⁰³.

The digital transformation may deepen the digital divide and introduce cybersecurity vulnerabilities. Addressing these issues is crucial for an inclusive and secure transformation, as the transition to smart, interconnected systems heavily relies on digital infrastructure and technologies that may not be accessible to all citizens¹⁶. This divide can lead to inequalities in benefitting from low-carbon solutions and participating in sustainable initiatives. For example, in Vienna people with lower social status, or belonging to certain gender and age groups, showed a lower adoption of smart home energy management systems¹⁰⁴. Furthermore, as cities become more digitally integrated, the scope for cybersecurity threats expands, potentially endangering critical infrastructure and the privacy of residents. Consequently, inclusive digital education, interoperable data systems and robust cybersecurity measures are essential to safeguard urban sustainable development goals against the risks of an increasingly connected world. At the global level, the Urban Transitions Mission - focused on supporting net-zero, resilient, and people-oriented cities - is also initiating efforts to provide data analytics to support urban planning¹⁰⁵.

Conclusions

The transition to zero emissions within urban contexts demands an orchestrated approach centred on the triple 'inter' synergy (integrity, interaction, and integration), where integrity addresses the ethical and moral foundations, interaction the consultative process, stakeholder involvement and multi-level governance aspects, and integration the holistic nature of the transition, including co-benefits, synergies, and trade-offs. This Perspective enucleates five practical recommendations that translate this synergy in the domains of emissions accounting and target setting, financial innovation, collaborative and reflexive governance, equity and inclusion, and integrated urban planning. The recommendations are interdependent and hinged on the need to generate, restore and/or protect consensus around the transition, to overcome the pitfalls of short-termism, top-down governance and unilateralism. The recommendations zoom in on the need to address interactions related to (i) residual emissions strategies and climate justice as critical to ensuring the integrity of net-zero commitments, (ii)

advanced science-policy-practice partnerships and well-crafted citizen engagement methods to operationalise co-creation and collective intelligence, and (iii) territorial cohesion and digital infrastructure as fundamental elements to pursue integrated urban planning and evidence-based

polymaking. This confluence of strategies is not a mere aggregation but a harmonised interface of practices with synergistic connections, leveraging cities as centres of change. The recommendations and their summary overview in Fig. 3 can be used as a checklist by cities to perform a first high-

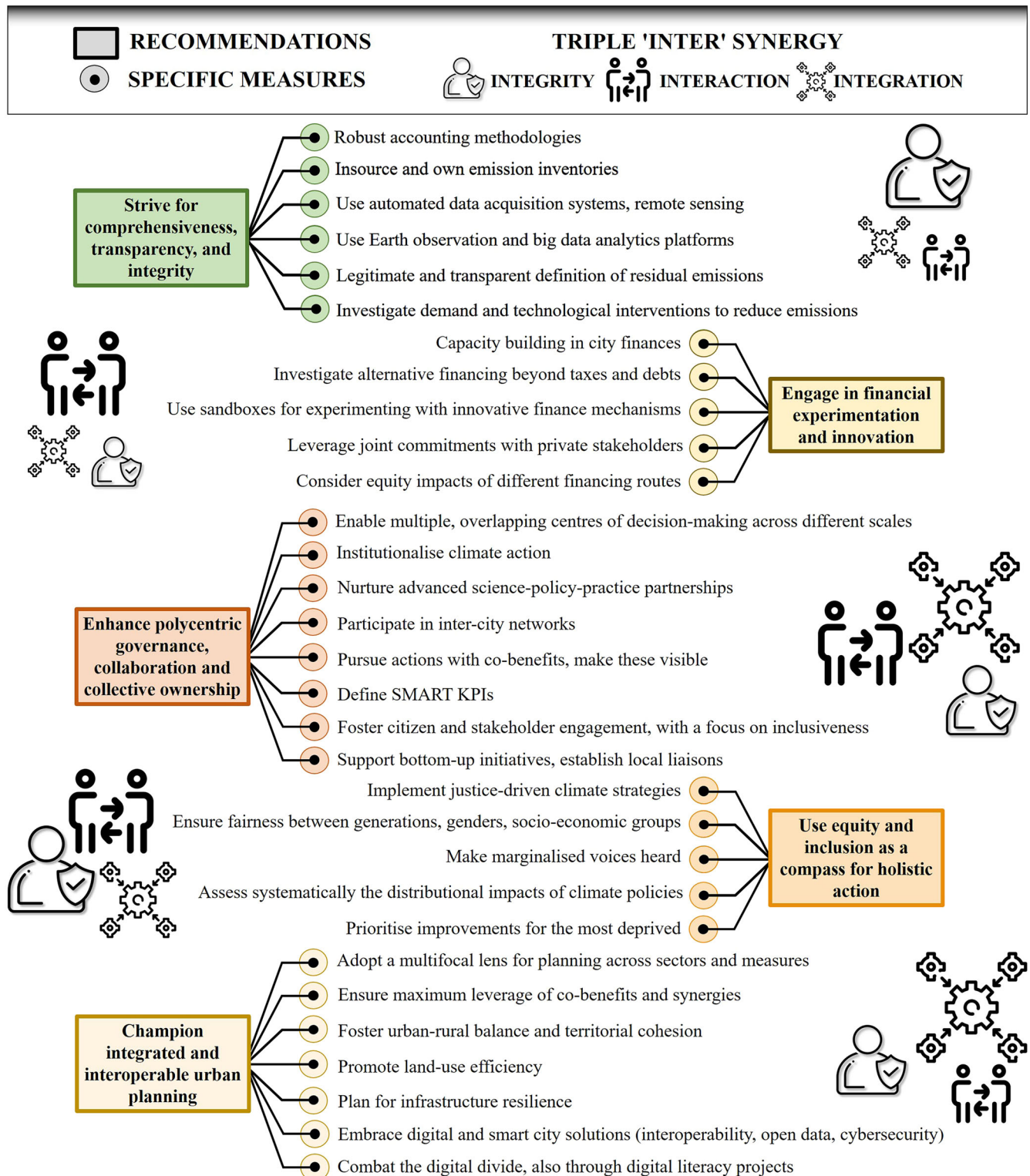


Fig. 3 | Summary of practical recommendations and associated specific measures and how they relate to the triple 'inter' synergy. The recommendations that are given in boxes are connected to associated measures as indicated in the legend. The icons representing integrity, interaction, and integration are sized proportionally to their relevance, on average terms, for each recommendation. The recommendations

and specific measures are based on insights developed from listening to the voices of cities and their stakeholders. The emphasis that is placed on the three elements of integrity, interaction, and integration can also vary across time as a city navigates its own course to climate neutrality and seeks to tailor strategies to local contexts and capabilities.

level assessment of their climate neutrality plans. The proposed recommendations and the possibility of bringing them into reinforcing interactions are essential yet not necessarily sufficient to achieve climate neutrality. Further, their implementation may necessitate navigating barriers in implementation and trade-offs, such as balancing the allocation of resources and capacity to build comprehensive inventories, formulate compelling business plans, and create new governance structures simultaneously. Cities may need to prioritise and sequence their efforts, acknowledging that enhancing polycentric governance, for instance, may require diverting resources from financial experimentation or integrated planning. Ultimately, each city must navigate its own course within this framework, tailoring strategies to local contexts and capabilities, and fostering a transition that is not only environmentally sustainable but also socially robust and technologically secure.

Data availability

No datasets were generated or analysed during the current study.

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References

- IPCC. Climate Change 2022: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. (Chapter 8). <https://www.ipcc.ch/report/ar6/wg3/chapter/chapter-8/> (2022).
- Hsu, A., Höhne, N., Kuramochi, T., Vilariño, V. & Sovacool, B. K. Beyond states: Harnessing sub-national actors for the deep decarbonisation of cities, regions, and businesses. *Energy Res. Soc. Sci.* **70**, 101738 (2020).
- Song, K., Burley Farr, K. & Hsu, A. Assessing subnational climate action in G20 cities and regions: Progress and ambition. *One Earth* In press <https://doi.org/10.1016/j.oneear.2024.10.001> (2024).
- Sachdeva, S., Hsu, A., French, I. & Lim, E. A computational approach to analyzing climate strategies of cities pledging net zero. *npj Urban Sustain.* **2**, 21 (2022).
- Sevil, A., Muñoz, G. & Godoy-Faúndez, A. Aligning global efforts for a carbon neutral world: the race to zero campaign. *J. Appl. Behav. Sci.* **58**, 779–783 (2022).
- Ulpiani, G., Vetter, N., Melica, G. & Bertoldi, P. Towards the first cohort of climate-neutral cities: expected impact, current gaps, and next steps to take to establish evidence-based zero-emission urban futures. *Sustain Cities Soc.* **95**, 104572 (2023).
- Kılıç, Ş., Ulpiani, G. & Vetter, N. Visions for climate neutrality and opportunities for co-learning in European cities. *Renew. Sustain. Energy Rev.* **195**, 114315 (2024).
- COP29 Declaration on Multisectoral Actions Pathways (MAP) to Resilient and Healthy Cities. <https://cop29.az/en/pages/cop29-declaration-on-multisectoral-actions-pathways-map-to-resilient-and-healthy-cities> (2024).
- Bracking, S. & Leffell, B. Climate finance governance: Fit for purpose?. *Wiley Interdiscip. Rev. Clim. Change* **12**, e709 (2021).
- Salvia, M. et al. Will climate mitigation ambitions lead to carbon neutrality? An analysis of the local-level plans of 327 cities in the EU. *Renew. Sustain. Energy Rev.* **135**, 110253 (2021).
- Hsu, A. et al. Performance determinants show European cities are delivering on climate mitigation. *Nat. Clim. Change* **10**, 1015–1022 (2020).
- Bansard, J. S., Pattberg, P. H. & Widerberg, O. Cities to the rescue? Assessing the performance of transnational municipal networks in global climate governance. *Int. Environ. Agreements: Polit. Law Econ.* **17**, 229–246 (2017).
- van der Heijden, J., Patterson, J., Juhola, S. & Wolfram, M. Special section: advancing the role of cities in climate governance – promise, limits, politics. *J. Environ. Plan. Manag.* **62**, 365–373 (2019).
- Egerer, M. et al. Urban change as an untapped opportunity for climate adaptation. *npj Urban Sustain.* **1**, 22 (2021).
- Fankhauser, S. et al. The meaning of net zero and how to get it right. *Nat. Clim. Change* **12**, 15–21 (2022).
- Ulpiani, G. & Vetter, N. On the risks associated with transitioning to climate neutrality in Europe: a city perspective. *Renew. Sustain. Energy Rev.* **183**, 113448 (2023).
- Palermo, V. et al. Uncovering divergences and potential gaps in local greenhouse gases emissions accounting and aggregation. *Current Research in Environmental Sustainability* **8**, 100263 (2024).
- Nguyen, X. P., Hoang, A. T., Ölçer, A. I. & Huynh, T. T. Record decline in global CO₂ emissions prompted by COVID-19 pandemic and its implications on future climate change policies. *Energy Sources A: Recov. Utiliz. Environ. Effects* **47**, 4699–4702 (2025).
- Wiedmann, T. et al. Three-scope carbon emission inventories of global cities. *J. Ind. Ecol.* **25**, 735–750 (2021).
- Chen, G. et al. Review on city-level carbon accounting. *Environ. Sci. Technol.* **53**, 5545–5558 (2019).
- Huovila, A. et al. Carbon-neutral cities: Critical review of theory and practice. *J. Clean. Prod.* **341**, 130912 (2022).
- Liu, B. et al. The landscape of city-level GHG emission accounts in Africa. *J. Ind. Ecol.* **28**, 1377–1391 (2024).
- Ulpiani, G., Vetter, N., Bertoldi, P. & Thiel, C. Shining light on residual emissions for cities. *Nat. Clim. Change* **14**, 302–305 (2024).
- Schleussner, C.-F. et al. Overconfidence in climate overshoot. *Nature* **634**, 366–373 (2024).
- Buck, H. J., Carton, W., Lund, J. F. & Markusson, N. Why residual emissions matter right now. *Nat. Clim. Change* **13**, 351–358 (2023).
- Buck, H., Carton, W., Lund, J. & Markusson, N. Why residual emissions matter right now. Available at SSRN <https://doi.org/10.2139/ssrn.4069521> (2022).
- Prütz, R., Fuss, S., Lück, S., Stephan, L. & Rogelj, J. A taxonomy to map evidence on the co-benefits, challenges, and limits of carbon dioxide removal. *Commun. Earth Environ.* **5**, 197 (2024).
- Realmondo, G. et al. An inter-model assessment of the role of direct air capture in deep mitigation pathways. *Nat. Commun.* **10**, 3277 (2019).
- Edelenbosch, O. Y. et al. Reducing sectoral hard-to-abate emissions to limit reliance on carbon dioxide removal. *Nat. Clim. Change* **14**, 715–722 (2024).
- Shindell, D. & Rogelj, J. Preserving carbon dioxide removal to serve critical needs. *Nat. Clim. Change* <https://doi.org/10.1038/s41558-025-02251-y> (2025).
- Lund, J. F., Markusson, N., Carton, W. & Buck, H. J. Net zero and the unexplored politics of residual emissions. *Energy Res. Soc. Sci.* **98**, 103035 (2023).
- Saeed Meo, M. & Karim, M. Z. A. The role of green finance in reducing CO₂ emissions: An empirical analysis. *Borsa Istanbul. Rev.* **22**, 169–178 (2022).
- Xu, B. & Lin, B. How can green finance effectively promote low-carbon cities? Evidence from 237 cities in China. *J. Environ. Manag.* **365**, 121641 (2024).
- Al Mamun, M., Boubaker, S. & Nguyen, D. K. Green finance and decarbonization: Evidence from around the world. *Financ. Res. Lett.* **46**, 102807 (2022).
- Wan, Q., Qian, J., Baghirli, A. & Aghayev, A. Green finance and carbon reduction: Implications for green recovery. *Econ. Anal. Policy* **76**, 901–913 (2022).
- Ulpiani, G., Rebolledo, E., Vetter, N., Florio, P. & Bertoldi, P. Funding and financing the zero emissions journey: urban visions from the 100 Climate-Neutral and Smart Cities Mission. *Hum. Soc. Sci. Commun.* **10**, 1–14 (2023).
- CCFLA. 2024 State of Cities Climate Finance. <https://citiesclimatefinance.org/publications/2024-state-of-cities-climate-finance> (2024).

38. UN-Habitat. World Cities Report 2024. <https://unhabitat.org/wcr/> (2024).
39. Ngwenya, N. & Simatele, M. D. Unbundling of the green bond market in the economic hubs of Africa: Case study of Kenya, Nigeria and South Africa. *Dev. South. Afr.* **37**, 888–903 (2020).
40. Solecki, W., Delgado Ramos, G. C., Roberts, D., Rosenzweig, C. & Walsh, B. Accelerating climate research and action in cities through advanced science-policy-practice partnerships. *npj Urban Sustain.* **1**, 3 (2021).
41. García-Lamarca, M. & Ullström, S. “Everyone wants this market to grow”: The affective post-politics of municipal green bonds. *Environ. Plan. E: Nat. Space* **5**, 207–224 (2020).
42. Diezmartínez, C. V. & Short Gianotti, A. G. Municipal finance shapes urban climate action and justice. *Nat. Clim. Change* **14**, 247–252 (2024).
43. Bazbauers, A. R. Translating climate strategies into action: An analysis of the sustainable, green, and resilient city action plans of the multilateral development banks. *Dev. Policy Rev.* **40**, e12577 (2022).
44. Holstenkamp, L. Financing Consumer (Co-)Ownership of Renewable Energy Sources BT - Energy Transition: Financing Consumer Co-Ownership in Renewables. in (ed. Lowitzsch, J.) 115–138 https://doi.org/10.1007/978-3-319-93518-8_6 (Springer International Publishing, Cham, 2019).
45. Gouldson, A. et al. Innovative financing models for low carbon transitions: Exploring the case for revolving funds for domestic energy efficiency programmes. *Energy Policy* **86**, 739–748 (2015).
46. Brauholtz-Speight, T. et al. Price support allows communities to raise low-cost citizen finance for renewable energy projects. *Nat. Energy* **5**, 127–128 (2020).
47. Ulpiani, G. et al. Report Analysing and Synthesising Expression of Interest (EOI) Data in View of Cities’ Preparedness, Barriers, Assistance Needs and Recommended Services - Internal Report. (2023).
48. Palermo, V., Bertoldi, P., Apostolou, M., Kona, A. & Rivas, S. Assessment of climate change mitigation policies in 315 cities in the Covenant of Mayors initiative. *Sustain. Cities Soc.* **60**, 102258 (2020).
49. Beckstedde, E., Correa Ramírez, M., Cossent, R., Vanschoenwinkel, J. & Meeus, L. Regulatory sandboxes: Do they speed up innovation in energy? *Energy Policy* **180**, 113656 (2023).
50. City Climate Finance Gap Fund. Turning resilient low-carbon ideas into strategies and finance-ready projects. <https://www.citygapfund.org/> (2025).
51. Lütkehermöller, K. The little book of city climate finance. New Climate Institute (2023).
52. Udeagha, M. C. & Breitenbach, M. C. The role of financial development in climate change mitigation: fresh policy insights from South Africa. *Biophys. Econ. Sust.* **8**, 1 (2023).
53. Robin, E. Rethinking the geographies of finance for urban climate action. *Trans. Inst. Br. Geog.* **47**, 393–408 (2022).
54. Biasin, A., Toxopeus, H., Pettenella, D., Polzin, F. & Masiero, M. Financing urban Nature-based Solutions (NBS): A literature review from the perspective of funders. *Nat.-Based Solut.* **6**, 100195 (2024).
55. Ostrom, E. Polycentric systems for coping with collective action and global environmental change. *Glob. Environ. Change* **20**, 550–557 (2010).
56. Ostrom, E. Beyond markets and states: polycentric governance of complex economic systems. *Am. Econ. Rev.* **100**, 641–672 (2010).
57. Milinski, M. & Marotzke, J. Economic experiments support Ostrom’s polycentric approach to mitigating climate change. *Humanit Soc. Sci. Commun.* **9**, 442 (2022).
58. Foster, S. R. & Laione, C. Ostrom in the city: Design principles and practices for the urban commons. in *Routledge Handbook of the Study of the Commons* 235–255 (Routledge, 2019).
59. Esposito, G., Paola, D. B. & Forliano, C. Unveiling the Role of Stakeholders’ Involvement in City Climate Neutrality: a Salience Theory Perspective. in *Abstract Conference Proceeding Convegno Nazionale AIDEA 2023” L’aziendalismo crea valore!”* 12–24 (AIDEA, 2023).
60. McPhearson, T. et al. Advancing urban ecology toward a science of cities. *BioScience* **66**, 198–212 (2016).
61. Shtjefni, D., Ulpiani, G., Vettters, N., Koukoulakis, G. & Bertoldi, P. Governing climate neutrality transitions at the urban level: A European perspective. *Cities* **148**, 104883 (2024).
62. Salvia, M. et al. Key dimensions of cities’ engagement in the transition to climate neutrality. *J. Environ. Manag.* **344**, 118519 (2023).
63. Montfort, S. et al. Systematic global stocktake of over 50,000 urban climate change studies. *Nat Cities* <https://doi.org/10.1038/s44284-025-00260-8> (2025).
64. Ulpiani, G. Do ambitious cities value collaboration in climate action? Insights from the first group of cities pursuing climate neutrality. *Cities* **162**, 105945 (2025).
65. Kılıç, Ş. et al. City–company collaboration towards aligned science-based target setting. *Nat. Sustain.* <https://doi.org/10.1038/s41893-024-01473-w> (2024).
66. Creutzig, F. et al. Towards a public policy of cities and human settlements in the 21st century. *npj Urban Sustain.* **4**, 29 (2024).
67. UN-Habitat. COVID-19 Response Plan. <https://unhabitat.org/un-habitat-covid-19-response-plan> (2020).
68. Möslinger, M., Ulpiani, G. & Vettters, N. Circular economy and waste management to empower a climate-neutral urban future. *J. Clean. Prod.* **421**, 138454 (2023).
69. Floater, G. et al. Co-benefits of urban climate action: A framework for cities. <https://eprints.lse.ac.uk/68876/> (London School of Economics and Political Science, 2016).
70. Sethi, M. Climate Co-benefits in Rapidly Urbanizing Emerging Economies: Scientific and Policy Imperatives. In *Ancillary Benefits of Climate Policy* (eds. Buchholz, W., Markandya, A., Rübelke, D. & Vögele, S.) 301–324 https://doi.org/10.1007/978-3-030-30978-7_17 (Springer International Publishing, Cham, 2020).
71. Roggero, M., Gotgelf, A. & Eisenack, K. Co-benefits as a rationale and co-benefits as a factor for urban climate action: linking air quality and emission reductions in Moscow, Paris, and Montreal. *Clim. Change* **176**, 179 (2023).
72. Sharifi, A. Co-benefits and synergies between urban climate change mitigation and adaptation measures: A literature review. *Sci. Total Environ.* **750**, 141642 (2021).
73. Everett, G. et al. Lifestyle and language barriers influence community engagement with green infrastructure. *Ambio* **52**, 1650–1660 (2023).
74. Scharfkillig, M. et al. Values and Identities—a policymaker’s guide. <https://doi.org/10.2760/349527> (2021).
75. Pereira, Á. G. & Völker, T. Chapter 8 - Engaging With Citizens. in (eds. Šucha, V. & Sienkiewicz, M. B. T.-S. for P. H.) 78–95 <https://doi.org/10.1016/B978-0-12-822596-7.00008-5> (Elsevier, 2020).
76. Chitsa, M., Sivapalan, S., Singh, B. S. & Lee, K. E. Citizen participation and climate change within an urban community context: insights for policy development for bottom-up climate action engagement. *Sustainability* **14**, 3701 (2022).
77. Vandyck, T., Della Valle, N., Temursho, U. & Weitzel, M. EU climate action through an energy poverty lens. *Sci. Rep.* **13**, 6040 (2023).
78. DellaValle, N. & Czako, V. Empowering energy citizenship among the energy poor. *Energy Res. Soc. Sci.* **89**, 102654 (2022).
79. Amorim-Maia, A. T., Anguelovski, I., Chu, E. & Connolly, J. Governing intersectional climate justice: Tactics and lessons from Barcelona. *Environ. Pol. Gov.* **34**, 256–274 (2024).
80. Ulpiani, G. et al. Do ambitious cities value collaboration in climate action? Insights from the first group of cities pursuing climate neutrality. *Cities* **162**, 105945 (2025).

81. Akinkuolie, T. A., Ogunbode, T. O., Adekiya, A. O. & Fapohunda, M. T. Indigenous climate change mitigation strategies in tropical cities—a review. *Front. Sustain. Cities* **6**, 1447400 (2024).
82. Nieuwenhuijsen, M. et al. The Superblock model: A review of an innovative urban model for sustainability, liveability, health and well-being. *Environ. Res.* **251**, 118550 (2024).
83. Manktelow, C. et al. Can co-creation support local heat decarbonisation strategies? Insights from pilot projects in Bruges and Mechelen. *Energy Res. Soc. Sci.* **99**, 103061 (2023).
84. Devine-Wright, P. Rethinking NIMBYism: The role of place attachment and place identity in explaining place-protective action. *J. Community Appl. Soc. Psychol.* **19**, 426–441 (2009).
85. Markkanen, S. & Anger-Kraavi, A. Social impacts of climate change mitigation policies and their implications for inequality. *Clim. Policy* **19**, 827–844 (2019).
86. Martiskainen, M. et al. New dimensions of vulnerability to energy and transport poverty. *Joule* **5**, 3–7 (2021).
87. Fitzgerald, J. Transitioning from urban climate action to climate equity. *J. Am. Plan. Assoc.* **88**, 508–523 (2022).
88. UN. Hobart: young people are vital to putting in place climate solutions. <https://www.un.org/en/climatechange/hobart-young-people-are-vital-putting-in-place-climate-solutions> (2025).
89. Della Valle, N., Ulpiani, G. & Vettors, N. Assessing climate justice awareness among climate neutral-to-be cities. *Hum. Soc. Sci. Commun.* **10**, 440 (2023).
90. Varş Husar, S. C. et al. What's next? Some priorities for young planning scholars to tackle tomorrow's complex challenges. *Eur. Plan. Stud.* **31**, 2368–2384 (2023).
91. Ürgü-Vorsatz, D. et al. Locking in positive climate responses in cities. *Nat. Clim. Change* **8**, 174–177 (2018).
92. Ulpiani, G., Vettors, N. & Maduta, C. Towards (net) zero emissions in the stationary energy sector: a city perspective. *Sustainable Cities and Society* <https://doi.org/10.1016/j.scs.2023.104750> (2023).
93. Camagni, R. Integrated Spatial Planning: Why and How? in *Seminal Studies in Regional and Urban Economics* (ed. Capello, R.) 391–398 https://doi.org/10.1007/978-3-319-57807-1_19 (Springer International Publishing, Cham, 2017).
94. Biesbroek, G. R., Swart, R. J. & Van Der Knaap, W. G. M. The mitigation–adaptation dichotomy and the role of spatial planning. *Habitat Int.* **33**, 230–237 (2009).
95. Kılış, Ş. Integrated urban scenarios of emissions, land use efficiency and benchmarking for climate neutrality and sustainability. *Energy* **285**, 128643 (2023).
96. Komninos, N., Kakderi, C., Panori, A. & Psycharis, Y. Three Conditions for Liveable Cities: Geographical Inclusion, Carbon Neutrality and Transport Innovation BT - The Future of Liveable Cities. in (eds. Fusco Girard, L., Kourtis, K. & Nijkamp, P.) 55–78 https://doi.org/10.1007/978-3-031-37466-1_4 (Springer International Publishing, Cham, 2023).
97. Perpiña Castillo, C. et al. Renewable energy production and potential in EU rural areas. <https://doi.org/10.2760/458970> (2024).
98. Frolking, S., Mahtta, R., Milliman, T., Esch, T. & Seto, K. C. Global urban structural growth shows a profound shift from spreading out to building up. *Nat. Cities* **1**, 555–566 (2024).
99. Garrido-Baserba, M. et al. Using water and wastewater decentralization to enhance the resilience and sustainability of cities. *Nat. Water* **2**, 953–974 (2024).
100. Hamel, P. et al. Mapping the benefits of nature in cities with the InVEST software. *npj Urban Sustain.* **1**, 25 (2021).
101. Sethi, M. & Mittal, S. Developing a smart tool for integrated climate action planning (ICLAP 2050) in Asia-Pacific Cities. *Comput. Urban Sci.* **2**, 45 (2022).
102. Istrate, A.-L., Popartan, L.-A., Auerbach, J., Gaspari, J. & Tavangar, M. R. Collaborative research for transitioning to Climate-Neutral Cities – contouring a prospective framework for integrated planning. *Planning Theory* 14730952231183303 <https://doi.org/10.1177/14730952231183303> (2023).
103. Ahlgren, B., Hidell, M. & Ngai, E. C.-H. Internet of things for smart cities: interoperability and open data. *IEEE Internet Comput.* **20**, 52–56 (2016).
104. Thunshirn, P., Ettwein, F. & Höferl, K.-M. Assessing the digital divide in the energy transition: Surveying the social factors influencing home energy management systems in Austria. *Energy Res. Soc. Sci.* **120**, 103941 (2025).
105. Urban Transitions Mission & Google. Transforming the future of urban planning with data and insights. <https://urbantransitionsmisson.org/transforming-the-future-of-urban-planning-with-data-and-insights/> (2024).
106. Massari M. Representation of transition outcomes along the GRETA's Energy Citizenship Awareness Ladder. <https://cordis.europa.eu/project/id/101022317/reporting> (2020).
107. Smith, S. M. A case for transparent net-zero carbon targets. *Commun. Earth Environ.* **2**, 24 (2021).
108. Dooley, K., Christiansen, K. L., Lund, J. F., Carton, W. & Self, A. Over-reliance on land for carbon dioxide removal in net-zero climate pledges. *Nat. Commun.* **15**, 9118 (2024).
109. Green, J. K. & Keenan, T. F. The limits of forest carbon sequestration. *Science* **376**, 692–693 (2022).
110. Luyssaert, S. et al. Trade-offs in using European forests to meet climate objectives. *Nature* **562**, 259–262 (2018).
111. Grassi, G. et al. On the realistic contribution of European forests to reach climate objectives. *Carbon Balance Manag.* **14**, 8 (2019).
112. Rodriguez Mendez, Q., Fuss, S., Lück, S. & Creutzig, F. Assessing global urban CO₂ removal. *Nat. Cities* **1**, 413–423 (2024).
113. Pan, H. et al. Contribution of prioritized urban nature-based solutions allocation to carbon neutrality. *Nat. Clim. Change* **13**, 862–870 (2023).
114. Doerr, N. & Porsild Hansen, J. “Climate translators” building trust and local democratic cooperation on green transition: Denmark and Germany. *Int. J. Comp. Sociol.* **65**, 479–498 (2024).
115. Mohammadpourilima, N. et al. 226–243 (Springer Nature Switzerland, Cham, 2024).
116. Luger-Bazinger, C. & Hornung-Prähauser, V. Innovation for sustainable cities: The effects of nudging and gamification methods on urban mobility and sustainability behaviour. *GI_Forum* **9**, 251–258 (2021).
117. Alt, M., Bruns, H., DellaValle, N. & Murauskaite-Bull, I. Synergies of interventions to promote pro-environmental behaviors – A meta-analysis of experimental studies. *Glob. Environ. Change* **84**, 102776 (2024).
118. Sovacool, B. K., Heffron, R. J., McCauley, D. & Goldthau, A. Energy decisions reframed as justice and ethical concerns. *Nat. Energy* **1**, 16024 (2016).
119. Newell, P., Srivastava, S., Naess, L. O., Torres Contreras, G. A. & Price, R. Toward transformative climate justice: An emerging research agenda. *Wiley Interdiscip. Rev.: Clim. Change* **12**, e733 (2021).

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Author contributions

G.U. conceptualised and designed the work, wrote the original draft, and produced the figures and tables. N.V. and C.T. contributed to the

conceptualisation, coordination, and editing of the original draft. N.d.V. contributed to conceptualisation, design, writing and editing of the original draft. G.U., N.V., C.T., N.d.V., Ş.K., V.P. and G.M. contributed to the review and approved the final paper for submission.

Competing interests

The authors declare no competing interests.

Additional information

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