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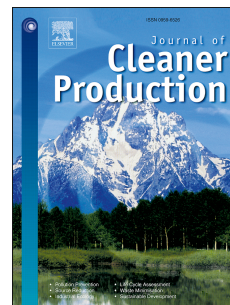
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Title page**• Title: How are cities planning to respond to climate change? Assessment of local climate plans from 885 cities in the EU-28****• Author names and affiliations:**

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How are cities planning to respond to climate change? Assessment of local climate plans from 885 cities in the EU-28

ABSTRACT

The Paris Agreement aims to limit global mean temperature rise this century well below 2 degrees Celsius above pre-industrial levels. This target has wide-ranging implications for Europe and its cities, which are the source of substantial proportions of greenhouse gas emissions. This paper reports the state of planning for climate change by collecting and analysing local climate mitigation and adaptation plans across 885 urban areas of the EU-28. A typology and analysis framework was developed that classifies local climate plans in terms of their spatial (alignment with local, national and international policy) and sectoral integration (alignment into existing local policy documents). We document local climate plans that we call type A1: non-compulsory by national law and not developed as part of international climate networks; A2: compulsory by national law and not developed as part of international networks; A3: plans developed as part of international networks. This most comprehensive analysis to date reveals that there is large diversity in the availability of local climate plans with most being available in Central and Northern European cities. Approximately 66% of EU cities have an A1, A2, or A3 mitigation plan, 26% an adaptation plan, 17% joint adaptation and mitigation plans, and about 30% lack any form of local climate plan (i.e. what we classify as A1, A2, A3 plans). Mitigation plans are more numerous than adaptation plans, but mitigation does not always precede adaptation. Our analysis reveals that city size, national legislation, and international networks can influence the development of local climate plans. We found that size does matter as about 70% of the cities above 1 million inhabitants have a comprehensive and stand-alone mitigation and/or an adaptation plan (A1 or A2). Countries with national climate legislation (A2), such as Denmark, France, Slovakia and the United Kingdom, are found to have nearly twice as many urban mitigation plans, and five times more likely to produce urban adaptation plans, than countries without such legislation. A1 and A2 mitigation plans are particularly numerous in Denmark, Poland, Germany, and Finland; while A1 and A2 adaptation plans are prevalent in Denmark, Finland, UK and France. The integration of adaptation and mitigation is country-specific and can mainly be observed in countries where local climate plans are compulsory, especially in France and the UK. Finally, local climate plans of international climate networks (A3) are mostly found in the many countries where autonomous, i.e. A1 plans are less common. The findings reported here are of international importance as they will inform and support decision-making and thinking of stakeholders with similar experiences or developments at all levels and sectors in other regions around the world.

KEY WORDS: *climate change, Paris Agreement, local climate plans, cities, urban areas, Urban Audit cities, Europe, adaptation, mitigation, SEAP/SECAP*

Abbreviations:

CO₂ – Carbon Dioxide

EC - European Commission

EU – European Union

GDP – Gross Domestic Product

GHG – Greenhouse gases

LCP – Local Climate Plan

SECAP – Sustainable Energy and Climate Action Plan

UA – Urban Audit

UK – United Kingdom

UN – United Nations

RESEARCH HIGHLIGHTS (max 85 characters including spaces):

- Analysis of the Local Climate Plans of 885 Urban Audit cities of EU-28
- About 66%, 26% and 17% of the cities have mitigation, adaptation and joint plans
- There is large diversity across the EU-28 with more plans in Central & Northern EU
- About 70% of cities > 1 million inhabitants have mitigation and/or adaptation plans
- Ratio between autonomous & mandatory LCPs is 1.8 (mitigation) and 5.0 (adaptation)

1. Introduction

Tackling climate change is a priority for the European Union (EU), which has set ambitious short and long-term emissions reduction targets, i.e. reducing greenhouse gases (GHG) emissions of 20% by 2020, 40% by 2030 and 80% by 2080 compared to 1990 levels (European Commission, 2011). Meeting these targets increases the likelihood that the aims of the Paris Agreement under the United Nations Framework Convention on Climate Change (UNFCCC, 2015) can be met. The central aim of the Paris Agreement is to keep global temperature rise this century well below 2 degrees Celsius above pre-industrial levels, and to pursue efforts to limit the temperature increase even further to 1.5 degrees Celsius. Furthermore, the agreement aims to strengthen the ability of countries to deal with the impacts of climate change.

Cities (referring to all local authorities with urban characteristics, i.e. urban areas, towns, and cities) are crucial actors of climate change mitigation and adaptation efforts (Kousky and Schneider, 2003; Rosenzweig et al., 2010), particularly in Europe where approximately 74%¹ of the population lives in urban areas. However, how and why cities engage in climate policy is a matter of current debate (Castán Broto, 2017; De Gregorio Hurtado et al., 2015; De Gregorio Hurtado et al., 2014; Heidrich et al., 2016; Olazabal et al., 2014; Reckien et al., 2015) and the effect of (binding and non-binding) national or international policies on the local level is not well understood (Kelemen, 2010). The state of climate engagement concerning mitigation and adaptation in European cities is partially assessed (Flacke and Reckien, 2014; Reckien, Diana et al., 2014). However, the risk of climate-related impacts and increased vulnerability and exposure of human and natural systems requires climate change mitigation *i.e.* addressing the causes of climate change, as well as climate change adaptation *i.e.* dealing with the consequences of a changed climate throughout all European cities.

There are significant synergies and trade-offs between mitigation and adaptation (Landauer et al., 2015), especially in cities (IPCC, 2015), which can play a key role in developing and implementing climate change programs. Cities are at the interface of local action and the regional, national and international level climate change adaptation and mitigation commitments (Heidrich et al., 2016). Castán Broto (2017) argues that cities play a pivotal role in transnational climate change governance, firstly, because cities can support processes of learning and exchange between local governments and other sub-national organizations. Secondly, they gather local resources and knowledge in order to implement specific schemes. Thirdly, they raise the profile of cities in the international agendas and thereby evoke the interest of political and business actors. In order for cities to excel in this pivotal role, and to contribute towards meeting international decarbonisation targets, cities need to design and implement local climate plans (LCPs). In this study, LCPs are considered as planning documents prepared at the city level that contain policies that are relevant to climate change adaptation and/or mitigation (see also the methods section below and Supplementary Information).

¹ www.statista.com/statistics/270860/urbanization-by-continent/ (last accessed 19 December 2017)

The role of national governments in LCP development and implementation can be highly influential at a local level (Heidrich et al., 2016; De Gregorio et al., 2015). The level of LCP development appears to reflect the governance in each Member State. It appears that wealthier federal governed Member States in central Europe are more proactive initially. Although once national legislation and policies are established LCP development multiplies also in more centrally governed Member States. However, if national governments are unable to provide guidance, cities often align themselves to international networks such as the International Council for Local Environmental Initiatives (ICLEI) Local Governments for Sustainability (ICLEI, 2008) or the Covenant of Mayors (Reckien, Diana et al., 2014). Climate change networks have arguably a large influence on cities in countries without or with weaker national climate policies (Heidrich et al., 2016; Reckien, Diana et al., 2014; Villarroel Walker et al., 2017). The largest networks in Europe are the EU Covenant of Mayors and the UN Compact of Mayors, although other international, national or sub-national/regional networks have formed to support the diffusion of international best practices and to help cities share climate change planning knowledge. Bauer and Steurer (2014) assume that regional climate change networks help prepare policy systems for innovation by spreading information on the magnitude and timing of climate impacts and pinpointing potential response options. However, the influence of networks, relative to local and national governance is only being uncovered (De Gregorio Hurtado et al., 2015; Reckien et al., 2015). Another factor is the adjacency to active states, which seems to urge neighboring countries to also tighten their mitigation policy (Biesenbender and Tosun, 2014; Tompkins and Amundsen, 2008).

European LCPs have been positively associated with the size of a city, gross domestic product (GDP) per capita and with adaptive capacity, representing forms of institutional capabilities and economic strength (Reckien et al., 2015). By contrast, cities with high unemployment rates, warmer summers, close proximity to the coast, and increased projected exposure to future climate impacts have significantly fewer LCPs (Reckien et al., 2015). Lack of resources, capacity in terms of preparedness as well as competence and political salience rank as the top barriers for local climate planning across countries, and especially lower income EU countries (Massey et al., 2014). In many cities lack of political commitment associated to inertia to integrate climate action in local policies arises also as a relevant barrier that needs to be addressed by specific research. Climate change planning in European cities is therefore often determined by local organisational capacity rather than proactive anticipation of future need (Reckien et al., 2015).

European national and local government climate change policies have prioritised mitigation over adaptation (Reckien, Diana et al., 2014). This might be motivated by other benefits of mitigation (Puppim de Oliveira et al., 2013) such as economic savings and improved energy security in addition to reduced emissions (Bulkeley and Kern, 2006; Heidrich and Tiwary, 2013; Hunt and Watkiss, 2011; Kousky and Schneider, 2003; Villarroel Walker et al., 2017; Wende et al., 2012). Notwithstanding, adaptation policy and planning in cities is seldom carried out systematically with a full range of measures across sectors (Wamsler et al., 2013), and often depends on alignment with other programmes (e.g. health) designed to address non-climatic problems as well.

This study analyses the LCPs of 885 cities (formerly Urban Audit (UA))—cities and towns in the

Eurostat repository and jointly collected by the National Statistical Institutes, the Directorate-General for Regional and Urban Policy and Eurostat—for the EU-28 countries. We first develop a typology of LCPs in Europe; next we identify and review existing LCPs according to the typology. We focus on stand-alone, comprehensive LCPs that were developed with climate change as the main motivation. Mainstreamed climate issues in other plans or climate related documents are not considered here. The study particularly addresses two research questions:

- What are the emerging patterns of LCPs distribution across the EU-28?
- How can the overall pattern be explained, i.e. what is the relative importance of local, national or international policies and networks in developing LCPs?

The quality of LCPs or content of LCPs is not assessed rather the distribution is examined and potential influential parameters or drivers are evaluated.

A previous study, conducted on a smaller sample of 200 cities across 11 EU Member States revealed a large variation in climate change response, which was most noticeable across city size on a North–South axes (Reckien et al., 2014a). That study, and a follow-up investigation (Heidrich et al., 2016), discussed the role of national legislations, international networks and activities in motivating the development and implementation of local strategies. A related study also examined potential drivers or barriers among a number of institutional, environmental and socio-economic urban characteristics (Reckien et al., 2015). The analysis presented here represents a significant advance in the number of cities analysed, and the breadth of information considered, paving the way for more detailed consideration of the engagement and preparedness of European cities to climate change.

2. Methodology and methods

2.1. *The sample of cities*

The analysis is based on the entire sample of UA core cities in the EU-28, along with some of the data provided within the UA database², now called "Statistics on European cities". The UA is run by the European Commission and Eurostat (Eurostat, 2017) and developed in cooperation with the national statistical offices to compare data across European cities and towns (urban areas). More than 900 urban areas are covered across EU-28 (plus Iceland, Norway, Switzerland and Turkey). Datasets include statistical information on individual cities and on their commuting zones (called Functional Urban Areas). A city is defined as a local administration unit (LAU) where the majority of the population lives in an urban centre of about at least 50,000 inhabitants. The Greater city is an approximation of the urban centre when this stretches far beyond the administrative city boundaries. The UA city sample currently contains 885 core cities and 22 greater cities or larger urban zones across the EU-28, that represent 25% of the EU's population.

² http://ec.europa.eu/eurostat/statistics-explained/index.php/Statistics_on_European_cities (last accessed: 26 May 2017); <http://ec.europa.eu/eurostat/web/cities/data/database> (last accessed 19th December 2017).

The UA cities are geographically dispersed and varying in size to ensure a balanced and regionally representative sample (see Figure 1) that includes large and smaller cities (below 50,000 inhabitants). The UA adopted the following criteria in order to ensure representativeness of the sample: cities in each country represent about 20% of the population in the country, reflect a good geographical distribution (at least one city from each NUT3 Region), and vary in size to include large and some smaller cities (below 50,000 inhabitants). The topics and datasets that are reported by the database are wide ranging and include for example demography, housing, health, environment, education and many others. The database is of great use for climate change and urban planners alike (Seto et al., 2014). For more details on the methodology, definition and classifications see Supplementary Information and Eurostat (2004).

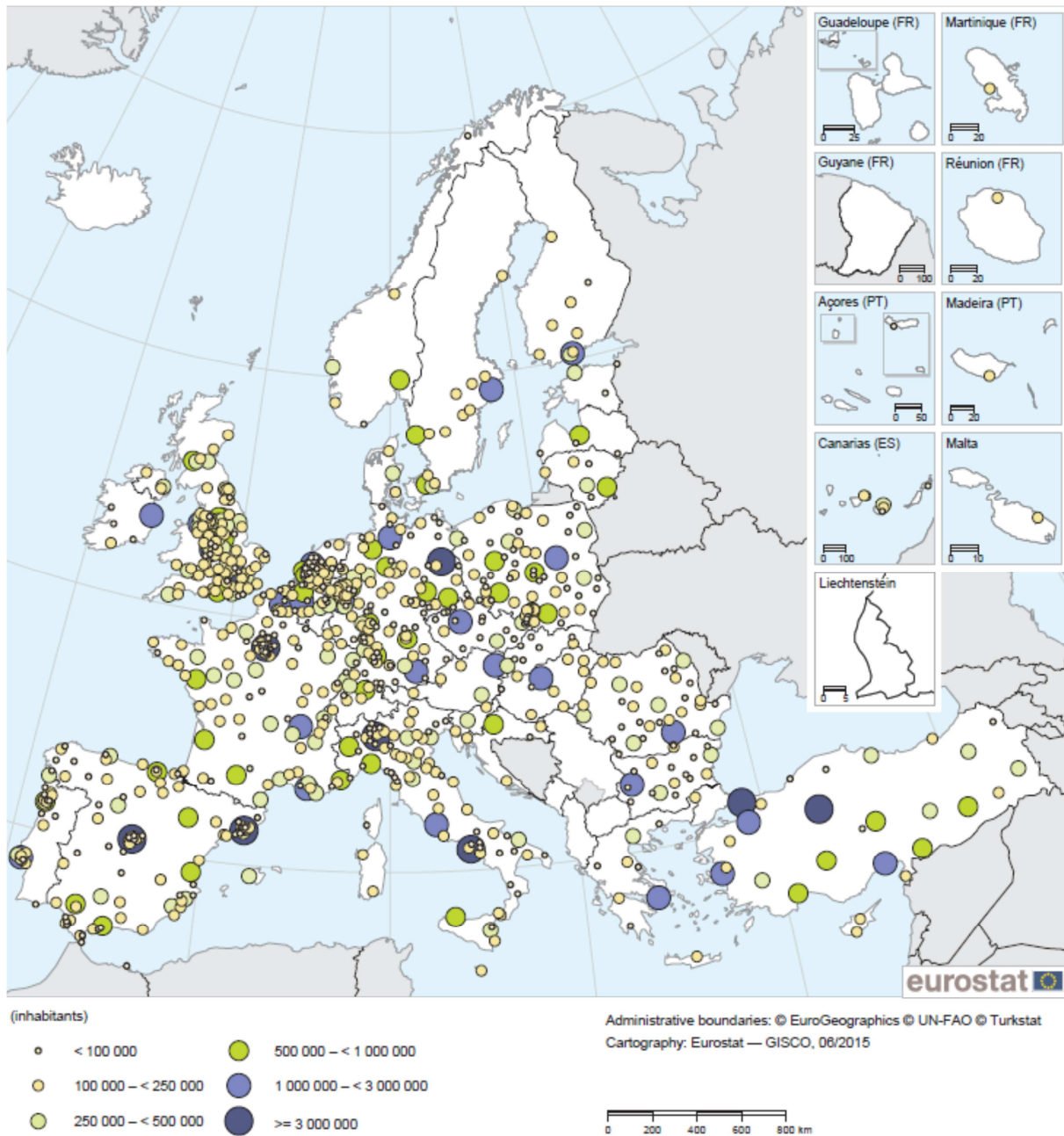


Figure 1: Map of the location of Eurostat Urban Audit cities, showing resident population as of 1st January 2012. Source: Eurostat (2015).

2.2. Classification of Local Climate Plans

The LCPs of European cities are drafted and published in a variety of forms, levels of detail, structure and scope. Some of the plans are comprehensive stand-alone documents, such as comprehensive adaptation or mitigation plans. Other LCPs are integrated into another document such as a sustainability plans, resilience plan, or Local Agendas 21, which sometimes integrate adaptation and mitigation. Increasingly, aspects of climate change are also covered by spatial development plans; sectoral plans, e.g. for heat waves, flooding, air quality or energy shortages; and plans prepared for other purposes but which are nevertheless relevant to climate change.

We developed a typology of LCPs that served as a framework for our analysis. It is based on two dimensions: the level of integration with other local policy documents, and the spatial dimension (Table 1: Typology of Local Climate Plans (LCPs)). This study only comprises LCPs with a clear focus on climate change and those developed for the entire urban region, i.e. plans of type A1, A2, and A3.

Spatial dimension	Integration with or placement within the existing local policy documents					
Type	Comprehensive and stand-alone (A)	Mainstreamed and inclusive (B)	Partial GHG sources and impacts, stand-alone (C)	Operational (D)	Related (E)	Areal (F)
Autonomous (1)	A1 - Local Climate Action Plan of the urban authority/administration that comprehensively addresses climate change, i.e. comprises actions in at least 2 sectors, independent from international networks or international funding in a stand-alone document. Adaptation or mitigation should be mentioned in the title or as a motivation in the preface/introduction, e.g.: Local Climate Mitigation Plan, Local Climate Adaptation Plan	B - Climate change aspects included in another municipal plan, e.g. sustainability plan, resilience plan, development/master plan, core strategy.	C - Local Climate Action Plan, addressing partial aspects of climate change in stand-alone documents, relating to particular sectors, such as energy, or particular impacts, such as heat waves (flooding, etc.)	D - Local Climate Action Plan for parts of the municipal operations, such as universities, schools, housing associations, hospitals, e.g. carbon management plan in the UK. It is site and operation specific i.e. for a hospital, university, or similar.	E - Plan with relevance to the climate issue but without a clear focus and no single section on climate change, e.g. urban development plans, municipal emergency plan, disaster risk reduction plan, civil protection plan.	F - Local Climate Action Plan for parts of a city/urban area.
National regulation (2)	A2 - Legally required Local Climate Action Plan, as stand-alone documents					
Internationally induced (3)	A3 - Local Climate Action Plan that was developed for international urban climate networks, such as Covenant of Mayors and Compact of Mayors, e.g. Sustainable Energy and Climate Action Plan					

	(SECAP), Sustainable Energy Action Plans (SEAP), etc.					
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National regulation (2)	A2 - Legally required Local Climate Action Plan, as stand-alone documents					
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A1 and A2: In this category we included LCPs relevant for the entire urban area that at least mention ‘climate’ or ‘climate change’ in the headline or as main motivation of the plan development in the introduction. In operating terms, these plans were detected through common search engines using common keywords for mitigation and adaptation (see Supplementary Information). In addition, websites of local governments, municipalities and/or authorities were checked with a special focus on those departments that might cover climate action (e.g., planning,

energy, sustainable development). When a Level A1 or A2 plan was missing, we moved to analyse the next level (A3).

A3: In absence of A1/2 LCPs we checked for plans that have been developed within the framework of international networks (in particular the Covenant of Mayors and the Compact of Mayors). We extracted and noted the presence of a Sustainable Energy Action Plan (SEAP) for mitigation; or a Sustainable Energy and Climate Action Plan (SECAP) that combines mitigation and adaptation, developed under the Compact of Mayors. It is important to bear in mind that some plans might have been developed independently and were later submitted to the Covenant of Mayors or the Compact of Mayors.

2.3. Selection of Local Climate Plans for the Urban Audit cities sample

For each country, a team of native or fully language proficient authors, compiled a database of local climate (mitigation and adaptation) plans through a combination of desk/web review and direct contact with local authorities. We used the opportunity of online reporting. Only in cases where further information and/or clarifications were needed we contacted the respective city representative. In all cases the respective plan or policy had to be or to be made available to us. A more comprehensive version of the analysis guidelines can be found in the Supplementary Information.

Within the developed database, we recorded the name, the web link, the date of search and whether the strategies are published in the same document, along with comments for each city and country. The relevant documents (plans and strategies) were downloaded and saved.

The LCP can either be officially adopted or acknowledged and noted by the local government; it can be binding or non-binding. The database includes drafts and finalized plans as well as current and past strategies, i.e. also those that had a timeframe which already passed (e.g. 2010-2016). We include also draft documents because we assume that the planning process is just as important as the plan itself (Heidrich et al., 2013; Millard-Ball, 2013) and that a draft plan can already produce effects such as awareness raising and capacity building. The size of a municipality or local area differs across Europe with implications for what counts as local climate plan. For example, in France, municipalities are small compared to other countries therefore the competence for LCPs was recently transferred from municipalities to city-regions (larger urban area) in the framework of the 2015 territorial reform. We used both municipal and city-region plans as urban plans in the French case, as many cities are still in the process of transferring the competence from one level to the other. A similar issue relates to cities in Ireland and the UK, where one city can make up multiple local authorities (Heidrich et al., 2013). We also reported plans for local authorities within a city (e.g. London) as well as those plans that merge multiple local authorities into one city.

The LCPs were searched between November 2016 and January 2017. In addition, information on membership and climate plans developed as part of international urban networks (e.g. Covenant of Mayors for Climate and Energy, Compact of Mayors) were retrieved from the organisations' website In May 2017.

3. Results

Some countries make it compulsory for cities and larger local governments to develop LCPs; whereas others leave the decision for LCP development up to the local level deciding on engagement and action. In line with the typology shown in Table 1 we here present the results of the analysis. As mentioned above we only report LCPs of type A1, A2, and A3 with the aim to concentrate on cities with strong and focussed climate change targets, i.e. with plans that only and comprehensively address climate change.

3.1. Type A1: Autonomous and comprehensive LCPs

National governments in 24 of the EU-28 countries do not require the preparation of LCPs. Table 2 shows the large disparities across these 24 European countries.

Overall, approximately 36% of the cities in this sample have an A1 mitigation plan. A1 mitigation plans are particularly numerous in Poland, Germany, Ireland, Finland and Sweden with more than two thirds of cities having a mitigation plan. There are far fewer adaptation plans than mitigation plans. Finland is a forerunner having an adaptation plan for most cities. Twelve other countries have an adaptation plan in less than a third of the cities. However, although mitigation LCPs are far more numerous than adaptation LCPs—which would suggest that mitigation precedes adaptation, there are some cities with an adaptation but no mitigation plan. This is, e.g., the case in Zagreb (Croatia) and Bologna and Ancona (Italy). Across the EU-24 sample, about 11% of cities have an A1 adaptation plan.

Some of the plans address mitigation and adaptation issues in the same document. This is the case in most Finnish cities, but also found in some Irish and Belgian cities. Overall only 3% of LCPs of type A1 in Europe are joint plans.

Overall, the cities in 10 of the 24 countries not demanding LCPs do not have any local A1 mitigation or adaptation plans. These are predominantly the cities in Southern, the South-East and the North-East of Europe, but also Luxemburg.

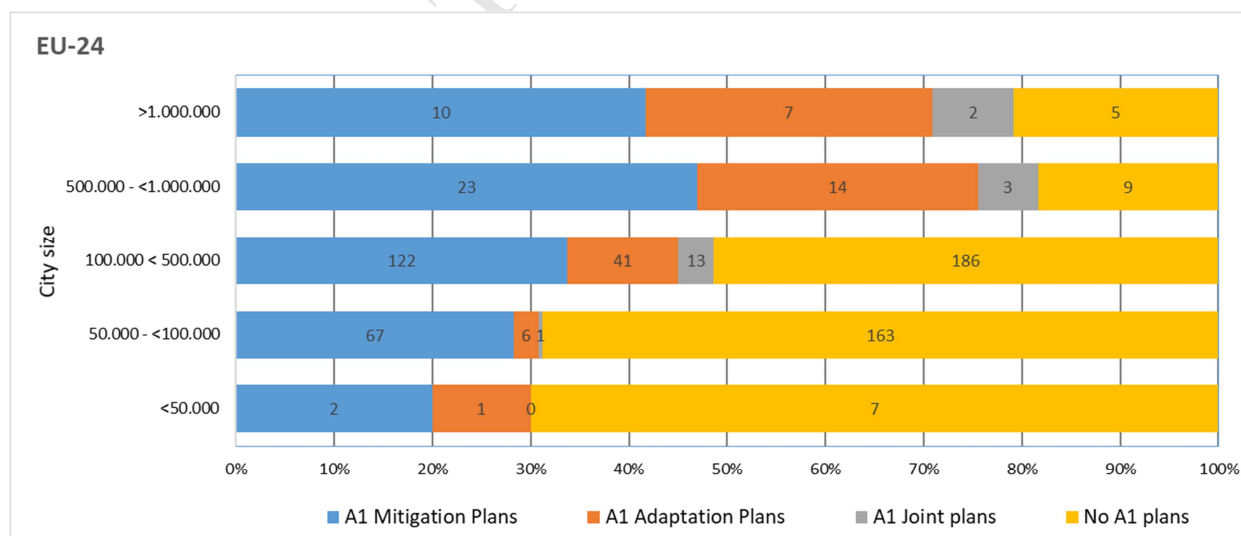
Table 2: Number of autonomous mitigation, adaptation and joint plans in Urban Audit Cities in 24 EU countries where the development of LCPs is not compulsory (excluding Denmark, France, Slovakia, United Kingdom)

	UA Cities	A1 Mitigation plans		A1 Adaptation plans		Joint A1 plans		No A1 plans	
	#	#	%	#	%	#	%	#	%
Austria	6	2	33.3					4	66.7
Belgium	11	5	45.5	1	9.1	1	9.1	6	54.5
Bulgaria	18							18	100.0
Croatia	5			1	20.0			4	80.0
Cyprus	2							2	100.0
Czech Republic	18	1	5.6	1	5.6			16	88.8
Estonia	3							3	100.0
Finland	9	7	77.8	7	77.8	7	77.8	2	22.2
Germany	125	101	80.8	31	24.8	4	3.2	21	16.8

Greece	9							9	100.0
Hungary	10							10	100.0
Ireland	5	4	80.0	1	20.0	1	20.0	1	20.0
Italy	76			2	2.6			74	97.4
Latvia	4							4	100.0
Lithuania	6							6	100.0
Luxemburg	1							1	100.0
Malta	1							1	100.0
Netherlands	51	15	29.4	1	2.0			35	68.6
Poland	68	66	97.1	2	2.9	1	1.5	2	2.9
Portugal	25	1	4.0	6	24.0			18	72.0
Romania	35	1	2.9	4	11.4	1	2.9	30	85.7
Slovenia	2							2	100.0
Spain	109	11	10.1	8	7.3	4	3.7	98	89.9
Sweden	13	10	76.9	4	30.8			2	15.4
EU-24	612	224	36.6	69	11.3	19	3.1	370	60.5

Figure 2 shows how the LCPs in countries without a national obligation to develop an LCP are distributed across city size. The larger the city gets, the more often they have an A1 mitigation plan and/or an A1 adaptation plan. Nearly 70% of the cities above 1 million inhabitants have a mitigation and/or adaptation plan. However, some of the small cities are also active, although the numbers are far from representative, because of the small sample in that category. Most joint plans are developed in large cities of more than 1 million inhabitants, suggesting a relation to economic or institutional capacity.

Figure 2: Distribution of LCPs across city size in the 24 countries without a national obligation to develop plans. Data of urban inhabitants relate to the total population on the 1st of January for the latest year available (2008-2016).



3.2. Type A2: Nationally required and regulated LCPs

While many national governments provide some policy guidance to local authorities on the production and design of LCPs, their content and legal status is often left to the discretion of local authorities. Only, Denmark (DK), France (FR), Slovakia (SK) and the United Kingdom (UK), have made the adoption of LCPs compulsory, setting the legal status and providing guidance on the development and content of plans.

Since 2008, local planning authorities in the UK have the statutory duty to include “policies designed to secure that the development and use of land in the local planning authority’s area contribute to the mitigation of, and adaptation to, climate change” in their local planning documents.³ The legislation demands the inclusion of climate change issues in general local planning documents addressing both mitigation and adaptation. The regulation applies to local planning authorities of all sizes.

In 2010, France made it compulsory for municipalities to adopt LCPs. The French local authorities are required to produce a Local Climate-Air-Energy Plan (*Plan Climat Air Energie Territorial*), which is a stand-alone document. It must include sections on mitigation and adaptation, but most often the focus is mitigation and particularly the link between energy policy, air quality and GHG emissions. However, these regulations only apply to areas with a certain number of inhabitants. Initially, LCPs were compulsory for municipalities of more than 50,000 inhabitants. From 2016 onwards, it includes smaller-size cities, being obligatory to municipalities with more than 20,000 inhabitants..

In Slovakia, it is obligatory to develop an Action Plan for Sustainable Energy (e.g. *Akčný plán trvalo udržateľnej energie mesta Nitra do roku 2020*) which are strategic framework documents. These frameworks are obligatory with regard to the National Energy Policy and the National Framework and Energy Strategy of the Slovak Republic, which relate to the obligations stemming from the EU directives 2006/32/EC - energy end-use efficiency and energy services, 2012/27/EU - energy efficiency, and 2003/87/EC. Cities are given the responsibility to influence the energy consumption and efficiency of their services provided to the public, key stakeholders and end users.

In Denmark, only local climate change adaptation plans are legally required, whereas mitigation plans are voluntary. However, preparing mitigation LCPs is indirectly included in the mandatory municipal heat supply plans, which are obligated by law and aim to reduce the energy sector’s dependence of fossil fuels within socio-economic boundaries (§1 in the Danish Heat Supply Law [LBK no. 523])⁴. Mitigation is organised under the Danish Climate Law [LOV no. 716] from 2014 with the goal to become a low emission society in 2050⁵. Ida Auken, a former

³ UK. *Planning and Compulsory Purchase Act*, section 19, subsection 1A, 2008.

⁴ <https://www.retsinformation.dk/forms/R0710.aspx?id=190081>; (last accessed 19 December 2017)

⁵ <https://www.retsinformation.dk/forms/R0710.aspx?id=163875>; (last accessed 19 December

Environmental Minister made it mandatory for Danish municipalities to include climate change adaptation into municipal spatial plans in 2013. The law amendment came into force by 1st of February 2018. According to the amendment, the municipalities should identify local areas that may be exposed to flooding and erosion as a result of climate change and state these in the municipal spatial plans. Furthermore, if urban development is planned in the designated areas the municipalities have to ensure the implementation of preventive measures. Moreover, Denmark is among the few countries with a Ministry of Climate, which was created in the wake of the UNFCCC Conference in Copenhagen in 2009 combining energy and buildings—even though adaptation and mitigation are in different ministries.

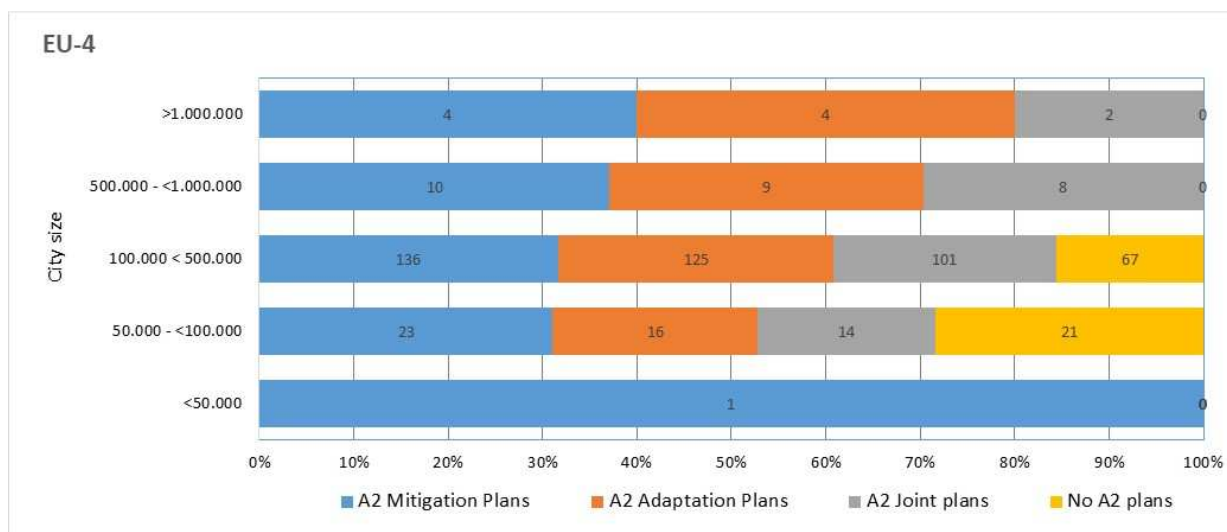
Table 3 shows the number of mitigation, adaptation and joint LCPs produced in the UA cities of Denmark, France, Slovakia and the UK, compared with the availability of LCPs in other countries. Some basic analyses show that cities with a national obligation to develop LCPs are proximately 1.8 more likely to have a mitigation plan and about 5.0 times more likely to have an adaptation plan—although this is also influenced by the time of regulation. Moreover, our sample indicates that the large majority of joint mitigation and adaptation plans (86.8%) were produced in cities with a national obligation and guidance for LCPs. Despite the presence of a legal requirement, one in four cities in France and one in three in the UK do not possess an A2 LCP and thus may not be complying with national regulations.

Table 3: Number of mitigation, adaptation and joint plans in four countries where LCPs are compulsory compared with other countries. The table shows all plans, i.e. also those that were developed before the national law demanded the development of Local Climate Plans.

	UA Cities		A2 Mitigation plans		A2 Adaptation plans		Joint plans		No A2 plans	
	#	#	%	#	%	#	%	#	%	
Denmark	4	4	100.0	4	100.0					
France	98	74	75.5	54	55.1	53	54.1	24	24.5	
Slovakia	8	6	75.0	1	12.5			1	12.5	
United Kingdom	163	90	55.2	95	58.3	72	44.2	63	38.7	
4 countries (A2)	273	174	63.7	154	56.4	125	45.8	88	32.2	
24 countries (A1)	612	224	36.6	69	11.3	19	3.1	370	60.5	
28 countries (A1 + A2)	885	398	45.0	223	25.2	144	16.3	458	51.8	

Figure 3 shows the distribution of compulsory LCPs (A2) across city size. The data reveals the same pattern as for autonomous LCPs in other countries and cities. Larger cities have more often an LCP than smaller cities—although the only city in the category below 50,000 inhabitants also has a plan. This is, however, not representative.

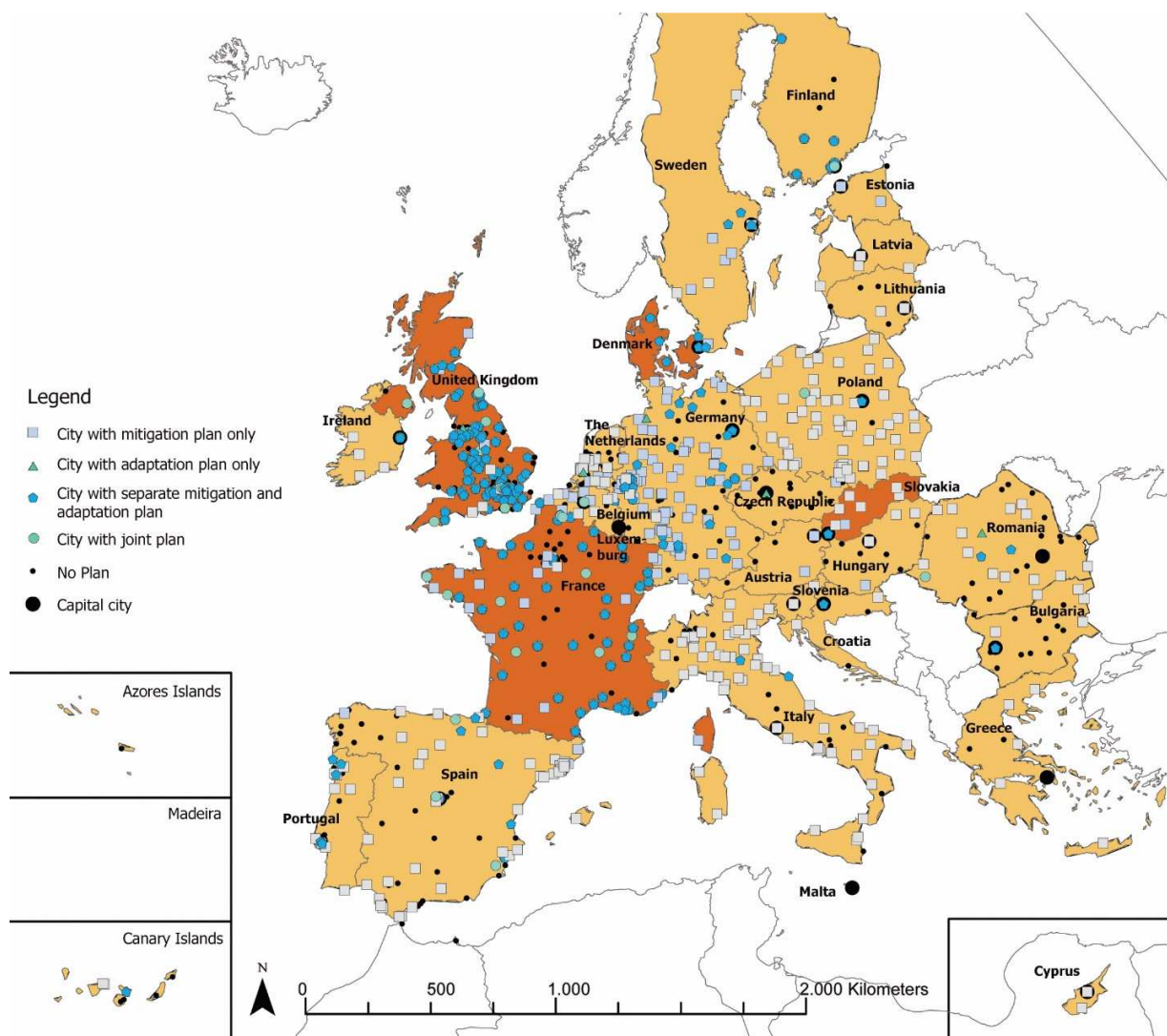
Figure 3: Distribution of LCPs across city size in countries with a national obligation to develop plans. Data of urban inhabitants relate to the total population on the 1st of January for the latest year available (2008-2016).



The findings regarding the distribution of A1 LCPs across countries and European regions is reinforced by

Figure 4. Cities in Eastern and Southern Europe have less A1 mitigation and adaptation plans, whereas Central and Northern European cities often have a LCP.

Figure 4: Status of local climate policies and plans of Type A1 and A2 across 885 cities in the European Union. Countries in beige do not demand their local governments to develop Local Climate Plans; countries in dark orange make it compulsory for cities and larger local governments to develop either Local Climate Mitigation Plans (Slovakia) or Local Climate Adaptation Plans (Denmark) or both (France, UK).



3.3. Type A3: Plans of international climate networks

International climate networks are important initiatives in boosting development of urban local climate plans (Heidrich et al., 2016; Reckien, D. et al., 2014). While there are also regional and national climate networks in many countries, the EU Covenant of Mayors for Climate and Energy and the UN Compact of Mayors are the most important initiatives at the international level.

The Covenant of Mayors brings together some 7000 local and regional authorities voluntarily committed to implementing EU climate and energy objectives on their territory. It was launched by the European Commission (EC) after the adoption of the 2020 EU Climate and Energy Package in 2008, aiming at endorsing and supporting the efforts deployed by local authorities in order to reach the goal of reducing GHG emissions and the implementation of sustainable energy

policies. The Covenant of Mayors (2016) asked signatories to prepare Sustainable Energy Action Plan (SEAPs), which are meant as a roadmap lying the cities' path to reduce carbon dioxide (CO₂) emissions by 20% by 2020. For adaptation, a similar network initiative—Mayors Adapt—was launched in 2014, inviting cities to make political commitments and take action to prepare for the impacts of climate change. End of 2015, both initiatives merged under the new integrated Covenant of Mayors for Climate & Energy. The new Covenant of Mayors asks signatories to prepare Sustainable Energy and Climate Action Plans (SECAPs), adopting the EU 2030 objectives to reduce CO₂ emissions by at least 40% and an integrated approach to climate change mitigation and adaptation⁶.

The Compact of Mayors is an international initiative launched in 2014 at the United Nations (UN) Climate Summit by the UN Secretary General and UN Habitat in collaboration with the C40 Cities Climate Leadership Group (C40), the Local Governments for Sustainability (ICLEI), and the United Cities and Local Governments (UCLG) (C40 ICLEI, 2012). As part of their commitment, cities agree to perform a series of key activities on mitigation and adaptation, including registering/ committing, taking inventory, creating target and metrics, and establishing a local climate action and adaptation plan⁷.

Both initiatives were successful in engaging cities. The EU Covenant of Mayors has been very successful in Europe and the UN Compact of Mayors successfully engaged many cities throughout the world. A Global Covenant of Mayors for Climate and Energy was launched in June 2016⁸ aimed at linking the two initiatives to generate synergies and avoid duplication, especially for EU local authorities.

Quantifying their success we hereafter report some basic statistics and analyses on the Covenant of Mayors and Compact of Mayors, intersecting with the UA sample. Table 4 shows that 356 or 40% out of 885 UA cities are signatories of the Covenant of Mayors. Among them, 334 cities or 38% have a SEAP, 10 cities or 1% have a SECAP and 93 cities or 10.5% have an adaptation commitment (some of them as SECAP). The status of all cities in the Covenant process is on average 2.1 (stage 1 - signature, stage 2 - action plan submitted, stage 3 - results monitored), showing that most cities have submitted an action plan and many more already monitor their results. Countries with the highest stage in the Covenant of Mayors process include Croatia, Lithuania and Portugal.

Regarding Compact of Mayors engagement Table 4, shows that 8% of the UA cities in our sample are members in the Compact of Mayors. They are on average at stage 1.6 in the process (standing for: 1- register commitment, 2 - take inventory, 3 - set reduction targets, 4 - create either a joint or individual action plan to address climate mitigation and adaptation), signifying

⁶ http://www.covenantofmayors.eu/about/covenant-of-mayors_en.html; (last accessed 19 December 2017)

⁷ <https://www.compactofmayors.org/resources/>; (last accessed 19 December 2017)

⁸ http://europa.eu/rapid/press-release_IP-16-2247_en.htm; (last accessed 19 December 2017)

that many cities of the Compact network are still at stage 1 and have not yet taken their inventory.

Comparing this with Table 2 we conclude that cities in countries where autonomous plans are less common tend to produce more internationally-induced plans, whereas cities in countries where autonomous plans are more common tend to engage less in international networks.

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1 **Table 4: Number of signatories of Covenant of Mayors (CoM, 2020 goal), Covenant of Mayors for Climate and Energy (CoM, 2030 goal), and the Compact of Mayors, with average**
 2 **stage in each process. Last update CoM: 22.05.2017, Compact: 20.02.2017. Key: Dark grey is > 66.7%, light grey is > 33.3% and <=66.7%; Mit. = Mitigation; Ada = Adaptation; w/o**
 3 **= without.**

	UA cities		CoM UA Signatories		CoM UA Signatories with SEAP (A3)		CoM UA Signatories w/o A1/A2 Mit. LCP		CoM UA Signatories with SECAP (A3)		CoM UA Signatories w/o A1/ A2 Ada LCP		Adapt Commitment (A3)		Average Covenant stage		Compact member		Average Compact Stage (Badge)
	N	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%		
Austria	6	2	33.3	2	33.3	1	16.7	0	0.0	0	0.0	1	16.7	2.0	0	0.0	0		
Belgium	11	9	81.8	8	72.7	3	27.3	1	9.1	0	0.0	4	36.4	2.3	1	9.1	1		
Bulgaria	18	5	27.8	5	27.8	5	27.8	0	0.0	1	5.5	1	5.6	2.2	3	16.7	1		
Croatia	5	3	60.0	3	60.0	3	60.0	0	0.0	0	0.0	1	20.0	3.0	1	20.0	1		
Cyprus	2	2	100.0	2	100.0	2	100.0	0	0.0	0	0.0	0	0.0	2.5	1	50.0	1		
Czech Republic	18	3	16.7	1	5.6	1	5.6	0	0.0	0	0.0	2	11.1	1.7	0	0.0	0		
Denmark	4	4	100.0	4	100.0	0	0.0	0	0.0	0	0.0	1	25.0	2.0	1	25.0	4		
Estonia	3	2	66.7	2	66.7	2	66.7	0	0.0	0	0.0	1	33.3	2.5	0	0.0	0		
Finland	9	8	88.9	7	77.8	0	0.0	0	0.0	0	0.0	2	22.2	2.5	3	33.3	1		
France	98	32	32.6	30	30.6	0	0.0	3	3.1	0	0.0	4	4.1	2.1	5	5.1	1		
Germany	125	37	29.6	35	28.0	2	1.6	3	2.4	0	0.0	14	11.2	2.4	6	4.8	1.5		
Greece	9	5	55.6	4	44.4	5	55.6	0	0.0	0	0.0	1	11.1	2.6	1	11.1	2		
Hungary	10	5	50.0	4	40.0	4	40.0	0	0.0	0	0.0	1	10.0	1.8	2	20.0	1		
Ireland	5	4	80.0	3	60.0	1	20.0	1	20.0	0	0.0	3	60.0	2.3	0	0.0	0		
Italy	76	58	76.3	56	73.7	56	73.7	0	0.0	0	0.0	15	19.7	2.4	5	6.6	1		
Latvia	4	4	100.0	3	75.0	4	100.0	0	0.0	0	0.0	1	25.0	2.5	1	25.0	1		
Lithuania	6	2	33.3	2	33.3	2	33.3	0	0.0	0	0.0	0	0.0	3.0	0	0.0	0		
Luxemburg	1	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0.0	0	0.0	0		
Malta	1	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0.0	0	0.0	0		
Netherlands	51	15	29.4	15	29.4	6	11.8	0	0.0	0	0.0	2	3.9	2.1	2	3.9	4		
Poland	68	9	13.2	7	10.3	1	1.5	0	0.0	0	0.0	2	2.9	2.2	5	7.4	1.2		
Portugal	25	17	68.0	17	68.0	15	60.0	1	4.0	0	0.0	5	20.0	2.8	5	20.0	2.2		
Romania	35	22	62.9	18	51.4	16	45.7	0	0.0	0	0.0	3	8.6	2.0	1	2.9	1		
Slovakia	8	4	50.0	2	25.0	2	25.0	0	0.0	0	0.0	3	37.5	1.5	0	0.0	0		
Slovenia	2	2	100.0	2	100.0	2	100.0	0	0.0	0	0.0	0	0.0	2.0	2	100.0	1		
Spain	109	66	60.6	64	58.7	49	45.0	1	0.9	1	1.0	20	18.3	2.4	10	9.2	2.2		
Sweden	13	10	76.9	10	76.9	3	23.1	0	0.0	1	7.7	2	15.4	2.6	5	38.5	1.6		
UK	163	26	16.0	26	16.0	3	1.8	0	0.0	0	0.0	4	2.5	2.3	8	4.9	2.4		

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EU-28	885	356	40.2	333	37.6	188	21.2	10	1.1	3	0.3	93	10.5	2.1	68	7.7	1.6
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Table 5 summarizes the statistics and shows that A1 and A2 LCPs are slightly more numerous than A3 LCPs. It further shows that 66.2% of EU UA cities have either an A1, A2, or A3 mitigation LCP; that 25.5% have an adaptation LCP; 16.6% are joint LCPs; and 29.8% have neither an A1, nor an A2 or an A3 LCP.

Table 5: Number of mitigation, adaptation and joint plans of Type A1, A2, and A3. Please note that we count the existence of a SECAP and Adapt Commitment as A3 adaptation LCP, because no more detailed information was available. Key: w/o = without.

	UA Cities		Mitigation plans		Adaptation plans		Joint plans		No plans	
	#	#	%	#	%	#	%	#	%	
A1 - 24 countries	612	224	36.6	69	11.3	19	3.1	370	60.5	
A2 - 4 countries	273	174	63.7	154	56.4	125	45.8	88	32.2	
A3, in cities w/o A1 or A2 – 28 countries	885	188	21.2	3	0.3	3	0.3	697	78.6	
A3, in cities with A1 or A2 – 28 countries	885	333	37.6	103	11.6	10	1.1	552	62.4	
All cities with A1, A2 or A3	885	586	66.2	226	25.5	147	16.6	264	29.8	

4. Discussion and Conclusion

Data collected for this study was last updated in January 2017 (with some exceptions, e.g. climate networks). This allowed plans developed in the wake and immediately after the 2015 UNFCCC Conference in Paris, which saw a significant increase of climate action at all levels to be included. Our dataset includes 885 cities in all 28 EU countries, being the first of its kind by providing a detailed database of local climate action. It is thus comprehensive and much more representative in terms of establishing patterns and effectiveness in achieving EU policy targets to combat climate change and meet the objectives of the Paris Agreement. This paper has introduced this data and provided an initial analysis. We intend to update this work at regular intervals to map, observe and compare the evolution of local climate planning over time. This will inform decision-making and thinking by stakeholders at all levels and sectors.

4.1. Methodological insights and challenges

- 1) **The accessibility of LCPs can be challenging, especially for medium and small-size cities.** In a few cases, we found some evidence of the existence of LCPs, but could not find a copy of the plan. LCPs might exist but are not always publicly available on the webpages of the municipality. While we are certain to have found the vast majority of LCPs for our sample, some other LCPs probably exist.
- 2) **The use of shared definitions across countries proved challenging.** For instance, despite the co-development of a theoretical framework providing a clear distinction of comprehensive, mainstreamed, partial and related plans the application of the framework to the different national situations proved difficult in practice. For example, it is difficult to know which plan was first when cities have both an A2 and A3 plan. We recorded most of them as A2, unless it was absolutely clear that the plan was only developed for the Covenant of Mayors and afterwards published as LCP. Similarly, there are difficulties to distinguish between the other categories, B, C, D, E, and F, not considered in this paper. For example, the distinction between A3 plans and C – Local Energy Plans is not straight forward. Additionally, the typology suggests a hierarchy moving from A to E, but this is not intended and should not be seen like it. A to E just shows the level on concentration or focus on the climate

change issue. However, level B plans can be more successful than Level A plans in addressing and implementing climate change issues in the real world, as climate issues are mainstreamed in other local political processes. What can also make classifying plans difficult is the fact that mitigation and adaptation are not always dealt with at the same level of detail, depth, or length. On top of that, in some countries there is a recent trend to either include LCPs into more integrated sustainability plans, such as in The Netherlands; in other countries, the opposite trend can be observed, with the transformation of Local Agendas 21 into more technical LCPs, such as in France. In this paper, we did not include sustainability plans or Local Agendas 21 in our study, which means that we might underrepresent the level of engagement in European cities.

- 3) **Another issue relates to recent municipal reforms of local authorities.** This had a significant impact on local climate planning, whose competence was sometimes moved from one level to the other. For instance, France merged a large number of smaller intermunicipal authorities into larger ones and the competence of LCPs moved up from municipalities to intermunicipal authorities, while Italy transformed its counties (*province*), which were previously responsible for most urban planning, into large intermunicipal authorities. In some cases, this made existing plans obsolete, thus creating a legal 'in-betweenness' that we found difficult to characterise. In this assessment, we included the lowest-level plans (e.g. municipal over intermunicipal), unless more recent higher-level plans existed in a context of territorial reform, and all existing plans regardless of their status (drafted, adopted, expired or obsolete). Then, lower-level plans interact with higher-level plans in the respective spatial planning systems. This is particularly salient in the case of water and climate plans and generally adaptation plans, which usually cover larger areas, such as in The Netherlands, Finland, and Italy. To keep consistency we therefore also included local plans of urban regions (larger areas with adjacent municipalities that are all part of the UA or plans for an urban region with its hinterland). For example, the metropolitan region of Helsinki has a plan that also covers the adjacent UA cities of Esbo, Vanda and Lahtis. It should also be mentioned that the restriction to UA cities introduces a distortion of representability. For some countries (e.g. Portugal where UA cities cover only 8% of municipalities), cities outside the UA may still have LCPs that were not accounted here.

4.2. Interpretation of the findings

- 1) **With regard to the drivers of LCPs, this assessment shows that the administrative level that promoted their development has an impact on local climate planning.** There are countries with a significant (three third or more) number of autonomously developed mitigation plans (type A1): Poland (97.8%), Germany (80.8%), Ireland (80.0), Finland (77.8%) and Sweden (76.9%). This may be due to several factors, such as the level of climate awareness, the presence of local expertise, the level of administrative decentralization, the presence of institutional capacity or political commitment, the impact of political parties and the amount of funding available. Future research might be able to elucidate which factors contribute the most and how they interact with each other and other factors.
- 2) **We found that the presence of national regulation has a significant impact on local climate planning.** Cities in Denmark, France, Slovakia and the UK, where LCPs are compulsory, are about 1.8 times more likely to have a mitigation plan, and

5.0 times more likely to have an adaptation plan than cities in other countries—although this is also influenced by the time of regulation. The case of Denmark is particularly interesting. This can perhaps be explained by the fact that in 2007 Denmark merged 271 smaller municipalities (*kommune*) into 98 larger units⁹, most of which have at least 20,000 inhabitants. This gives them significant human and financial resources compared to most other countries in the EU. Many of the responsibilities of the former counties were taken over by the larger municipalities, including climate policy. Moreover, our sample indicates that almost all joint mitigation and adaptation plans (87.0%) were produced in Denmark, France, Slovakia and the UK. It seems that, without national regulation, local authorities are reluctant or do not have the capacity to produce joint plans. It is worth highlighting that French and British cities represent about 30% of all UA cities and are therefore particularly well-represented in this analysis.

- 3) **Nevertheless, this assessment also shows that there are countries where a significant number of LCPs were developed under the Covenant of Mayors:** Cyprus, Denmark, Slovenia, Latvia (100.0%), Finland (88.9%), Belgium (81.8%), Ireland (80.0%), Sweden (76.9%), Italy (76.3%) and Estonia (66.7%). Within our sample, the EU Covenant of Mayors has five times as many signatories as the UN Compact of Mayors. No country has a significant number of members of Mayors Adapt. In the light of these results, we suggest that, in countries where autonomous LCPs are rare and cities are not required by national legislation to develop plans, such as Cyprus, Slovenia, Latvia, Belgium, Ireland, Italy, Malta, but also Portugal (64.0%), Romania (62.9%) and Spain (60.6%), international networks such as the Covenant of Mayors raise the awareness, build the capacity and, often through EU-funded projects, provide the expertise and the funding necessary to develop LCPs. The case of Spain and Italy is particularly interesting, as the number of Spanish and Italian signatories is particularly high. They represent more than one-third (35.0%) of the signatories of the Covenant in our sample, while local authorities from Italy and Spain constitute more than three-quarters (76.7%) of all the signatories at the time of writing. However, the UA sample is probably not a representative sample in terms of cities signatories of the Covenant of Mayors, considering that it contains only few cities with less than 50,000 inhabitants, while local authorities of all sizes can sign the Covenant. This is the case for Malta, where several smaller cities that make part of the Valletta UA city have submitted action plans to the Covenant of Mayors for Climate and Energy but these do not cover the entire UA city. The Covenant of Mayors and the UA cities also differ in other ways, e.g. the Covenant of Mayors is mostly focused on what the local authority owns, rather than the city as a whole; the timeframe is often different; and it covers administrative areas of a few hundred people to several million. This means that, while our sample can be considered as representative of European cities, it is perhaps not fully representative of the signatories of the Covenant. Nevertheless future research should assess which factors contribute the most in preparing LCPs and how these interact.

4.3. Final conclusions

Our analysis from 885 cities across the 28 European countries has shown that approximately

⁹ <http://www.oim.dk/arbejdsomraader/kommunal-og-regionaloekonomi/kommunale-opgaver-og-struktur/kommunalreformen-i-2007.aspx>

66% of the EU UA cities have either an A1, A2, or A3 mitigation LCP; that 26% have an adaptation LCP; 17% are joint LCPs; and about 30% of cities have neither an A1, nor an A2 or an A3 LCP.

Although far more numerous, mitigation plans does not always precede adaptation plans, which is different from an earlier assessment (Reckien, Diana et al., 2014). There is large diversity across the EU with more plans in Central and Northern EU, which is a recurrent picture. City size, national regulation and international climate networks are influential parameters in driving LCPs. About 70% of the cities above 1 million inhabitants have an A1 or A2 mitigation and/or an adaptation plan. The difference in LCPs between countries that demand local authorities to develop LCP and those that do not is of a factor 1.8 for mitigation and of factor 5.0 for adaptation. We also saw that the EU Covenant of Mayors has an important role, encouraging smaller cities, e.g., in Italy and Spain, as well as in other countries, to engage in climate action.

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6. References

- Bauer, A., Steurer, R., 2014. Innovation in climate adaptation policy: are regional partnerships catalysts or talking shops? *Environmental Politics* 23(5), 818-838.
- Biesenbender, S., Tosun, J., 2014. Domestic politics and the diffusion of international policy innovations: How does accommodation happen? *Global Environmental Change* 29, 424-433.
- Bulkeley, H., Kern, K., 2006. Local government and the governing of climate change in Germany and the UK. *Urban Studies* 43(12), 2237-2259.
- C40 ICLEI, 2012. Global Protocol for Community-Scale Greenhouse Gas Emissions, Technical Report C40 Cities Climate Leadership Group and ICLEI Local Governments for Sustainability in collaboration with: World Resources Institute, World Bank, UNEP, and UN-HABITAT, São Paulo, Brazil.
- Castán Broto, V., 2017. Urban Governance and the Politics of Climate change. *World Development* 93, 1-15.
- Covenant of Mayors, 2016. Covenant of Mayors. http://www.eumayors.eu/index_en.html. (Accessed 30th September 2016).
- De Gregorio Hurtado, S., Olazabal, M., Salvia, M., Pietrapertosa, F., Olazabal, E., Geneletti, D., D'Alonzo, V., Di Leo, S., Reckien, D., 2015. Understanding How and Why Cities Engage with Climate Policy: An Analysis of Local Climate Action in Spain and Italy. . TEMA:

Journal of Land Use, Mobility and Environment. SpI(ECCA), 23-46.

De Gregorio Hurtado, S., Olazabal, M., Salvia, M., Pietrapertosa, F., Olazabal, E., Geneletti, D., D'Alonzo, V., Feliú, E., Di Leo, S., Reckien, D., 2014. Implications of governance structures on urban climate action: evidence from Italy and Spain, BC3 WORKING PAPER SERIES. Basque Centre for Climate Change, Bilbao, pp. 1-47.

European Commission, 2011. A Roadmap for moving to a competitive low carbon economy in 2050. European Commission, Brussels.

Eurostat, 2004. Urban Audit: Methodological Handbook.

Eurostat, 2015. Statistics on European cities http://ec.europa.eu/eurostat/statistics-explained/index.php/Statistics_on_European_cities. (Accessed 30.05. 2017).

Eurostat, 2017. Cities (Urban Audit)- Overview. Eurostat, <http://ec.europa.eu/eurostat/web/cities>.

Flacke, J., Reckien, D., 2014. The Climate Engagement Index, in: Dawson, R.J., Wyckmans, A., Heidrich, O., Köhler, J., Dobson, S., Feliú, E. (Eds.), Understanding Cities: Advances in integrated assessment of urban sustainability. Centre for Earth Systems Engineering Research (CESER), Newcastle University, Newcastle, UK.

Heidrich, O., Dawson, R., Reckien, D., Walsh, C., 2013. Assessment of the climate preparedness of 30 urban areas in the UK. *Climatic Change* 120(4), 771-784.

Heidrich, O., Reckien, D., Olazabal, M., Foley, A., Salvia, M., S. De Gregorio Hurtado, Orru, H., Flacke, J., Geneletti, D., Pietrapertosa, F., J.J.P. Hamann, Tiwary, A., Feliu, E., Dawson, R.J., 2016. National climate policies across Europe and their impacts on cities strategies. *Journal of Environmental Management* 168, 36-45.

Heidrich, O., Tiwary, A., 2013. Environmental appraisal of green production systems: Challenges faced by small companies using life cycle assessment. *International Journal of Production Research* 51(19), 5884-5896.

Hunt, A., Watkiss, P., 2011. Climate change impacts and adaptation in cities: a review of the literature. *Climatic Change* 104(1), 13-49.

ICLEI, 2008. The Five Milestone Process. <http://www.iclei.org/index.php?id=810>. (Accessed 29th April 2012 2012).

IPCC, 2015. Climate Change 2015: Synthesis Report. , in: Meyer, R.K.P.a.L.A. (Ed.) Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change Intergovernmental Panel on Climate Change (IPCC), Geneva, Switzerland, p. 151.

Kelemen, R.D., 2010. Globalizing European Union environmental policy. *Journal of European Public Policy* 17(3), 335-349.

Kousky, C., Schneider, S.H., 2003. Global climate policy: will cities lead the way? *Climate Policy* 3(4), 359-372.

- Landauer, M., Juhola, S., Söderholm, M., 2015. Inter-relationships between adaptation and mitigation: a systematic literature review. *Climatic Change* 131(4), 505-517.
- Massey, E., Biesbroek, R., Huitema, D., Jordan, A., 2014. Climate policy innovation: The adoption and diffusion of adaptation policies across Europe. *Global Environmental Change* 29, 434-443.
- Millard-Ball, A., 2013. The Limits to Planning: Causal Impacts of City Climate Action Plans. *Journal of Planning Education and Research* 33(1), 5-19.
- Olazabal, M., De Gregorio Hurtado, S., Olazabal, E., Pietrapertosa, F., Salvia, M., Geneletti, D., D'Alonzo, V., Feliú, E., Di Leo, S., Reckien, D., 2014. How are Italian and Spanish cities tackling climate change? A local comparative study, BC3 WORKING PAPER SERIES. Basque Centre for Climate Change, Bilbao, pp. 1-27.
- Puppim de Oliveira, J.A., Doll, C.N.H., Kurniawan, T.A., Geng, Y., Kapshe, M., Huisingh, D., 2013. Promoting win-win situations in climate change mitigation, local environmental quality and development in Asian cities through co-benefits. *Journal of Cleaner Production* 58, 1-6.
- Reckien, D., Flacke, J., Dawson, R.J., Heidrich, O., Olazabal, M., Foley, A., Hamann, J.J.P., Orru, H., Salvia, M., Gregorio Hurtado, S., Geneletti, D., Pietrapertosa, F., 2014. Climate change response in Europe: what's the reality? Analysis of adaptation and mitigation plans from 200 urban areas in 11 countries. *Climatic Change* 122(1-2), 331-340.
- Reckien, D., Flacke, J., De Gregorio Hurtado, S., Salvia, M., Heidrich, O., Dawson, R., Olazabal, M., Foley, A., Orru, H., Geneletti, D., Pietrapertosa, F., 2014. Urban climate change response and the impact of climate networks in Europe, in: Dawson, R., Wyckmans, A., Heidrich, O., Köhler, J., Dobson, S., Feliu, E. (Eds.), *Understanding Cities: Advances in integrated assessment of urban sustainability*, Final Report of COST Action TU0902. Centre for Earth Systems Engineering Research (CESER), Newcastle, UK.
- Reckien, D., Flacke, J., Olazabal, M., Heidrich, O., 2015. The Influence of Drivers and Barriers on Urban Adaptation and Mitigation Plans-An Empirical Analysis of European Cities. *PloS one* 10(8), 21.
- Rosenzweig, C., Solecki, W., Hammer, S.A., Mehrotra, S., 2010. Cities lead the way in climate-change action. *Nature* 467(7318), 909-911.
- Seto, K., Dhakal, S., Studies, E., United, P., 2014. Human Settlements, Infrastructure and Spatial Planning, Climate Change Mitigation of Climate Change Regional and Urban Audit quality analysis and methodological improvements. Final draft glossary on Urban Audit statistics UN World Urbanization.
- Tompkins, E.L., Amundsen, H., 2008. Perceptions of the effectiveness of the United Nations Framework Convention on Climate Change in advancing national action on climate change. *Environmental Science & Policy* 11(1), 1-13.
- UNFCCC, 2015. Adoption of the Paris Agreement, in: *United Nations Framework Convention on Climate Change (UNFCCC) (Ed.)*. United Nations, Paris, France, p. 31.
- Villarroel Walker, R., Beck, M.B., Hall, J.W., Dawson, R.J., Heidrich, O., 2017. Identifying

key technology and policy strategies for sustainable cities: A case study of London. *Environmental Development* 21, 1-18.

Wamsler, C., Brink, E., Rivera, C., 2013. Planning for climate change in urban areas: from theory to practice. *Journal of Cleaner Production* 50, 68-81.

Wende, W., Bond, A., Bobylev, N., Stratmann, L., 2012. Climate change mitigation and adaptation in strategic environmental assessment. *Environmental Impact Assessment Review* 32(1), 88-93.

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