



Research article

Key dimensions of cities' engagement in the transition to climate neutrality

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ABSTRACT

Urbanization and the concentration of energy-consuming economic activities make cities responsible for more than 70% of global greenhouse gas emissions. At the same time, cities are becoming increasingly vulnerable to climate change impacts. The European Cities Mission launched a call in September 2021 to set out on a path towards “100 climate-neutral and smart cities by 2030”. A very large and diverse sample of 344 candidate cities in 35 countries (a subset of the 362 considered eligible to participate in the Cities Mission) was used to conduct this timely research aimed at identifying the main dimensions on which cities are working to achieve a smart and sustainable transition.

The research focused on five main dimensions: local climate planning, climate emergency declarations, participation in networks, international projects and competitions. Results show that only 20 (5.8%) cities have no experience in any of them, while there are 18 (5.2%) cities that have in their background activities that fall under all dimensions. Moreover, networking is the most important dimension, among the five analysed, for cities applying for this Mission, involving 309 cities (approximately 90% of the sample). This is followed by local climate planning, involving 275 cities (80%) and city participation in international projects, involving 152 cities (44%). Cities that have declared a climate emergency are less than a fifth of the sample and are very unevenly distributed in only 37.1% of the countries represented (interestingly, all the UK cities in the sample). Similarly, only 49 cities (14.2%) have received international awards.

The results provide insights into the main efforts currently being made by cities to engage in the transition to climate neutrality and may be useful to practitioners, scholars and policy-makers at all levels to improve their knowledge of the steps they need to take to support this process and amplify its scope.

1. Introduction

Over 72% of the EU population lives in urban areas - defined as cities, towns and suburbs, covering 17% of the land area - and nearly a quarter of the EU population is still at risk of poverty and/or marginalisation (European Commission, 2019). The urban population has continued to grow in the last 50 years at the expense of the countryside that has gradually been depopulated (Nabielek et al., 2016).

Urban areas are at the centre of transformation process to achieve the

European Green Deal goals and to fulfil commitments related to several international initiatives (including the UN's 2030 Agenda for Sustainable Development, the UN-Habitat's New Urban Agenda, the New European Urban Agenda, the Paris Agreement) and to support the New European Bauhaus movement (European Union, 2022a). The latest IPCC's report on Mitigation of Climate Change devotes Chapter 8 to “Urban systems and other settlements” (IPCC, 2022) where it is highlighted that although the global share of emissions that can be attributed to urban areas is increasing, these areas can create opportunities to increase resource efficiency and significantly reduce greenhouse gas

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List of abbreviations			
CCCs	Climate City Contracts	DE	Germany
CEDs	Climate Emergency Declarations	EL	Greece
CoM	Covenant of Mayors for Climate and Energy	HU	Hungary
EC	European Commission	IE	Ireland
EoI	Expressions of Interest	IT	Italy
GDP	Gross domestic product	LV	Latvia
GHG	Greenhouse Gas	LT	Lithuania
LCPs	Local Climate Plans	LU	Luxembourg
SDGs	Sustainable Development Goals	MT	Malta
SE(C)AP	Sustainable Energy (and Climate) Action Plan	NL	Netherlands
TA	Targeted Analyses	PL	Poland
TMNs	Transnational Municipal Networks	PT	Portugal
<i>Country codes</i>		RO	Romania
AT	Austria	SK	Slovakia
BE	Belgium	SI	Slovenia
BG	Bulgaria	ES	Spain
HR	Croatia	SE	Sweden
CY	Cyprus	AL	Albania
CZ	Czech Republic	BA	Bosnia and Herzegovina
DK	Denmark	IS	Iceland
EE	Estonia	IL	Israel
FI	Finland	ME	Montenegro
FR	France	NO	Norway
		TR	Turkey
		UK	United Kingdom

emissions (GHG) through systematic transition pathways of infrastructure and urban form towards net zero emissions. But cities are also historically plagued by air pollution and its effects on public health, and the regulation of anthropogenic emissions from urban sources has also been the focus of various policy instruments in recent decades (Baró et al., 2014; Maione et al., 2016). Air pollution and climate change mitigation are commonly regarded as two challenges independent of each other and addressed within different policy frameworks (Maione et al., 2016), although the synergies and co-benefits between them have long been known (Nemet et al., 2010; Thurston and Bell, 2014; Zhang et al., 2017). Following the principle that “breathing clean air” is a human right according to the United Nations Assembly, some cities in Europe have already pursued greater coherence between local climate and air quality plans developing plans where climate strategies align with actions to reduce air pollution, such as London, Barcelona and Milan (Barcelona pel Medi Ambient, 2011; City Council of Milan, 2022; Greater London Authority, 2018).

As evidence of the central role cities have assumed in the political and scientific debate, cities have become a “living laboratory” in which to test new development models for the cities of the future in order to make them inclusive, safe, resilient and sustainable, as emphasised by the Sustainable Development Goal (SDG) 11 (United Nations, 2023).

Many new categories of cities and their combinations have entered the political discourse, as highlighted by de Jong et al. (2015). These include the ‘sustainable city’, the ‘low-carbon city’, the ‘smart city’ and, recognising the role ICT can play in realising the vision of a sustainable city also the ‘intelligent sustainable city’ (Ratan, 2015). The concept of ‘smart city’ has been quite fashionable in the political arena in recent years (Caragliu et al., 2011) and there are many definitions for it. One of the most widespread definitions is based on the identification of six ‘axis’ (dimensions): smart economy; smart mobility; smart environment; smart people; smart living; and, smart governance (European smart-cities project, 2007). Complementarily, there is a growing need to monitor urban sustainability (Zoeteman et al., 2015) and the success of climate mitigation policies (Rivas et al., 2022b), as well as benchmarking for cities (European Commission, 2015). There have also been

several attempts to measure the performance of sustainable (Lo-Iaco-no-Ferreira et al., 2022), green (Meijering et al., 2014), and smart cities (Ntafalias et al., 2021) based on an indicator system. The use of a set of indicators is also at the basis of EU initiatives for urban sustainability, such as the Green City Accord (GCA) (European Commission, 2022a), and city awards, such as the European Green Capital Award (ECGA) (European Commission, 2022b).

In accordance with the ongoing scientific debate on cities and urban areas as drivers of transformation for the achievement of the SDGs, the EC Horizon Europe research and innovation framework program 2021–2027 launched a Mission (in the following referred as “Cities Mission”) aimed at delivering “100 climate neutral cities in Europe by 2030”. The Mission also aims to ensure that these cities act “as experimentation and innovation hubs to put all European cities in a position to become climate-neutral by 2050” (European Commission, 2020). The Mission considers a smart city “as an enabler of climate-neutral city” pointing out the key role played by smart grids in an urban energy system and the need to systematically integrate smart city projects in the context of cities’ decarbonization (European Commission, 2020).

The Cities Mission went through an ‘early delivery’ phase (2020–2022), in which the cities laid the foundations, and is currently in the ‘main phase’ (2022–2030). At this stage, each of the selected cities is implementing a Climate City Contract (CCC), which formulates goals and targets, ensures stakeholder involvement and includes an action plan for coordinated strategies and their responsibilities ‘towards climate transformation and neutrality’ (European Commission, 2020). Cities are being assisted in this by the Mission Platform from a technical, regulatory and financial perspective. This support is particularly important for small cities that generally suffer from a lack of experience and scarce influence on key mitigation sectors (such as transport and industry) (Rivas et al., 2022a).

Translating the vision of carbon neutrality into concrete strategies and action plans highlights the increasingly important role that ‘urban experimentation’ can play in this landscape of activities and efforts deployed by cities (Shabb et al., 2022). Urban experimentation can allow new innovations, technologies and policies to be tested with

citizens and stakeholders under real conditions in order to induce radical social and technical transformations (Evans and Karvonen, 2010). Urban living labs are among several successful forms of urban experimentation and can enable municipalities, citizens and stakeholders to develop and test social, technical and organisational innovations through co-creation and stakeholder involvement (Castán Broto and Bulkeley, 2013).

But what are the main factors that can guide and support a smart and sustainable transition of urban areas towards carbon neutrality? In agreement with Shabb et al. (2022), who see the Cities Mission as strongly rooted in the commitment that many cities have demonstrated for decades through climate action, this paper argues that this commitment can be operationally expressed through five main dimensions.

First, Local Climate Planning, which is mainly carried out by policy-makers and major stakeholders and is only recently adopting participatory models. Its objective is to address climate change mitigation, by reducing the release of greenhouse gases into the atmosphere, and/or adaptation, by reducing the vulnerability of natural and human systems to the effects of these changes (Dodman, 2012). Reckien et al. (2019) distinguished between “dedicated” Local Climate Plans (LCPs) and ‘vertically’ or ‘horizontally’ mainstreamed LCPs, depending on whether climate objectives are addressed within ‘sectoral’ or ‘cross-sectoral’ plans.

Second, Climate Emergency Declarations (CEDs), which since 2016, when Melbourne’s Darebin Council became the first local government in the world to declare a climate emergency, are reaffirming the climate leadership of local governments (Chou, 2021). As pointed out by Rode (2019), in recent years CEDs have produced an “acceleration in climate policy debates, consciousness and activism that had long seemed unimaginable”, while local governments are calling for “stronger climate planning, and the development of more in-house capacity to respond” (Greenfield et al., 2022).

Third, Transnational Municipal Networks (TMNs). Climate actions in TMNs are “growing strategies for urban climate governance” (Mokhles and Davidson, 2021) and the number of cities participating in TMNs has increased significantly in recent decades (Castán Broto and Bulkeley, 2013). As Schroeder et al. (Schroeder and Bulkeley, 2009) point out, these networks act as drivers of local action by facilitating cities through international cooperation.

Fourth, International competitions and City Awards. Cities participating in these competitions are driven by a desire to get involved and show that they are already on the path to green transition and innovation to create a healthier and smarter environment for their citizens. The awards enable the presentation of design principles and models for other cities and encourage the exchange of good practice (de Vries, 2021). Winning the award can, thus, bring several advantages, especially in terms of prestige, good reputation and tourist attraction and can trigger, as in the case of the European Network of Green Capitals, new collaborations between the cities involved.

Fifth, the participation of cities in International Projects on energy and climate related issues. This is an under-researched aspect, although the EU and the Commission offer several funding programmes to support cities in promoting sustainable urban development and active cooperation (European Commission, 2022c). Among them, the European Commission’s H2020 Framework has provided different funding opportunities on urban issues (Clerici Maestosi et al., 2019), particularly aimed at Lighthouse cities, helping to define the standards that smart cities should achieve (Haarstad and Wathne, 2019). Participation in international projects is almost always decided and carried out mainly by municipal staff and any external consultants.

Following the call for expressions of interest (EoI), which expired on January 31, 2022, 377 cities responded and, after preliminary verifications (mainly on “the population thresholds” and on the inclusion of “the requisite declaration or letter of support from the mayor”), 362 were considered eligible to participate in the Cities Mission (European

Union, 2022b). On April 28, 2022, the list of 100 EU cities plus 12 cities from countries associated with “Horizon Europe”, the EU’s research and innovation programme (2021–2027), was published. These cities were selected by expert reviewers according to the evaluation criteria included in the Info Kit for Cities (European Commission, 2022d), which include the cities’ level of ambition, preparedness, existing and planned commitment to climate neutrality, commitment to involve citizens and stakeholders, as well as inclusiveness, diversity and geographical balance. Maximising the impact at national level is also one of the added values of the Cities Mission.

The very large and diverse sample of cities aspiring to be involved in the Cities Mission provides a very interesting case study to pursue this objective. However, their Expression of Interest (EoI) or a dataset containing their answers to the 374 questions it contained remained confidential and was never made available to researchers, practitioners and public authorities to learn more about these cities and, in particular, to draw inspiration from their previous experiences and future plans towards climate neutrality. A very recent study by Ulpiani et al. (2023) carried out an in-depth analysis of these EoI to assess the credibility and estimate the effects of their mitigation commitments in terms of GHG emissions reduction.

This research aims to complement the lack of public data on the candidate cities to the Cities Mission with a qualitative descriptive analysis of their past and present experiences that represent the starting point towards the challenge of becoming climate neutral, in order to identify the determining factors that drive cities to “get involved” and set ambitious medium-to long-term goals. As the data and information contained in the EoIs are not publicly accessible, this baseline study provides a rich and organised collection of qualitative and quantitative data, made available as a free Mendeley dataset (Salvia et al., 2023), which are valuable for defining and describing the current state of cities’ efforts towards sustainability and climate change mitigation.

Specifically, two main research questions are addressed.

- i) How “active” are the candidate cities in the EU Mission “Climate-Neutral and Smart Cities”, in pursuing smart and climate projects and initiatives?
- ii) What are the most important influencing factors, among the five dimensions analysed, that prompted cities to undertake this process?

This paper is structured in five main sections. After this introduction, a description of the sample analysed, and the methods adopted is provided. The main results obtained are presented and critically discussed, to then conclude with key messages and further research needs.

2. Materials and methods

The research work was developed starting from the definition of the research questions, the identification of the sample of cities to be analysed, the initial identification of the research methods to be used, the selection of the dimensions and the appropriate indicators to help answer the research questions.

The next phase involved data collection and preliminary analysis: key information and data for the selected cities were, first, collected and organised according to the chosen dimensions and indicators in a spreadsheet dataset. A preliminary analysis of this data was then carried out to check its completeness and availability for the selected sample. The research questions and methods were then refined according to the actual availability of the data.

The dataset was then analysed, first for each dimension and then in aggregate form, to allow for a comprehensive description of cities’ efforts to embark on an effective path towards climate neutrality. To this end, a Geographical Information System (GIS)-based representation was used to visualize key data collected for the city sample and identify possible common homogenous trends across geographic regions.

The sample of cities analysed, the main data collected, and the

analytical framework based on the comparison of cities across the selected dimensions are described below.

More details about the city sample can be found in [Appendix A](#) in the Supplementary Materials and in the Mendeley dataset ([Salvia et al., 2023](#)) linked to this article.

2.1. City sample

The participation of cities to the EU Mission “Climate-Neutral and Smart Cities”, the so-called *Cities Mission*, was limited to those with at least 50,000 inhabitants, with the exception of countries with few larger cities (Croatia, Cyprus, Estonia, Ireland, Latvia, Lithuania, Luxembourg, Malta, Slovenia and Slovakia) for which this threshold was lowered to 10,000 inhabitants. The set of candidate cities, therefore, includes ‘cities, towns, major cities and metropolitan regions’, as emphasised by [Ulpiani et al. \(2023\)](#), which will generally be referred to as ‘cities’ throughout this study.

Not all 362 eligible cities gave their consent to be publicly named as “applicants” for this Mission thus the sample analysed initially consisted of all cities included in the list officially published on February 24, 2022 and further updated on March 4, 2022 ([European Commission, 2023](#)). This resulted in a sample consisting of 289 cities in the EU 27, and 48 cities from 8 countries associated or with the potential of being associated to Horizon Europe (Albania, Bosnia and Herzegovina, Iceland, Israel, Montenegro, Norway, Turkey and United Kingdom), for a total of 337 cities. On April 28, 2022, the European commission announced the cities selected to participate in the Cities Mission comprising 100 EU cities plus 12 cities from associated countries ([Otto et al., 2021](#)).

Therefore, the sample was further expanded to include the 7 selected cities (including 4 capital cities) not included in the initial list of candidates: Zagreb (HR), Dublin (IE), Amsterdam (NL), Bucharest (RO), plus Thessaloniki (EL), Padova (IT), and Differdange (LU). The 112 cities were selected based on four main criteria: cities from every Member State, capital cities, small, medium, and large cities, frontrunners and less prepared cities.

[Fig. 1](#) shows the 112 cities selected, but also the overall sample of cities analysed in this study, which includes 296 cities in the EU 27, and 48 cities in 8 associated countries, for a total of 344 cities in 35 countries. In particular, as shown in [Supplementary Figure A1](#), 37 candidate cities (11% of the overall sample) are Italian, followed by 30 German cities (9%), and an almost equal number of Spanish, Turkish and French cities (25, 24, and 23 respectively). Of the 27 candidate capitals, 24 were selected, while Ankara (TR), Jerusalem (IL) and Tirana (AL) were excluded.

[Fig. 1](#) also highlights the distribution of candidate cities to the mission by population size: 133 cities (39% of the total sample) have a population lower than 100,000 inhabitants (size S), followed by 101 cities (29%) between 100,000 and 250,000 inhabitants (size M); 45 of them (13%) have between 250,000 and 500,000 inhabitants (size L); 41 (12%) between 500,000 and 1,000,000 inhabitants (XL), 22 (6%) have a population between 1,000,000 and 5,000,000 inhabitants (XXL). Of the 133 candidate cities (39% of the total sample) below 100,000 inhabitants, only 15 cities were selected: Differdange – LU, Gozo – MT, Tauragė – LT, Lappeenranta – FI, Tartu – EE, Eilat – IL, Velenje & Kranj – SI, Kalamata, Kozani & Trikala – EL, Gabrovo – BG, Sonderborg – DK, La Louvière - BE, Helmond – NL.

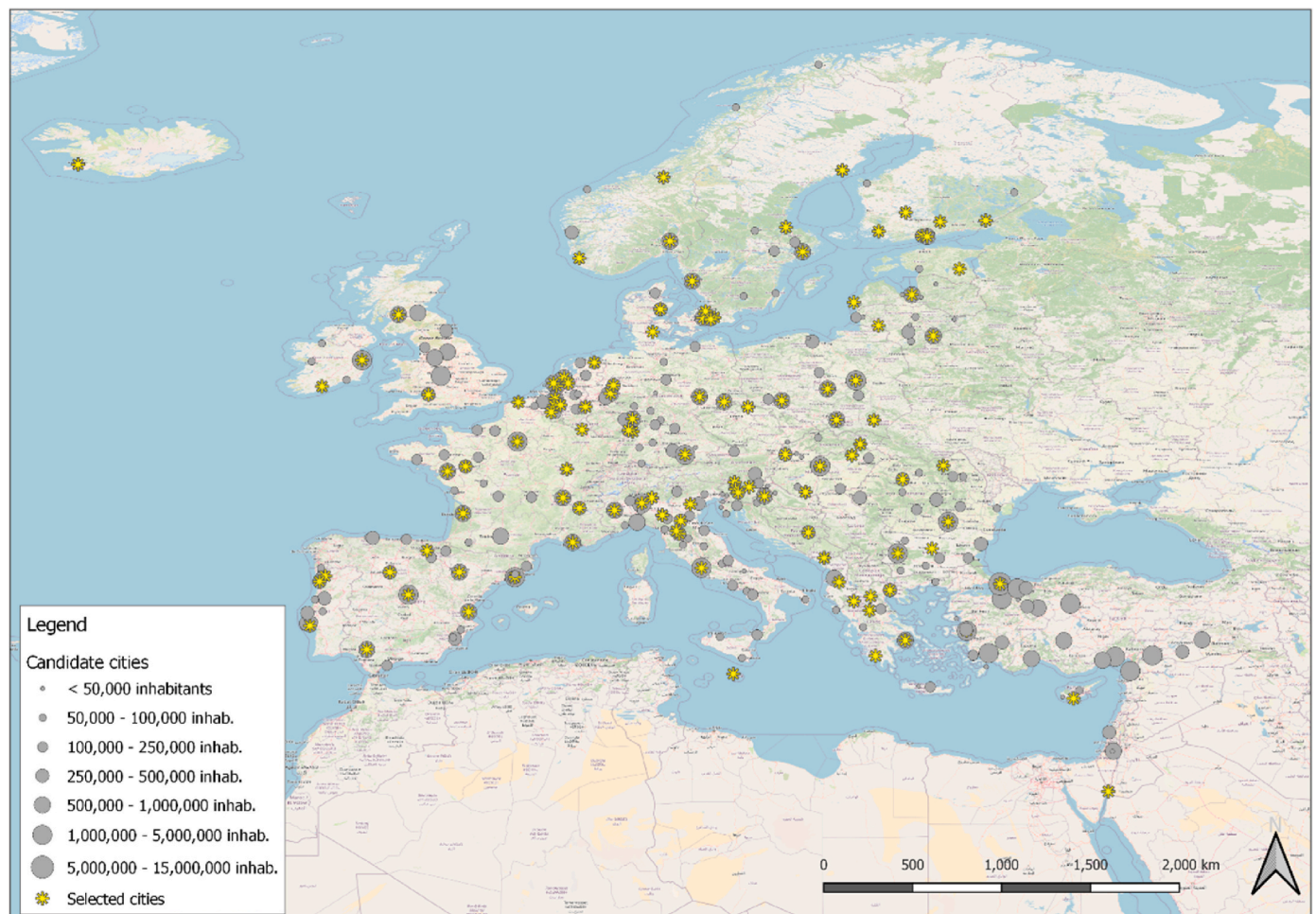


Fig. 1. The analysed sample (344 cities), by population size.

These values highlight the great interest in the Cities Mission that has arisen among smaller cities, which are also particularly active and ready to declare a climate emergency (Salvia et al., 2023), even though when it comes to taking climate action their role is generally less than that of internationally known leaders, hampered by a common lack of capacity (Kern, 2019). As highlighted by Rivas et al. (2022b), smaller cities are also less likely to monitor their GHG emissions for progress towards the climate target set in their LCPs, especially in Southern and Eastern Europe.

The sample cities were also characterised in terms of gross domestic product (GDP) per capita (average 2010–2018) at the NUTS3 level. These data were mainly extracted from Kona et al. (2021) for GCoM member cities and supplemented, for cities not included in this dataset, by those extracted from the Eurostat dataset (Eurostat, 2023). The 2010–2018 average annual per capita GDP of the sample cities varies widely from a low of 3,656 euro per inhabitant per year in Asenovgrad (Bulgaria) to 101,450 euro per inhabitant per year in Ivry-sur-Seine (France), with an average value of 25,864 euro per inhabitant. This wide difference in GDP values also highlights the substantial differences in economic development across the 35 countries in which the cities in the sample are located.

It should be noted that in some cases two or more municipalities applied jointly for EoI, highlighting the importance of inter-municipal alliances to reach a critical mass in the pursuit of common goals, as witnessed also by recent examples of joint SEAPs prepared under the Covenant of Mayors (Cerutti et al., 2013). This was found, in particular, in one case in Greece (West Athens - 9 cities), in two cases in Italy (Assisi including Bastia, Cannara, Bettona and Valfabbrica, Union of Romagna Municipalities), in three cases in Portugal (Comunidade Intermunicipal da Região de Coimbra, Intermunicipal Community of the West, and Municipalities of Abrantes and Tomar), in one case in Spain (Municipalities of Ceuti and Molina de Segura), and in one case in Israel (Municipal Association Beit Hakerem Haglili Cluster). Of these, in the case of West Athens (EL) and Union of Romagna Municipalities (IT) it was not possible to identify the population and other indicators due to the lack of specification of the list of candidate cities involved in the mission application.

2.2. Data collection and analysis

The research method was aimed at characterising the cities in the sample with reference to their level of engagement in previous activities and initiatives related to five main dimensions: 1) development of Local Climate Plans (LCPs), 2) participation in Transnational Municipal Networks (TMNs) and initiatives, 3) Climate Emergency Declarations (CEDs), 4) involvement in international research and demonstration projects, and 5) participation in international competitions and city awards. Since the expressions of interest submitted by the candidate cities were never made public, publicly available data was collected and analysed for each of these five dimensions. This intensive work was mainly carried out in February–October 2022, with the exception of the local climate plans (and their targets) that were updated in March 2023 to record any improvements in the cities' ambition towards carbon neutrality, as described below. To ensure consistency of data, the work was primarily based on latest available data from pan-European databases retrieved from the web (e.g., Eurostat, websites of transnational climate alliances and international cooperation programmes, CORDIS, etc.).

2.2.1. Local climate plans (LCPs)

Previous studies (e.g. (Reckien et al., 2019, 2014; Salvia et al., 2021a,b),) have shown that Sustainable Energy (and Climate) Action Plans - SE(C)APs developed in the framework of the Covenant of Mayors (CoM) are currently one of the most widespread types of LCP in European cities. Therefore, the main source for data for LCPs was the dataset of GHG inventories for 6,200 cities from EU, EFTA countries and UK,

Western Balkans, Eastern and Southern EU neighbourhood countries, signatories of the Global Covenant of Mayors for Climate and Energy (GCoM) initiative as of end of 2019, made available by Kona et al. (2021). Each sample city was searched in this dataset to retrieve information on the year of accession and the mitigation reduction targets set within their SEAP (SECAP). A further check was then made on the CoM website (Covenant of Mayors for Climate and Energy, 2023) to update existing information on the planning actions and ambitions of the sample of cities and remove cities that have not yet adopted a SEAP/-SECAP, but only a Baseline Emission Inventory. Furthermore, for the EU27 and UK cities included in the Urban Audit database without a SEAP/SECAP (116 cities, or 33.7% of the sample), basic information on the existence of a local climate mitigation plan and, if so, the name and website of the plan, were derived from the datasets (Reckien et al., 2020 Salvia et al., 2021a,b); developed from two previous studies. Based on this information, further searches were conducted on the web and on official city websites to identify and update the presence of climate plans using mainly the following keywords: '[City name] climate plan/mitigation plan/adaptation plan' in the native language using Google Translate Web (Google, 2023).

The content of the plans thus found was then analysed to determine the greenhouse gas emission reduction targets and the years within which they were to be achieved (target years).

2.2.2. Transnational municipal networks (TMNs) and initiatives

In this study, the main TMNs on climate change active in Europe were researched and analysed, with a focus on those supporting cities in the development of LCPs. The following energy and climate-related networks and initiatives (Table 1) were therefore taken into account: 100 Intelligent Cities Challenge, C40 Cities (C40), Carbon Neutral Cities Alliance (CNCA), Cities Race To Zero Campaign, Climate Alliance (CA), Energy cities, Eurocities, Covenant of Mayors for Climate and Energy (CoM), Local Governments for Sustainability (ICLEI), POLIS transport innovation, Resilient Cities Network, Green City Accord, Aalborg Charter.

The participation of the candidate cities in the Cities Mission in each of these thirteen initiatives was then verified and recorded in our dataset in binary form (0/1).

2.2.3. Climate emergency declarations (CEDs)

It is argued that local planning processes can also be triggered by climate emergency declarations (Ruiz-Campillo et al., 2021), which are affecting more and more cities around the world and raising public awareness of climate change. Several initiatives are emerging to encourage and support municipalities that adopt a CED, as the Council Action in the Climate Emergency (CACE) (CACE, 2022). There are also climate networks, such as the Climate Alliance, which provide a template for city members to draft their own climate emergency resolution and declaration.

Information on the existence of a CED for the sample cities was taken from the Climate Emergency Declaration & Mobilisation in Action (CEDAMIA) website (Cedamia, 2022), which contains the most comprehensive and up-to-date list of national and local jurisdictions, that have declared a CE. Also in this case, the CEDs availability for each sample city was verified and recorded in our dataset in binary form (0/1).

2.2.4. International projects

An important part of the work consisted in searching the online archives and datasets of the main European Union funding programmes that count the sample cities as beneficiaries and which, in our experience, are the most attractive for the cities wishing to get involved in international projects. The focus was on funding programmes that operate on a pan-European level, covering all EU Member States and beyond. The resulting projects offer cities a privileged opportunity to create networks to develop good practices and facilitate the exchange

Table 1

Overview of the transnational municipal networks and the initiatives and the main web sources used in this study.

Name (acronym)	Main aim	Web source
100 Intelligent Cities Challenge	EC initiative with ~136 cities to achieve intelligent, socially responsible and sustainable growth via advanced technologies on citizen participation and digitisation, green economy, etc.	https://www.intelligentcitieschallenge.eu/cities
C40 Cities (C40)	Global network of mayors of circa 100 world-leading cities collaborating to deliver the urgent climate action.	https://www.c40.org/cities/
Carbon Neutral Cities Alliance (CNCA)	Collaboration of leading global cities working to achieve carbon neutrality in the next 10–20 years	https://carbonneutralcities.org/cities/
Cities Race To Zero Campaign	Global campaign to rally city leadership and support for resilient and zero carbon recovery from the pandemic. It is part of the Race To Zero global campaign mobilising a coalition of 1049 cities, 67 regions, etc. committed to achieving net zero carbon emissions by 2050 at the latest.	https://racetozero.unfccc.int/join-the-race/whos-in/
Climate Alliance (CA)	A group of 2000 municipalities, districts, regional governments, NGOs and other organisations across 25 EU countries working to combat climate change. Each city member commit to continually cut GHG emissions, aiming for a 95% reduction by 2050	https://www.climatealliance.org/fileadmin/Inhalte/2_Municipalities/2022-01-Member_List_International.pdf
Energy cities	Community of thousands of cities in 30 EU countries committed to reach climate neutrality by 2050 and to align their local strategic development with the Paris Agreement.	https://energy-cities.eu/members/
Eurocities	The leading network of major European cities, working together on different focus areas including Climate change and energy transition Smart cities & digital transformation, Clean and active mobility	https://eurocities.eu/cities/
Covenant of Mayors for Climate and Energy (CoM)	Global initiative originating in Europe in which circa 11,000 signatory mayors commit to achieve climate neutrality by 2050, undergoing a structured LCP process	https://www.covenantofmayors.eu/plans-and-actions/action-plans.html

Table 1 (continued)

Name (acronym)	Main aim	Web source
Local Governments for Sustainability (ICLEI)	including mid-term targets Global network of more than 2500 local and regional governments across 125+ countries. Actions go beyond climate and cover sustainability policy and “local action for low emission, nature-based, equitable, resilient and circular development”	https://iclei-europe.org/our-members/
POLIS transport innovation	Network of European cities and regions collaborating to develop innovative technologies and policies for local transport.	https://www.polisnetwork.eu/who-we-are/members/
Resilient Cities Network	Global urban resilience network bringing together knowledge, practice, partnerships, and funding to empower their members to “build safe and equitable cities for all”	https://resilientcitiesnetwork.org/downloadable_resources/Press_Room/Member_Cities.pdf
Green City Accord	A European Commission initiative to make cities greener, cleaner and healthier. By signing the agreement, cities pledge to step up their efforts in five areas by 2030: air and water quality, biodiversity protection, noise pollution and the circular economy.	https://environment.ec.europa.eu/topics/urban-environment/green-city-accord_en
Aalborg Charter	Urban sustainability initiative approved by the participants at the first European Conference on Sustainable Cities & Towns in Aalborg, Denmark	https://sustainablecities.eu/fileadmin/repository/Aalborg_Charter/Aalborg_Charter_signatories.pdf

and transfer of experiences. The six main funding programmes considered in this study are: Horizon 2020, the EU’s research and innovation funding programme from 2014 to 2020; the EU’s European Territorial Cooperation (Interreg) 2014–2020 and, in particular, three funding programmes of Interregional Cooperation involving cities under the strand C (Interreg Europe, ESPON, 2020 and URBACT III); the LIFE Programme; and the Urban Innovative Actions (UIA).

The search was carried out for each funding programme by ad-hoc topics and/or keywords concerning climate, environment, energy and smart cities issues, as specified in Table 2. The partnerships of the set of projects obtained was then analysed, one by one, and compared with the list of cities in the sample. The result of this work is a spreadsheet in our dataset in which the title, the topic and website of the projects involving the sample cities are reported by funding programme.

2.2.5. International competitions and city awards

They represent a valuable experience for a city that can bring several benefits in terms of increased international (and national) visibility and attention, greater attractiveness for future projects and investments, and renewed public interest and sense of belonging among citizens. Winning

Table 2
Overview of funding programmes, search criteria and main web sources used in this study.

Name (acronym)	Main aim	Search criteria	Web source
H2020	The Smart City and Communities Lighthouse projects have resulted in important innovations in the domains of mobility, smart buildings, smart infrastructure, citizen engagement and data platforms, as well as city governance.	Projects were searched on the EC CORDIS database based on the topics: H2020 lighthouse projects, energy, climate change, society, transport and mobility.	https://cordis.europa.eu/search/en
Interreg Strand C	Interregional Cooperation (2014–2020) Interreg Europe aims to help reduce disparities in the levels of development, growth and quality of life in and between European regions.	Using the online search tool, 228 approved projects in the “Green” and “Smart” topics were found. The partnership of each project was analysed and compared with the list of cities in the sample.	https://www.interregeurope.eu/search-approved-projects
	In ESPON 2020 Targeted Analyses (TA) are aimed at transferring knowledge, share experience and facilitate the use of European territorial evidence rooted in real place-based policy development processes. Cities are among the stakeholders of ESPON TA.	For each of the 28 available Targeted Analyses, the list of involved stakeholders was analysed and compared with the list of sample cities, noting the projects and their involved cities.	https://www.espon.eu/targeted-analyses
	URBACT III aims to foster sustainable integrated urban development in cities across Europe. It helps cities to work together and develop integrated solutions to common urban challenges.	The list of 681 projects funded by the URBACT III programme was filtered through four thematic objectives (1. Research, technological development and innovation; 2. Access to and use of ICT; 4. Low carbon economy in all sectors; 6. Environmental protection and resource efficiency) and the sample cities identified.	https://urbact.eu/files/list-urbact-iii-beneficiaries
LIFE	The LIFE Programme is entirely dedicated to environmental, climate and energy objectives. It aims to contribute to the transition to a clean, circular, energy-efficient, climate-neutral and climate-change resilient economy.	Projects funded between 1992 and 2021 were searched on the EC LIFE public database, using the keyword “climate” among their “Titles”, “Themes” and/or “Keywords” and identifying those projects that include the sample cities	https://webgate.ec.europa.eu/life/publicWebsite/search

Table 2 (continued)

Name (acronym)	Main aim	Search criteria	Web source
Urban Innovative Actions (UIA)	It is an Initiative of the European Union that provides urban areas throughout Europe with resources to test new and unproven solutions to address urban challenges.	among the “Beneficiaries”. Projects focused on these topics were considered: Climate adaptation, Air quality, Circular economy, Culture and cultural heritage, Digital transition, Energy transition, Housing, Sustainable use of land and nature-based solutions, and Urban mobility.	https://uia-initiative.eu/en/uia-cities

cities can then serve as role models to inspire other cities and promote best practices to all other cities. Three major awards were looked at dealing with sustainability and innovation: the European Green Capital Award (EGCA), the European Capital of Innovation Award (iCapital), and the European Capital of Smart Tourism (Table 3).

As concerns the EGCA, the winning and finalist cities for the 14-year period from 2010 to 2023 were collected and compared with the list of sample cities. In the case of iCapital, the study focused on the winner (ranked 1st) and runners-up cities (ranked 2nd, 3rd, etc.) awarded from 2016 to 2020 (5 years). Finally, the award-winning cities, the winners of the four categories and the finalists selected for the European Capital of Smart Tourism award (2019, 2020 and 2022) were analysed. For cities that competed several times for the same award, only the best finish was considered (e.g., for Finland’s Lahti, which was a finalist of the EGCA in 2019 and winner in 2021, only the latter result was considered for scoring purposes).

The set of data collected and organised in the previous phases of the research constituted an important knowledge base. The data collected were cross-referenced, organised into a dataset and analysed to obtain useful indications on the level of involvement and activity of the sample cities in each of the five dimensions analysed. To complete the characterisation of the cities in terms of geographical distribution, GIS maps were produced using QGIS software (QGIS project, 2023).

Table 3
Overview of the city awards and the main web sources used in this study.

Name (and acronym)	Main aim and key information	Web source
European Green Capital Award (EGCA)	Each year it rewards cities that stand out for their environmentally friendly urban lifestyle. Starting in 2010, one European city (EU 27) is selected each year as the European Green Capital of the year.	https://ec.europa.eu/environment/europeangreencapital/
European Capital of Innovation Award (iCapital)	A prize to the most innovative cities ecosystems recognising the experimentation of governance practices by city administrators	https://eic.ec.europa.eu/eic-funding-opportunities/eic-prizes/european-capital-innovation-awards_en
European Capital of Smart Tourism	An award for cities that successfully respond to the new challenges and demands of the tourism sector, including the evolution of digital tools, products and services and sustainable development.	https://smart-tourism-capital.ec.europa.eu/cities/competition-winners-2020_en

3. Results and discussion

This section presents and discusses the main results for each of the five dimensions considered, first in numerical terms and then in relation to their geographical distribution. More details on the results obtained for each dimension can be found in [Appendix An](#) of the Supplementary Materials due to space limitations. A related outcome of the research is the Mendeley dataset ([Salvia et al., 2023](#)).

3.1. Each study dimension in figures

The analysis showed that 275 cities (79.9% of the total sample) have a *Local Climate Plan* that sets greenhouse gas reduction targets, both in terms of CO₂ and CO₂ equivalent, while 69 cities (20.1%) have no plan at all. Among these 275 cities, 229 cities (83.3%) have a SEAP and/or SECAP, while 46 (16.7%) cities have another type of LCP.

As detailed in Section 2.2, the status of local climate plans (and their targets) at the end of 2019, as made available by [Kona et al. \(2021\)](#), was updated in March 2023 through an in-depth research and content analysis of new plans (or updates to existing ones), in an attempt to intercept any updates and record any improvements in cities' ambition

towards carbon neutrality. This is in line with the approach taken by [Rivas et al. \(2021\)](#) in assessing the possible influence of signatory cities' continued adherence to the CoM 2020 and 2030 initiatives in terms of developing ambitious plans.

In the case of subsequent LCPs (e.g., referring to CoM, 2020 and then to CoM, 2030) and/or in the case of intermediate targets set within the same LCP, all the available targets were recorded to better define the cities' climate mitigation pathways. [Ulpiani et al. \(2023\)](#) also investigated the various targets set by cities over the years, highlighting the ambition that has grown over the years to achieve carbon neutrality within the Cities Mission. Accordingly, [Supplementary Figure A2](#) shows the greenhouse gas emission reduction targets and the years by which they were to be achieved (target years), referring to different baselines. This diversity of base years on which targets are set is a common limitation of studies comparing the commitments of different cities ([Rivas et al., 2022a](#)).

[Supplementary Figure A2](#) shows that 94 cities (or 34.3% of the 275 cities with an LCP) have set a minimum or initial target to reduce greenhouse gases by 20 per cent or less by 2020, as a direct consequence of the European Union's '20-20-20' climate and energy targets. The only exception is two German cities (Herne and Schweinfurt) that have



Classes of cities mitigation ambition	Average population (2018)	Average GDP per capita [Euro per inhabitant]	Classes of population (No. of cities)					
			S	M	L	XL	XXL	
no target	303885.4	22286.8	40	14	5	4	6	69
20% or less	272559.0	22162.0	15	13	4	2	1	35
21-30%	225693.6	22186.2	20	8	9	7	0	44
31-40%	387768.8	23617.8	26	33	16	16	9	100
41-50%	284006.6	39031.4	8	8	1	2	1	20
51-80%	310541.9	30296.9	15	18	6	5	3	47
more than 80%	777063.4	36360.2	11	7	4	5	2	29
	355080.7	25864.2	135	101	45	41	22	344

Fig. 2. Distribution of sample cities according to their average annual Gross Domestic Product per capita (at NUTS 3 level) and mitigation ambition classes (CO₂/CO_{2eq} reduction targets). The size of the bubbles represents in relative terms the population of the city covered by the corresponding Local Climate Plans.

chosen 2030 as their target year.

This minimum or initial target increases from 21% to 30%, from 31% to 40% and from 41% to 50% for 86 cities (31.4%), 54 cities (19.7%) and 15 cities (5.5%) respectively.

Focusing on the maximum target set by the 275 cities in the sample with an LCP, 79 of them (28.8%) set a maximum GHG emission reduction target of 30%, 100 cities (36.5%) between 31% and 40%, 20 cities (7.3%) between 41% and 50%, 47 cities (17.2%) between 51% and 80%. In addition, the most ambitious cities aiming at carbon neutrality, i.e. with a GHG emission reduction target between 81% and 100%, are 29 (10.6%).

Interestingly, among the last group of cities with the highest ambitions (29 cities aiming for a GHG reduction of more than 80%), 86.2% of them had previously set a less ambitious target and/or had set an intermediate target. This percentage increases slightly (86.5%) when considering the sample cities aiming for a GHG reduction of 75% or more.

This behaviour agrees with the findings of Rivas et al. (2021) who emphasised that ‘previous experience in local climate action initiatives allows municipalities to set more ambitious targets’.

Fig. 2 shows the classes of mitigation ambition of the sample cities, that is the maximum target of CO₂/CO₂eq emission reduction declared in their LCPs, in relation to their GDP per capita and classes of population (as introduced in Section 2.1 City sample). It shows that the average annual GDP per capita ranges from 22,162.0 euro per inhabitant for cities aiming to reduce CO₂/CO₂ emissions by 20% or less to 23,617.8 euro per inhabitant for those with a target between 31% and 40%. On the other hand, cities aiming for more ambitious mitigation targets are those with a higher GDP per capita, reaching a maximum average value of EUR 39,031.4 per inhabitant for cities with a mitigation target between 41% and 50%.

Looking at the size of cities by mitigation target, it can be seen that more than half of the cities (58%) that do not have an EoI, and thus have not set a mitigation target before, are the smallest ones (size S, with a population of less than 100,000). This is certainly due to the considerable number of EoIs submitted by smaller cities, but probably also to the general lack of expertise and resources on local climate planning that characterises small cities.

Regarding the previous involvement of cities in *Transnational*

Municipal Networks and other international energy and climate initiatives, Fig. 3 shows that 309 cities (90%) participate in at least one network, and that the GCoM confirms its predominant role in climate networking as found, for instance, in (Reckien et al., 2014), involving 256 cities (74.4% of the total number of cities in the sample). This is also confirmed by (Ulpiani et al., 2023) which shows that 76% of the 362 candidate cities are signatories of the GCoM. It is followed by the urban sustainability initiative Aalborg Charter, which involves 141 cities (41.1%) and Eurocities (108 cities or 31.4%). Although launched only in June 2020 (C40 cities, 2023) the Cities Race To Zero Campaign involves 78 cities (22.7%) in the sample, followed by ICLEI (72 cities, or 20.9%) that confirms its role as a network of local and regional governments committed to sustainable development and the implementation of Local Agenda 21.

Looking at the *Climate Emergency Declarations*, the data search pointed out that only 63 cities (18.4% of the sample) have declared climate emergency. It is worth noting that 100% of the UK cities in the sample have a CED, confirming the great importance of the CED movement in this country, as highlighted by Salvia et al. (2023).

Turning to the analysis of the sample cities’ involvement in international projects, Fig. 4 summarises the distribution of city projects by funding programme. It can be seen that, as far as sample cities are concerned, 152 cities (44.2%) were involved in international projects, and that URBACT is the most popular funding programme, followed by Interreg Europe, LIFE, H2020 Lighthouse & Cities, UIA and ESPON 2020.

Focusing on each of these funding programmes, it can be seen that within the URBACT III programme 129 projects involving 82 candidate cities to the Cities Mission were implemented. With regard to the most common themes under which these projects were founded, 54 of them (41.9%) were under “6. Environmental protection and resource efficiency”, followed by 39 (30.2%) projects under “1. Research, technological development and innovation”, and 14 (10.9%) under “4. Low carbon economy in all sectors”.

Of the 228 projects approved under the ‘Green’ and ‘Smart’ themes of the *Interreg Europe* programme, 96 involved 57 candidate cities, of which 94.8 per cent were from the EU 27. Focusing on the sub-themes most closely related to the Cities Mission, Zero-carbon urban mobility is the most frequent sub-theme with 20 projects (20.8%), followed by

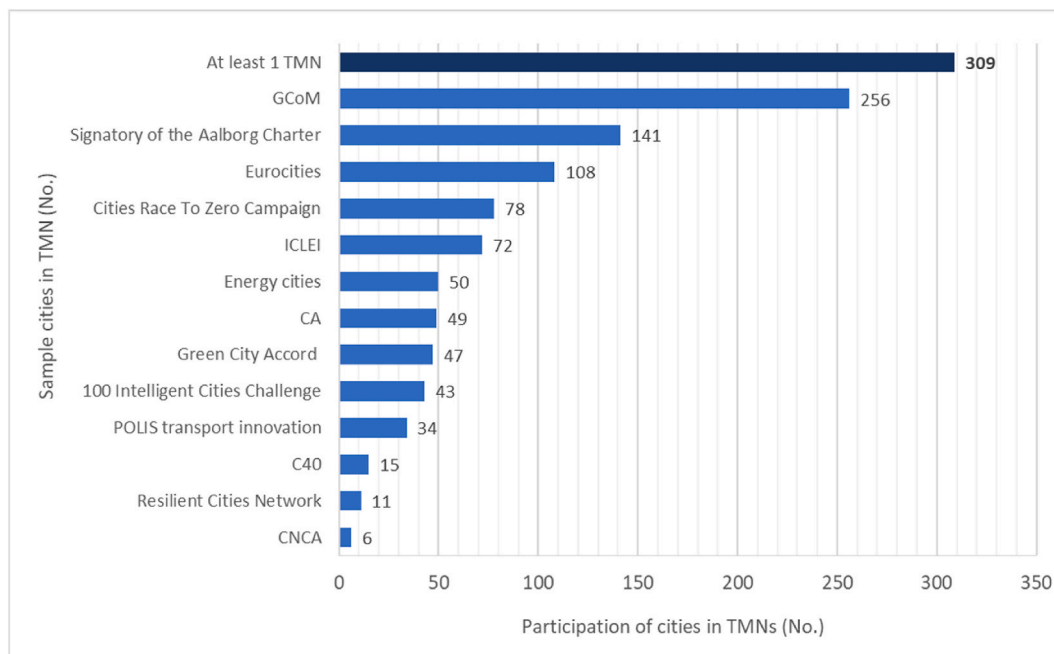


Fig. 3. Total number of cities in the sample involved in a Transnational Municipal Network.

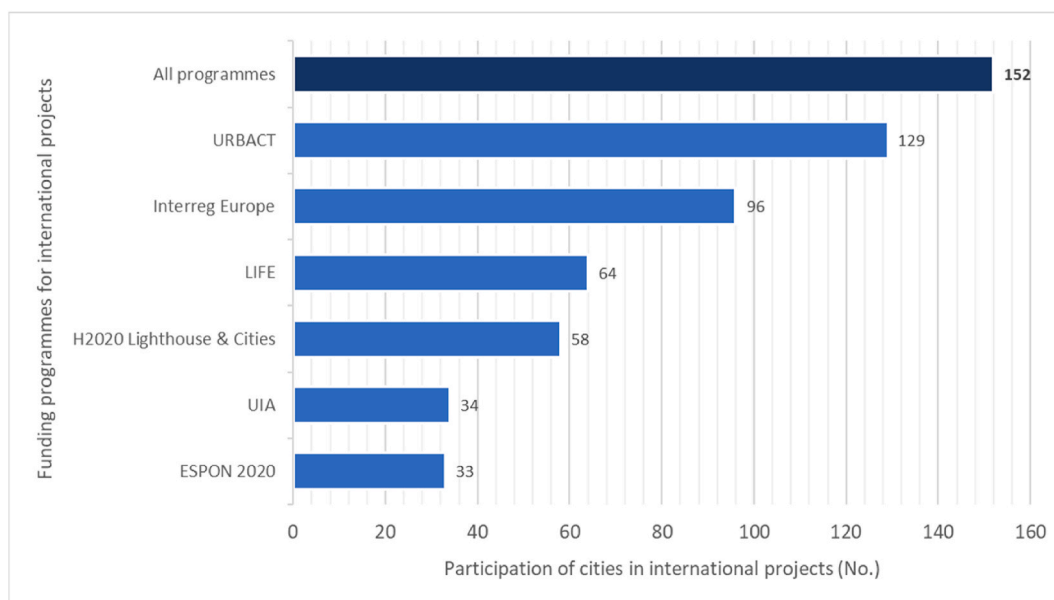


Fig. 4. Number of cities in the sample participating in European projects, by funding programme.

S3, Industrial transition & entrepreneurship with 18 approved projects (18.8%), SME competitiveness with 14 projects (14.3%), Circular economy with 12 projects (12.5%), Renewable energy and Energy efficiency counted together a total of 11 projects (11.5%), Digitisation 7 projects (7.3%), while Climate change involved only 3 projects (3.1%).

In the EC LIFE programme, 49 European champion cities participated in 64 projects, while 58 projects involving the 112 mission cities were funded as H2020 Smart City and Communities Lighthouse projects.

In the EC LIFE programme, 49 European cities in the sample participated in 64 projects, while 58 projects involving 54 candidate cities were funded as H2020 Smart City and Communities Lighthouse projects.

Regarding the *Urban Innovation Actions (UIA)*, 28 European cities and 1 UK city were involved in 34 projects. Air quality, Climate adaptation and Circular economy are the most popular topics in the UIA projects involving the sample cities (5 projects each), followed by Culture and cultural heritage, Housing and Urban mobility (4 projects each) and Digital transition and Energy transition (3 projects each).

For *ESPON 2020*, 24 sample cities were involved among the stakeholders of 33 funded Targeted Analyses (TA): 22 cities from the EU-27, 1 city from the UK (Manchester) and 1 city from the Associated Countries (Oslo). ESPON METRO “The role and future perspectives of Cohesion Policy in the planning of Metropolitan Areas and Cities” is the TA involving most of the sample cities (7), followed by ACPA “Adapting European Cities to Population Ageing: Policy Challenges and Best Practices” with 6 cities.

The cities in the sample are also quite active in terms of participation in international competitions and city awards, as shown in [Supplementary Figure A3](#). The successes achieved by 49 EU 27 and UK cities in the three European competitions considered in this study can be summarised as follows: 5 winner cities of the European Green Capital Award, 5 of the European Capital of Smart Tourism, and 3 of the European Capital of Innovation. Moreover, 15 finalists of the ECGA, 17 finalists and 12 runners-up of the European Capital of Innovation, 5 finalists and 3 category winners of the European Capital of Smart Tourism. This means that 295 cities (85.8% of the total sample) have never achieved a significant placing in these international competitions.

3.2. Overlapping dimensions and their geographical representation

Overlapping the efforts of cities across the dimensions considered in

this study is very useful to provide a comprehensive knowledge base on the efforts of the candidate cities in the Cities Mission and to lay the groundwork for critical comparison and discussion.

The Venn diagram in [Fig. 5](#) compares the activities and experiences of the sample cities in the five dimensions considered in this study. It shows that only 20 (5.8%) candidate cities for the mission have no experience in any of the activities described by the 5 dimensions considered in this study. In opposite, there are 18 (5.2%) cities that have in their background initiatives and activities falling under all five. Interestingly, except for Toulouse (FR), 17 of these are among the 112 selected cities in this first phase of the Cities Mission ([Fig. 1](#)): Amsterdam (NL), Barcelona (ES), Bologna (IT), Bristol (UK), Brussels (BE), Dublin (IE), Glasgow (UK), Helsinki (FI), Krakow (PL), Lyon (FR), Madrid (ES), Malmö (SW), Milan (IT), Nantes (FR), Paris (FR), Torino (IT), Toulouse (FR) and Valencia (ES).

It can also be noted that 44 cities (12.8%) can count on previous experiences falling under one dimension, which is mainly represented by networking (32 cities) and only marginally by LCPs (8 cities), EU projects (3 cities) and CED (1 city), while no city obtained an award without having been involved in other activities.

In contrast, most cities (117 cities or 34.0%) are involved in 2 dimensions, including 103 cities in LCPs and TMNs, followed by 100 cities (29.1%) covering 3 dimensions (LCPs, TMNs and EU projects for 75% of them), and 45 cities (13.1%) in 4 dimensions.

The importance of networking for cities applying for the Mission is also made evident by the fact that 309 cities (89.8% of the sample) participate in TMNs, followed by 275 cities (79.9%) with an LCP, 152 cities (44.2%) were involved in international projects, while only 63 cities (18.3%) declared a climate emergency and 49 cities (14.2%) received an international award. A total of 264 cities are members of TMNs and have implemented an LCP, 146 cities are members of TMNs and have participated in at least one EU project, and 139 cities have participated in an EU project and developed an LCP.

It is worth noting that out of 63 cities with a CED, 59 (93.7%) have developed an LCP, which seems to suggest that the declaration of climate emergency can reach cities not previously engaged in local climate planning, confirming the findings of [Salvia et al. \(2023\)](#) for the Italian case study.

All cities with an international award (49 cities) are members of one or more climate alliance and most of them (47 cities) have developed an LCP.

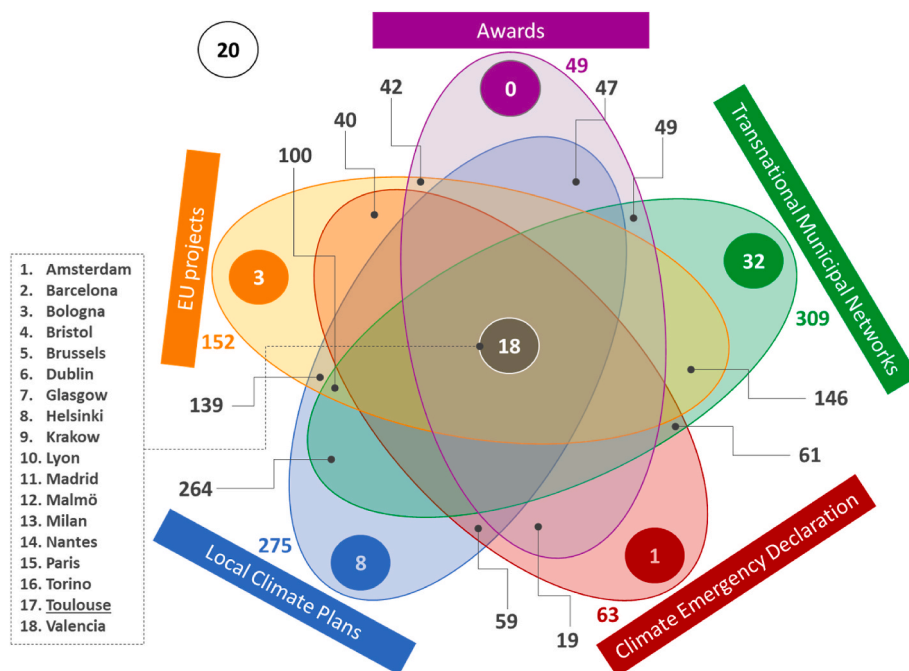


Fig. 5. Overview of the activities and experiences of Cities Mission candidate cities in the 5 dimensions (5-set Venn diagram).

Fig. 6 represents the geographical distribution of the sample cities with reference to their involvement and activity in each of the five dimensions analysed (Fig. 6a-e), and in all of them together (Fig. 6f).

Fig. 6a and 6b highlight the wide and relatively equal spread of LCPs and participation in TMNs of the analysed cities, although some shortcomings can be observed especially for cities in Eastern and Southern European countries.

275 cities (79.9%) have an LCP, in particular all the sample cities in the Nordic countries, such as Denmark, Finland, Norway and Iceland, and the United Kingdom (Supplementary Figure A4), in agreement with the findings of Kern (2019), Rivas et al. (2021), and Salvia et al. (2021a, b) on the geographical distribution of European cities leading in climate action. Notably, all 7 Croatian cities in the sample also have a SEAP/-SECAP developed under the Covenant of Mayors (CoM), as a result of the high percentage of the total urban population (70.3%) covered by the CoM in this country (Cerutti et al., 2013). The predominance of plans developed within the CoM over the total number of LCPs is made evident by the same figure, which also shows the exception of Polish, German and French cities in the sample, where 75.0%, 63.0% and 42.9% of local climate plans were developed outside the CoM commitments, respectively.

308 cities (89.5%) are involved in at least one TMN (Supplementary Figure A5). Besides the GCoM, the urban sustainability initiative Aalborg Charter, and Eurocities, which seems to have reached almost all countries, some geographical peculiarities can be observed.

In particular, the Climate Alliance appears to be significant mainly for German cities (28 out of a total of 49 member cities in the sample), the Cities Race To Zero campaign mainly for French cities (12 out of 78 cities), followed by German, Swedish and UK cities (7 cities each).

108 cities in the sample are members of Eurocities, including mainly French (11), Spanish (10), German, Italian and Dutch cities (8 each). Among the 50 members of Energy cities, 15 French cities stand out, while Aalborg Charter signatories are almost all Italian (22 out of 141) and Spanish (21) followed by 11 Portuguese and 10 German cities.

Fig. 6 c shows that the cities that have declared a climate emergency are distributed among only 13 out of 35 countries, notably the United Kingdom and 12 European countries (Supplementary Figure A6); these include Italian and German cities (14 and 12 respectively), and all British cities included in the sample (8), confirming the widespread

presence of CEDs in this country as reported in the CEDAMIA dataset (Cedamia, 2022).

The sample cities participating in European projects (Fig. 6d) are also very evenly distributed, with a main concentration in Northern Italy, the Netherlands and Belgium. The best performing cities in the sample in each funding programme are as follows.

- *URBACT III*: Parma (IT), Wrocław (PL), Alba Iulia (RO), Manchester (UK) and Suceava (RO) with 4 projects each, followed by Tartu (EE), Paris (FR), Trikala (EL), Gdansk (PL), Braga (PT), and Porto (PT) with 3 projects each.
- *Interreg Europe*: Tartu (EE) and Bologna (IT), being involved in 5 projects each, followed by Reggio Emilia (IT) with 4 projects, Gabrovo (BG), Florence (IT), Genoa (IT), Turin (IT), Timisoara (RO), Gävle (SE) and Birmingham (UK) with 3 projects.
- *LIFE*: Bologna (IT) with 5 projects, followed by Malmö (SE) with 3 projects, while only 9 cities, Helsinki (FI), Turku (FI), Florence (IT), Milan (IT), Padova (IT), Reggio Emilia (IT), Turin (IT), Rotterdam (NL) and Seville (ES) participated in 2 projects.
- *H2020 Smart City and Communities Lighthouse*: Rotterdam (NL), funded under 3 projects, and Bratislava (SK) and Gothenburg (SE), funded under 2 projects. Furthermore, 51 cities in the sample were involved in a single project funded under this H2020 programme theme, which was the focus of a previous study by Clerici Maestosi et al. (2019).
- *Urban Innovation Actions*: Ghent (BE) taking part in 3 actions and Brussels (BE), Paris (FR) and Budapest (HU) in 2 actions each.
- *ESPON 2020*: Brussels, Turin and Oslo with 3 TAs each, followed by Lyon, The Hague, Warsaw and Barcelona with 2 TAs each.

The overall participation of the sample cities in these funding programmes (Supplementary Figure A7) thus highlights the great interest and capacity of Italian cities to participate in international projects (79 projects, or 20.7% of the total number), followed by Spanish (35 projects, 9.2%) and Portuguese cities (27 projects, 7.1%).

As far as international awards are concerned (Fig. 6e), however, most of southern Europe seems to be less active than, for example, northern regions, especially the Scandinavian ones. Copenhagen (DK), Lahti (FI), Grenoble (FR), Lisbon (PT) and Bristol (UK) were winner cities of the

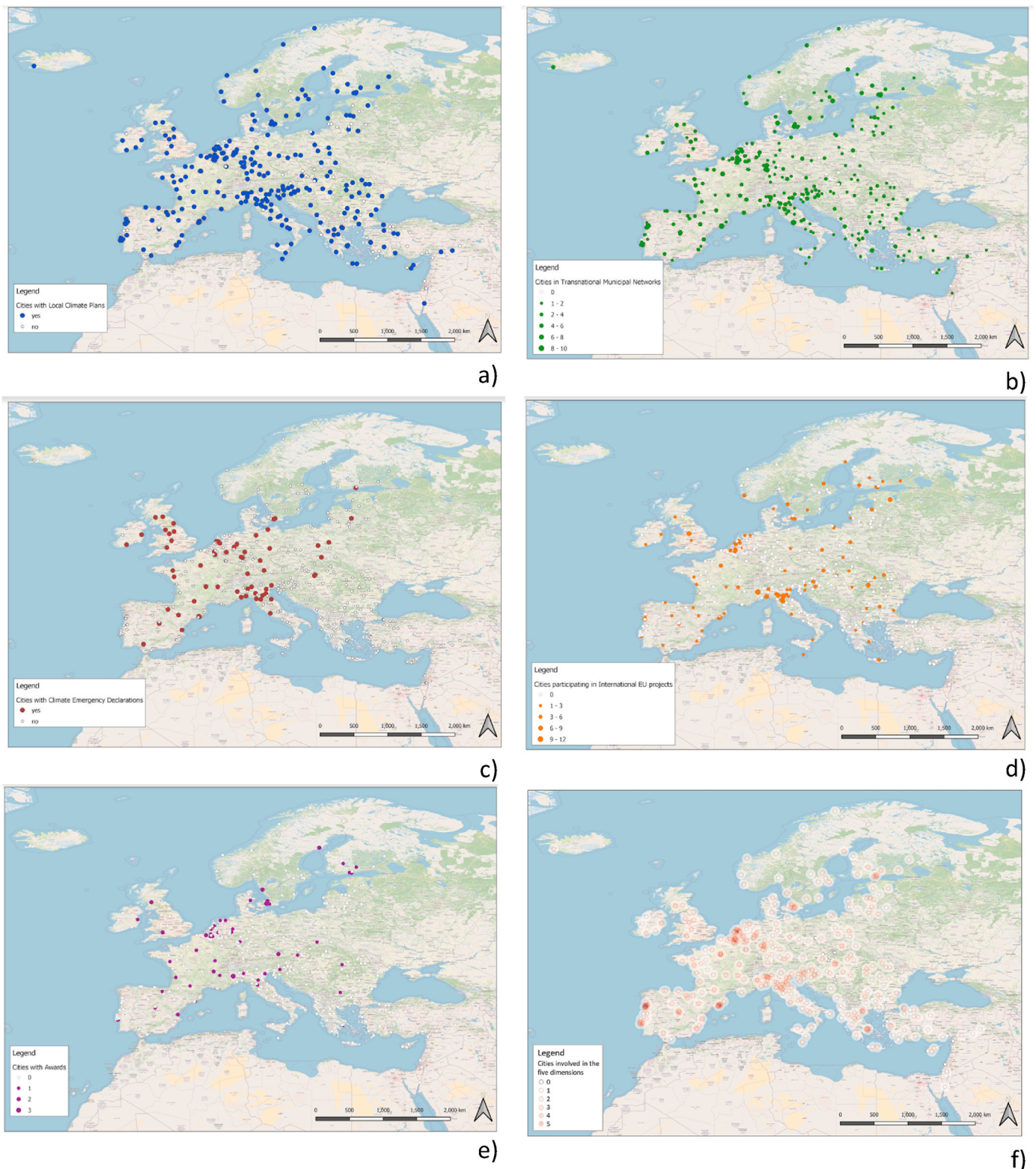


Fig. 6. Geographical representation of the sample cities: with and without Local Climate Plans (a); participating in one or more Transnational Municipal Network groups (b); having declared a climate emergency (c); having been involved in one or more international projects (d); having been awarded in an international competition (e); active in the five dimensions considered (f).

European Green Capital Award, Bordeaux (FR), Gothenburg (SW), Helsinki (FI), Lyon (FR) and Valencia (ES) became the European Capital of Smart Tourism, while Amsterdam (NL), Athens (EL) and Leuven (BE) became the European Capital of Innovation (Supplementary Figure A3). With three appearances each in the list of cities with satisfactory results

in the international awards, Copenhagen (DK) and Turin (IT) are the most successful cities in the sample. In addition, 12 cities are included twice (Linz, Ghent, Helsinki, Lyon, Amsterdam, Lisbon, Valencia, Gothenburg, Helsingborg, Umeå, Bristol and Glasgow) and 35 cities are included only once in the same list.

The intersection of the above data resulted in the overview map in Fig. 6 f, which represents the most active and enterprising cities considering the five dimensions as a whole with progressively darker colours. The map shows interesting clusters of cities very active in climate action in northern Portugal, northern Italy, around Spain's Barcelona, Belgium and the Netherlands.

4. Conclusions

The EU Mission 'Climate Neutral and Smart Cities' (the so-called Cities Mission) launched in 2021 a call for a roadmap towards '100 climate neutral and smart cities by 2030'. The subset of 362 eligible cities, consisting of 344 cities (86% from the EU-27 and the remaining 14% from associated or negotiating countries) listed in the official Mission documents, constitutes a very large and diverse sample and was used in this study to identify the factors that drive cities to set ambitious medium- and long-term climate goals towards climate neutrality. Qualitative descriptive research was conducted by investigating the level of activity of cities in five main dimensions: local climate planning, climate emergency declaration, participation in networks, international projects and competitions.

Since the expressions of interest submitted by the candidate cities have never been made public, publicly available data for each of these five dimensions were collected, analysed and made available as a free Mendeley dataset. To ensure data consistency, the work was mainly based on the latest available data from pan-European databases retrieved from the web.

The analysis of the results by individual dimension showed that 275 cities in the EU-27 and the UK have a local climate plan, which in 83.3% of cases is a SEAP/SECAP developed within the Global Covenant of Mayors for Climate and Energy (GCoM). This reflects the fact that three quarters of the candidate cities for the Mission are members of the GCoM.

More than one third of the cities with a local climate plan set a minimum or initial target in line with the European Union's '20-20-20' climate and energy targets, and about the same number of cities started with a target of 30%. The analysis of the maximum GHG emission reduction targets set by climate plans provides useful information on the ambition of cities: most cities (36.5%) set this target between 31% and 40%, 17.2% between 51% and 80%, while 10.6% of the sample aim for carbon neutrality (i.e., a target above 81%), most of them (86.2%) relying on previous LCPs and/or intermediate targets, confirming the importance of prior experience in local climate action initiatives supported by the scholars.

90% of the cities participate in at least one Transnational Municipal Network: apart from the best known and most studied GCoM, less than half (41.1%) of the cities are signatories of the Aalborg Charter and there are also geographical peculiarities in the success of other initiatives, such as the Climate Alliance in Germany, the Cities Race To Zero campaign and Energy cities mainly in France. Cities declaring climate emergency are less than one fifth of the sample and are very unevenly distributed in only 13 countries (out of the total 35 covered by the study): 100% of candidate cities in the UK, followed by 40% of German cities and 36% of Italian cities. With regard to the distribution of city projects by funding programme, the study shows that URBACT is the most popular funding programme with 121 projects involving the sample cities, followed by Interreg Europe (93), and almost tied LIFE (60) and H2020 Lighthouse & Cities (55). Copenhagen (DK) is the only city in the sample to have won 2 awards (ECGA and the European Capital of Smart Tourism) and was also a finalist in the European Capital of Innovation competition.

The overlapping of the cities' efforts in the five dimensions considered in this study shows that 324 cities in the sample, i.e. 94.2%, had experience in at least one of the activities described by the five dimensions considered in this study. On the other hand, only 18 cities (5.2%) have had experiences that fall into all five categories: 17 of these

are among the 112 cities selected by Cities Mission, demonstrating that the five dimensions selected seem to capture quite well the level of "activism" of the sample cities in pursuing smart and climate projects and initiatives. Networking is the most important influencing factor, among the five analysed, for cities applying for this Mission, involving 309 cities (approximately 90% of the sample). This is followed by local climate planning, involving 275 cities (80%) and the participation of cities in international projects, involving 152 cities (44%). Climate emergency declarations and international recognitions involve only a small fraction of the cities in the sample (63 cities, or 18.4%, and 49 cities, or 14.2%, respectively) with climate emergency declarations geographically concentrated in only a few countries, first and foremost the United Kingdom.

These results and the rich dataset made available by this research can be useful for researchers, planners and decision makers to shed light on the possible motivations for cities to voluntarily embark on the ambitious path towards climate neutrality and to define effective models for making cities greener, more resilient and smarter.

The study shows also that although large European cities are generally quite well organised in terms of planning and networking on energy and climate issues, small cities still suffer from several barriers (first and foremost, the lack of experienced staff and funding) that make them less prepared and competitive. Looking at the 112 cities selected by the Cities Mission, 24 are capital cities and only 15 have a population of less than 100,000. It is worth noting that 8 Expression of Interests were submitted jointly by two or more small cities, highlighting the importance of inter-municipal alliances to achieve critical mass in the pursuit of common environmental and climate objectives. This seems to suggest that, in order to amplify the impact of the City Missions on other cities, special attention must be paid to the involvement and support of smaller cities, to help them untangle and actively participate in the many initiatives that have emerged in recent years on energy and climate transition. This is also important in order to help cities take advantage of the various funding opportunities that are often not utilised simply because they are not aware of them or lack the necessary expertise.

The study has some limitations. First, regarding greenhouse gas emissions: the target set by cities for CO₂ and CO₂eq reductions is often not differentiated, and the emission reduction targets refer to different base years. Secondly, as found in previous studies, old plans often disappear from institutional websites when they are replaced by existing ones, so it is often impossible to keep track of previous plans and their targets. Third, the web search for local climate plans and their objectives in a foreign language can be influenced by the way climate plans are titled in that specific country. In addition, the analysed cities may be involved in other projects not covered by the analysis because they are financed by other funding programmes (e.g., the Cross-border Cooperation (Interreg A) and Transnational Cooperation (Interreg B) strands of the ERDF, the Cohesion Fund (CF), grants from the European Investment Bank, etc.) or categorised under different keywords. The same applies to other transnational municipal networks, climate alliances and initiatives that are steadily increasing over time.

Nevertheless, this study makes an innovative contribution to existing research on the climate action of cities, since, to the best of our knowledge, there is no study of this kind that addresses all five of these dimensions, especially with such a large and diverse sample provided by the subset of candidate cities.

Further research developments will focus on a continuous update and analysis of the climate planning activity of European cities and their ambition to reduce greenhouse gas emissions. This will make it possible, in particular, to monitor and evaluate whether, in what terms and after how long it will be possible to witness a possible rebound effect of the ambition and transition paths implemented by the 112 cities participating in the EU Cities Mission in other urban areas of the relevant countries to evaluate their effectiveness in contributing to the climate neutrality objectives advocated by the Green Deal. In addition, further

research will also focus on urban planning activities in terms of local air pollution and air quality, with the aim of investigating whether synergies and co-benefits between climate change and air pollution can also be found in current planning practices and to provide decision-makers and practitioners with concrete examples and good practices to make their cities more resilient and sustainable.

Credit author statement

MS: Conceptualization, Data collection and curation, Investigation and Visualization, Writing - original draft, Writing - review & editing, FP: Data collection and curation, Investigation and Visualization, Writing - review & editing, VDA: Data collection and curation, Investigation and Visualization, PCM: Data collection and curation, Investigation and Visualization, SGS: Conceptualization, Writing - review & editing, DR: Supervision, Writing - review & editing.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

The data will be made available as a Mendeley dataset at the same time as publication.

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Appendix A. Supplementary data

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