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Funding and financing the zero emissions journey: urban visions from the 100 Climate-Neutral and Smart Cities Mission

Giulia Ulpiani ¹✉, Enrique Rebolledo², Nadja Vettters³, Pietro Florio ¹ & Paolo Bertoldi ¹

Cities play a critical role in delivering emission-free futures, yet the financial capacities, together with the unprecedented estimated capital requirements represent substantial barriers to climate action. In this study, we use data collected through the European Mission on 100 Climate-Neutral and Smart Cities to investigate how 362 ambitious, yet differently prepared cities are fostering climate investment, under three aspects of (i) financial readiness, (ii) financial proactiveness, and (iii) financial innovation. On one hand, according to their self-assessment, over 70% of the cities have not yet estimated—not even roughly—the total investment needed to become climate neutral and the majority (i) have experience in financing only a few specific climate projects, (ii) are ill-equipped to tap capital markets, (iii) have developed only marginally co-financing with the private sector, and (iv) have taken no steps to establish an investor-ready pipeline of projects contributing to climate neutrality. On the other hand, cities are at the forefront of financial innovation, creating blueprints and business models that are being tested under a learning-by-doing approach, creating deep and long-lasting transformative change, and establishing coordinating mechanisms with new critical players. In this context, current financial management, regulation, and institutional arrangements are key barriers to unlocking access to financing and creating an enabling environment for investment at the city level. The different levels of maturity in terms of financial readiness and institutional arrangements are discussed as the catalysers of climate financing at the city level.

¹European Commission, Joint Research Centre (JRC), Ispra, Italy. ²Natus Capital, Madrid, Spain. ³European Commission, Joint Research Centre (JRC), Brussels, Belgium. ✉email: Giulia.ULPIANI@ec.europa.eu

Introduction

Combining climate neutrality and economic recovery is a daunting challenge, as the scale of the financial investment needed to transition the world to net-zero emissions is unprecedented. It has been estimated that, globally, 6.9 trillion USD are required per year until 2030 in infrastructure investments to meet the Paris Agreement's 1.5 °C goal (OECD et al., 2018). Further, a recent conservative overview of the required investment shifts for the European energy and transport infrastructure by 2035 disclosed a steep uptick of +41% already within the very near term (2021–25) as compared to the previous 5 years: the surge is driven by renewable power plants, electricity grids, and rail infrastructure and reaches 302 billion €/year (Klaaßen & Steffen, 2023). Overcoming this investment gap requires investor-led initiatives and governmental policies with the specific objective of 'greening' finance (Steffen, 2021; Sun et al., 2022; Taghizadeh-Hesary & Yoshino, 2019) while demonstrating how green market leaders can thrive by taking an early market position and investing in green technologies, despite the initial cost premium. Numerous virtuous initiatives in this direction already exist (e.g., Climate Action 100+ (2023); Coalition for Climate Resilient Investment, 2023) and those listed in Annex III of (Mac Nulty et al., 2021). Nonetheless, there is a pressing need to deepen the understanding of the enablers and hindrances to finance a greener future while safeguarding values of justice and equity at multiple geopolitical levels ("Financing a Greener Future," 2023; Honegger, 2023; Robin, 2022).

In this study, the focus is on the role of local governments in the facilitation of financing for the delivery of climate neutrality (i.e., (net) zero emissions). Cities are key players in the transition as they sit at the intersection of civil society, private sector, and R&I institutions, while consuming 78% of the world's energy and producing more than 60% of greenhouse gas (GHG) emissions (United Nations, 2022). In their effort to greening investments cities also need to test innovative funding and financing mechanisms necessary to stimulate investment at the pace and scale required to align with net-zero greenhouse gas targets (Sugar & Webb, 2022). According to the Cities Climate Finance Leadership Alliance, the estimated investment to decarbonise and enhance the resilience of urban infrastructure reaches USD 4.5–5.4 trillion per annum (CCFLA, 2021). Analysis of data from the Covenant of Mayors (a movement that succeeded at mobilising thousands of local and regional authorities to develop climate action plans and investments) reveals that the unit CO₂ emissions reduction cost in cities is currently at 456 €/ton with notable differences among countries (Pablo-Romero et al., 2018). The analysis further highlights that cities are prioritising climate actions (e.g., more efficient public lighting, behavioural changes, energy upgrades in municipal buildings) that are less capital intensive than those associated with heavy urban infrastructure, such as transportation system and local electricity production investments, typically accounting for more than 50% of the total cost for the transition to net zero. The exception is photovoltaic actions that are on the rise globally and at all scales (Pablo-Romero et al., 2018; Palermo et al., 2020; Giulia Ulpiani et al., 2022). Nonetheless, compelling economic cases have been formulated for cities in both developed and developing countries to invest, at scale, in cost-effective low-carbon measures (Gouldson, Colenbrander, et al., 2015). The results suggest that if these investments were made in cities globally, they could generate reductions equivalent to 10–18% of the global energy-related GHG emissions already in 2025. Investment of 0.4–0.9% of city gross domestic product (GDP) per year would generate savings of 1.7–9.5% GDP by 2025 in the form of reduced energy bills with an average payback period of approximately 2 years at non-concessional interest rates. GHG emissions in cities could be

reduced by almost 90% by 2050 with technically feasible, widely available measures, potentially supporting 87 million jobs in 2030 and generating a global economic dividend of USD 24 trillion (Coalition for Urban Transitions, 2019). Similarly, a report from the International Finance Corporation estimates that urban sustainable investment opportunities in six sectors (waste, water, renewable energy, electric vehicles, public transport, green buildings) in emerging markets would have the potential to attract more than \$29.4 trillion in cumulative climate-related investments by 2030 (IFC, 2018). These figures become even more relevant when compared to the cost of inaction. The Swiss Re Institute's stress-test analysis run in 2021 estimated that under a zero-mitigation scenario, up to 18% of global GDP could be lost by 2050 (Swiss Re Institute, 2021). Despite the encouraging prospect and momentum, climate finance flows for cities reached an estimated USD 384 billion annually on average in 2017/2018, far short of urban climate finance needs (CCFLA, 2021). Cities continue to face significant headwinds in mobilising finance for transformational climate action and struggle to build up the capacity to master and combine different funding and financing instruments.

While trying to access funds from upper levels of governance (e.g., EU funds (Economidou et al., 2023)), cities deal with a number of challenges that are regulatory and budgetary (e.g., share of co-financing from cities, fiscal restrictions, impossibility to increase debt, impact of COVID-19 on local government's revenues), political (e.g., divergence with national governments), and capacity-related (e.g., insufficient administrative and technical knowledge) in nature (Negreiros & Falconer, 2021). Further, while public funding can provide the economic basis for local action, large sums will need to be channelled through the private sector, including from local businesses and population groups with high socioeconomic status (Nielsen et al., 2021; OECD, Bank W & Environment UN, 2018). The UN Sustainable Development Goals (United Nations, 2015) have placed great emphasis on collaborative frameworks and the private sector's crucial contribution to closing the climate gap in terms of investment and leadership in innovation (Shahbaz et al., 2020). However, this may be particularly cumbersome in a landscape with limited alignment between climate priorities and economic incentives, business models, diverse stakeholder interests, and revolving administrations with varying agendas. Moreover, a certain diversification in environmental regulations is needed to promote sustainable green development where the relationship between economic interests and climate action is more synergetic and balanced (Wang et al., 2023). In this sense, cities need to (i) develop the technical expertise to identify and promote climate-neutral projects that are financially viable, by unlocking sources of income to make them palatable to the investor community (Colenbrander et al., 2017), (ii) establish platforms for collaborative learning, specifically around pilot urban projects, thereby stimulating voluntary private engagements (Alkhani, 2020; Hughes et al., 2020), (iii) reach critical mass in order to be attractive to private investors, and (iv) set up an enabling regulatory framework attentive to barriers uplift.

An additional dimension worth investigating is that of financial innovation. The long-termism that characterises climate action is seldom aligned with the risk appetite of investors (Taghizadeh-Hesary & Yoshino, 2020). As such, the conventional financial system (e.g., the ecosystem of investors, markets, and instruments) could have a hampering rather than enabling role in climate mitigation pathways unless risk management aversion is properly modelled and addressed (Battiston et al., 2021). For instance, several studies have empirically confirmed the contribution of digital finance to environmental improvement at the

city and regional levels (Ren et al., 2023; Sun et al., 2023; Wang et al., 2023) as a way to enhance the transparency and accountability of the transition process while producing costs savings (e.g., on transactions, on the collection of data and information) that can be leveraged for environmental, social and governance investments. In addition, carbon markets and sustainable finance taxonomy are two rapidly growing market mechanisms that promise a surge in climate finance and a simultaneous decline in GHG emissions. However, their potential inefficiencies (e.g., related to oil price shocks) pose challenges to investors (for effective diversification and risk mitigation in their investment portfolios) and to policymakers (in the delivery of effective carbon emission reduction strategies) and require deeper investigation of causal links and determinants (Ren et al., 2022). Further, whether innovative financing mechanisms are the readily available answer to materialise climate action is still debated. Novel approaches may be held back by regulation that focuses on stability, avoiding forum shopping, and preventing fraud, to the exclusion of other interests, particularly ignoring innovation and renewal (Zilgalvis, 2014).

In this complex interplay of enablers and inhibitors, motivations and deterrents of greened urban finance, the direct input from cities and their perspective is seldom accounted for in existing literature, unless focused on small groups of cities or on specific regional/national contexts. Large-scale research is needed to answer the multitude of questions on the financial dilemma around climate neutrality in cities (Gouldson, Colenbrander et al., 2015), such as:

- What are the origins of the gap between expected green investment and real expenditure in cities? Are scientific means sufficient to explain the gap or does it respond to complex city-specific dynamics?
- How are cities acting to blend public and private finance to achieve the right risk and return profile?
- How are cities monetising the externalities and co-benefits that come with climate mitigation to increase investors' appetite?
- How are cities preparing bankable projects ready for investment and packaging their pipeline of projects into portfolios that can be financially attractive?
- What forms of financial innovation are currently being tested by cities in delivering climate action and which formulas are going to be experimented in the near future?
- What are the main barriers to closing the investment gap that cities perceive within and beyond their domain?
- What are the evolutionary steps for local governments in the setup and delivery of complex investment plans able to materialise climate neutrality?
- What are the future research and policy avenues to guarantee the onset of a truly green urban finance?

This study aims to address all these questions by leveraging an unprecedented dataset, recently collected by the European Commission through the Expression of Interest (EOI) questionnaire designed in the context of the European Mission on 100 Climate-Neutral and Smart Cities (European Commission, 2021). The dataset contains information on where 362 ambitious cities stand with regards to financing climate neutrality plans, based on their own assessment and perspective, and with the common backdrop of reaching (net) zero emissions by 2030. The cohort of cities is highly diversified in terms of national contexts, climate action preparedness, financial readiness, and economic prosperity, so that conclusions can be generalised and multiple pathways to reach mature investment strategies can be delineated. The analysis is structured around four pillars: (i) the process of

investment estimation and its breakdown, (ii) the use of innovative financing and funding schemes, (iii) how cities put together the building blocks of investment strategies, and (iv) the potential for tapping capital markets. An analysis of cities' responses about risk management and systemic barriers that hinder financial planning and mobilisation is further provided followed by a discussion around the main findings and how they compare with existing evidence. The analysis returns a unique portrayal of the status quo on the role of green finance in achieving sustainable urban development and possesses important research and policy implications, notably as concerns the design and diversification of investment portfolios for an accelerated transition to climate neutrality in different urban contexts.

Aims and methods

The European Mission on 100 Climate-Neutral and Smart Cities (hereinafter, the Mission) was launched by the European Commission in 2021 with the overarching goal of supporting 100+ cities in Europe and beyond in reaching absolute- or net-zero emissions by 2030, making them the example for all other cities to follow suit by 2050. Cities could express their interest in participating in the Mission by filling an all-encompassing questionnaire. The questionnaire was designed to cover all key technological and non-technological aspects related to climate neutrality. With a total of 374 questions and thousands of answer options, the EOI design required extensive conceptual analysis by a large group of experts in the domain of climate mitigation planning with knowledge of governance, legislation, policy, and economic aspects. A subset of questions was formulated to explore cities' financial mobilisation capacities, experience and investment readiness for climate-neutral actions as well as their capacity to estimate the capital requirements for investment and the funding and financing needed for the transition, while reflecting on barriers, gaps, assistance needs, risks, and favourable conditions. These questions (see Fig. 1) provide the basis for the analysis presented in this paper and touch on aspects of (i) financial readiness, (ii) financial proactiveness, and (iii) financial innovation. Cities were also questioned about their ability to tap into capital markets, i.e., the meeting point where financial instruments are exchanged between suppliers (typically banks and investors) and those who seek capital for their own use (businesses, governments, and individuals). Finally, as financing climate action heavily depends on mobilising the associated investment ecosystem, cities were asked whether they were actively working with established investment/finance partners to build an investor-ready pipeline of projects contributing to climate neutrality.

In total, the answers from 362 cities are analysed. The pool of cities covers all EU Member States and representatives from Türkiye, United Kingdom, Norway, Israel, Albania, Iceland, Bosnia and Herzegovina, and Montenegro, as shown in Fig. 2. Cities as small as 11,148 inhabitants and as populous as 15,000,000 inhabitants are included, with more than half falling in the 50,000–200,000 range. Per capita emissions vary in the 3.1 and 5.8 tCO₂e/inhabitant interquartile range with the median at 4.3 tCO₂e/inhabitant (dedicated analysis in (Ulpiani, Vetter, Melica, et al., 2023)). The median GDP (extracted at 30 arc-sec resolution for the year 2015 from the dataset by (Kummu et al., 2018)) is 2.97 billion € and the interquartile range is 0.87–8.02 billion €. The median GDP per capita (displayed in Fig. 2) is 20.1 k€ and the interquartile range is 12.1–29.5 k€. As such the dataset offers a great diversity of contexts and starting points, suitable to generalise results and to enucleate city profiles. Indeed, relying on data that are elicited through a homogenous procedure (i.e.,

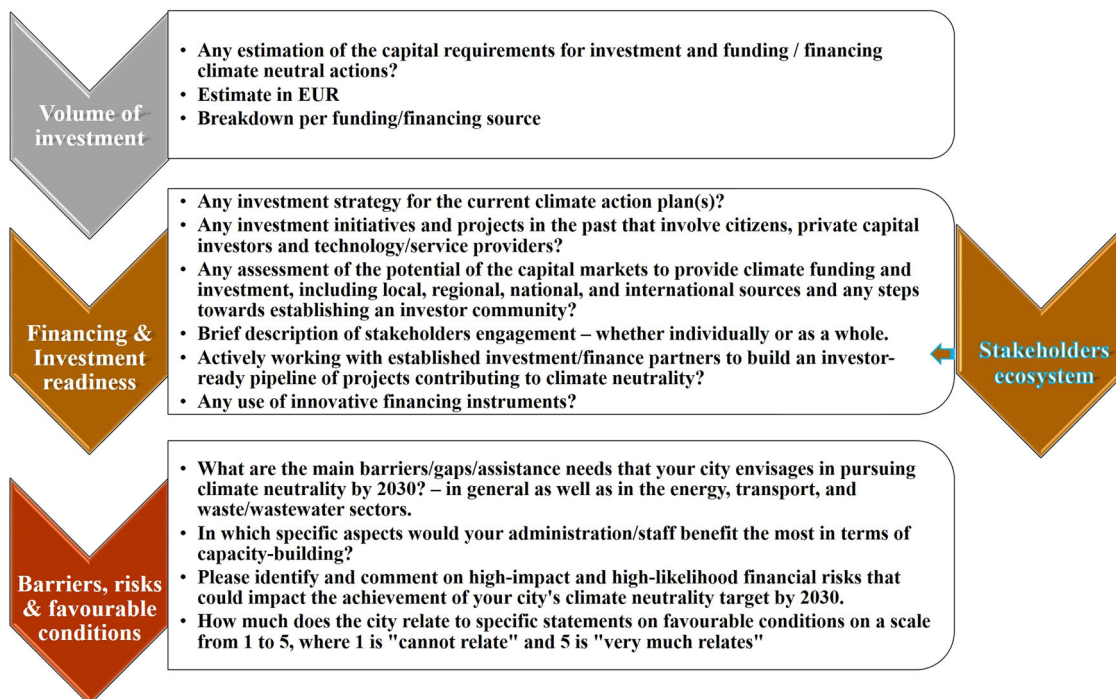


Fig. 1 EOI questions under investigation. Three macro-sections of the questionnaire dedicated to funding and financing the zero emissions journey are encompassed (volume of investment; financing and investment readiness; and barriers, risks and favourable conditions) and interlaced with the stakeholders ecosystem described by eligible cities.

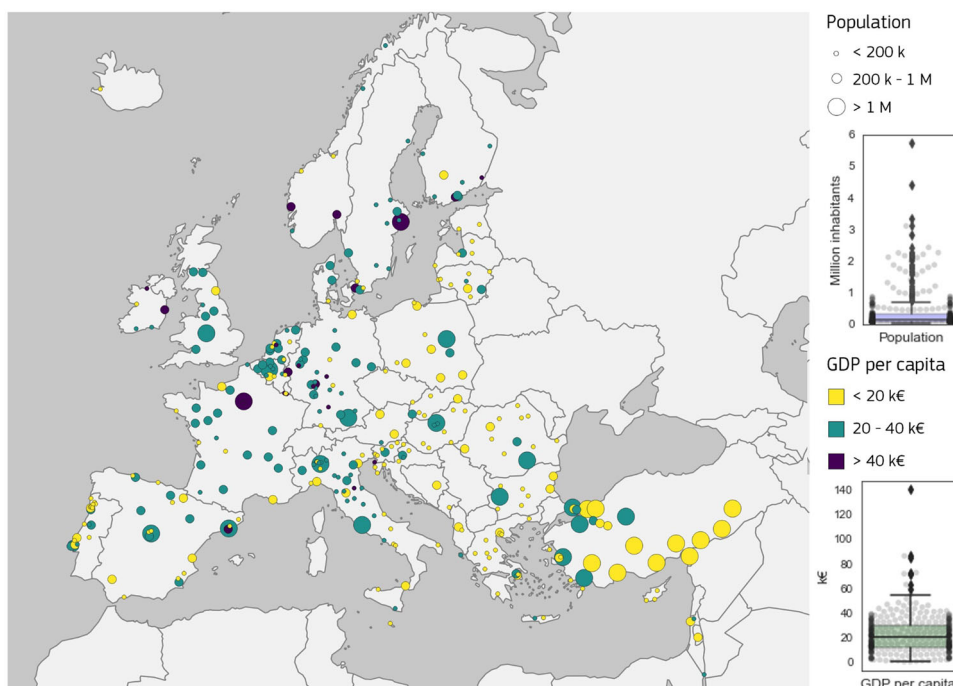


Fig. 2 Map of the cities that expressed interest in the Mission. Some eligible cities did not give consent to be identified and were excluded from the mapping while included in all analyses. The size of the circle represents the population group (from less than 200,000 inhabitants to over 1,000,000 inhabitants) as declared in the EOI. The colour indicates the associated GDP per capita class (from less than 20 k€ to over 40 k€). The boxplots show the statistical distribution of the population (y-axis cut at 6 million inhabitants for better visibility) and GDP per capita in the pool of 362 cities. The original GDP data from (Kummu et al., 2018) were converted from USD to € considering the mean USD-€ conversion factor over the year 2015 (Cambioeuro, 2023).

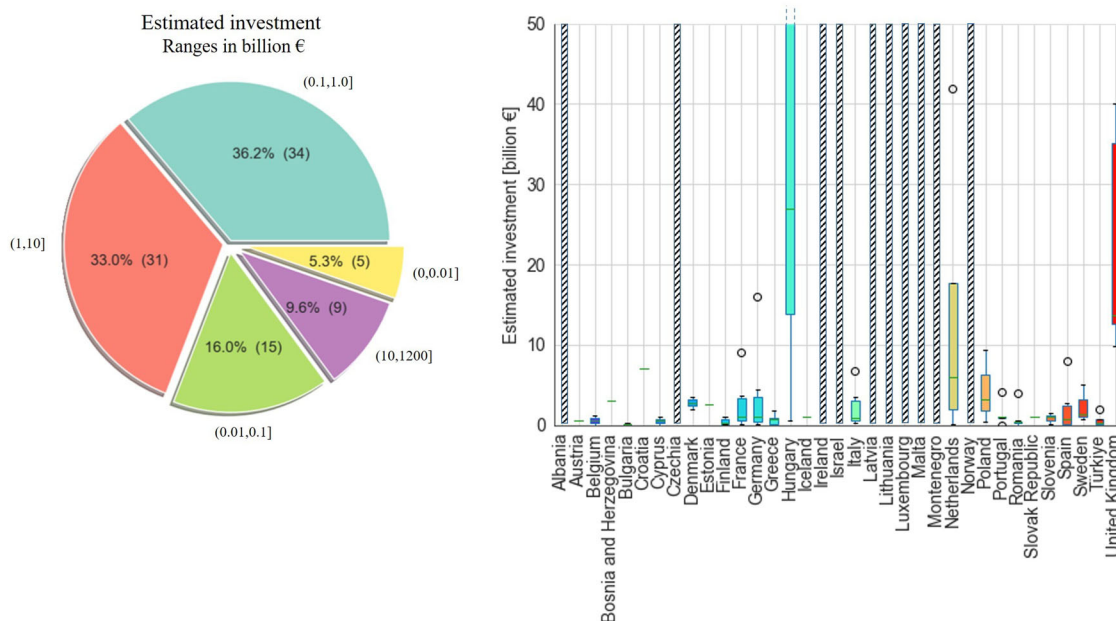


Fig. 3 Estimated total investment to reach climate neutrality by eligible cities ($n = 94$). In the boxplot, the y-axis is cut at 50 Billion € for better visibility, yet Hungarian and Spanish figures could exceed 1 Trillion €. The hatched columns indicate countries where no city estimated the investment.

survey), descriptive of a significant sample of respondents, and related to a well-defined climate action programme, promotes the development of a scientifically sound analysis of the role of green finance in cities today and its expected evolution in the near future.

The analysis is based on descriptive statistics as concerns multiple-choice questions and on an extraction-based text summarisation technique that combines tf-idf (term frequency-inverse document frequency) analysis and k-means clustering for free-text questions, as described in (Ulpiani, Vettors, Shtjefni, et al., 2023). Statistically significant groups are investigated via one-way ANOVA or Kruskal-Wallis tests depending on the distribution of the data, with the former applied in case the assumptions of normality (Shapiro-Wilks test) and homoscedasticity (Bartlett’s test) are met. The analysis is performed on the estimated investment with groupings based on city size (population), GDP, mean population density, and geographical group. The mean population density is obtained as the average number of inhabitants per square kilometre across all populated grid cells within the city boundary, as extracted from the GHS-POP dataset of the European Commission’s Global Human Settlement Layer (GHSL) for the year 2020 (Schiavina et al., 2023). For size, GDP, and density, groups are based on quantiles ($<Q1$, $Q1-Q2$, $Q2-Q3$, and $>Q3$), while geographical groups are obtained by dividing the cohort of cities into Southern Europe (147 cities), Western Europe (96 cities), Central/Eastern Europe (68 cities), and Northern Europe (51 cities), according to (Publication Office of the European Union, 2023), with Israeli cities assigned to Southern Europe. Details on the statistical distribution of the groupings are provided in Supplementary Information-Note 1.

Results

Estimated volume of investment. In total, 356 cities declared whether they have estimated the capital requirements to reach climate neutrality. Of those, 7 cities (2.0%) indicated having a detailed assessment, 88 (24.7%) an approximation, and the vast majority (261, 73.3%) no estimation at all. Almost all cities that claimed to have estimated—to some extent—the capital needs

provided the total envisioned volume of investment (94 out of 95). According to the pie chart in Fig. 3, in most cases (nearly 70%), the estimate falls in the 0.1–10 billion € range, however, 9 cities flagged more substantial investment needs (up to 1.2 trillion €), out of which 4 were from the United Kingdom and 2 from Hungary. In stark contrast, 5 cities claimed that the needed investment would be maximum 10 million €. These figures are not adjusted for population or income levels, and they may consider multiple estimation methodologies, ranging from sector-specific, project-specific, and city-wide investments, restricting the comparison among cities. Overall, the median investment touches 1 billion € and the interquartile range (IQR) is 0.23–3.15 billion €. When the outliers are removed according to the 1.5 IQR rule, the median is slightly over 0.7 billion € and the IQR becomes 0.11–1.49 billion €. In this case, assuming a linear expenditure over the 8-year time between 2023 (the beginning of the implementation phase of the Mission) and 2030, an investment of 13.75–186.25 million € per annum is expected by cities. Northern cities indicated higher capital needs, while Central/Eastern cities would spend less on median terms, however, the Kruskal-Wallis test reveals no statistically significant difference among geographical groups. In contrast, groups based on population are statistically different (one-way ANOVA, p -value < 0.001), with the most pronounced differences observed between population groups below the median and the group exceeding the 3rd quartile (Tukey’s honestly significantly differenced—HSD-test). Conversely, groupings based on the GDP per capita and mean population density are not statistically significant.

Figure 4 shows the breakdown per funding/financing source of the capital investment estimates. Some observations can be drawn:

- 71 cities included regional, national, EU funds and financing with a fairly homogeneous distribution across different percent bands, highlighting a diversified scenario in terms of economic reliance on higher levels of governance.
- 68 cities included private financing, however, the vast majority (64.7%) indicated no more than 40% of the costs covered via private contributions.
- 74 cities included own funds in their breakdown, however, for the vast majority of them (52 cities) the contribution falls into

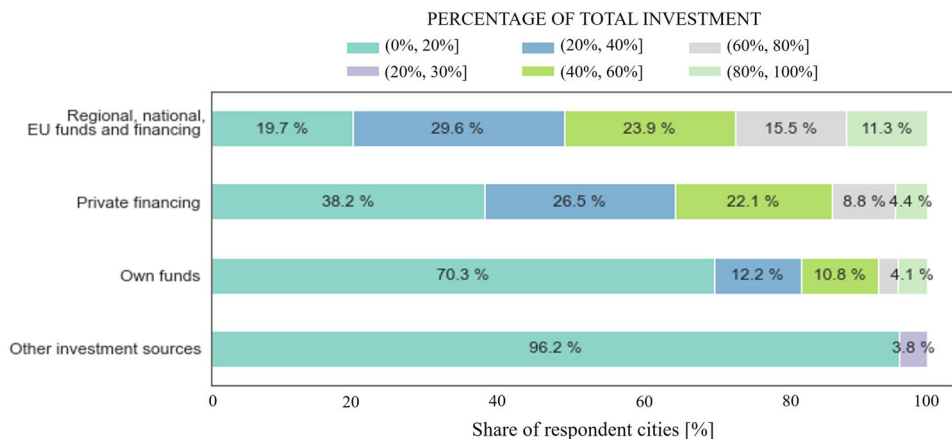


Fig. 4 Breakdown by funding/financing source of the capital needs estimated by eligible cities. Stacked bars are coloured according to the proportion of the total investment attributed to each source (in percent bands), while the percentages inside the bars indicate the corresponding share of respondent cities.

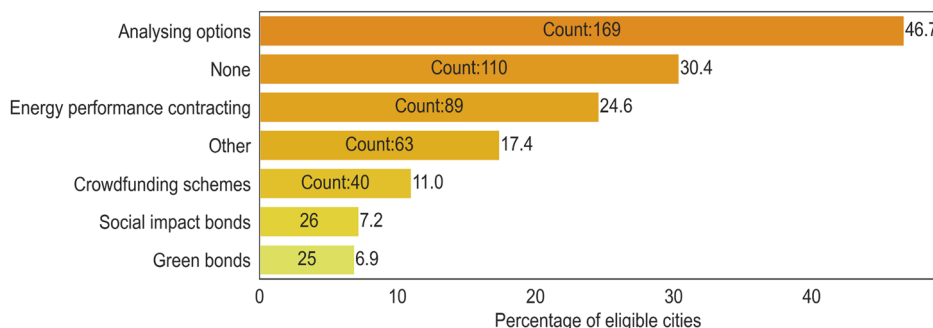


Fig. 5 Familiarity with innovative financing instruments among eligible cities (n = 350). Four specific instruments are singled out in the answer options: energy performance contracting, crowdfunding schemes, social impact bonds, and green bonds.

the lowest percent band ($\leq 20\%$). This entails that while eligible cities consider necessary to draw from self-owned capital, they also flag that this would cover a small share of the costs of transitioning to climate neutrality.

-26 cities complemented the mix with other investment sources that typically cover no more than 10% of the costs and mostly linked to the use of innovative financing instruments.

Not all percentages add up to 100%: 6 cities deviated by more than 5%, with a maximum total of 122.12% and a minimum total of 9%.

Innovative financing instruments. The heavy reliance on ‘conventional’ instruments such as public financing and EU funding versus the limited involvement of private resources is demonstrated by cities’ answers on the use of innovative financing instruments (Fig. 5). The vast majority of the cities (77.1% of 350 respondents) declared no experience with such instruments, yet most of them (169 cities) expressed their intention to analyse potential avenues (Fig. 5). Energy Performance Contracting (EPC) is the most popular instrument (24.6%), whereas social impact and green bonds are in the toolbox of only 51 cities, out of which 9 from Sweden, 8 from Spain, 5 from Germany and Turkey, 4 from Finland, Italy and The Netherlands, and 2 from Iceland as well as Portugal. In total, 30% of the respondent cities ticked more than one option showing diversity in the range of innovative financing instruments they have been using: 61 cities selected 2 options, 28 cities selected 3 options, 13 cities selected 4 options, and 4 cities selected all 5, internally consistent, answers

(all but ‘None’, and ‘Analysing options’). Of the 17 cities having used 4+ innovative instruments, 3 are from Italy as well as Spain, and 2 are from Germany as well as The Netherlands and Turkey with a population between around 60,000 inhabitants to over 4 million inhabitants (median of nearly 650,000 inhabitants).

A significant share of cities (17.4%) identified ‘Other’ innovative financing instruments, offering a complementary picture on the diverse and integrated solutions devised by cities in mixing conventional and innovative financing, as well as on mechanisms to improve creditworthiness, transparency, and fiscal management. Such financing solutions are analysed below under three categories: (i) innovation in financial products, (ii) innovation in financial arrangements, and (iii) innovation in engaging with the private sector.

Innovation in financial products. Innovative financing has been introduced by several cities in Belgium, Denmark, Germany, France, The Netherlands, and Sweden, and include:

- Innovative loan schemes in cooperation with banking institutions to finance the energy transition, linking citizens, financiers, and investors;
- Innovative crowdfunding schemes (i) where the city partners with local energy communities and rents public building roofs to install solar power or (ii) stipulated under a fund structure instead of a company;
- Innovation in tax design, by defining a series of green financial mechanisms and fiscal incentives, including taxing packaging, property taxes, and accelerated depreciation;

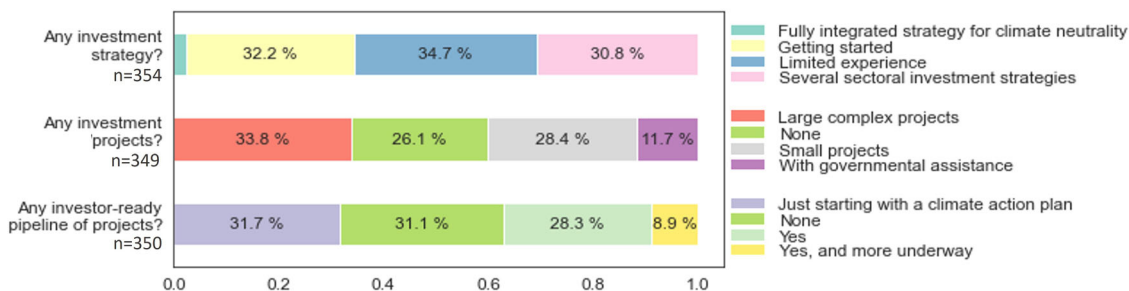


Fig. 6 Eligible cities' level of experience with investment strategies, initiatives, and projects contributing to climate neutrality. Different answer options are marked with different colours and associated with the corresponding percentage of respondent cities.

- Leasing contracts for solar equipment to avoid facing the steep initial capital expenses;
- Loans to citizens for energy retrofits, typically paid back under an on-bill financing scheme;
- Financing schemes, such as public-private partnerships (PPPs), where the new transport lines are financed with national funds matched with city investments in real estate and raised through land value capture to further scale up private investments.

Innovation in financial arrangements. Innovative financing is not limited to the introduction of a financial product or instrument, as financial arrangements are critical when it comes to defining the institutional architecture for implementation. Examples of innovations in this domain come from cities in Austria, Denmark, Finland, France, Hungary, The Netherlands, and Norway and include:

- climate action financed through publicly owned companies (e.g., transport or energy/water utilities) or through dedicated funds that link the business community and the academia/R&I institutions;
- Funds coupled with public companies that invest in energy savings in municipal real estate, following an EPC approach. The fund collects revenues obtained via solar and wind installations owned by the municipality, distributing benefits among citizens;
- Revolving funds with an equity participation dedicated to energy efficiency and renewable energy;
- Climate funds not only focused on the implementation of climate action measures, but also on financing pilot and demonstrative projects;
- Power purchase agreements on buildings;
- Innovations in green procurement by adding a series of sustainability considerations to the energy performance contracting, including smart city functions and less pollution;
- Use of standardised systems to access debt markets, where the city can raise funds under a transparent and efficient system, such as that offered in the context of online auction platforms.

Innovation in engaging with the private sector. The EOI dataset shows that 76.5% of the eligible cities consider the private sector as a key stakeholder. This positive perception of inclusiveness and collaboration is substantially reduced when specific private sector stakeholders are concerned, such as financial institutions, energy communities, and utilities, scoring substantially lower. For example, 'financial institutions' are flagged as a key stakeholder only by 38.4% of the cities, despite their critical role in facilitating access to the means for an effective materialisation of the transformative process (OECD, 2021).

Innovations in engaging with the private sector include cooperation and compensation schemes, based on donations or sponsorships, linking climate action with other social priorities, such as job creation and circular economy. Examples of this sort of innovations come from cities in France, Italy, The Netherlands, Poland, Portugal, Slovak Republic, and Spain and include:

- One-stop-shops, with information and credit intermediation services to facilitate citizens access to finance (including crowdfunding schemes, loans and guarantees) in line with recent evidence (Bertoldi, Boza-Kiss, et al., 2021).
- Foundations aimed at introducing climate action as a catalyser for job creation;
- Sponsorship-based initiatives to foster urban greenery, funded by the private sector;
- Compensation mechanisms, where companies or citizens can offset their residual greenhouse gas emissions by purchasing carbon credits and supporting local transition projects, on a voluntary basis.

Investment strategy. The top bar in Fig. 6 shows where eligible cities stand in terms of investment strategy for the current climate action plan(s). Most cities (237 out of 354) declared that they have limited experience (i.e., only in financing a few specific projects) or that they are just getting started with estimating investment needs. Only 8 cities expressed their interest in the Mission with a fully integrated investment strategy/programme to deliver climate neutrality (no more than one from the same country, in the 65,000–1,000,000 inhabitants range).

Further, the second bar in Fig. 6 shows that an almost equal share of the 349 respondent cities (around 30%) declared that they have developed larger projects, involving complex financial structures and multiple stakeholders or that they have developed relatively small projects involving a few stakeholders. Other 91 cities launched no such initiatives/projects in the past. It is relatively common to see that projects and flagship initiatives for climate action have been implemented with government assistance, including regional, national and EU bodies support (11.7%). This shows how support from higher levels of governance is relevant in building momentum and improving the business environment by assuming initial risks and early action.

Finally, when asked whether they are actively working with established investment/finance partners to build an investor-ready pipeline of projects contributing to climate neutrality, most respondent cities (220 out of 350) declared that they are just starting with a climate action plan or that they have taken no action in this regard (bottom bar in Fig. 6). In total, 31 cities announced a pipeline of projects that are ready for investment and are actively working with investment/finance partners in building new pipelines. Out of them, 5 are from The Netherlands,

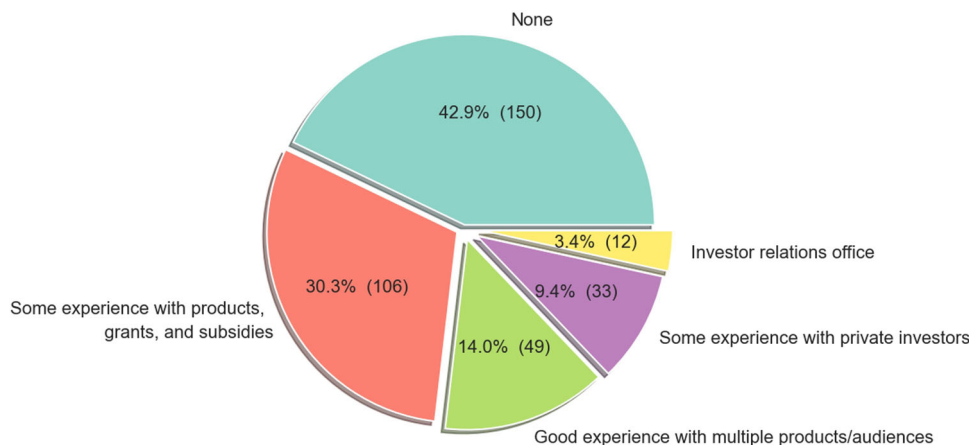


Fig. 7 City answers to the EOI question “Any assessment of the potential of capital markets?” (n = 350). The five answer options are graded from “None” (lowest level) to “Investor relations office” (highest level). The pie chart is ordered by decreasing percentage of respondent cities.

4 from Spain, 3 from France as well as Turkey, and 2 from Finland, Italy, and Sweden. The size of these cities varies considerably, from a minimum below 15,000 inhabitants to a maximum of 15 million inhabitants. As these figures almost overlap with the population range of the entire cohort of eligible cities, it may be inferred that the city size is not a determinant in this context.

Capitalising on the experience in multiple sectors with small or large projects is key to develop an investment-ready project pipeline. However, project pipelines are typically derived from climate action or neutrality plans that do not necessarily assure their financial readiness. This partially explains the fact that 62.8% of the cities require investment preparedness assistance, before aiming at accessing financing. The remaining 32.7% of cities consider that an investor-ready pipeline of projects is in place. These cities are more familiar with large complex projects, less dependent on national governmental assistance, and more experienced in driving investment in sectoral strategies, which justifies, at least partially, the availability of project pipelines.

Potential of tapping capital markets. When asked about the experience acquired over time in assessing the potential of capital markets, and thus in involving private sector operators, investors, or financiers, cities demonstrated limited expertise. Figure 7 shows what cities thought was the answer option that best described their current situation:

-Most cities (42.9% of the 350 that answered the question) have never assessed the potential of capital markets in providing climate funding and investment and have made no steps towards establishing an investor community;

-The second highest share of cities (30.3%) has gained some experience in using financial products in combination with national/eu grants and subsidies, while 49 cities can juggle between multiple financial products and different investor audiences, and have accumulated experience in multiple projects. In total, 12 cities have an investor relations office, out of which 3 are from Hungary and as many from Sweden.

For any answer except “None”, cities could describe how they have engaged with the relevant actors, whether individually or as a whole. The analysis of 174 free-text responses shows a more detailed experience and creativity in tapping capital markets, adopting a combination of financial and non-financial instruments and approaches, to leverage public and private financing. Described in Supplementary Information—Note 2, these include (i) flexible funds to trigger city or sectoral climate action, (ii) city

funds to support riskier ventures (e.g., to support start-ups), (iii) investment packages complemented with financial contributions from individuals to leverage citizen contributions, (iv) flagship projects to mobilise investment (e.g., innovation parks or district development), (v) investment funds managed by private firms with a strong focus in mobilising equity financing, (vi) investment offices specialised in combining multiple financial streams while managing the associated risks, and (vii) climate and green bonds to scale up financing.

Barriers and risks versus favourable conditions. The majority of the most frequent barriers in pursuing climate neutrality by 2030 flagged by cities are of an economic nature. In total, 354 cities specified what are the critical hurdles foreseen, and among 24 answer options, ‘lack of funding/financing schemes’ is by far the top choice (239 eligible cities, 66%). No other option was selected by more than 168 cities (46.4%). This is compounded by 3 other interconnected barriers that feature in 4th, 5th and 9th position in the ranking: (i) prohibitive investment costs (131 cities, 36.2%), (ii) slow/disaggregated financial process (115 cities, 31.8%), and (iii) difficulties in building collaborations between public and private sectors (102 cities, 28.2%). In stark contrast, ‘Lack of market competition’ is the least important barrier, at the very bottom of the ranking (17 cities, 4.7%). The weight that budgetary constraints play in weakening visions for climate-neutral urban futures is also evident by the ranking of main barriers in the two driving sectors for GHG emissions reduction: energy and transport. In both sectors, the top barrier is ‘High initial capital costs’ as identified by 250 cities (almost 70% of the eligible cities) and by 229 cities (63.3%), respectively. Any other barrier was selected by maximum 31% and 38% of the eligible cities.

The reasons behind such a strong dominance of financial barriers are explained in the section of the EOI that deals with financial risks (among other risk categories as analysed in (Ulpiani & Vetter, 2023)). Primarily, cities underline that the magnitude of financial resources to be mobilised for the roll-out, implementation and infrastructural interventions to materialise climate-neutral targets is unprecedented and exceeding by several orders of magnitude the typical budget local administrations are responsible for. This also reflects what cities flagged as key requirements in capacity building. Out of 19 possible assistance needs (e.g., monitoring, reporting, verification, procuring R&I solutions, digitalisation, computing, data analysis), the three options related to funding/financing hold the top positions: (i) ‘Knowledge on climate finance’ (181 eligible cities, 50%), (ii) ‘Investment planning’ (157 cities, 43.4%), and (iii) ‘Project

Table 1 Share of eligible cities that lack crucial elements in terms of funding/financing climate action.

| | Share of eligible cities |
|--|--------------------------|
| No estimation of the capital requirements for investment and funding/financing climate-neutral actions | 261 out of 356 |
| No investment initiatives/projects in the past that involve citizens, private capital investors and technology/service providers | 91 out of 349 |
| No assessment of the potential of the capital markets to provide climate funding and investment nor steps towards establishing an investor community | 150 out of 350 |
| No investor-ready pipeline of projects contributing to climate neutrality | 109 out of 350 |

development through pre-feasibility to finance-ready (150 cities, 41.4%). As such, this is where cities believe they should invest the most to create the internal force to deliver on climate neutrality. Cities flag the multiple sources of financial uncertainties that would need to be controlled for, namely:

- uncertainties in securing private investment, increased interest rates, ineffective legislative control of the indebtedness level, national underfunding, and high fiscal risk due to a restriction in access to credit for private investment;

- legislative and regulatory uncertainties causing private funding and financing to be easily diverted where laws and rules are not clearly set or come with frequent modifications (e.g., for new technologies, for carbon capture, for hydrogen, for aspects were national and local governments tend to misalign the most);

- uncertainties linked to political instability that negatively impacts the local capacity to secure sufficient and long-term governmental support for climate action.

In ‘bumpy’ political contexts, the main risk is that the funding lines on environmental and decarbonisation policies may lose their current budget allocations following national crises or political deadlocks. In addition, instabilities accentuate inflation, currency imbalances and market upheavals which in turn might hinder political commitments. This may pose a risk of adversely affecting the decision-making mechanisms of investors as well as cities’ ambition.

While purely economic barriers stand out, several other obstacles are equally important, creating a series of risk and barrier dependencies. Notably, the fragmentation of responsibilities is a critical barrier for 46.4% of the eligible cities, insufficient administrative and/or operational capacity for 44.5%, slow/disaggregated authorisation process for 30.1%, regulatory red tape for 28.7%, lack of enabling policy at country level for 24.0%, and uncertainty about regulation and taxation for 21.8%. All other barriers at cross-sectoral level are indicated by less than 20% of the cities.

Against the above risks, and to complete the picture, cities seldom relate to (i) favourable economic conditions (e.g., high tax revenues), (ii) fast funding/financing processes, and (iii) sufficient own funding schemes. Further, they typically find themselves lagging behind in securing internal and external funding/financing for climate projects (see the analysis in Supplementary Information—Note 3).

Discussion

The EOI analysis reveals that cities having the ambition to become climate-neutral by 2030 consider the development and assessment of investment opportunities and accessing financing as top priorities. However, the majority of eligible cities are not yet fully ready for investment at scale. Notably, an important share of cities showed signs of very low preparedness in dealing with funding/financing climate action, as recapped in Table 1.

Reportedly, many European cities have insufficient administrative and technical knowledge to present their climate action plans as a business proposition, prepare funding applications, and ensure the bankability of potential investments, as also found in

(Negreiros & Falconer, 2021). It is common for cities to use simplified methods to assess the ticket size of an investment, resulting in either disproportionately high capital needs, or extremely low figures (see Fig. 3). Thus, there is a clear need for strengthening capacities in preparing investment plans and in connecting investment to project planning in a portfolio approach. This is further demonstrated by the fact that nearly 50% eligible cities identified the need for capacity building on climate finance, and becomes particularly relevant in view of the intended expansion of renewable energy capacity at the cross-sectoral level proposed by cities in the context of the Mission and examined in (Ulpiani, Vettors, Shtjefni, et al., 2023).

To address the challenge of investment estimation, cities engage with a diverse financing ecosystem to understand project dynamics under multiple business models, capital structures, and sectors. Nonetheless, the level of engagement with financial institutions, energy communities and utilities is, on average, very low. These capacities are fully available only in 7 cities currently equipped with a detailed investment estimation. Despite this limitation, responses provided in the EOI by cities having defined an investment estimation show a very rich set of solutions and approaches, with frequent involvement of the private sector, leveraging its essential role and leadership in business and industrial innovation (Alkhani, 2020). Blueprints and innovative models are being explored by cities for co-financing, adopting a practical approach not only in investment estimation, but also in involving key stakeholders in dialogues and collaboration, including investors, pension funds, public and private companies, operators, and the broad private sector community. As observed in (Gouldson, Colenbrander, et al., 2015), this is key to transition under conditions of institutional learning, where deep and long-lasting transformative and coordinating mechanisms are established across all key players.

Most cities tend to underestimate the potential of working with the private sector on investment estimation as an open-ended process as well as in co-devising innovation in financing. Yet, moving from the business-as-usual public financing to private and blended finance requires the capacity to introduce procedural changes in how investment is managed within the institutional architecture, circumscribed to the timescale of political cycles, institutional restrictions, complex EU procurement rules, and annual budget regulations.

In general, investment strategies should be seen as a continuous process that involves an upstream component of fundraising, complemented by a downstream process that is related to the implementation of priority projects. At each step, delivering on climate neutrality calls for financial innovation since emerging business models offer the potential to address long-standing barriers to investments (Bertoldi, Economidou, et al., 2021). From the upstream side, institutional capacities for managing investment, including issuing green debt, have been deployed to tap capital markets. This has helped in financing new and existing infrastructure, working together with banks and insurers, and in fostering blended investment. This institutional arrangement has been adopted by cities characterised by solid creditworthiness to access domestic and international capital markets to fund climate action.

From the downstream side, where the business case for each project is relevant, innovation in financial instruments is essential. Cities have introduced Energy Performance Contracting provided by energy service companies (ESCOs), as a means to transfer risk to a third party, while allowing a better use of the limited city budget by allocating it as an operational cost, rather than using it to finance initial capital costs. ESCO markets are driven by market forces as much as by dedicated policy measures (Bertoldi & Boza-Kiss, 2017). In this domain cities face a dilemma: sectoral plans involving climate action present more specific business cases, however they pose a series of challenges for cities in planning and fostering synergetic action across multiple domains. Exemplary is the case of the linkage among electric vehicle infrastructure, energy storage and decentralised energy, mobility, and district and building renovation. Cities can stimulate investment by the private sector through regulation, mandating, e.g., electric cars, renovation of buildings or use of renewable energy sources, then the private sector (ranging from utility operators to private citizens) must invest. Hence, innovation is needed to produce integrated and holistic approaches in both climate action plans and their financing, considering the interdependencies not only in physical terms, but also in the financial flows between the building blocks of climate action plans.

Right in the middle of upstream and downstream processes, there is a space where different interactions with the private sector take place. Oftentimes, these interactions are structured through a fund structure to raise and manage capital, collecting revenues from multiple sources (e.g., green taxes) and targeting a specific set of priorities. Cities also engage with the private sector with other innovative schemes, such as PPPs, green procurement, crowdfunding, or real estate development. Lastly, some cities interact with the private sector under voluntary sponsorships to improve urban infrastructure and greening the city. As a result, cities can choose how to optimise their role in the institutional setup, sometimes taking a leading role in changing citizens' behaviour and improving the business landscape, and other times having a more cooperative approach by being part of, e.g., an energy community.

In this multi-level scenario, cities need to fully understand the effectiveness of the different approaches, instruments, and institutional arrangements they have at hand to facilitate the transition to climate neutrality. ESCOs, green bonds, carbon taxes, and PPPs are very attractive to cities and have proved to be effective at supporting the transition to a greener and more sustainable economy (Teti et al., 2022). Notably, among Environmental, Social, and Governance (ESG) debt options, green bonds are dominant and their issuance proved to enhance corporate profitability, growth potential, green innovation potential, and green responsibility potential (Zheng et al., 2023). However, only one in seven eligible cities is leveraging this instrument, possibly because ESG solutions require a set of previous arrangements before coming to fruition. At the same time, it is important for cities to assess if conventional financing schemes can render better results in the long run. A functional ecosystem of stakeholders is also critical to juggle the complexities of accessing finance and the burdens in putting together investment plans that are aligned with multiple policies and plans, at the national and local levels. Examples of this are the vertical alignment of cities' climate action plans with the Paris Agreement, Nationally Determined Contributions, national climate policies and reporting mechanisms (Melica et al., 2018). Horizontal alignment (including city-to-city cooperation) is also challenging, as climate action involves multiple sectors, different stakeholders and constituencies, including social policies.

Having an investment strategy is thus essential to align investments, policies and climate action. Financial instruments

(products), investment management approaches (investment offices), investor profiling techniques (audience, private investors), public sector instruments (grants and subsidies), and risk assessment frameworks are all key elements in an investment strategy; however, in analysing the more detailed free-text responses from cities, it is clear that cities have a broader perspective on the potential approaches for tapping into capital markets while linking their project pipelines with capital markets under multiple and parallel work streams. Notably, new forms of city-level direct-funding schemes are being tested. Scientific evidence demonstrates that well-designed funds possibly covering a variety of subsidised policy domains, including monitoring and reporting systems and leveraging revolving and rewarding mechanisms, can fill the "implementation" gap between policy intentions and policy outcomes (e.g., GHG emissions reduction and the institutional transformation in the transition), while enabling experimentation and innovation in policy-making and investment (Gouldson, Kerr, et al., 2015; Peng & Bai, 2021). Notably, such funds can catalyse a series of virtuous institutional changes and create avenues to engage business stakeholders and raise public awareness (Peng & Bai, 2021).

Cities are generally still ill-equipped to tap capital markets. This can be inferred from the responses of eligible cities showing that 150 of them have performed no assessment of such markets. The understanding of investor involvement must be broadened, as the concept of reaching out to an investor as an entity can be intimidating for cities. Cities must be ready to face and dialogue with the private sector by reducing information asymmetries in capacities and knowledge, while protecting citizen's interests. For this, practical and reliable approaches include working with financial operators, private and public companies that can have a more focused investment strategy in accessing capital markets, as well as through energy communities and crowdfunding. Thus, the nature of the organisation that is mandated to tap capital markets for scaling up financing is fundamental. For instance, a public company, a fund, a city's investor office or a third-party contractor will have a better risk profile and financial attractiveness than a team within the Department of environmental protection of a city. Further, the attractiveness of low-carbon measures needs to be considered in concertation with other policy goals (e.g., poverty reduction, equity and inclusion, ecological integrity, energy security, mobility, air quality and health, city liveability, etc.) as advocated in (Colenbrander et al., 2017). In their study, the authors conclude that, wherever possible, cities should prioritise mitigation options that will deliver against wider SDGs (Sustainable Development Goals) objectives based on the various co-benefits that come with climate action (e.g., air quality, road safety, job creation) to stimulate public and private enthusiasm for low-carbon development, while developing appropriate forms of engagement and governance.

Further, cities could redistribute and reinvest the returns from climate-neutral investments, e.g., through revolving funds, up to the point where all investments are cost-neutral if the GHG price is included by, e.g., issuing a carbon tax (Gouldson, Colenbrander, et al., 2015; Gouldson, Kerr, et al., 2015). This could enable countries with limited resources to invest more heavily and more effectively in low-carbon development, even in contexts of austerity (Gouldson, Kerr, et al., 2015). Finally, as climate change is an expensive collective problem that will be felt unequally around the world and within communities, sustainable and equitable financing would address disparities and reduce the economic cost of the transition where it is most socially burdening (Financing a greener future, 2023).

Yet, cities need the technical, financial and fiscal capacity to manage investment in a transparent manner. The trust and commitment of a city towards climate action, or neutrality, is not

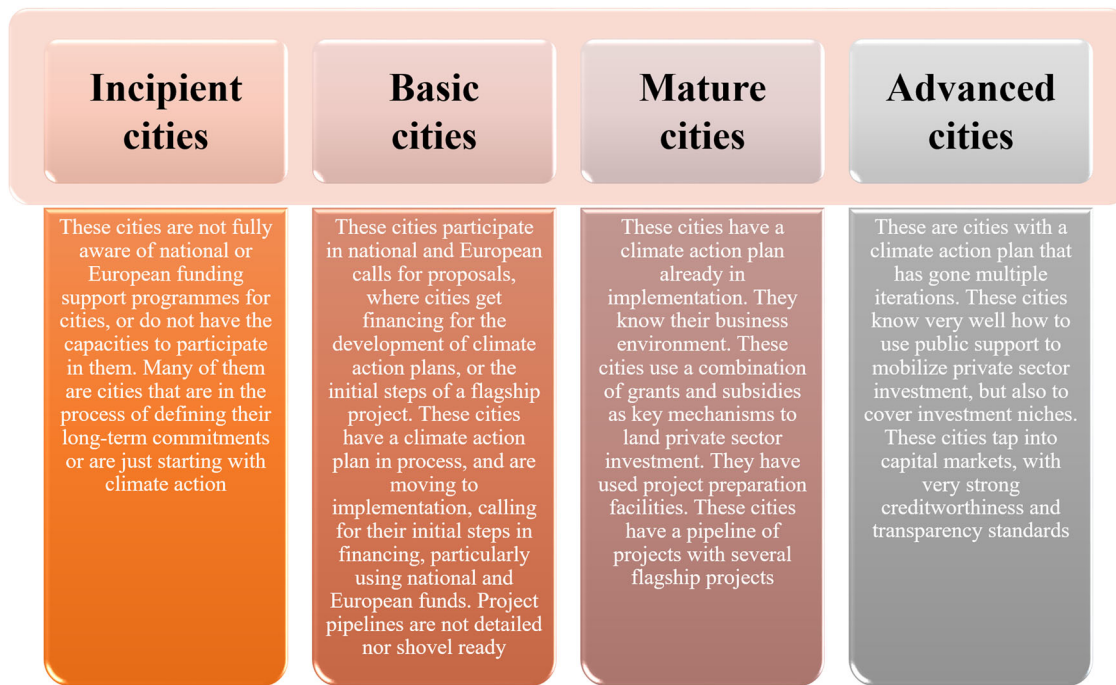


Fig. 8 City profiles in relation to climate financing. The evolution path includes four steps, representative of incipient to advanced cities.

necessarily the first step, but it helps in building a trusting relationship with investors and the public. Finally, closely tracking public funds utilisation efficiency through sturdy monitoring and reporting frameworks that account for trends in energy savings and GHG emissions reductions is key to a controllable riskscape (Dębkowska et al., 2022).

With regards to investment strategies, elements that emerge across responses substantiate the observation that, in their quest for financing, cities go through a series of incremental steps that can be defined as in Fig. 8.

These incremental steps show how the building blocks of any investment strategy should target financial mobilisation, according to the investment readiness of a city. A demand emerges to develop financial tools suitable to any step of the evolutionary pathway not to stall the transition to climate neutrality, notably when it comes to incipient cities (typically smaller local authorities) that need to build the financial grounds to sustain their ambition, as also advocated in (Palermo et al., 2020).

However, risks and challenges exist and may transcend the city realm, calling for a set of financing solutions in tandem with well-developed national-local coordination. This emerges clearly from the analysis of the main barriers that—in this study, differently from other on-topic literature—is based directly on city inputs, thus reflecting their own perception. Such barriers are amalgamated into five main narratives:

-Sound financial management. The lack of budget planning and risk assessment are seen as barriers to strengthen investment planning and the development of robust pipelines. For a significant share of cities, basic capacities for fiscal and financial planning must be activated to address climate investment, calling for coordination and transparency as critical elements to improve creditworthiness and thus access financial markets. Yet, between 21.8 and 44.5% of the cities highlight insufficient administrative and operational capacities to create bankable projects, lack of an enabling policy at the country level, and uncertainty about regulation

and taxation as key barriers, while having difficulties in building collaborations with the private sector (28.2%). These are the same barriers that affect cities of emerging economies willing to support climate investments (Cities Climate Finance Leadership Alliance, 2023). Eligible cities demonstrate that different steps exist in the process of fully overcoming them.

-Institutional architecture and regulation. The institutional setup can catalyse commitments from investors, business, and citizens. The fragmentation of responsibilities is a barrier flagged by 46.4% of the cities. On top of this, cities very often add difficulties in dealing with eligibility, procedures and requirements to access funding/financing and attract investment (Kata & Pitera, 2023; Negreiros & Falconer, 2021). This is reflected in the responses of cities that face slow financial processes (31.8%), or in the fact that only 12.9% of them reportedly benefit from favourable conditions in funding and financing. Cities are further posed with the dual challenge of complying with the vertical coordination and policy alignment necessary to reach the institutional capacity and fiscal autonomy to finance zero-carbon transitions (Colenbrander et al., 2017; Seto et al., 2021), and with appropriate horizontal coordination mechanisms, considering multiple agencies with competing investment opportunities. Cities claim that authorisation processes are slow (30.1%) and climate strategies are constrained by regulatory red tape (28.7%). Further, political divergences between different levels of government constitute critical obstacles cities face when seeking EU climate-related funds, that are mostly directed to national governments. Cases have been reported where cities have lined up in opposition to their national central governments and have created “free cities” pacts to get direct access to the EU funds (Negreiros & Falconer, 2021). Similarly, there is evidence—for instance in the energy upgrade of buildings—that, when local, regional and/or national financial schemes are properly coordinated a blended financial and technical solution could render higher energy savings and deeper societal engagement (Economidou et al., 2023).

-Financial market conditions. Cities have difficulties in accessing financial markets and are frequently unaware of

available financial products and risk mitigation schemes. Cities often mention in their free-text responses that credit ratings, interest rates and the volatile economic environment are significant barriers to the implementation of climate measures. Only a few cities currently boast extensive use of financial products, including the use of guarantees, as well as financial structures, such as special purpose vehicles, investment promotion agencies, or offices offering technical assistance in getting financing. Credit ratings are linked to the financial management of a city, and it is often used as a metric for creditworthiness. A lower credit rating will require a city to look for alternative, often more expensive, financing (Seto et al., 2021).

-Reliance on external support and technical assistance. Several national and European banks support cities in accessing financing through specific funds, project preparation facilities and risk mitigation products. Notably, the European Investment Bank announced its desire to increase its share of commitments dedicated to climate action to 50% by 2025, implying an expected investment volume of 30 billion €/year (EIB, 2020). A substantial proportion of cities indicated a high reliance on this kind of funds, and to a lesser extent, the use of risk mitigation facilities. While this is not negative, it is consistent with the frequently flagged shortcomings in terms of governance and capacity, with 'Insufficient administrative and/or operational capacity' and 'Lack of technical or commercial skills and information' selected by 44.5% and 13.3% of the eligible cities, respectively.

-Inflation and supply chain disruption. These two elements are prominent in the free-text responses from the cities. Supply chains are being altered, with manufacturing taking place across the globe, availability of materials at stake, or rising prices for energy. While inflation and supply chain analysis are not commonly considered in the access to financing, these are key elements to monitor, as they affect the required investment, hindering the capacity of a city to put projects on the ground. Further, they also touch on the required financial innovation to mitigate business failures and disruptions, including physical, transition- and currency-related risks.

Against this backdrop, it is worth noting that frameworks to capture the interdependence between the investors' perception of future climate risk, the credibility of climate policies, and the allocation of investments in the economy are being developed (Battiston et al., 2021). Further, novel mechanisms to increase private participation and the role of public financial institutions and non-banking financial institutions (e.g., pension funds, insurance companies) in green finance and investment, are being explored to overcome the deterrents of high risk and low rate of return, by developing green credit guarantee schemes (lower credit risk), establishing community-based trust funds, and addressing green investment risks via financial and policy de-risking (Taghizadeh-Hesary & Yoshino, 2020).

Conclusions and policy recommendations

In the finance world, climate neutrality equals making tremendous strides in designing, implementing, and financing climate action. This is particularly true for local governments that, to overcome their limited funding and regulatory capacity, are asked to show a high degree of ambition, creativity, and innovation, while pairing political will with fiscal and sound financial management.

The financing approaches to climate action captured in this analysis represent the diversity in terms of institutional capacities and national contexts where public and private investments are structured. While significant progress has been made, challenges

remain not only in financing, but in structuring and integrating climate action in decision-making. Cities have shown creative approaches in introducing innovative financing, ranging from changes in institutional financial arrangements and procedures to the development and use of financial products that consider the different risk profiles of projects and market segments to attract the private sector. Best practices, blueprints, and incremental steps are identified as means to support cities in saving time and resources when devising financing instruments and institutional arrangements that better fit their needs and context.

Cities participating in the European Mission to reach climate neutrality by 2030 are front-running climate action. In the process, new institutional capacities will be built, more ambitious climate mitigation strategies will be pursued, and new financing arrangements will be tested, thus inspiring other cities on the same pathway. The following policy recommendations are suggested based on our research:

- Cities should **deepen their collaboration with financial institutions to better design projects and business models, thus enhancing the potential for implementation.** In this context, financial institutions, including pension funds, public companies with fiduciary duties and local commercial banks, need to be considered as part of the cities' ecosystem, as they are well equipped to support the climate transition.
- **Public financing should target sectors and niches that are perceived as risky** or not profitable by the private sector and it should crowd-in rapid private financing commensurate with the investment scale of climate neutrality. One-stop-shops, with information and credit intermediation services, should be spread and better operationalised to facilitate citizens' access to finance and thus unlock crowdfunding schemes, loans and guarantees.
- **Aligning policies, investment and citizen mobilisation for climate neutrality across jurisdictions and levels of governance is fundamental.** The reliance on national and European funds to kick start and implement climate policies is a key catalytic resource in this direction.
- **Capacity building and training remain a critical bottleneck to access financing.** Strengthening capacities would help cities in having a concrete and manageable project pipeline to start discussions with the private sector. Twinning projects and neighbourhood policies could be established, where more advanced cities (many in the cohort of Mission Cities) can help strengthen other local administrations through a transfer of skills and knowledge. This would enable joint ventures to climate neutrality and may unlock the possibility of bolder metropolitan or regional actions.
- **There are multiple avenues to start a climate investment strategy at the city level,** either top-down (prioritising scopes, size, and investment vehicles) or bottom-up (prioritising needs, initiatives, and stakeholders). A blend of the two approaches may deliver more far-reaching programmes and a wider mobilisation of investment flows and stakeholders. On the other hand, what cities cannot afford is not having an investment strategy process in place.
- Companies and banks have crafted and keep crafting new instruments to help fund the climate transition. **Cities should experiment more** with, e.g., green bonds and ESG debt options in general, as well as with newer instruments (e.g., sustainability-linked bonds) that carry penalties for borrowers if they fail to meet certain targets. This could increase the potential of timely and effective implementation. At the same time, it is important for cities to assess if

conventional financing schemes can render better results in the long run.

- **Sector-specific projects can be a practical approach to kick-start an investment strategy, considering the use and integration of multiple financing schemes.** Specifically, some sectors are more attractive for the private sector, thus facilitating the work of investment offices. These sectors are mainly those where concessions or public service contracts are possible, such as energy and transport, utilities and public buildings.

Overall, the analysis of the EOI questionnaire (i) answers the pressing need to deepen our understanding of the enablers and hindrances to finance a greener future in cities, (ii) provides empirical evidence of the drivers for insufficient mobilisation of finance flows in urban climate action, (iii) highlights best practices and specific roadmaps for a truly blended public–private approach to climate investments, and (iv) discusses the role of financial innovation by demonstrating how conventional and innovative instruments need to be both part of the economic toolbox of cities. Many research questions, so far unaddressed, are thus investigated by giving a voice in the scientific debate to hundreds of cities, at different stages of green finance maturity. While this is the main strength of this study compared to existing literature, it also represents its major limitation as the EOI answers strongly depend on the expertise and knowledge of the city representative(s) who filled the questionnaire and on the data available to cities at the time of their expression of interest. Future research will aim at gathering scientific evidence in view of distilling the determinants for green finance, across city-specific attributes (e.g., size, urban layout, demographics) and contextual factors (e.g., climate, creditworthiness, ESG rating, and national and regional governments). Moreover, dedicated investigations will be needed to disclose (i) how strategic would be the assistance from higher governance tiers even in advanced stages of project financing, (ii) how enabling could be the private sector through holistic, innovative, and adaptable approaches, and (iii) how planning and governance processes can be improved to enable holistic visionary approaches and consensus around climate mitigation. Future publications based on the EOI questionnaire will complement this analysis with insights on other critical building blocks for climate-neutral strategies, such as integrated urban planning, technological advancement, and efficient resource management and may provide some initial answers to these additional research questions.

Data availability

The datasets generated and analysed during the current study are not publicly available due to confidentiality agreements.

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Author contributions

GU: conceptualisation, data collection, formal analysis, visualisation, writing—original draft preparation, writing—review editing. ER: formal analysis, writing—original draft preparation, writing—review editing. NV: conceptualisation, data collection, writing—review editing. PF: data collection, visualisation, writing—review editing. PB: writing—review editing.

Competing interests

The authors declare no competing interests.

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Correspondence and requests for materials should be addressed to Giulia Ulpiani.

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