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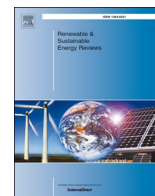
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Dedicated versus mainstreaming approaches in local climate plans in Europe

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ABSTRACT

Cities are gaining prominence committing to respond to the threat of climate change, e.g., by developing local climate plans or strategies. However, little is known regarding the approaches and processes of plan development and implementation, or the success and effectiveness of proposed measures. Mainstreaming is regarded as one approach associated with (implementation) success, but the extent of integration of local climate policies and plans in ongoing sectoral and/or development planning is unclear. This paper analyses 885 cities across the 28 European countries to create a first reference baseline on the degree of climate mainstreaming in local climate plans. This will help to compare the benefits of mainstreaming *versus* dedicated climate plans, looking at policy effectiveness and ultimately delivery of much needed climate change efforts at the city level. All core cities of the European Urban Audit sample were analyzed, and their local climate plans classified as dedicated or mainstreamed in other local policy initiatives. It was found that the degree of mainstreaming is low for mitigation (9% of reviewed cities; 12% of the identified plans) and somewhat higher for adaptation (10% of cities; 29% of plans). In particular horizontal mainstreaming is a major effort for local authorities; an effort that does not

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necessarily pay off in terms of success of action implementation. This study concludes that climate change issues in local municipalities are best tackled by either, developing a dedicated local climate plan in parallel to a mainstreamed plan or by subsequently developing first the dedicated and later a mainstreaming plan (joint or subsequent “dual track approach”). Cities that currently provide dedicated local climate plans (66% of cities for mitigation; 26% of cities for adaptation) may follow-up with a mainstreaming approach. This promises effective implementation of tangible climate actions as well as subsequent diffusion of climate issues into other local sector policies. The development of only broad sustainability or resilience strategies is seen as critical.

List of abbreviations including units and nomenclature

CoM	Covenant of Mayors
EU	European Union
EU-28	28 Member States of the European Union
GHG	greenhouse gases
LCP	local climate plan
NUTS	Nomenclature of Territorial Units for Statistics

SDGs	The Sustainable Development Goals
SEAP	Sustainable Energy Action Plan
SECAP	Sustainable Energy and Climate Action Plan
SI	Supplementary Information
UA	Urban Audit
UK	United Kingdom
UNFCCC	United Nations Framework Convention on Climate Change
US	United States

1. Introduction

The Sustainable Development Goals (SDGs), the New Urban Agenda and the Paris Agreement together with the Sendai Framework for Disaster Risk Reduction are the main global, complementary initiatives launched to move towards a more sustainable and prosperous future. Within these frameworks, combating the cause of climate change and adapting to its effects are among the most urgent issues that countries and cities must face in the near future [1,2]. In particular, the role of cities is gaining prominence within supranational (e.g. European Union, UN-Habitat) and national governments committing to achieve the sustainable development goals and responding to the threat of climate change [3,4]. Increasingly, cities around the world respond by developing local climate plans or strategies [5–9]. Several city-led initiatives, such as the EU Covenant of Mayors (CoM) [10] and the UN Compact of Mayors, which from June 2016 joined the Global Covenant of Mayors for Climate and Energy [11], or the C40 Cities Climate leadership group [12] and ICLEI – Local Governments for Sustainability are leading their partner cities in developing local climate plans (LCPs), focusing both on greenhouse gases (GHG) emissions’ mitigation (i.e. carbon reductions) and on climate change adaptation (i.e. impact and vulnerability reduction).

There is growing research aiming to assess the advances on LCPs through the review of policy documents at several levels. These studies can be assigned to the research field of ‘plan evaluation’ and ‘plan quality studies’, an established framework for analyzing the contents of, e.g., local climate plans and assessing their strengths and deficiencies, e.g. in reaching their targets. For adaptation, one of the earliest reports was published in 2012 [13] assessing the progress on local climate planning in 468 cities across the globe. Another global study on local climate adaptation planning was published in 2016 [6], focusing on 401 cities. Both concluded that adaptation initiatives were mostly at an early stage, while developing frameworks to characterize climate change adaptation planning on the ground. Stults and Woodruff [7], Woodruff and Stults [14] and Woodruff [15] assessed local adaptation plans of the United States (US) and concluded that although the 44 cities in the sample had selected varied and theoretically appropriate actions, there are questions regarding their actual implementation and learning via climate networks. Another recent North-American study looked at the quality of local climate plans in 63 local communities of Canada [16] supporting the findings from US American municipalities that mitigation is prioritized over adaptation as well as showing that monitoring and evaluation practices are weak and stakeholder participation insufficient.

In Europe, Reckien et al. [8,17] analyzed LCPs of 200 cities regarding mitigation and adaptation and found that there was substantial

diversity in, among other things, the regional distribution across Europe as well as the plans’ ambition and scope. Also, mitigation in European cities was found to be prioritized over adaptation. Similar analyses looking at both, local mitigation and adaptation plans have been conducted for 30 cities in the United Kingdom (UK) [9], 58 cities in Italy and Spain [18,19] and for 109 cities in Portugal [20]. Scholars identified drivers of and barriers to the development of local climate plans in the study of the 200 European cities [17] as well as to adaptation action across 147 European local adaptation strategies [21]. Authors agreed that the cities’ local capacity, particularly in terms of economic strength, employment and climate governance, substantially determines the existence and ambition of LCPs, even though national and regional climate mitigation and adaptation contexts also play a role [17,18,20,22,23]. Despite the fact that studies have attempted to identify drivers and barriers for local climate action [17,21], reasons for particularly low adaptive capacity still remain understudied [21]. Whereas a growing number of local governments around the world [5–7,14] provide information on the implementation processes of planned adaptation and mitigation actions, insights on implementation success, and the effectiveness of plans and actions in achieving mitigation and adaptation is also only beginning to be a topic of scientific debate.

One aspect assumed to strongly relate to implementation success is the degree of mainstreaming of climate policies and actions [24–26]. Mainstreaming in the climate change literature is defined as “the integration of policies and measures to address climate change in ongoing sectoral and development planning and decision-making” [22, p. 749]. It is regarded as one of two distinct policy options to address climate change, next to developing stand-alone climate policies [27] or what Uittenbroek et al. [28] refer to as the ‘dedicated approach’ of local climate planning. Others see a continuum of integration of local plans from narrowly addressing single impacts to broader sustainability [29] or resilience issues [30].

The literature on climate change mainstreaming is extremely diverse as regards thematic focus [28,33–36], involved sectors [37–41], governance levels [32,42–46] and case study distribution [47–55]. What stands out is the focus on adaptation mainstreaming; aspects of mitigation mainstreaming are hardly covered. This may be explained with the relative success of mainstreaming mitigation in the EU policy frameworks [42], whereas challenges for adaptation mainstreaming remain significant [56,57].

Mainstreaming climate change aspects is assumed to be advantageous as it would allow realizing possible trade-offs and potential synergies across policy domains [31], e.g. adaptation and mitigation policies with the local transport policy, aiming at, amongst others, ensuring the success of adaptation and preventing maladaptation [32],

promoting sustainable investments of resources (financial and human resources), and reducing the sensitivity of development activities to current and future climatic conditions [26]. However, Lyles et al. [29] find that narrowly planned LCPs perform better in terms of plan integration than broader scope sustainability plans, operationalized by number of referenced plans and land use policies included. Concerns regarding broader scope plans, e.g. resilience plans [30], are also raised by other scholars. Resilience plans seem to offer a (unused) platform to address multiple policy issues related to climate change adaptation, but a lack of critical elements hinders localities to truly prepare for climate change [30]. It is argued that broader scope local adaptation plans, in particular, fail to work in favor of just adaptation and to address the distributional impacts of climate change (e.g. in New York City [58]), although there is a particular need for the integration of adaptation with poverty alleviation measures [59].

The previous observations also indicate that there are two forms of mainstreaming usually being distinguished: the integration of climate

change policy measures into (a) sectoral policies (vertical approach) or (b) broader planning frameworks, e.g., more holistic sustainability or resilience plans (horizontal approach) [32,60]. Rauken et al. [32] identified these two approaches when analyzing adaptation mainstreaming in Norwegian cities' drawing on Underdal's concept of policy integration [61] and Lafferty and Hovden's distinction between a vertical ('greening' of one sector alone) and a horizontal (jointly 'greening') approach to Environmental Policy Integration [32,62]. A number of scholars agree to the distinction between vertical and horizontal mainstreaming [63,64], whereas others equate horizontal integration with (true) mainstreaming [65]. Rauken et al. [32] also note that the distinction is less clear in practice—realizing that most local decision-making has vertical (delegated responsibility) and horizontal (cooperation and coordination) elements. They also see that every climate policy will need to be integrated somewhere (at least vertically into sectors) when moving from policy setting to action and implementation. Scholars also distinguish between programmatic,

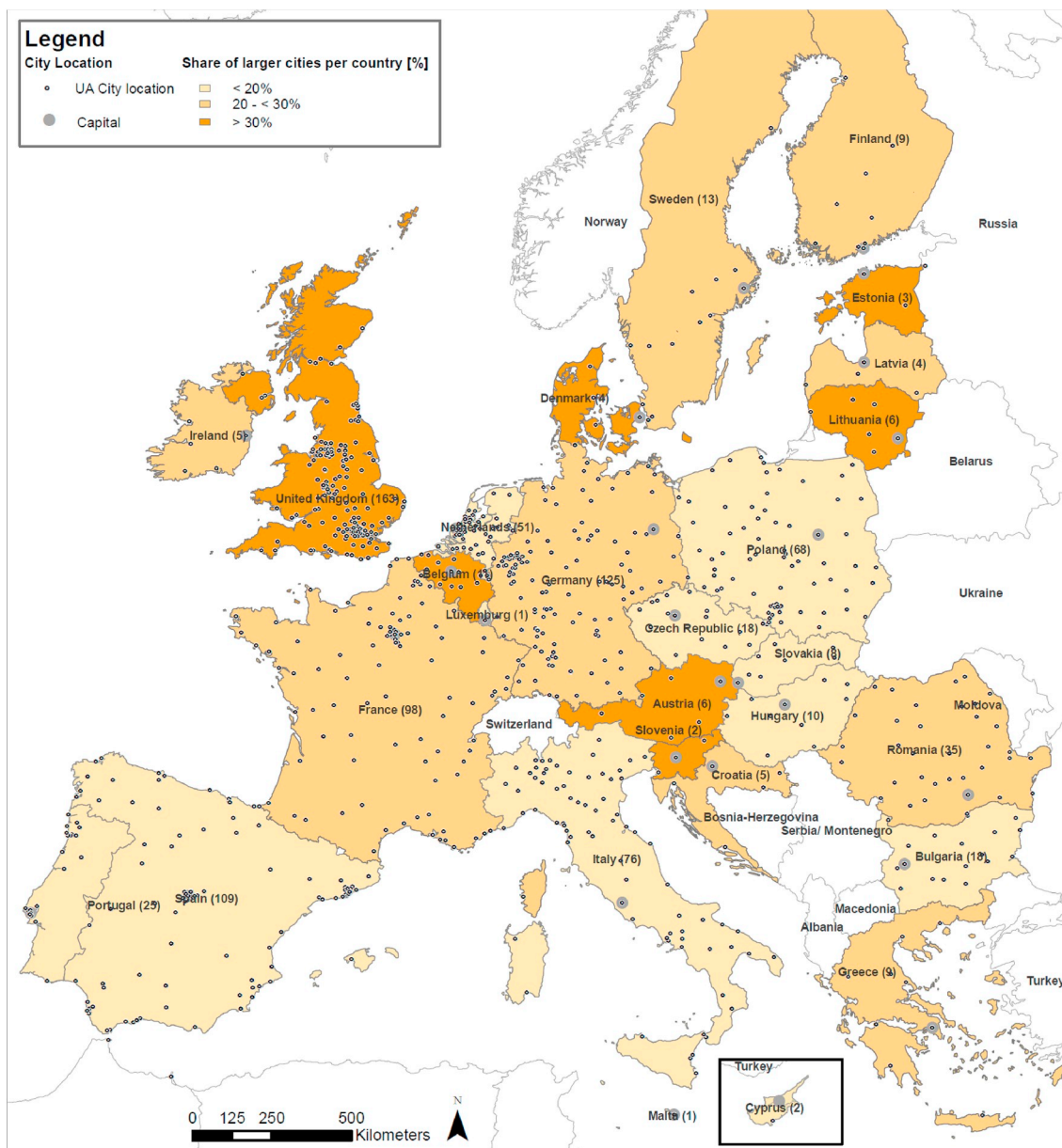


Fig. 1. Map of the location of Eurostat Urban Audit cities [69], showing the share of larger cities per country as country shading. Larger city is defined as above 250.000 inhabitants. Data: resident population as of 1st January of latest year available (2011–2017, depending on city and country) from Eurostat (2018), except Fareham (UK), Spijkenisse (NL), and Croatia (Wikipedia).

managerial, inter- and intra-organisational, regulatory, and directed mainstreaming [66], but this is at a higher detail than local plans. In this work, the distinction between horizontal and vertical mainstreaming is taken further. In the following, dedicated LCPs (climate change policies), horizontally (sustainability and resilience as well as masterplans with integrated climate change issues) as well as vertically mainstreamed LCPs (heatwave plans, flood plans, energy use and efficiency plans with reference to climate change) are distinguished (for a more detailed description see the methods' section).

Comparing these different mainstreaming approaches Rauken et al. [32] found that policy development is slower and potentially more challenging, but also perhaps more robust in municipalities that have chosen a horizontal, cross-sectoral approach to mainstreaming than in municipalities that have chosen a vertical sector approach (ibid, p. 408). Uittenbroek et al. [67] deliver potential reasons for the differences in implementation speed investigating Dutch cities. They argue that the dedicated approach (and potentially the vertical mainstreaming approach, too), being based on direct political commitment to climate adaptation, implies political agenda setting, resource allocation, and clear policy objectives, which are expected to facilitate rapid implementation due to political pressure and new structures. In contrast, the (broader) mainstreaming approach is based on indirect political commitment, relying on policy domains in which it is integrated. Institutional entrepreneurs and framing are considered necessary to establish policy synergies and to mobilize actors and resources. An implication is that implementation is erratic, as entrepreneurs have to pioneer working within and breaking through existing structures. It may therefore also be more challenging. Hence, scholars argue that mainstreaming adaptation and mitigation in existing local governance frameworks might be preferable in theory, though limited in practice [26].

Investigating the extent of using the mainstreaming approach in contrast to the dedicated approach in local climate planning in European cities is the main aim of this paper. Based on a database of LCPs and plan typology previously developed [5], the study identifies whether cities plan for climate change in dedicated policy documents or through other local policy documents and plans that mainstream climate change (both vertically or horizontally). The following research questions are posed: (1) *Are climate change issues in European cities addressed by way of dedicated or mainstreamed LCPs?* (2) *Can the resulting patterns be related to climate policies at the European, national and/or regional levels?* The questions are examined by way of empirical data and policy analysis.

The paper is organized as follows: the subsequent section 2 describes the data and methods. This is followed by the presentation of results in section 3. Section 4 discusses the main findings as compared with scholarly literature and along exemplary, national and international European policies, while section 5 provides conclusions based on the main findings of this study.

2. Material and methods

2.1. I. The city sample

This study uses Eurostat's Urban Audit (UA) database—currently known as “Statistics on European cities” (Urban Audit Database [68]). The database was developed with the aim of comparing data across European urban areas complying to a common protocol. More precisely, the study makes use of the 885 UA “core cities” of the EU-28 [69] (Fig. 1), which represents on average 35% of the population in each country (see also SI 1). The UA sample was drawn by the European

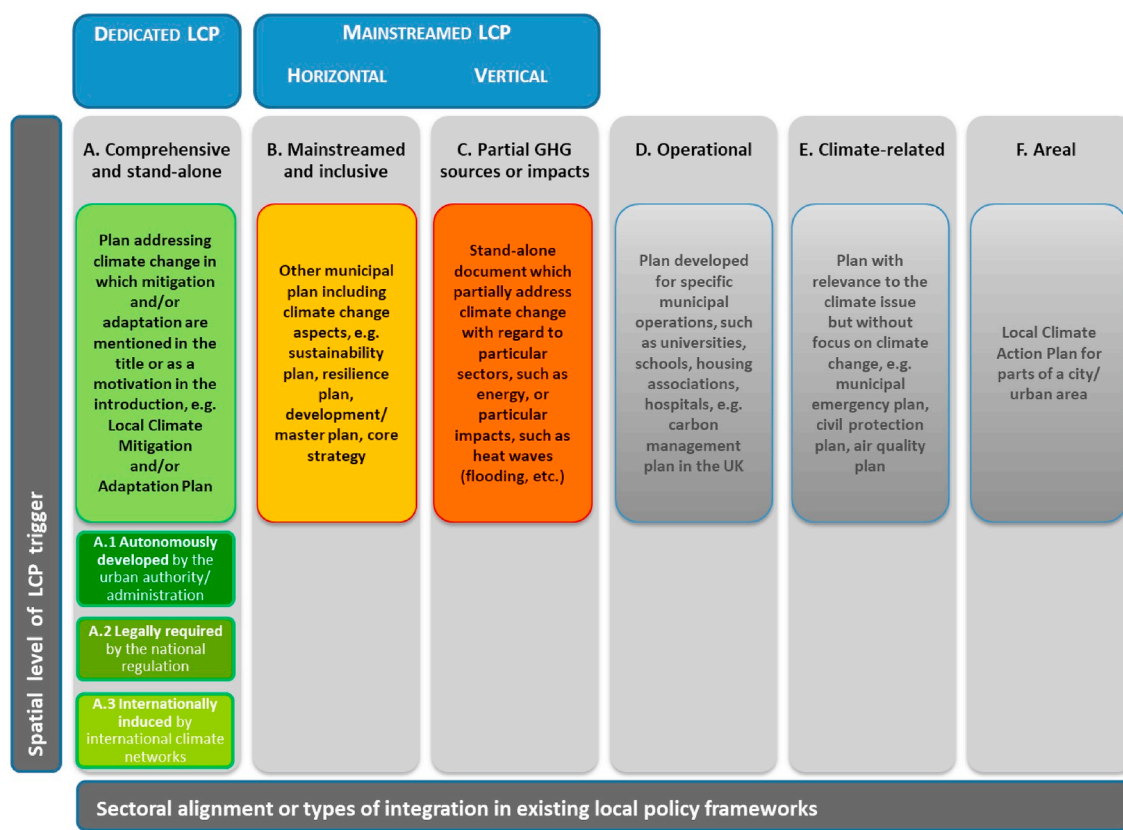


Fig. 2. Typology of local climate plans (modified after Reckien et al. [5]). Previously Reckien et al. [5] analyzed different forms of type A plans (type A1, A2, A3). This distinction is shown for reasons of consistency, but is not relevant for the analysis in this paper. This study compares (all) previously identified type A plans with the number of currently and solely identified mainstreamed plans, i.e. type C and type B plans.

Commission and Eurostat (European Statistics Office) in collaboration with the 28 national statistical offices. The sample is representative in size and regional distribution per country. Representativeness is guaranteed per following criteria: (i) at least 20% of the population should be covered in each country, (ii) a balanced geographical distribution is given, i.e. at least one city from each NUTS3 Region is included, and (iii) the diversity in city size is respected, including medium and large (above 50,000 inhabitants) as well as small cities (below 50,000 inhabitants). More information about the database can be found in Urban Audit Database [68].

Assuming an EU-28 population of 511,516,974 (latest years available 2009–2017), the sample study covers 37.3% of the total EU-28 population. Fig. 1 presents a map of the location of Eurostat Urban Audit cities including clusters of population. More information about the collected city data and statistics in each country can be found in Supplementary Information (SI) 1.

2.2. ii. The classification system

The typology (Fig. 2) of Reckien et al. [5] is used as a classification system, focusing on type A, B, and C plans—representing dedicated LCPs (type A), horizontally mainstreamed LCPs (type B) and vertically mainstreamed LCPs (type C). Type B LCPs are cross-sectoral, respecting interactions between different policy fields and aiming for broader goals than climate change—hence have been called ‘horizontally mainstreamed’ in this work. Type C plans are sectoral plans, e.g. addressing the energy sector, and have therefore been classified as ‘vertically mainstreamed’. Reckien et al. [5] classify the different approaches of local governments along their spatial triggers, at least for type A (local, national and international). However, the distinction of spatial triggers is not relevant to this study. This presented work has taken the same dataset but crucially extended the study by investigating and comparing the number of European local areas that start local climate planning via type A, B, or C, i.e. a dedicated versus a mainstreamed approach. The basis of this analysis forms a comparison of the frequency of type A versus type B and C plans that address climate change mitigation and adaptation across the 885 Urban Audit (UA) [69] cities in the European Union (EU).

2.3. iii. LCPs under focus

Corresponding with the typology of Reckien et al. [5] Fig. 3 illustrates the step-by-step approach applied for data collection. For each city in the study database the analysis started looking for dedicated, comprehensive and stand-alone LCPs (type A LCPs). If an A plan was found for mitigation, adaptation or both (joint plans), then this LCP was assigned to the city under investigation and a new case study was analyzed. On the contrary, if the city did not have such a plan the search went on with the next step of the hierarchy (i.e. type B, and then type C). This hierarchical approach allowed the team to assign to each city the plan most focused on climate change (mitigation and adaptation) and available at the time of searching (Nov. 2016 - August 2017).

The database includes LCPs that were finalized and approved by the city council or local authority. Published draft documents were also included if available to us. In a few cases where a plan was mentioned but not available online, the municipality was contacted to investigate the state of the municipality's climate actions and to request related documents. Subsequently, the characterizing information for each plan was extracted based on a common protocol/ structure (Table 1).

3. Results

The findings are first presented separately for mitigation and adaptation per country, and then summarized by jointly looking at mitigation and adaptation in a pan-European perspective.

Overall, 664 mitigation LCPs (of all types) were found across 26 out

of the 28 countries, which translates into 75% of the cities (see SI 2 for exact figures per country). Cities in Luxembourg and Malta, two small countries with a single UA city (Luxembourg and Valletta), have no LCP that cover the entire UA city area. Out of the total of 664 mitigation LCPs, only 77 are regarded as mainstreamed LCPs. This translates into 9% of cities in the EU-28 having a mainstreamed mitigation LCP and 12% of all mitigation LCPs having a mainstream character.

Fig. 4 shows the distribution of all types of mitigation LCPs per country. One can see that the majority of mitigation LCPs are of type A that are comprehensive and stand-alone plans with a dedicated focus on the climate challenge (#587 type A). Overall, type B, and C plans, those that represent a form of mainstreaming of the climate issue, are found to be much fewer (#77 of type B and C; see SI 2). Sizeable numbers of mainstreamed plans are found in the UK (mostly municipal energy plans, core strategies and also sustainability plans) and the Netherlands (all sustainability plans). Spain, Austria, Romania, Germany, Italy and Estonia have also mainstreamed plans. Percentage-wise Austria sticks out: 50% of the 6 Austrian cities have mainstreamed LCPs. Austria is followed by Estonia and the UK (33% of cities with mainstreamed LCP) as well as the Netherlands (20% of cities with mainstreamed LCP).

Type A Mitigation – Dedicated LCPs: The most numerous type A1 mitigation LCPs are recorded for Germany, where 101 of the 125 cities in the sample have a type A1 dedicated mitigation LCP. However, percentage-wise, Denmark and Poland top that with 100% and 97% of the cities having type A1 mitigation LCPs, respectively. In France, Slovakia and the UK national regulation demands local authorities to develop mitigation LCPs; hence type A2 mitigation LCPs are common. In many other countries type A3 plans are numerous. Both, cities in Cyprus and Slovenia, and all four cities in Latvia, have type A3 mitigation LCPs—representing 100% of cities that developed mitigation LCPs as part of international climate networks.

Type B Mitigation – Horizontally mainstreamed LCPs: LCPs of type B are cross-sectoral, respecting and enhancing interactions between climate measures and other policy fields and aiming for broader goals than climate change mitigation. Type B plans are mostly recorded

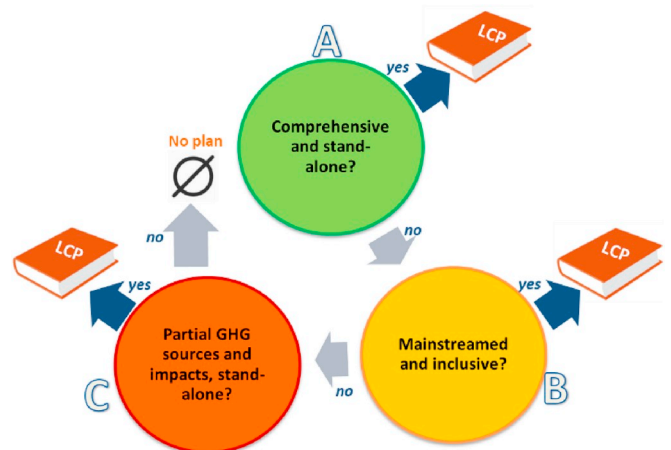


Fig. 3. Review protocol - Step-by-step approach to investigate LCP availability [see also 5]. Available LCPs were searched between November 2016 and August 2017 by native or fully language proficient authors through web searches on: a) Common search engines, using keywords for mitigation and adaptation for each specific national language such as: [city name] Climate Change Strategy; Climate Change Action Plan; Climate Change Adaptation Plan/Strategy; Climate Change Mitigation Plan/Strategy, Climate Change and Energy; Climate Change and Environmental Protection, Municipal Energy Plans; Heatwave Plan; Flood risk Plan, etc., b) Websites of local governments, municipalities and/or other authorities, with a specific focus on those departments/offices generally in charge of climate action (e.g. planning, environment, energy, sustainable development), c) International databases, e.g. made available by the Covenant of Mayors and Compact of Mayors.

Table 1

Key information collected for each city/LCP. Key: * EU CoM/Step 1: Signature of the CoM; Step 2: Submission of the SEAP/SECAP; Step 3: Submission of the monitoring report; ** UN CoM/Phase 1: Commitment; Phase 2: Inventory; Phase 3: Target; Phase 4: Plan.

Cities	Local Climate Plans		
	A1/A2	A3	B/C/D/E
General information	Mitigation plan	EU Covenant of Mayors Initiative	With clear motivation for and (single) focus on mitigation
<ul style="list-style-type: none"> ● Country ● City Code ● Date of search/download ● Population 	<ul style="list-style-type: none"> ● Plan availability (yes/no) ● Name/Title of the Mitigation plan (latest or current, in case multiple are available) ● Weblink or Contact of Person at municipality ● Comments ● Previous/earlier Mitigation plans available? (yes/no) 	<ul style="list-style-type: none"> ● SEAP (yes/no) ● Status SEAP (1-2-3)* ● SECAP (yes/no) ● Status SECAP (1-2-3)* ● CoM Adapt commitments ● Mayors Adapt ● SEAP/SECAP weblink 	<ul style="list-style-type: none"> ● Energy and Carbon management plans with CO2/GHG emission reductions (yes/no) ● Weblink or Contact of Person at municipality ● Comments
	Adaptation plan	UN Compact of Mayors Initiative	With clear motivation for and (single) focus on adaptation
	<ul style="list-style-type: none"> ● Plan availability (yes/no) ● Name/Title of the Adaptation plan (latest or current, in case multiple are available) ● Weblink or Contact of Person at municipality ● Comments ● Previous/earlier Adaptation plans available? (yes/no) 	<ul style="list-style-type: none"> ● Compact member (yes/no) ● Compact Stage (1-2-3-4)** ● Compact weblink 	<ul style="list-style-type: none"> ● Heat wave, Flood risk and Water/Wastewater management plans (yes/no) ● Title ● Weblink or Contact of Person at municipality ● Comments

for the UK (19 development plans/Core strategies, and 10 sustainability plans), the Netherlands (10 sustainability plans), and Austrian cities (1 master/development plan). Overall, type B plans seem to be developed in countries and cities with a long history of climate and environmental policy, such as the UK and The Netherlands. In these countries, integrating the climate issue in plans developed under other policy goals seems currently ‘mainstream’, assumed to harness co-benefits and minimizing trade-offs and conflicts.

Type C Mitigation LCPs – Vertically mainstreamed LCPs: Here, municipal energy plans with a reference to climate change and/or mitigation targets were recorded. These are mostly found in Austria (2 LCPs), Estonia (1 LCP), Italy (1 LCP) and the UK (1 LCP). Overall, the total number of cities pursuing this approach as their main climate response (without a type A or B plan) is small.

It is hard to identify any geographical pattern as regards mitigation LCPs (Fig. 4), though some Southern European as well as smaller countries seem to have more A3 LCPs—dedicated LCPs initiated by international climate networks—than Northern European and larger countries. Other than that, there are no clear geographical clusters as regards dedicated and mainstreamed mitigation LCPs.

Regarding adaptation LCPs, overall, 321 adaptation LCPs (of type A to C) were found across the sample, i.e. in 36% of the cities (SI 2). A total of 92 out of the 321 LCPs found on adaptation are to be classified as type B and C. Hence, 10% of the cities in the EU have a mainstreamed adaptation plan, while 29% of the available adaptation LCPs have to be regarded as mainstreamed according to the definition in this study.

Fig. 5 shows the distribution of types of adaptation LCPs across countries (for comparative statistics in a table see SI 2). It reveals that the majority of adaptation LCPs are also of type A (#229). Type B and C adaptation LCPs amount to 92 plans and cities, respectively. Cities with mainstreamed adaptation LCPs are mostly found in the UK (section in Core strategy and municipal flood plans with reference to climate change) and Poland (municipal flood plans with reference to climate change). The list changes substantially when looking at percentages. It is topped by Slovakia and followed by Ireland, with more than 60% of the cities in these countries having a mainstreamed adaptation LCP. In Sweden and Croatia still 40% and 34% of cities, respectively, have a mainstreamed adaptation plan.

Type A Adaptation – Dedicated LCPs: type A1 Adaptation LCPs are particularly numerous in Finland with nearly 80% of the cities

having a type A1 adaptation plan (7 LCPs). Next are cities in Sweden (4 LCPs), Germany (31 LCPs), and Portugal (6 LCPs), where about 10–20% of cities have a type A1 adaptation LCP. Type A2 LCPs, i.e. local adaptation plans mandatory by national law, are found in Denmark, France, and the UK. However, not all cities in these countries have yet developed adaptation LCPs. For example, only about 55% of cities in France (54 LCPs) have an adaptation LCP. Moreover, some of these plans cover adaptation so sparsely that it is debatable whether to record it as adaptation LCP. Contrary to mitigation, there are hardly any type A3 adaptation LCPs, i.e. those developed as part of a membership in international climate networks.

Type B Adaptation – Horizontally Mainstreamed LCPs integrate climate aspects in other comprehensive environmental strategies, such as resilience strategies, sustainability strategies, master/development plans. Proportionately, most type B adaptation LCPs have been recorded for Sweden (6 LCPs), where climate change goals are mostly integrated in master/development plans (5 LCPs). In absolute terms, the UK scores first. This analysis recorded different types of adaptation LCPs in the UK: master/development plans (28 LCPs), sustainability plans (6 LCPs), and resilience plans (3 LCPs).

Type C Adaptation – Vertically Mainstreamed LCPs relate to municipal flood or heatwave plans. Municipal flood plans with a reference to climate change were found in Slovakia (4 LCPs), Ireland (2 LCPs), Poland (15 LCPs), and the UK (18 LCPs). Flood plans are mandatory by the EU Directive 2007/60/EC on the assessment and management of flood risks. So, theoretically all cities at larger rivers should have a flood risk plan, but apparently only a fraction of those address the challenge of climate change (note, the number of UA cities per country at larger rivers, i.e. in need of developing a flood plan according to the EU Directive also varies—a comparison across countries is therefore difficult with the study database). The development of local flood risk plans illustrates a sectoral approach, where flood protection is often treated separately from climate change. Therefore, climate change mainstreaming into urban flood risk planning is missing (as e.g. in the Czech Republic, where all cities at rivers have a flood plan, but these do not consider climate change). Even though, according to the Directive, Member States are expected to consider climate change and sustainable land use practices in the flood risk management cycle. Municipal heatwave plans are recorded for a number of Austrian (1 LCP), Croatian (2 LCPs), and Slovakian cities (1 LCP), but are rare overall, at least as the only adaptation related plan of a city.

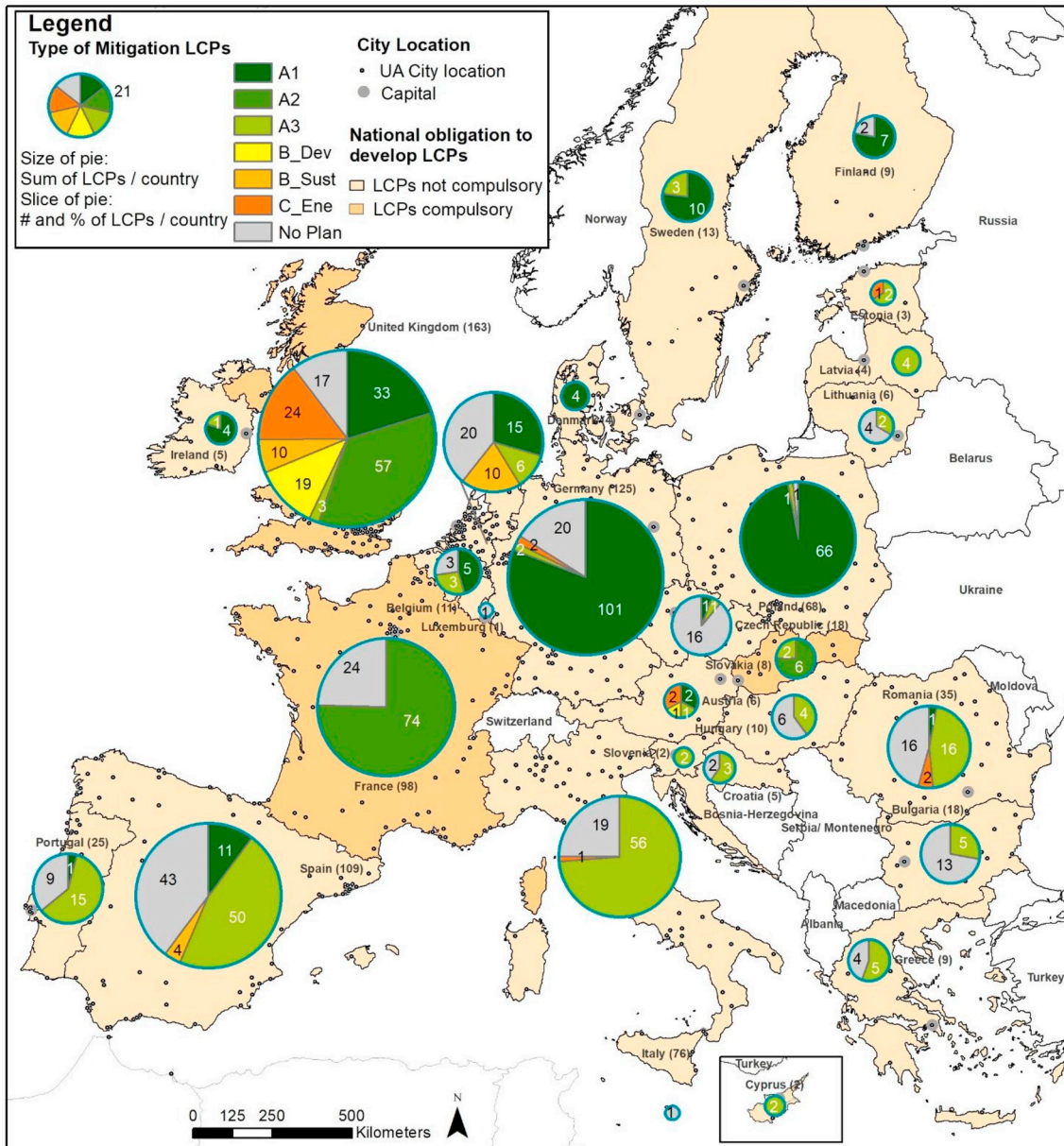


Fig. 4. Map of types of Local Climate Mitigation Plans (Mitigation-LCPs) across 885 cities of the Urban Audit Core collection of cities [68] in the EU-28 countries. Key: Pie charts - Dark, medium and light green represent type A LCPs, which are dedicated LCPs. Yellow to dark orange represents type B and C LCPs, those that represent a form of mainstreaming of the climate issue. Grey patches depict UA cities without a LCP. Country coding and labelling - The figure in brackets behind the name of the country corresponds to the total number of UA cities in the country, e.g. 'Austria (6)' means that there are 6 Austrian cities in the database. The size of the pie chart shows the same information in a visual sense. Exact numbers are shown in SI 2. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

As regards geographical distribution (Fig. 5) adaptation LCPs in the study sample are less common in Southern Europe. Northern European cities are pioneers in local climate adaptation, potentially because they have had more experience with climate change events, such as flooding [70]. With the exception of the UK, Ireland and Sweden, some countries in Eastern Central Europe have proportionately more mainstreamed plans than other parts of Europe. Other differences between dedicated and mainstreamed adaptation LCPs are not visible in geographical terms.

Table 2 shows an overview of all the findings of our analysis confronting both adaptation and mitigation LCPs and their distribution across cities (circles in first row) as well as plans (circles in second row). The empirical study reveals that the degree of mainstreaming of climate issues at the local level is low for mitigation and a bit, but not much higher for adaptation.

4. Discussion

The main aim of the paper was to investigate the extent of the use of both, the vertical and horizontal mainstreaming approach in contrast to the dedicated approach in local climate planning in European cities. The categories comprise: 1) dedicated, stand-alone climate change policy documents (Local Climate Plans); 2) vertically mainstreamed plans (heatwave plans, flood plans, energy use/efficiency plans with relation to climate change); 3) horizontally mainstreamed plans (sustainability, resilience, development/master plans integrating climate change issues). The latter two categories integrate and therefore mainstream the complex issue of climate change in other local policy documents and plans. The study used data of Reckien et al. [5] combined with an ad-hoc approach for classifying typology information.

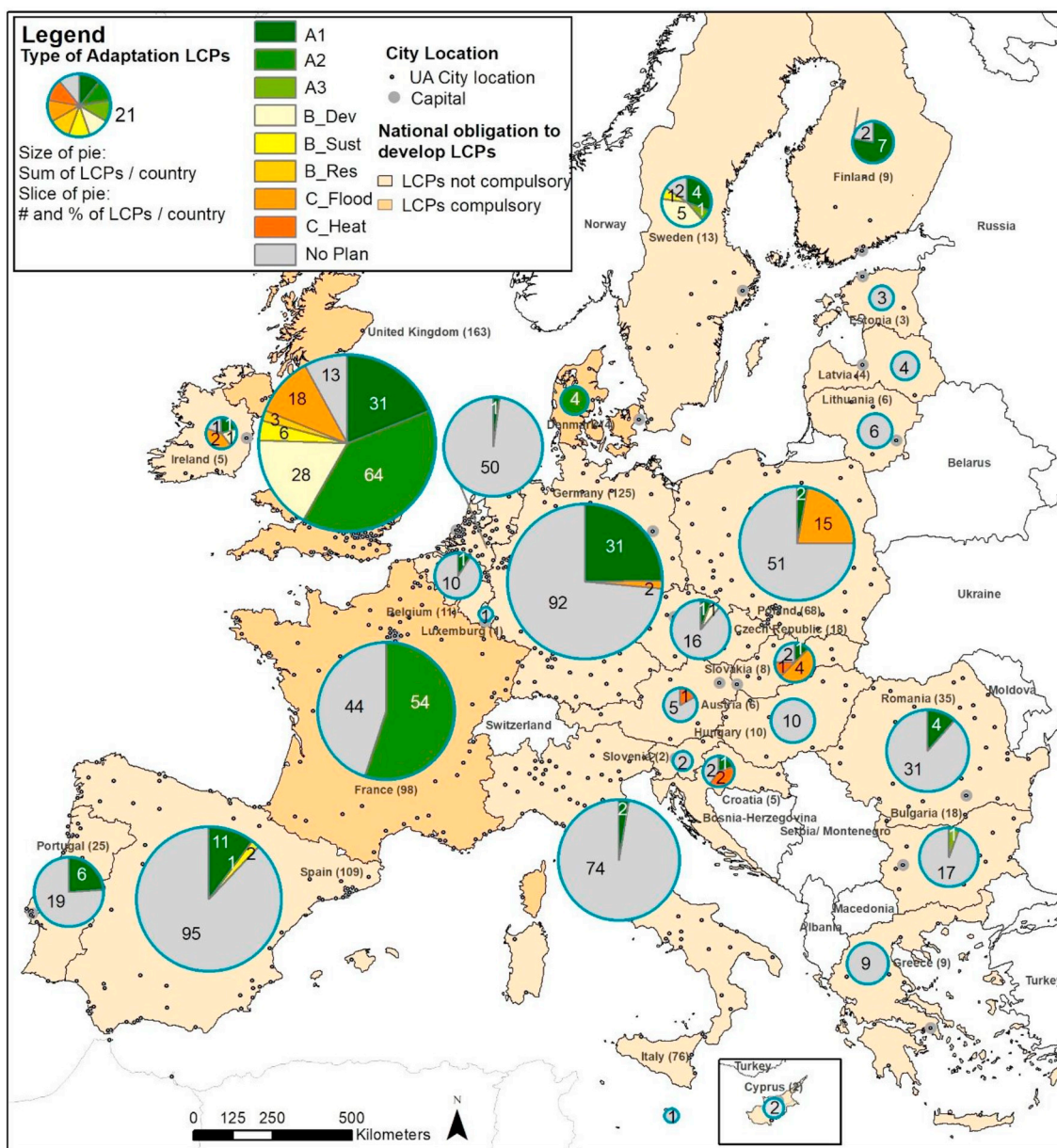


Fig. 5. Map of types of Local Climate Adaptation Plans (Adaptation-LCPs) across 885 cities of the Urban Audit Core collection of cities in the EU-28 countries [68]. Key (see also Fig. 4): Pie charts - Dark, medium and light green represent type A LCPs, which here represent dedicated LCPs. Yellow to dark orange represents type B and C LCPs and a form of mainstreaming of the climate issue. Grey patches depict cities without LCPs. Country coding and labelling - The figure in brackets behind the name of the country corresponds to the total number of UA cities in the country. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

The following two research questions were posed:

- (1) Are climate change issues in European cities addressed by way of dedicated or mainstreamed LCPs?

Overall, the study shows that a lot more cities in Europe use the dedicated approach as compared with the mainstreaming approach as the main way to address the climate challenge. The findings also confirm the outcome of other studies [5,6,8,9,13,16] showing that less policy activity is currently taking place in adaptation as compared with mitigation. For example, 75% of cities have a local mitigation plan, and 9% of those have a mainstreaming character; approximately 36% of cities have an adaptation LCP, of which 10% use a mainstreaming approach. As suggested in the literature, mainstreaming is a major effort for local authorities [26,32,67]—an effort not made by many cities.

Additionally, it was shown that cities with adaptation LCPs decide about three times as often for a form of mainstreaming, as compared with mitigation—12% of mitigation LCPs and 29% of adaptation LCPs, respectively, have a mainstreaming character. Also in the literature mainstreaming is mainly discussed within the context of local adaptation—potentially because of the challenges for adaptation mainstreaming, while mainstreaming mitigation, at least in the higher EU policy frameworks [42], is a proclaimed success [56,57]. Another potential reason is the widely adopted notion of adaptation being more local as compared to mitigation as well as (more) multi-dimensional and holistic, therefore predestined for mainstreaming.

However, because of the challenges of adaptation mainstreaming, a higher percentage of it also translates into more complex implementation and in turn potentially lower speed of adaptation implementation [32]—supporting other findings [7][14][15]. It

Table 2

Summary of findings. Key: Greenish colours refer to plans with a dedicated approach; yellow and orange colours refer to plans using a mainstreamed approach. Please note that only one LCP per city is reported, from the highest (type A) to the lowest (type C) level. This means that the corresponding number shown for type C LCPs refers to those cities that only have a type C plan and no type A or type B LCPs, while some cities with a type A plan might also have a type B or type C LCP.

	Mitigation	Adaptation
1 Overall: Number of Type A + B + C LCPs found across all cities	<p>Total: 75%, 664 cities</p> <ul style="list-style-type: none"> No Mitigation LCPs (incl. not found & information only): 25% A1 Mitigation LCPs: 30% A2 Mitigation LCPs: 15% A3 Mitigation LCPs: 21% B Section of Master/Development plan: 2% B Section of Sustainability Plan: 3% C Municipal Energy Plan: 4% 	<p>Total: 36%, 321 cities</p> <ul style="list-style-type: none"> No Adaptation LCPs (incl. not found & information only): 64% A1 Adaptation LCPs: 12% A2 Adaptation LCPs: 14% A3 Adaptation LCPs: 0% B Section of Master/Development plan: 4% B Section of Sustainability Plan: 1% B Section of Resilience Plan: 0% C Municipal Flood Plan: 5% C Municipal Heat(wave) Plan: 0%
2 Overall: Number of Type A + B + C LCPs found across all plans	<ul style="list-style-type: none"> A1 Mitigation LCPs: 39% A2 Mitigation LCPs: 21% A3 Mitigation LCPs: 28% B Section of Master/Development plan: 3% B Section of Sustainability Plan: 4% C Municipal Energy Plan: 5% 	<ul style="list-style-type: none"> A1 Adaptation LCPs: 32% A2 Adaptation LCPs: 38% A3 Adaptation LCPs: 1% C Municipal Flood Plan: 13% C Municipal Heat(wave) Plan: 1% B Section of Resilience Plan: 1% B Section of Sustainability Plan: 3% B Section of Master/Development plan: 11%
3 Type A	<p>Total: 66%, i.e. 587 of 885 cities</p> <p>The majority of mitigation LCPs in European cities are of type A—dedicated and stand-alone plans:</p> <ul style="list-style-type: none"> Denmark, Poland, Germany A1 (29%) France Slovakia and UK A2 (15%) In other countries A3 more common (mitigation LCPs as part of international climate networks) (21%) 	<p>Total: 26%, i.e. 229 of 885 cities</p> <ul style="list-style-type: none"> A1 Adaptation plans are particularly numerous in Finland Type A2 plans are found in Denmark, France, and the UK. Hardly any type A3 adaptation LCPs developed in the framework of international climate networks.
4 Type B	<p>Total: 5%, i.e. 44 of 885 cities</p> <p>In countries with long history on climate and environmental policy (UK and NL)</p>	<p>Total: 5%, i.e. 47 of 885 cities</p> <p>Mostly in Sweden and the UK integrated in the master/development plans</p>
5 Type C	<p>Total: 4%, i.e. 33 of 885 cities</p> <p>Municipal energy plans with a reference to climate change and mitigation targets are found in Austria, Estonia, and the UK</p>	<p>Total: 5%, i.e. 45 of 885 cities</p> <p>Type C Adaptation LCPs relate to Municipal Flood (Slovakia, Ireland, Poland, and the UK) or Heatwave plans (Austrian, Croatian, and Slovakian cities)</p>
6 Overall: Degree mainstreaming in LCPs	<p>9% of cities (row 2 and 4 + 5);</p> <p>12% of plans (row 1)</p>	<p>10% of cities (row 2 and 4 + 5);</p> <p>29% of plans (row 1)</p>

underlines the conclusion of Klein et al. [26] that mainstreaming adaptation and mitigation actions in existing local governance frameworks might be preferable in theory, but limited in practice.

Whether, as Rauken et al. [32] suggest, mainstreamed policies are also more robustly embedded in municipalities’ political processes cannot be easily answered with the data underlying this study. However, Lyles et al. [29] found that narrowly planned LCPs perform even better in terms of plan integration than broader scope sustainability plans. In their study of local municipalities in the US, dedicated, narrowly planned LCPs involved more planning agencies and land use policies than broader scope plans. Formal involvement of planning agencies in adaptation planning processes is associated with more plan integration. In that sense, narrowly focused LCPs may be better than conceptually broader plans for both, speed of plan implementation as well as policy integration.

Nonetheless, some scholars may see the need for both the vertical and the horizontal mainstreaming approach [31,32] and the risks or disadvantages of using only one approach have also been found in other areas of policy action. For example, in gender mainstreaming (in different geographic frameworks) as well as “urban mainstreaming” (related to the programming period 2007–2013 of the Cohesion Policy of the EU [71]) it was observed that due to mainstreaming the specific

policy scope got blurred. As a result, many stakeholders asked for the parallel implementation of concrete measures to maintain the visibility and focus of the policy objectives along with the mainstreaming vision. In the case of the urban dimension of the Cohesion Policy, the mentioned problem led to an amended approach adopted for the subsequent policy period 2014–2020, in which, in order to achieve more effective results, the urban dimension was importantly fostered and allocated a significant budget [72]. With regard to gender mainstreaming the vision adopted by the EU in the framework of its equal opportunities policy now consists of a “dual track approach” in which (more general) gender mainstreaming is complemented with very specific actions to advance women issues.¹

(2) Can the resulting patterns be related to climate policies at the European, national and regional levels?

Mainstreaming may be related to national characteristics, motivation and ‘incentives’ and our data gives some insights into these

¹ <https://eige.europa.eu/lt/gender-mainstreaming/toolkits/gender-institutional-transformation/gender-mainstreaming-and-institutional-transformation>.

questions. Those countries that do have proportionately many mainstreamed mitigation plans in this sample are countries with a long history in environmental planning, i.e. UK (adaptation and mitigation) and the Netherlands (mitigation). The Netherlands is particular in that respect; it only has mainstreamed plans for mitigation and none for adaptation. This has to be explained with the national level of adaptation and risk mitigation, the so-called Delta program that protects the Netherlands against flooding and other extreme weather events and assures that sufficient fresh water is available everywhere across the whole country. The municipalities do not play a major role in water policy and planning. In that respect, climate change adaptation in the Netherlands is managed at the national level. Mainstreaming may also be initiated by national strategies and frameworks that foresee and mention mainstreaming. For example, in the German mitigation (“Klimaschutzplan 2050”, 2016) and adaptation strategy (“Deutsche Anpassungsstrategie”, 2008²) there is no mentioning of “mainstreaming”. However, in the respective action plan³ on climate change adaptation “mainstreaming” is mentioned three times (on 73p.), e.g. “Climate change impacts and adaptation needs should be taken into consideration in plans and decisions (known as ‘mainstreaming’)” (p.9).

The same counts for the word “local”. It is assumed to induce adaptation at the local governance level when mentioned in national programs [18]. For example, in Finland, the country with proportionately most adaptation LCPs in this sample, the National Adaptation Strategy of 2005 and the launch of the National Adaptation Plan of 2014 highlight the role of the regional and local level. Germany is another example. In both, the German mitigation (“Klimaschutzplan 2050”, 2016) as well as adaptation strategy (“Deutsche Anpassungsstrategie”, 2008, and respective action plan) the word local (“lokal”) is mentioned (4 times on 92p. in the mitigation document; 34 and 43 times on 73p. of the adaptation documents, respectively). In Portugal, for example, the National Adaptation Strategy (ENAAAC, RCM 24/2010 [73]) explicitly mentions that local authorities have a fundamental role to play and land management and cities are highlighted as one strategic adaptation area, aligned with water, health, and others. However, in Portugal only more recently adaptation LCPs are being developed and only in cities not part of the UA sample [5].

However, mainstreaming does not only occur in economically strong countries. For example, Poland and Slovakia have relatively large percentages of mainstreamed adaptation LCPs. Earlier findings suggested that local climate planning is related to economic or institutional resources [17,21]. Our data show that this does not count for mainstreaming. Instead, our data indicate that adaptation mainstreaming is understood as a truly local process that needs people, participation and engagement—and therefore more social and governance aspects than economic ones.

This analysis has limitations. First, the review protocol (Fig. 3) involves a decision flow in which only one plan per city is reported—the one on the highest “classification level” according to Reckien et al. [5]. In many active cities, though, there may be multiple plans that deal with the climate challenge. These can be consecutive plans or plans of different administrative levels or departments. It may also relate to cities with both dedicated and mainstreamed plans. In that case, a city with a mainstreamed LCP was only identified when no dedicated, type A plan was available. The analysis shows cities that only use a mainstreaming approach (first and right away), and does not account for cities that use both approaches. As a consequence, the analysis might slightly underestimate the total amount of mainstreamed LCPs and cities with such a plan. As mainstreaming is more prevalent in cities of countries with a long history of environmental planning and risk,

however, mainstreaming might only come after a period of dedicated adaptation planning—an issue not covered here, but interesting for future research.

A second limitation is related to the review protocol, which requires that each analyst classifies any found plan into the given typology. However, in some cases the distinction between some types of plans might be ambiguous. This is the case, for example, when distinguishing (i) type A3 mitigation plans from type C mitigation LCPs (i.e. municipal energy plans). The analysis framework also requires to decide which plans in each country are to be regarded as climate plans, and hence considered in the analysis, independently from their type. With an enormous multitude of policy and governance forms, planning traditions, local mandates and local jurisdictional sizes found in Europe this decision is at times not easy to take. This analysis does not strongly differentiate between, e.g., a strategy, an action plan, an implementation plan, a monitoring plan, or other. However, strategies and action plans with tangible vulnerability or emission reduction objectives have been a target in this study. For that reason, e.g., it was decided not to consider the Spanish instrument called EDUSI (Integrated Sustainable Urban Development Strategy) launched in the framework of the urban dimension of Cohesion Policy in the country. Although it mentions climate change and calls for specific action on mitigation, in its current first stage no targets and objectives are defined.

A third limitation is that this study mostly relied on searching local administrations’ websites and search engines. Only, when conflicting information was found on the website (e.g. of an existing plan, but this was not published) and in countries where it was known that many municipalities do not provide the plans on their website, e.g. in France, the local administrations were contacted.

Finally, the UA sample [68] was selected as a representative sample for the EU context, but this sample also has limitations. In some countries, e.g. in Portugal, the most active cities for LCPs are not in the UA sample. In small countries, LCPs may have been implemented in different administrative units, such as in Malta, where the Valletta UA city extends beyond the city of Valletta and includes other cities/councils. Several smaller cities making up 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. For an extensive discussion of the limitations see SI 3.

5. Conclusions

The aim of this paper was to investigate the extent of using a mainstreaming approach in local climate planning in European cities as compared with a dedicated approach, i.e. dedicated stand-alone climate policy documents addressing the climate challenge. The dataset comprises 885 UA cities in all 28 EU countries, which are representative in size and geographical distribution per country.

Results show that about three times the number of local authorities that plan for adaptation than those that plan for mitigation choose a mainstreaming approach (12% of mitigation plans are mainstreamed; 29% of adaptation plans are mainstreamed). The findings reflect the notion that adaptation is (more than mitigation) understood as a local, multi-dimensional and holistic process. The data point towards the influence of national guidelines in local climate planning (motivating and/or demanding cities to act) and a relation to the history in environmental planning (more mainstreamed LCPs when there is a long history in environmental planning in the country). Moreover, in this sample mainstreaming does not predominantly occur in economically strong countries. Instead, the data indicate that adaptation mainstreaming is understood as a truly local process that needs people, participation and engagement—and therefore more social and governance aspects than economic ones.

Mainstreaming is assumed an indicator for the effectiveness of a policy outcome, e.g. as regards robustness of implementation and acceptance by stakeholders. Mainstreaming also allows for the holistic

² http://www.bmu.de/fileadmin/bmu-import/files/english/pdf/application/pdf/das_gesamt_en_bf.pdf.

³ http://www.bmu.de/fileadmin/bmu-import/files/pdfs/allgemein/application/pdf/aktionsplan_anpassung_klimawandel_en_bf.pdf.

approach intrinsic to the successful implementation of the interconnected United Nation's Sustainable Development Goals. However, a number of findings speak against (broad, horizontal) mainstreaming as an effective means of policy implementation and success. Together with the major efforts needed from local authorities to follow the (horizontal) mainstreaming approach, e.g. as regards political commitment, resources, endurance and implementation speed, either a dedicated approach or a "dual track approach" might be favoured and able to harness the advantages of both approaches.

Therefore, this study together with scholarly analyses call for a joint or subsequent "dual track approach"—in which municipalities develop and adopt the dedicated and mainstreaming plan jointly, or start with a dedicated approach and later mainstream local climate issues. A dedicated local climate plan ensures focus, while a subsequent sectoral and horizontal mainstreaming approach is needed for every climate policy to move from policy setting to action, implementation, and diffusion. Developing broad sustainability or resilience strategies only is seen as critical.

However, it is recognised that neither the existence of LCPs, nor their mainstreaming has been proven to guarantee effectiveness in emissions and/or vulnerability reduction—this and related studies only analyse local climate plans. In order to evaluate effectiveness in emission and vulnerability reduction, the advantages of mainstreaming versus dedicatedly planning for climate change need to be analyzed in terms of policy outcomes (instead of policy outputs) [66,74]. This falls out of the scope of this study and will be the focus of future research. Also, more general studies on local climate policy effectiveness and success of planning for climate change at the local level are urgently needed.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.rser.2019.05.014>.

References

- Mendizabal M, Heidrich O, Feliu E, García-Blanco G, Mendizabal A. Stimulating urban transition and transformation to achieve sustainable and resilient cities. *Renew Sustain Energy Rev* 2018;94:410–8. <https://doi.org/10.1016/J.RSER.2018.06.003>.
- Sharifi A, Yamagata Y. Principles and criteria for assessing urban energy resilience: a literature review. *Renew Sustain Energy Rev* 2016;60:1654–77. <https://doi.org/10.1016/J.RSER.2016.03.028>.
- COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS A policy framework for climate and energy in the period from 2020 to 2030/* COM/2014/015 final */2014.
- UNITED NATIONS 2015. Resolution adopted by the general assembly on 25 september 2015. Transforming our world: the 2030 agenda for sustainable development. New York: UN: n.d.
- Reckien D, Salvia M, Heidrich O, Church JM, Pietrapertosa F, De Gregorio-Hurtado S, et al. How are cities planning to respond to climate change? Assessment of local climate plans from 885 cities in the EU-28. *J Clean Prod* 2018;191:207–19. <https://doi.org/10.1016/j.jclepro.2018.03.220>.
- Araos M, Berrang-Ford L, Ford JD, Austin SE, Biesbroek R, Lesnikowski A. Climate change adaptation planning in large cities: a systematic global assessment. *Environ Sci Policy* 2016;66:375–82. <https://doi.org/10.1016/j.envsci.2016.06.009>.
- Stults M, Woodruff SC. Looking under the hood of local adaptation plans: shedding light on the actions prioritized to build local resilience to climate change. *Mitig Adapt Strategies Glob Change* 2017;22:1249–79. <https://doi.org/10.1007/s11027-016-9725-9>.
- Reckien D, Flacke J, Dawson RJ, Heidrich O, Olazabal M, Foley A, et al. Climate change response in Europe: what's the reality? Analysis of adaptation and mitigation plans from 200 urban areas in 11 countries. *Clim Change* 2014;122:331–40. <https://doi.org/10.1007/s10584-013-0989-8>.
- Heidrich O, Dawson RJ, Reckien D, Walsh CL. Assessment of the climate preparedness of 30 urban areas in the UK. *Clim Change* 2013;120:771–84. <https://doi.org/10.1007/s10584-013-0846-9>.
- Covenant of Mayors for climate & energy. 2018.
- Global covenant of Mayors for climate & energy. 2018.
- C40 cities. 2018.
- Carmin J, Nadkarni N, Rhie C. Progress and challenges in urban climate adaptation planning. Boston, MA. 2012.
- Woodruff SC, Stults M. Numerous strategies but limited implementation guidance in US local adaptation plans. *Nat Clim Change* 2016;6:796–802. <https://doi.org/10.1038/nclimate3012>.
- Woodruff SC. City membership in climate change adaptation networks. *Environ Sci Policy* 2018;84:60–8. <https://doi.org/10.1016/j.envsci.2018.03.002>.
- Guyadeen D, Thistlethwaite J, Henstra D. Evaluating the quality of municipal climate change plans in Canada. *Clim Change* 2018;1–23. <https://doi.org/10.1007/s10584-018-2312-1>.
- Reckien D, Flacke J, Olazabal M, Heidrich O. The influence of drivers and barriers on urban adaptation and mitigation plans—an empirical analysis of European Cities. *PLoS One* 2015;10:1–21. <https://doi.org/10.1371/journal.pone.0135597>.
- De Gregorio Hurtado S, Olazabal M, Salvia M, Pietrapertosa F, Olazabal E, Geneletti D, D'Alonzo V, Di Leo S, Reckien D. Understanding how and why cities engage with climate policy: an analysis of local climate action in Spain and Italy. *TeMA - J Land Use Mobil Environ* 2015;23–46. <https://doi.org/10.6092/1970-9870/3649>.
- Olazabal M, Hurtado SDG, Olazabal E, Pietrapertosa F, Salvia M, Geneletti D, et al. How are Italian and Spanish cities tackling climate change? A local comparative study. 2014.
- Campos I, Guerra J, Ferreira JG, Schmidt L, Alves F, Vizinho A, et al. Understanding climate change policy and action in Portuguese municipalities: a survey. *Land Use Policy* 2017;62:68–78. <https://doi.org/10.1016/j.landusepol.2016.12.015>.
- Aguiar FC, Bentz J, Silva JMN, Fonseca AL, Swart R, Santos FD, et al. Adaptation to climate change at local level in Europe: an overview. *Environ Sci Policy* 2018;86:38–63. <https://doi.org/10.1016/J.ENVSCI.2018.04.010>.
- De Gregorio Hurtado S, Olazabal M, Salvia M, Pietrapertosa F, Olazabal E, Geneletti D, D'Alonzo V, Feliu E, Di Leo DR S. Implications of governance structures on urban climate action: evidence from Italy and Spain. 2014.
- Heidrich O, Reckien D, Olazabal M, Foley A, Salvia M, de Gregorio Hurtado S, et al. National climate policies across Europe and their impacts on cities strategies. *J Environ Manag* 2016;168. <https://doi.org/10.1016/j.jenvman.2015.11.043>.
- Climate Policy Info Hub. Mainstreaming climate change adaptation in the EU Web Page 2018:1–8 <https://climatepolicyinfohub.eu/mainstreaming-climate-change-adaptation-eu>, Accessed date: 19 December 2018.
- Parry ML, Anziani OF, Palutikof JP, Linden PJ van der, Hanson CE. *Climate change 2007: impacts. Cambridge: Adaptation and Vulnerability*; 2007.
- Klein RJT, Schipper ELF, Dessai S. Integrating mitigation and adaptation into climate and development policy: three research questions. *Environ Sci Policy* 2005;8:579–88. <https://doi.org/10.1016/j.envsci.2005.06.010>.
- Pietrapertosa F, Khokhlov V, Salvia M, Cosmi C. Climate change adaptation policies and plans: a survey in 11 South East European countries. *Renew Sustain Energy Rev* 2018;81:3041–50. <https://doi.org/10.1016/J.RSER.2017.06.116>.
- Uittenbroek CJ, Janssen-Jansen LB, Spit TJM, Salet WGM, Runhaar HAC. Political commitment in organising municipal responses to climate adaptation: the dedicated approach versus the mainstreaming approach. *Environ Pol* 2014;23:1043–63. <https://doi.org/10.1080/09644016.2014.920563>.
- Lyles W, Berke P, Overstreet KH. Where to begin municipal climate adaptation planning? Evaluating two local choices. *J Environ Plan Manag* 2018;61:1994–2014. <https://doi.org/10.1080/09640568.2017.1379958>.
- Woodruff SC, Meerow S, Stults M, Wilkins C. Adaptation to resilience planning: Alternative pathways to prepare for climate change. *J Plan Educ Res* 2018. <https://doi.org/10.1177/0739456X18801057>.
- Kok MTJ, de Coninck HC. Widening the scope of policies to address climate change: directions for mainstreaming. *Environ Sci Policy* 2007;10:587–99. <https://doi.org/>

- 10.1016/j.envsci.2007.07.003.
- [32] Rauken T, Mydskje PK, Winsvold M. Mainstreaming climate change adaptation at the local level. *Local Environ* 2015;20:408–23. <https://doi.org/10.1080/13549839.2014.880412>.
- [33] Pasquini L, Cowling RM, Ziervogel G. Facing the heat: barriers to mainstreaming climate change adaptation in local government in the Western Cape Province, South Africa. *Habitat Int* 2013;40:225–32. <https://doi.org/10.1016/j.habitatint.2013.05.003>.
- [34] Wamsler C, Luederitz C, Brink E. Local levers for change: mainstreaming ecosystem-based adaptation into municipal planning to foster sustainability transitions. *Glob Environ Chang* 2014;29:189–201. <https://doi.org/10.1016/j.gloenvcha.2014.09.008>.
- [35] Vasileiadou E, Tuinstra W. Stakeholder consultations: mainstreaming climate policy in the energy directorate? 2014.
- [36] Vincent K, Colenbrander W. Developing and applying a five step process for mainstreaming climate change into local development plans: a case study from Zambia. *Clim Risk Manag* 2018;21:26–38. <https://doi.org/10.1016/j.crm.2018.04.005>.
- [37] Alhassan S, Hadwen WL. Challenges and opportunities for mainstreaming climate change adaptation into WaSH development planning in Ghana. *Int J Environ Res Public Health* 2017;14. <https://doi.org/10.3390/ijerph14070749>.
- [38] De Roeck F, Orbie J, Delputte S. Mainstreaming climate change adaptation into the European Union's development assistance. *Environ Sci Policy* 2018;81:36–45. <https://doi.org/10.1016/j.envsci.2017.12.005>.
- [39] Giupponi C. Decision support for mainstreaming climate change adaptation in water resources management. *Water Resour Manag* 2014;28:4795–808. <https://doi.org/10.1007/s11269-014-0776-y>.
- [40] Widmer A. Mainstreaming climate adaptation in Switzerland: how the national adaptation strategy is implemented differently across sectors. *Environ Sci Policy* 2018;82:71–8. <https://doi.org/10.1016/j.envsci.2018.01.007>.
- [41] Musah-Surugu JI, Owusu K, Yankson PWK, Ayisi EK. Mainstreaming climate change into local governance: financing and budgetary compliance in selected local governments in Ghana. *Dev Pract* 2018;28:65–80. <https://doi.org/10.1080/09614524.2018.1398717>.
- [42] Berkhout F, Bouwer LM, Bayer J, Bouzid M, Cabeza M, Hanger S, et al. European policy responses to climate change: progress on mainstreaming emissions reduction and adaptation. *Reg Environ Change* 2015;15:949–59. <https://doi.org/10.1007/s10113-015-0801-6>.
- [43] Clar C, Steurer R. Mainstreaming adaptation to climate change in a federal state setting: policy changes in flood protection and tourism promotion in Austria? SSRN Electron J 2014. <https://doi.org/10.2139/ssrn.2643380>.
- [44] Cuevas SC. The interconnected nature of the challenges in mainstreaming climate change adaptation: evidence from local land use planning. *Clim Change* 2016;136:661–76. <https://doi.org/10.1007/s10584-016-1625-1>.
- [45] Hanger S, Haug C, Lung T, Bouwer LM. Mainstreaming climate change in regional development policy in Europe: five insights from the 2007–2013 programming period. *Reg Environ Change* 2015;15:973–85. <https://doi.org/10.1007/s10113-013-0549-9>.
- [46] Wamsler C, Pauleit S. Making headway in climate policy mainstreaming and ecosystem-based adaptation: two pioneering countries, different pathways, one goal. *Clim Change* 2016;137:71–87. <https://doi.org/10.1007/s10584-016-1660-y>.
- [47] Ayers J, Huq S, Wright H, Faisal AM, Hussain ST. Mainstreaming climate change adaptation into development in Bangladesh. *Clim Dev* 2014;6:293–305. <https://doi.org/10.1080/17565529.2014.977761>.
- [48] Di Giulio GM, Bedran-Martins AMB, Vasconcellos M da P, Ribeiro WC, Lemos MC. Mainstreaming climate adaptation in the megacity of São Paulo, Brazil. *Cities* 2018;72:237–44. <https://doi.org/10.1016/j.cities.2017.09.001>.
- [49] Friend R, Jarvie J, Reed SO, Sutarto R, Thinphanga P, Toan VC. Mainstreaming urban climate resilience into policy and planning; reflections from Asia. *Urban Clim* 2014;7:6–19. <https://doi.org/10.1016/j.uclim.2013.08.001>.
- [50] Gao Q. Mainstreaming climate change into the EIA procedures: a perspective from China. *IJCCSM-04-2016-0040 Int J Clim Chang Strateg Manag* 2017. <https://doi.org/10.1108/IJCCSM-04-2016-0040>.
- [51] Khailani DK, Perera R. Mainstreaming disaster resilience attributes in local development plans for the adaptation to climate change induced flooding: a study based on the local plan of Shah Alam City, Malaysia. *Land Use Policy* 2013;30:615–27. <https://doi.org/10.1016/j.landusepol.2012.05.003>.
- [52] Ogato GS, Abebe K, Bantider A, Geneletti D. Towards mainstreaming climate change adaptation into urban land use planning and management: the case of ambo town, Ethiopia. 2017. p. 61–85. https://doi.org/10.1007/978-3-319-49520-0_5.
- [53] Pasquini L, Ziervogel G, Cowling RM, Shearing C. What enables local governments to mainstream climate change adaptation? Lessons learned from two municipal case studies in the Western Cape, South Africa. *Clim Dev* 2015;7:60–70. <https://doi.org/10.1080/17565529.2014.886994>.
- [54] Saito N. Mainstreaming climate change adaptation in least developed countries in South and Southeast Asia. *Mitig Adapt Strategies Glob Change* 2013;18:825–49. <https://doi.org/10.1007/s11027-012-9392-4>.
- [55] Sharma D, Tomar S. Mainstreaming climate change adaptation in Indian cities. *Environ Urbanization* 2010;22:451–65. <https://doi.org/10.1177/0956247810377390>.
- [56] Keskitalo E, Carina H, Pettersson M. Can adaptation to climate change at all be mainstreamed in complex multi-level governance systems?: a case study of forest-relevant policies at the EU and Swedish levels. *Implement. Clim. Chang. Adapt. Cities Communities. Integr. Strateg. Educ. Approaches. Encyclopedia of Global Archaeology/Springer Verlag*; 2016. p. 53–74.
- [57] Linnerooth-Bayer J, Dubel A, Sendzimir J, Hochrainer-Stigler S. Challenges for mainstreaming climate change into EU flood and drought policy: water retention measures in the Warta River Basin, Poland. *Reg Environ Change* 2015;15:1011–23. <https://doi.org/10.1007/s10113-014-0643-7>.
- [58] Fainstein SS. Resilience and justice: planning for New York City. *Urban Geogr* 2018;39:1268–75. <https://doi.org/10.1080/02723638.2018.1448571>.
- [59] UNDP-UNEP. Mainstreaming climate change adaptation into development planning: a guide for practitioners. 2011.
- [60] Harvey J, Heidrich O, Cairns K. Psychological factors to motivate sustainable behaviours. *Proc Inst Civ Eng - Urban Des Plan* 2014;167:165–74. <https://doi.org/10.1680/udap.14.00001>.
- [61] Underdal A. Integrated marine policy: what? Why? How? *Mar Policy* 1980;4:159–69. [https://doi.org/10.1016/0308-597X\(80\)90051-2](https://doi.org/10.1016/0308-597X(80)90051-2).
- [62] Lafferty W, Hovden E. Environmental policy integration: towards an analytical framework. *Environ Pol* 2003;12:1–22. <https://doi.org/10.1080/09644010412331308254>.
- [63] Nunan F, Campbell A, Foster E. ENVIRONMENTAL MAINSTREAMING: THE ORGANISATIONAL CHALLENGES OF POLICY INTEGRATION. *Publ Adm Dev* 2012;32:262–77. <https://doi.org/10.1002/pad.1624>.
- [64] van den Berg M, Coenen F. Integrating climate change adaptation into Dutch local policies and the role of contextual factors. *Local Environ* 2012;17:441–60. <https://doi.org/10.1080/13549839.2012.678313>.
- [65] Dovers SR, Hezri AA. Institutions and policy processes: the means to the ends of adaptation. 1. *Wiley Interdiscip Rev Clim Chang*; 2010. p. 212–31. <https://doi.org/10.1002/wcc.29>.
- [66] Runhaar H, Wilk B, Persson Å, Uittenbroek C, Wamsler C. Mainstreaming climate adaptation: taking stock about “what works” from empirical research worldwide. *Reg Environ Change* 2018;18:1201–10. <https://doi.org/10.1007/s10113-017-1259-5>.
- [67] Uittenbroek CJ. From policy document to implementation: Organizational routines as possible barriers to mainstreaming climate adaptation. *J Environ Policy Plan* 2016;18:161–76. <https://doi.org/10.1080/1523908X.2015.1065717>.
- [68] Database - Eurostat 2018 <https://ec.europa.eu/eurostat/web/cities/data/database>, Accessed date: 10 December 2018.
- [69] Eurostat. Annex 2 — cities participating in the urban Audit data collection. 2015.
- [70] Jensen A, Nielsen H, Nielsen M. Climate adaptation in local governance: institutional barriers in Danish municipalities. Aarhus; 2018.
- [71] European Commission. Fostering the urban dimension: analysis of the operational programmes co-financed by the European regional development fund (2007–2013) - regional policy - European commission 2008:1–56. https://ec.europa.eu/regional_policy/en/information/publications/evaluations-guidance-documents/2008/fostering-the-urban-dimension-analysis-of-the-operational-programmes-co-financed-by-the-european-regional-development-fund-2007-2013, Accessed date: 10 December 2018.
- [72] De Gregorio Hurtado S. The EU urban policy in the period 2007–13: lessons from the Spanish experience. *Reg Stud Reg Sci* 2018;5:212–30. <https://doi.org/10.1080/21681376.2018.1480903>.
- [73] Portuguese Council of Ministers. ENAAC- Portuguese national climate change adaptation strategy. Resolution of the Council of Ministers; 2010.
- [74] Grumm JG. The analysis of policy impact. Fred greenstein and nelson polsby, editor. *Policies policy-making handb. Polit. Sci.*. Addison-Wesley Pub. Co.; 1975. p. 441–8.