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Mainstreaming Climate Change Adaptation into Local Planning

Insights from Barcelona and Turin municipalities

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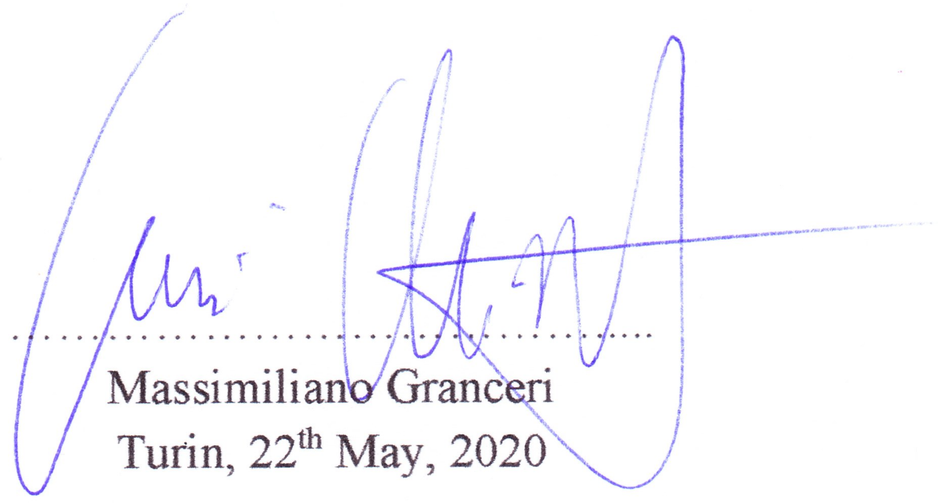

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Summary

Climate Change Adaptation (CCA) has recently emerged as a key issue in global debate and the Paris Agreement (2015) highlighted the crucial role of cities and local governments in addressing climate-related impacts. Due to the cross-cutting nature of CCA, international organizations (e.g. United Nations, European Union) encourage its cross-sectoral integration into local planning frameworks – conceptualized in the notion of 'mainstreaming'.

Local governments engaged in CCA planning are currently a minority, mostly large-sized cities, and the planning tools they use for tackling CCA are heterogeneous (e.g. comprehensive plans, master plans, CCA-dedicated plans, resilience strategies). In the European Union context, cities mostly employ the dedicated approach (i.e. CCA plans or CCA and mitigation joint plans) and this approach *de facto* frames CCA as a new sectoral issue.

Despite the different tools employed in CCA planning, there is still an implementation gap and these tools – especially the dedicated ones – are seldom integrated into the local planning frameworks. Furthermore, the role of science-based climate information in CCA mainstreaming as well as CCA co-production are the two main aspects in need of further investigation.

Exploring the different stages of policy-making processes and the Science-Policy interface, this research aims to address the mechanisms of CCA integration into local planning frameworks and implementation. These processes are analysed through the use of a theoretical lens, 'mainstreaming' – the core concept of this thesis – which provides a critical perspective for the examination of: i) science-based climate information and services that feed CCA planning and eventually affect CCA integration, and ii) dedicated planning tools and their impacts on CCA integration and implementation.

The research was carried out through an analytical framework, designed in accordance with literature review findings. The framework consists of a set of qualitative criteria aimed at assessing the credibility – reliability, accuracy, and

legitimacy – of climate information and services; the degree of CCA integration into local planning frameworks; and the relevance and consistency of CCA measures and monitoring systems. The analysis draws on a qualitative research approach with triangulation of secondary data analysis, in-depth semi-structured interviews, and participant observations.

The limited understanding of how CCA policies and plans are integrated into local planning frameworks in Southern Europe justifies the central focus area of the thesis, with Barcelona (ES) and Turin (IT) as main case studies. Both municipalities, respectively coastal large- and inland mid-sized cities, employ a dedicated planning approach, with a difference in experience (Barcelona can be classed as relatively mature, whereas Turin is a relative "newcomer").

Results constitute a valuable indication for scholars and policy-makers. This thesis argues that what is actually mainstreamed into local planning frameworks is climate information which, as a consequence, should always be investigated when researching CCA planning and policy. Another important issue that arises relates to the consistency of CCA measures. In fact, the complexity and multi-risk nature of climate change require researching the inner conflicts among CCA measures, which can also cause disservices – research fields yet to be properly explored.

Based on the empirical findings, relevant attention should be given to intra-organisational coordination among key municipal departments; to the involvement of knowledgeable local stakeholders from the pre-planning phase; and the strategic use of CCA-dedicated planning tools.

Finally, this exploratory research provides valuable methodological and conceptual insights and paves the way for a better understanding of the joint application of co-production and mainstreaming concepts in CCA planning research.

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To the memory of Carlos

Firmeza no pensamento. Sempre.

Premise: how to read this thesis

This Philosophy Doctorate, PhD henceforth, Thesis is made of seven chapters, starting from the introductory chapter (1), and consisting of three parts.

Part I includes two chapters: research design (2) and theoretical framing (3).

Chapter two (2) introduces the research setting, including the research approach (2.1), the methods (2.2), the analytical framework (2.3), and the limitations (2.4). The analytical framework was applied throughout the second part: the two chapters (4 and 5) where the cases' analysis is described.

Chapter three (3) addresses the theoretical basis of the research topics and consists of literature reviews and state-of-art of the climate change adaptation (CCA) planning and three more literature reviews, which were carried out on the fields of CCA mainstreaming using a systematic approach, climate information and services, and co-production in the fields of urban planning and climate services.
The main literature reviews are the ones on CCA planning (3.1) and CCA mainstreaming (3.2), which led to find the research gaps and to identify the geographical focus of this research.
The literature review on climate information and services (3.3) gave an overview of the concepts in theory and practice. The review spotlights on the inherent characteristics of climate information creation and the concepts and approaches commonly used for climate and weather risk analysis, i.e. the return-period notion, and the climate modelling issue.
The review on the co-production concept (3.4) addresses its theoretical basis and its application in the fields of urban planning, climate services and CCA.

Section 3.5 sums up the previous four sections and prepares for the Thesis' II part. The *file rouge* that connects the first four sections relates to the purpose to identify the most pertinent and feasible approaches and criteria for assessing the whole process of CCA planning through the 'mainstreaming' lens. Moreover, a theoretical alignment of the concepts of mainstreaming and co-productions is proposed in 3.5.1 sub-section.

Part II consists of two chapters on the case studies analysis and results: chapter 4 for Barcelona and chapter 5 for Turin. Before describing and interpreting the findings, the second part starts outlining the CC issue in the Mediterranean context and overviewing the two case studies.

Chapter four is divided into five sections. The introductory section (4.1) describes the Barcelona's climate change effects suffered to-date (4.1.1) and the Spanish CCA planning state-of-the-art (4.1.2) – from the National (Spain) to the Regional (Catalunya) level.
The climate information and services issues are addressed in section 4.2, where the climate change scenarios (4.2.1) and risk analysis (4.2.2) delivered to Barcelona municipality are described.
Section 4.3 addresses the Climate Plan's, called Pla Clima, participatory design, spotlighting on the CCA-related plans and measures placed under the Pla Clima and analyses the CCA integration among the sectors involved.
Section 4.4 focuses on the Pla Clima co-implementation and describes the projects and the actors that were funded for implementing the Pla Clima (4.4.1) and their relatedness with the CCA issue (4.4.2), and, finally, analyses the monitoring system used for the Pla Clima (4.4.3).
The last section, 4.5, discusses the findings and highlights the insights of the chapter.

Chapter five is divided in four sections. It begins with an introduction (5.1) on the Turin case's climate change effects suffered to-date (5.1.1) and on the Italian National CCA planning state-of-the-art (5.1.2). Section 5.2 addresses the climate change analysis (5.2.1) delivered to the Turin municipality.
Section 5.3 focuses on the CCA policy-making process and spotlights on the background of the process and its kick-starter (5.3.1) and the CCA-related measures collected from the sectors involved in the process and designed *ex-novo* addressing heatwaves and floods (5.3.2).
The last section, 5.4, discusses the findings and highlights the insights of the chapter.

Part III addresses the discussion (6) and the conclusions (7).

Chapter six begins with a brief sum-up of the thesis aims and gaps tackled. Section 6.1 addresses the main research question through the answers of the sub-questions (6.1.1, 6.1.2).
The last section (6.2) reflects on the research and practice agenda of CCA planning and mainstreaming. Sub-section 6.2.1 illustrates potential follow-ups for future research and applications in the form of recommendations (6.4.2), which are tailored-made for the politicians, practitioners and policy-makers that lead or co-lead CCA planning processes.

Finally, chapter seven pulls the strings and closes the doctoral dissertation highlighting the arguments of the thesis and the most important insights.

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Chapter 1

Introduction

1.1 Climate change adaptation planning and mainstreaming: context and gaps

Climate Change, CC henceforth, is one of the main drivers threatening the present and future of cities (European Environment Agency, 2012b; IPCC, 2015). CC carries a series of inherent challenges, all of them starting with the un- prefix: uncertainty (Dessai, Hulme, Lempert, & Pielke, 2009; Fankhauser, Smith, & Tol, 1999; Wardekker, 2011), unexpectedness (Lee & Farlow, 2019), unpredictability (Claruis et al., 2014; Gupta et al., 2010), and unknowingness (Termeer & van den Brink, 2013; Woodruff, 2016). Thus, CC is a problem, which some scholars define as 'super wicked' (Lazarus, 2009; Levin, Cashore, Bernstein, & Auld, 2012), that can be tackled in two ways: i) at the source, reducing green-house gas emissions, known as Mitigation; ii) on the effects, reducing or moderating current and future impacts, known as Adaptation. According to the last United Nations-Department of Economics and Social Affairs' report, urban areas house the majority of the world's population (UN-DESA, 2019) and cities are key drivers for innovation in today's society, regionally and globally. Cities are critical and sensitive contexts in CC research and action, due both to their role as large producers of greenhouse gases and to being places where the lives and wellbeing of their inhabitants are increasingly being threatened by climate-related risks.

Despite several decades of research on and action for CCM, the current climatic state of the Earth, as detailed in the latest IPCC report "Global Warming of 1.5 ºC" (IPCC, 2018), is worsening in terms of beneficial conditions for human habitation. In fact, the report highlights the need to limit global warming to 1.5°C, compared to 2°C, or more. In simple terms: we (human beings) are creating risks faster than we are reducing them.

"*Most scientific literature specific to global warming of 1.5°C is only just emerging. This has led to differences in the amount of information available and gaps across the various sections of this chapter. In general, the number of impact studies that*

specifically focused on 1.5°C lags behind CC projections in general, due in part to the dependence of the former on the latter. There are also insufficient studies focusing on regional changes, impacts and consequences at 1.5°C and 2°C of global warming" (IPCC 2018, p. 272). Hence, paraphrasing IPCC's scientific gaps explanation, what we do know is that we don't know how the Earth's climate will react to these stimuli. If, on one hand, CCM efforts are still needed, on the other hand, CCA, and the planning of it, has to be considered a critical option to be addressed (Ford & King, 2015), both in research and in practice.

When referring to a planned CCA strategy, the type of adaptation investigated in this PhD Thesis, the decision making processes were defined as constituting a 'super wicked' problem due to the inherent characteristics of "*severe uncertainty, divergent stakeholder understanding and interests, dynamic socio-environmental interactions and limited understanding of natural and societal responses to future climatic changes*" (Bhave, Conway, Dessai, & Stainforth, 2016, p. 4 citing Lazarus, 2009; Mearns, 2010; Head, 2014; Levin et al., 2012). Moreover, as argued by Birkmann et al. when referring to urban areas, "*adaptation cannot be addressed sufficiently through the sole implementation of [small to] large-scale structural measures that aim to adjust the built environment. (…) [B]eside the physical structures, the planning system and multi-level governance structures also have to change in order to ensure all relevant topics and aspects are covered, and all relevant stakeholders are included*" (2010, p. 202). The concept of Adaptive Urban Governance supports the need for this paradigm shift and the move towards the improvement of planning systems, tools and governance processes with a more integrated , cross-sectoral, multi-level approach (Birkmann, Garschagen, & Setiadi, 2014). In other words, "*adaptation must be seen as part of the dynamics of societies rather than simply being a technical adjustment to biophysical change by society*" (Eriksen, Nightingale, & Eakin, 2015, p. 524).

1.1.1 Climate change adaptation planning and governance: the local, the urban, and the cross-sectoral integration

CCA has for a long time been framed as an area of action to be undertaken at the global and national scale. As stated and investigated by Ayers, this sounds paradoxical (2010) because adaptation to CC happens at a local scale and most of its benefits stay *in-situ*. Therefore, due to its highly context-specific nature, being dependent on the climatic, environmental, social, and political conditions in the specific region (Fussel, 2007), the local (e.g. municipal, metropolitan), which has been recognised as highly important or even the most important level for CCA (Birkmann et al. 2010; Carter et al. 2015), is the scale taken in this research.

Nevertheless, this doesn't mean that all the responsibilities for CCA planning fall to local governments because the international, national, and regional levels also play a critical role in defining the local CCA strategies (Nalau, Preston, & Maloney, 2015).

CCA planning has emerged as a key issue in the global debate (Moss et al., 2013; Preston, Rickards, Fünfgeld, & Keenan, 2015) and the Paris Agreement (2015)

kickstarted a challenging journey on CCA that obliges cities to act on CC impacts. However, the number of urban systems actively addressing CCA through planning is still a minority, as shown by recent scientific studies, most of which focus on large cities (Reckien et al. 2018; Tiepolo, Pezzoli, and Tarchiani 2017; Tiepolo, Ponte, and Cristofori 2016; Woodruff et al. 2018).

Two recent CCA planning reviews, whose geographical *foci* are the tropical and subtropical regions, show that CCA is tackled with a range of different tools, e.g. contingency plans, Master plans, Resilience strategies, among others. These reviews highlighted that CCA is mostly included within comprehensive development plans (Tiepolo et al., 2016, 2017), which tackle this cross-cutting issue holistically. However, cities, especially in the EU (Reckien et al. 2018), continue to employ traditional planning approaches e.g. ad-hoc sectorial CCA-oriented plans or CCA+CCM joint plans. This approach is known as "dedicated" (Uittenbroek 2014), otherwise called "add-on" (Wamsler, 2014).

Generally, these CCA-related plans are of low quality (Tiepolo et al., 2016), and are often lacking in terms of implementation (Biesbroek et al. 2013; Wheeler 2008; Woodruff and Stults 2016). Furthermore, in some cases these plans and their related documents have started disappearing – being removed on purpose after a political mandate – from official municipalities' webpages, making them no longer traceable (Reckien et al. 2019). In addition, cities also tackle the CCA issue with actions and measures taken by local government departments, such as environment – often the one assigned to the CC issue (Birkmann & von Teichman, 2010; Lehmann, Brenck, Gebhardt, Schaller, & Süßbauer, 2015) –, spatial planning, water management, and mobility (Uittenbroek, Janssen-Jansen, and Runhaar 2013). However, even though CCA-related plans and measures can be operative in the short term, they are often not integrated within local planning frameworks[1] and are not designed to last in the medium- and long-term (Tiepolo et al., 2016). Despite various attempts to understand CCA policies, plans, strategies, and actions (Brouwer, Rayner, and Huitema 2013; Saleemul Huq et al. 2003; Juhola 2010; Keskitalo 2010a; Rauken, Mydske, and Winsvold 2015; Reckien et al. 2019; Reckien et al. 2014; Reckien et al. 2018; Storbjörk 2010; Tiepolo, Pezzoli, and Tarchiani 2017; Uittenbroek 2014; Wamsler and Brink 2014), still little is known about how to make CCA long-lasting and integrated across sectors (Ayers et al. 2014) especially at the local level.

Among the inner challenges that CCA planning has to tackle, including inter-sectoral integration –mainstreaming – and multi-scale administrative level coordination, there are also the challenges to avoid or minimize unsuccessful CCA (Doria et al. 2009; Adger, Arnell, and Tompkins 2005), predict (and avoid) potentially dangerous maladaptation (Barnett & O'Neill, 2010; Brooks, 2011; Brown, 2011; Heyd & Brooks, 2009; Magnan et al., 2016; Wise et al., 2014), and maximise opportunities from a changing climate (Dessai et al., 2009).

[1] The general planning and management system of a local government is a set of plans, programmes, measures, strategies, projects, laws, rules, codes, agreements, and ongoing spatial development and decision-making processes. In this thesis, this compound of planning tools is called the 'local planning framework'.

1.1.2 Mainstreaming climate change adaptation: why is it an important area of research?

International organizations, both public, e.g. European Union (EU), and private (e.g. C40 Alliance, Rockefeller Foundation), are encouraging governments at lower levels to implement CCA-oriented programmes, plans, and policies. These actors set up international platforms, foster research (e.g. Horizon2020-EU), fund projects (e.g. 100 Resilient Cities) and often coordinate transnational municipal networks (Andonova, Betsill, & Bulkeley, 2009; Fünfgeld, 2015; Harris, 2009; Haupt, 2019; Haupt & Coppola, 2019; Kern & Bulkeley, 2009; Moloney & Fünfgeld, 2015). They play an active role in local planning and should be considered in CCA investigation, since they also support local governments through providing guidelines, connecting local municipalities for good practices exchanges or setting up city-to-city learning (C2CL) projects.

In the documents they provide (e.g. EEA 2012, 2017; OECD 2009; UN-HABITAT 2015) they repeatedly use a word which describes the aim of implementing cross-sectoral integration into government sectors and policy agendas. The keyword they use, which is the main theoretical concept of this Thesis, is "mainstreaming".

Mainstreaming has its roots in social development discourse and was first used for gender-related issues in 1985 (Jahan, 1995). Conceptually, Picciotto defines it as a dynamic concept that suggests a *"deliberate perturbation in the natural order of things"* (2002, p.323). It subverts the *status quo* and it does not evoke painful disruption (2002). When applied to the CCA field, mainstreaming is defined in many different ways (Runhaar, Wilk, Persson, Uittenbroek, & Wamsler, 2018), sometimes considered as a synonym of integration, incorporation, normalization (Ford, Pearce, Duerden, Furgal, & Smit, 2010), or absorption (Pelling, 2011).

In this thesis mainstreaming is conceptually defined as the process of cross-sectoral integration of a specific issue, i.e. CCA, both horizontally and vertically, of policies and measures, into the operative and planning framework of an organization, e.g. a local governmental body – municipality (Dewulf, Meijerink, & Runhaar, 2015; Huq et al., 2003; Klein et al., 2007; Klein & Persson, 2009; Runhaar et al., 2018; Wamsler, Luederitz, & Brink, 2014).

Governments have to lead processes of CCA policy and planning across sectors and scales. The conventional rigid administrative structure and planning constituencies, which have their roots in the past century, are based on the Weberian principles of conformity, specialisation and silos[2] (Bourgon, 2009) and rigid *modii operandi* like 'predict-and-provide' (Bruno Soares, Alexander, & Dessai, 2018; Vaughan & Dessai, 2014) and 'command-and-control' (Roo, 2017). From this issue arises the challenge for governments to coordinate the policy and decision-making processes among their tiers.

[2] A silo mentality relates to the reluctance to share information with employees of different sectors or departments in the same organization. This attitude hampers coordination among government tiers and is seen as reducing the organization's efficiency and, at worst, contributing to a damaged work flow (Klein and Persson 2009; Pasquini, Cowling, and Ziervogel 2013; Pasquini et al. 2015).

CCA mainstreaming is a buzzword, often vaguely defined, used in both grey and academic literature. The related research field is a niche (Runhaar et al., 2018) that includes several gaps and lacks. The literature review undertaken as part of this thesis led to conclusions that differ from those of a similar review co-authored by the most important scholars of this niche (ibid.). Runhaar et al. argued that there is a need to increase research efforts on both planning outputs (e.g. plans, strategies, programmes) and outcomes – otherwise called implementations (2018). This view is insufficient in not considering the process(es) as a whole, despite being stated meanwhile by two of the co-authors, i.e. Persson A. and Runhaar H., in Environmental Policy Integration research (Persson & Runhaar, 2018). Moreover, there is still something missing in the way CCA mainstreaming is studied and this relates to the climate inputs, namely the climate-related information that feeds the CCA planning processes e.g. CC assessments, CC scenarios, climate-related risk analysis.

1.1.3 Climate information and services: why it is important to include them in climate change adaptation mainstreaming research?

CCA local planning is almost always (Tiepolo et al., 2017) fed by climate information, which is mainly produced by climate scientists and disaster risk analysts. The climate information produced (Füssel, 2007) is sometimes framed in terms of climate services (Bruno Soares, Alexander, and Dessai 2018), which support local policy-making and planning and tailored according to governments' needs. The flow of this information is often top-down and rigid and delivered and expressed in documents with many technicalities and a lack of readability for non-experts (Coulter, Serrao-Neumann, & Coiacetto, 2019). This climate knowledge derives from the application of science-based models that, even though hyper-sophisticated, have imperfections and carry uncertainties (Keys et al., 2019). A way to overcome these deficiencies, which has started taking pace in the last decade, is through civic engagement, whose maximum expression is the co-production of climate knowledge and CCA measures, climate services, and CCA planning and implementation (Bremer et al., 2019; Vincent, Daly, Scannell, & Leathes, 2018).
Climate information, together with its conceptual evolution, i.e. climate services (CS), is a critical aspect of CCA planning. Academic literature in these fields has recently started criticizing the studies that tackle the CC issue with just science-based approaches – what Vaughan and Dessei call "knowledge elitism" (2014). CC with the 'un' that embeds, i.e. un-predictability, un-expectedness, un-certainty, and un-knowingness, challenges the aims of scientists, which seek the achievement of perfection of models and projections, despite basing their studies on data (e.g. historical weather series) and concepts (e.g. return-period) that have limits (Sobell and Tippett 2014). Moreover, climate-related information, also in the form of services, are often produced with a "predict-and-provide" mentality (Soares 2016) by knowledge elites or experts (e.g. knowledge brokers) and delivered with a rigid top-down approach (Bremer et al., 2019; Nunan, Campbell, & Foster, 2012).

1.1.4 Geographical focus: European Union

The European Union (EU) is an emblematic case because it has created platforms, i.e. Covenant of Mayors, Mayors Adapt, and Compact of Mayors (CoM) for Climate and Energy[3], with the aim of encouraging local governments to tackle CCA and CCM through planning. In order to join the current active platform, i.e. CoM for Climate and Energy, local governments have to commit to the network with the condition that a CCA *ad hoc* plan will be designed and approved. Actually, municipalities are willing to join the network and accomplishing this task for several reasons, e.g. access to technical and/or financial support, interests in becoming CCA champions, transforming political inertia into proactive and effective CCA policy-making and rising societal CCA awareness (De Gregorio Hurtado et al., 2015; Haupt, 2018; Haupt, Chelleri, van Herk, & Zevenbergen, 2019). Hence, CoM provides documents and guidelines, sets a goal, i.e. CCA-dedicated plan and ambitions, and through this it influences the policy-making of local government administrations in EU member countries. In a nutshell, the message that CoM sends to local policy-makers is to use a dedicated cross-cutting planning approach for tackling CCA. At the same time, the EU, through their environment- and climate-focused Agency, i.e. European Environmental Agency (EEA), also provides documents and guidelines (e.g. EEA 2012, 2017), confirming what other international organizations also state (OECD 2009; UN-HABITAT 2015), suggesting CCA be tackled holistically and integrated into the planning frameworks through the concept of 'mainstreaming'.

In the European context, the EU used the 'mainstreaming' concept for "*climate-proofing EU action*" (European Commission 2013), meaning that CCA goals should be integrated into government departments. The EEA mentions mainstreaming in the 12/2016 and the 02/2017 (EEA, 2016, 2017) reports, considering it a way to link climate and non-climate policies and as a successful strategy when concerning infrastructure and spatial planning. The EU also plays a further active role in developing local CCA planning because it fosters research (e.g. Horizon2020) and action (e.g. EU-LIFE+ programme). This context, composed of a range of proactive strategies as well as contradictions, provides the geographic frame of this thesis.

The state-of-the-art of CCA planning and the literature review on CCA mainstreaming undertaken in this doctoral research, outlined in sections 3.1 and 3.2 respectively, led to a further specification and focusing of the research field of this thesis. In fact, there is limited understanding in the scientific literature of how CCA policies are integrated into local planning frameworks in southern Europe (De Gregorio Hurtado et al., 2014, 2015; Olazabal et al., 2014; Pietrapertosa et al., 2019). Southern European countries are less active in tackling CCA through planning, compared to central and northern European countries (Reckien et al., 2018), and municipalities in southern Europe have had to deal with a general lack

[3] The Compact of Mayors for Climate and Energy is the only one active nowadays and it has substituted the other previous ones, i.e.: Covenant of Mayors, Compact of Mayors, Mayors Adapt.

of national support (De Gregorio Hurtado et al., 2014; Pietrapertosa et al., 2019). Hence, southern Europe, with its generally homogeneous climate (Rubel & Kottek, 2010) and range of similar non-climate characteristics (i.e. urban dimensions, socio-economic status, planning and administrative systems, culture) is the geographical focus of this thesis and where the case studies were identified and selected.

1.2 Research arguments, aims, and questions

CCA is a topical research field composed of challenges and clear gaps that still need to be tackled and addressed. In fact, it is considered "*an arena of innovation, even more than the more mature field of mitigation*" (Anguelovski and Carmin 2011, p.172). Due to the broadness of this research field and the related risks in getting lost within this universe, this PhD thesis focuses on specific dimensions of the research field: i) spatial scale, i.e. the local; ii) typology of organization, i.e. governments; iii) administrative level, i.e. the municipal; iv) purpose, i.e. planned; v) context: i.e. urban.

Academic literature on CCA mainstreaming, especially in the recent review carried by Runhaar et al (2018), focuses only on planning tools and on their outcomes, namely the CCA measures implemented. This thesis argues that for a complete and exhaustive understanding of CCA mainstreaming, researchers have to include climate information and CC-related analysis in their studies. Another criticism of this thesis that arose from the systematic literature review – outlined in section 3.2 – relates to the analytical approaches used for studying and assessing CCA mainstreaming. Runhaar et al., in their recent CCA mainstreaming review, stated and recommend further research using the barriers and enablers approach (Moser & Ekstrom, 2010). Nevertheless, this thesis research approach contrasts them and a consistent number of scholars in the fields of Environmental and Climate Policy Integration and CCA mainstreaming that used or agreed with the barriers/drivers/enablers analytical approach (Biesbroek et al. 2013; Biesbroek 2014; Eisenack et al. 2014; Huitema et al. 2016; Keskitalo et al. 2016; Moser and Ekstrom 2010; Runhaar et al. 2018; Uittenbroek 2016; Uittenbroek, Janssen-Jansen, and Runhaar 2013).

Some of these scholars, i.e. Biesbroek R., after a PhD thesis (2014) and almost 10 years of research on CCA barriers (Biesbroek, Swart, and van der Knaap 2009), argued in response to Eisenack et al. (2014) on the barrier thinking due to its *"…overly reductionist comprehension of the [CCA] decision-making process…" (Biesbroek et al. 2015 p. 493). "This highly linear and functionalist understanding of decision-making assumes that socio-political systems would be automatically adjusting to changes in the absence of barriers. As a consequence of such a view, the complexities of collective decision-making on adaptation are reduced to simple input–output models in which important internal dynamics and processes are absent. (…) Categorizing any factor or process as a barrier reduces complex and highly dynamic decision-making processes into simplified, static and metaphorical statements about why current outcomes are 'incorrect'"* (Biesbroek et al. 2015 pp. 493-494).

Furthermore, CCA mainstreaming, due to the inherent uncertainties that CC carries, should not be studied as just a mere description of objectives, tasks and resources allocation and distribution (Klein et al., 2007; Persson & Klein, 2009; Uittenbroek, Janssen-Jansen, Runhaar, 2013; Wamsler, 2015). Hence, building on Biesbroek et al critics (2014), this thesis argues that the "barriers" approach has evident limits and, therefore, calls for the elaboration of an analytical framework that embraces the complexity of the CC issue and includes the climate inputs – the climate-related information (e.g. CC projections, CC scenarios assessments) – which have been excluded to-date from the studies on CCA mainstreaming. In fact, this thesis is framed along with the Science-Policy interface and acknowledges the importance of considering the science-based climate information production and delivery at the service of policy-making and integration processes. Moreover, this research is aware of the fact that different agents, both actors and networks, play a key role in the local CCA governance.

During the development of the thesis, another key concept arose, which is the "co-production" – also called "co-creation" (Voorberg, Bekkers, & Tummers, 2015). Co-production is generally defined as the involvement of individual citizens and groups in public service delivery (Verschuere, Brandsen, & Pestoff, 2012) and it is an approach that has been applied by several scholars (Albrechts, 2013; Bovaird & Loeffler, 2012; Olazabal, Chiabai, Foudi, & Neumann, 2018; Verschuere et al., 2012; Voorberg et al., 2015) in different fields, e.g. urban planning (Albrechts, 2013), and climate science (Bremer et al., 2019), with diverse aims and purposes, e.g. climate services production and provision (Vincent et al., 2018), CCA measures design (Wamsler, 2017), adaptive co-management of public goods and spaces (Armitage, Marschke, & Plummer, 2008).

Mainstreaming, as the main theoretical keyword of this research, along with co-production are the key concepts of this thesis. Currently, there are few investigations including both notions within the CCA framework (Brink & Wamsler, 2018; Wamsler, 2017; Ziervogel, Archer van Garderen, & Price, 2016). The question: how *"[CCA] mainstreaming can help municipalities derive greater benefit from citizen interactions [?]"* (Brink and Wamsler 2018, p.96) is still unanswered. Furthermore, none of these papers endeavours to theoretically align the concept of mainstreaming with the co-production practice.

Therefore, justified by the need for further research into CCA planning, basing the investigation on these detailed *foci* and aiming to illuminate and respond to the current research gaps as outlined in this introduction and here again synthetically listed:

- CCA integration into local planning frameworks and its implementation are low,
- the role of CCA-dedicated planning and policy approaches is still unclear, and unknown in the CCA mainstreaming field,
- the role of science-based climate information and services in CCA mainstreaming is still largely unknown,

- the co-production and mainstreaming joint application in local CCA planning is less uncovered,

the main question of this PhD thesis is:

- What are the key challenges that affect local planning in Climate Change Adaptation policy integration and implementation?

The objective is to understand the mechanisms that enhance CCA integration within local planning frameworks and where and why local CCA planning finds impediments in reaching the ultimate goal, namely the implementation of CCA measures.
This research question will be answered through two sub-questions, which are:

  - How do science-based climate information and services affect climate change adaptation policy integration?
  - How do dedicated planning approaches affect climate change adaptation integration into local planning frameworks and implementation?

In order to investigate these issues, the lens through which this research is conducted, is through consideration and examination of the concept of 'mainstreaming'. Due to its theoretical and conceptual nature and its infancy in local CCA empirical research, mainstreaming is the theoretical approach – whose maximum application is perhaps utopic – used to analyse the CCA policy integration and planning processes, and the urban governance of CCA. Furthermore, aware of the existing gaps in the synthesis of the fields of CCA mainstreaming and co-production, this research also examines and discusses the theoretical complementarity between the two notions.
This thesis aims to answer these questions and tailor recommendations for a specific type of city i.e. medium- to large-sized ones. These local governments – medium and large municipal city administrations – have stronger technical, political, and institutional capacities than those of small-sized cities, (De Gregorio Hurtado et al., 2015; Haupt et al., 2019; Reckien et al., 2018) – fundamental characteristics for complex policy-making processes and CC mainstreaming (Tiepolo, 2017).

For the sake of clarity and the readers' expectation, the goal of this thesis is not to provide innovative or effective CCA measures, but is rather to be read as an investigation into CCA planning "groundwork". Hence, the aim of this PhD thesis is to understand how to create the basis for long-lasting and integrated CCA planning that can reach effective implementation. Due to this purpose, the thesis aims to serve a specific audience that has to deal with CCA planning and mainstreaming in research and practice, which consists of: i) scholars from different disciplines, already mentioned, that are interested in the integration of CCA policy and the democratization of CC knowledge production; ii) practitioners i.e. urban and spatial planners, urban entrepreneurs, public servants, public policy and territorial governance experts; iii) politicians and decision-makers; and iv) donors and project evaluators.

1.3 Research outline

This PhD thesis is an interpretive research investigation and employs a qualitative approach. It is an inter-disciplinary study that revolves around the field of CCA and explores the overlapping fields of local and urban planning, climate policy, policy integration and mainstreaming, climate information and services and civic engagement and co-production.

This research follows a pathway made of several steps, i.e. (re)definition of the research scope, review of scientific literature, identification of research gaps, identification and definition of the geographical context and case studies, (re)definition of the analytical framework, selection and application of the methods, and findings analysis. Figure 1.1 shows the conceptual and simplified research flow.

This study employs a multi-case study research approach – two cases i.e. Barcelona (ES) and Turin municipalities (IT) – and the analysis of the cases was carried out through an analytical framework, which was tailor-made in accordance with the findings of the literature review and consists of a set of qualitative criteria. The aim of this research is not to compare the two cases but rather to use them for answering the research questions and at the service of the analytical framework validation.

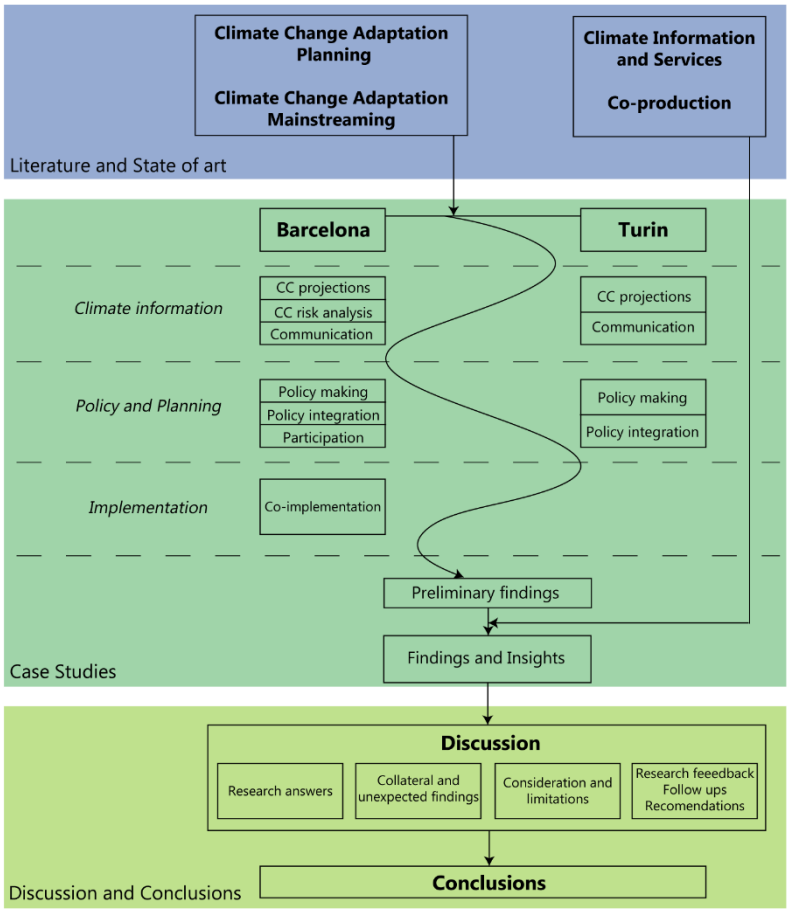

Figure 1. 1 - PhD Thesis research conceptual flow

This research focuses on the southern European context and the case studies investigated are Barcelona (ES) and Turin (IT), respectively coastal large- and inland mid-sized cities. Both cases employ a CCA-dedicated planning approach with a difference in the timing of the CCA planning – Barcelona is relatively experienced, whereas Turin is a relative "newcomer".
Moreover, Barcelona is involved in several international networks, in a local CCA-related network and is currently taking part in an EU-funded project addressing CCA and UR. Turin is also involved in several international networks, one, in particular, that is a C2CL programme, and also participated in an EU-funded project that tackles CCA and DRR, which triggered the current CCA policy-making process. Furthermore, the municipality government of Barcelona designed the plan's goals through a public engagement process and has started co-implementing the CC joint Plan with external private and public actors – officially committed to a local network. Turin, in contrast, frames the policy-making process within the administrative boundaries involving five departments, and exchanging in parallel with the foreign municipalities of the C2CL programme.
The inner cases of the two contexts are complementary and cover a wide spectrum of the current topical tools used at the service of CCA. Therefore, taken together, they offer a coherent and complete setting for answering the research questions of this thesis.

PART I – RESEARCH DESIGN AND THEORETICAL FRAMING

Chapter 2

Research design

This chapter outlines the research approach carried for this PhD Thesis. The first section, 2.1, outlines the research design including the methodological approach, the research purpose, how the research journey flowed during the three years of PhD course and concludes with the explanation of the case study selection.
The second section, 2.2, gives an overview of the methods applied in the thesis.
The third section, 2.3, outlines the analytical framework of this Thesis, which is based on the literature reviews' findings explained in chapter 3.
The fourth section, 2.4, spotlights on the challenges faced during the research, outlines the approaches and methods used nowadays for complex issues that embed uncertainties and explain the limitations of the research.

2.1 Research approach and case studies

This PhD thesis consists of an exploratory investigation of complex policy dynamics using a specific theoretical lens, i.e. 'mainstreaming'. This choice implies selecting, integrating, and interpreting different data and information. It employs an interpretive approach (Silva, 2016) focusing on the meaning of CCA that key actors make in the policy and planning context. Accordingly, it mainly relies on qualitative research methods (Yin & Campbell, 2017) that have been selected based on the conditions and characteristics of the case studies.
Analysis of complex policy-making processes requires the understanding and interpreting of policy documents and how they are developed in a given time span. Interviews with key actors allow understanding policy and planning dynamics from different perspectives as well as assessing knowledge and policy integration dynamics, which are not explicitly mentioned or clearly stated in policy documents. In addition, participant observations allow to better frame information and data acquired with their inherent context.

This thesis is an inter-disciplinary research that revolves around the field of CCA and explores the overlapping fields of local and urban planning, climate policy, policy integration and mainstreaming, climate information and services, and co-production. It applies a multiple-case study design (Bryman, 2008; Yin & Campbell, 2017) where the case studies analysis was carried using the same analytical framework, explained in the 2.3 section, and the selection of the methods was tailor-made on the conditions and characteristics of the case studies (e.g. typology of data, accessibility to data and actors, phase of the CCA planning process).
This research was a pathway made of several tasks, i.e. (re)definition of the research scope, review of scientific literature, identification of research gaps, identification and definition of the geographical context and case studies, (re)definition of the analytical framework, selection and application of the methods, findings analysis (see Fig. 2.1).
On first, the research began with literature reviews of CCA planning and CCA mainstreaming fields. The former included also a state-of-the-art of CCA local planning, and the latter was reviewed with a systematic approach, which is frequently used in CCA studies (Berrang-Ford, Pearce, & Ford, 2015; Runhaar et al., 2018; Torres, Pablo Rodríguez Sánchez, De Oliveira Nascimento, Leitão, & Granceri, 2016).
This first phase was propaedeutic for:

- defining the geographical context,
- discovering the theoretical gaps, and
- building the analytical approach.

From the outset, I chose to work in a specific socio-economic context, i.e. developed countries (i.e. OECD's), and more specifically in the European Union (EU). Due to the results of the CCA mainstreaming literature review, supported also by the CCA local planning state-of-the-art, that highlighted the geographical gaps, southern Europe was chosen as the macro-region of this research. Southern Europe has been already investigated by scholars from urban resilience and local CCA planning fields (Chelleri, 2018; De Gregorio Hurtado et al., 2014, 2015; Granceri, 2018; Olazabal et al., 2014; Pietrapertosa et al., 2019; Zografos, Klause, Connolly, & Anguelovski, 2020) but the CCA mainstreaming review's results showed that the southern European context is less studied.
This region includes Countries with similarities and can be considered as a *unicum* in terms of:

- climate characteristics (Rubel & Kottek, 2010)
- socio-economic conditions (Di Mascio & Natalini, 2015; Tulumello, Cotella, & Othengrafen, 2019)
- urban areas dimensions and population density (De Gregorio Hurtado et al., 2015)
- spatial planning (Giannakourou, 2005; Janin Rivolin, 2018), governance (De Gregorio Hurtado et al., 2014) and public administration systems (Alba & Navarro, 2011; Kickert, 2011; Ongaro, 2011).

The aim was to investigate on a homogeneous context that allowed to select the case studies – the cities – in order to conduct the research analysis with the purpose of validation of the analytical approach. The research analytical approach was created *in itinere*. It started as the result of the first literature reviews and was then refined based on the first analytical "coring" performed for the case studies.

A further literature review was done as a complement to the previous ones, focussing on i) climate information and services and ii) co-production concept applied on both fields of urban planning and climate services. This further exploration in the literature happened meanwhile the case studies analysis.

Before identifying the case studies, some explorative visits were carried out, i.e. Barcelona, Bologna and Turin, which were done *in-situ*. I talked also with the municipal servants of Bilbao, Athens and Lisbon, which were met during the attendance of international policy-makers conferences (i.e. Resilient Cities 2017, Open European Conference 2017).

The cases selected to be studied were Barcelona and Turin, and accordingly, to the availability of information and access to the actors and networks *in-situ*, a set of methods was defined (schematized in table 2.2). The methods used for analysing Barcelona's inner cases were official documents analysis, semi-structured interviews, participation to seminars, and official internal meetings observations. For Turin, the methods differ lightly because I participated actively in the CCA plan-making process: I observed and interacted actively with the actors, and I also provided information relevant to the process in form of visual presentation and documents, namely two posters of local CCA planning good practices from the Global North (see Appendix C). The findings for both cases are the results of more than one year of field research and the cases were analysed simultaneously.

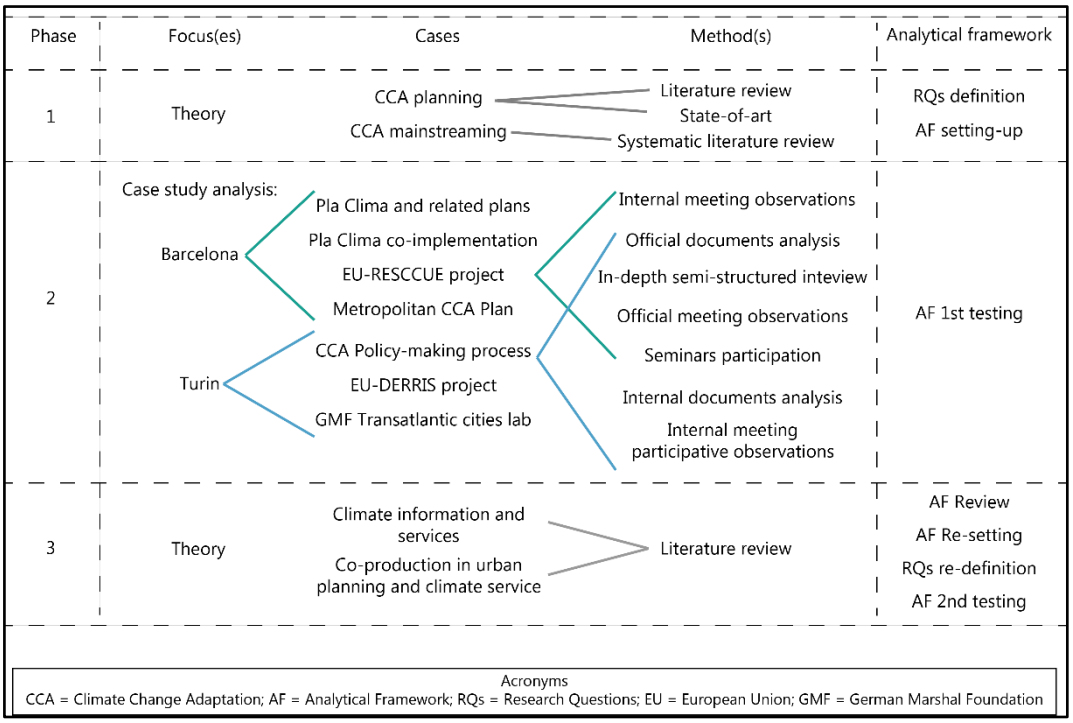

Figure 2. 1 - PhD thesis research flow chart (Made by the Author)

2.2 Methods

This section explains the methodological approach of the thesis. In this thesis, a mix of methods has been used to collect qualitative data (see Table 2.1). Overall, the research applies a set of triangulated methods, which are listed below:

- Secondary data analysis
- Interviews
- Participant observations

Focus	Inner cases	Chapter Section	Method(s) and Approach(es)
Literature review	CCA planning	3.1	State-of-the-art Literature review
	CCA mainstreaming	3.2	Systematic review
	Climate information and services	3.3	Literature review
	Co-production	3.4	Literature review
Barcelona case study analysis	- *Pla Clima* process and related plans - *Pla Clima* co-implementation phase - EU-funded RESCCUE project - BCN metropolitan CCA Plan	4	- Official documents and plans analysis - In-depth semi-structured interviews - Seminars participation - Official meeting observation
Turin case study analysis	- CCA inter-departmental working group - EU-DERRIS project - German Marshall Foundation's (GMF) Transatlantic cities programme	5	- Official public and internal documents' analysis - In-depth semi-structured interviews - Seminars participation - Official meetings participative observations

Table 2. 1 – Overview of research *foci* and related methods applied

Case studies' analysis was based on the three methods and started with the secondary data analysis i.e. official public policy documents and climate-related assessments. In both cases, the first phase of documents' analysis was supported by public events' attendance (i.e. CCA plan presentation, EU-funded projects presentations, city-to-city learning programme's workshops and conferences). Interviews were carried in the second phase along with participant observations of the internal municipal meetings and workshops. In Barcelona case, the CC-dedicated plan, namely *Pla Clima*, and its related policy-making process, are the core of the analysis. The RESCCUE project and the metropolitan CCA plan were investigated but have a secondary role. In Turin case, CCA plan-making process is the core of the analysis, which was investigated jointly with the DERRIS project and the GMF city-to-city learning programme.

Secondary data analysis

The analysis of secondary data, carried through a classic desk research methodology, consisted of:

- Scientific literature review
- Grey literature review
- Official documents analysis (public and internal)

It included academic and grey literature addressing i) CCA planning and ii) CCA mainstreaming, and the academic literature addressing iii) climate services and iv) co-production in the CC and urban planning fields. Moreover, the analysis included policy and planning documents provided by the case studies i.e. plans, programmes, laws, protocols, reports, assessments, and diagnosis.

The CCA mainstreaming study (see BOX 2.1 for complete methodological explanation) applies a systematic literature review method (Gough, Thomas, & Oliver, 2012). "*Systematic review refers to a focused review of the literature that seeks to answer a specific research question using pre-defined eligibility criteria for documents and explicitly outlined and reproducible methods*" (Berrang-Ford, Pearce, & Ford, 2015, p.756 citing Cooper and Hedge 1994; Gough et al. 2012).

Differently from other approaches to research literature analysis, the systematic reviews "*incorporate an explicit layer of methodological systematization, adding transparency and reproducibility to the review process*" (Berrang-Ford et al., 2015, p.756). Moreover, systematic reviews differ from more traditional reviews because they use '*systematic and explicit methods to identify, select, and critically appraise relevant research, and to collect and analyse data from the studies that are included in the review'* (Moher, Liberati, Tetzlaff, Altman, & Group, 2009).

Hence, this approach was used for the CCA mainstreaming literature review because the 'mainstreaming' is the core concept of this study and needed a thorough academic definition in order to identify the research gaps and questions.

The other topics, i.e. CCA planning, Climate information and services, and CC and Urban planning co-production were not investigated with a systematic approach, but rather with a traditional one, using the on-line databases of Web of Science and Scopus.

Documents from municipalities and other public organizations were analysed and most of them were accessed through website browsing.

In the case of Barcelona, some internal documents related to CC projections were asked to the *Area Metropolitana de Barcelona* and *Servei Meterologic de Catalunya*. In the case of Turin, the internal document related to CC projections was asked to Turin municipality and *Agenzia Regionale per la Protezione Ambientale* (ARPA). In both cases, I asked the interviewees to get access to the documents after the interviews.

BOX 2.1 – CCA mainstreaming systematic approach

The papers reviewed were found by searching on the on-line database of Web of Science (WoS). The first step was defining a suitable search string. According to the goals of this study, topical keywords were used i.e. Mainstreaming, Climate, Adaptation, Integration, Climate Policy Integration. Urban, City, Local, Municipal jointly with Plan and Policy were chosen because the local level and urban areas are the *foci* of this study, and others were excluded e.g. regional, national. Boolean operators (i.e. AND, OR) and wildcards (i.e. *, ") were used in order to either enlarge or diminish the range of options.

The search phrase is:
(mainstream AND ((integrat* AND climat* AND adaptation) OR (climat* AND adaptation AND ((urban OR city OR local OR municipal) AND (plan* OR polic*))) OR (climat* AND adaptation AND "Climate Policy Integration")))*

The timespan defined in the search is from 2000 to 2017, and the query was done in January 2018. This search produced a first set of 202 papers.
In the second phase, where the abstracts were reviewed, a set of papers was excluded because the mainstreaming term was not well defined or was used just in the noun version[4]. This step unveiled 40 documents.
Once the first selection of papers – to being fully read – was defined, the next step was to review and extract the main definitions. In this phase, the bibliometric analysis was carried out with the citations, authors and co-citations methods.
A bibliometric analysis was conducted with the purpose to identify influential publications, scholars and cluster of inter-linked scholars.
The citations, authors and co-citations analysis are the bibliometric methods used in this paper to quantitatively evaluate academic literature. To assess these citations, authors and co-citations, the VOS viewer software (Perianes-Rodriguez, Waltman, & van Eck, 2016), which supports analysis and elaborates bibliometric networks.
The next step was excluding the papers with just theoretical contents (i.e. 80), therefore including just the empirical ones. In this phase, the 82 empirical papers were analysed with the objective to select and review the ones that assessed the CCA mainstreaming using a consistent analytical framework.
The last step was mapping the empirical studies with the aim to find in which geographical context and country the local CCA mainstreaming studies are framed.

[4] The mainstream, as a noun, "is the 'principal course of activity' or the 'major current of opinion'" (Picciotto 2002, p.323)

Interviews

In total 34 in-depth interviews were realized: 13 for Turin case, 21 for Barcelona case. All of them were key actors of the CCA planning processes and were asked semi-structured questions. The interviews were carried out between April 2018 and July 2019 and were conducted *in-situ* or via phone. The ones contacted via phone were already known beforehand or were met in person after the interview. The interviews were conducted in Italian for the Turin case, and in Spanish and English for the Barcelona case.

Most of the actors interviewed were local policymakers and public servants (e.g. political entrepreneurs, plan coordinators, urban planning technicians). Moreover, also politicians and practitioners were interviewed, and also citizens, in the case of Barcelona's plan co-implementation. A group of citizens as part of a school foundation or local association were also interviewed.

For Barcelona, the interviewees were 10 public servants – 8 from Barcelona municipality, 1 from Barcelona metropolitan body, 1 from Catalan Meteorological Agency –, 1 technician from Barcelona Regional – the public/private agency that made the CC risk analysis – 9 practitioners, and 1 citizen representing a group of 7 people that are part of a Primary School Association.

In the case of Turin, the interviewees were 1 politician, 1 political entrepreneur and 11 municipal servants.

In both cases, the in-depth semi-structured interviews' questions (see Appendix A for more details) for policy-makers and municipal servants focused on:

- CC hazards and CC analysis perception
- CCA understanding and perception
- Policy and planning coordination between sectors and organizations
- Sectoral CCA measures planned and implemented
- Perception of CCA-dedicated policy and planning processes

For both cases, the actors involved the CC analysis and assessments were interviewed using the same structure based on climate information reliability, accuracy, and legitimacy.

In the case of Barcelona's co-implementation, the interviewees were the 10 leaders of the projects funded by the municipality. 10 out of the 11 projects were considered, the one missing never answered and never appeared in the internal meetings. The interviews conducted for this set of actors were made of open questions that round on the interviewees':

- Awareness of CC effects and perception of Pla Clima's climate information
- CCA understanding and CCA/CCM definitions
- CCA relation with their projects
- Perception of the indicators provided by the municipality.

Participant observations

In both case studies, I attended public seminars and internal meetings.
Observations were helpful in the understanding of the interaction between municipal servants, between municipal servants and the CCA plan coordinator, between municipal servants and practitioners.

In Barcelona, I arrived when the plan-making process was already finished with the CC-dedicated Plan officially operative. I could attend the official presentation of the Climate Plan, the official presentation of the Climate Plan follow-ups, and 2 internal meetings regarding the process of Climate Plan co-implementation.
Observing the co-implementation phase helped in analysing the exchanges between the municipal servants and the participants, especially on the way they were supported in the selection of the indicators, which were then used for assessing their projects' progress.

In Turin, I attended 3 internal meetings for the CCA policy-making process, 1 internal meeting for the C2CL programme, 2 public events about the City-to-city learning programme, 2 public events about the EU-funded project.
In the Turin case, the approach differs from Barcelona's because albeit unofficially (neither a contract nor an agreement was signed) I observed the internal meetings in a participatory manner. I actively interacted with local actors, i.e. policy entrepreneur, municipal servants, and politicians, providing climate-related information through a formal presentation about CCA mainstreaming and planning, and a review of the CCA local plans in the Global North (see Appendix C).

2.3 Analytical framework

This section explains the analytical framework through which the results were analysed and explained.
The analysis revolves around a core, the local municipal government, which is the pivot where policies and plans are designed and implemented, and where the CCA issue is locally mainstreamed.
The framework isn't based on the classic linear policy setting (Moser et al., 2010) but considers it as an erratic and iterative process where:

i) climate-related information (e.g. CC scenarios, climate risk assessment, CCA good practices) flows into the local planning framework through different "entry points" (e.g. International project, plan-making process), and from different agents (e.g. foreign municipality, knowledge broker, citizens, transnational municipal networks, local networks),
ii) climate-related information flows within the local organization, among the sectors and departments; how the information was treated and transformed into CCA measures and how these new measures were integrated with the existing ones that were already included in the on-going plans and programmes,
iii) the climate knowledge and CCA measures are produced or eventually co-produced,
iv) the CCA plans, measures, projects are designed, implemented, and monitored.

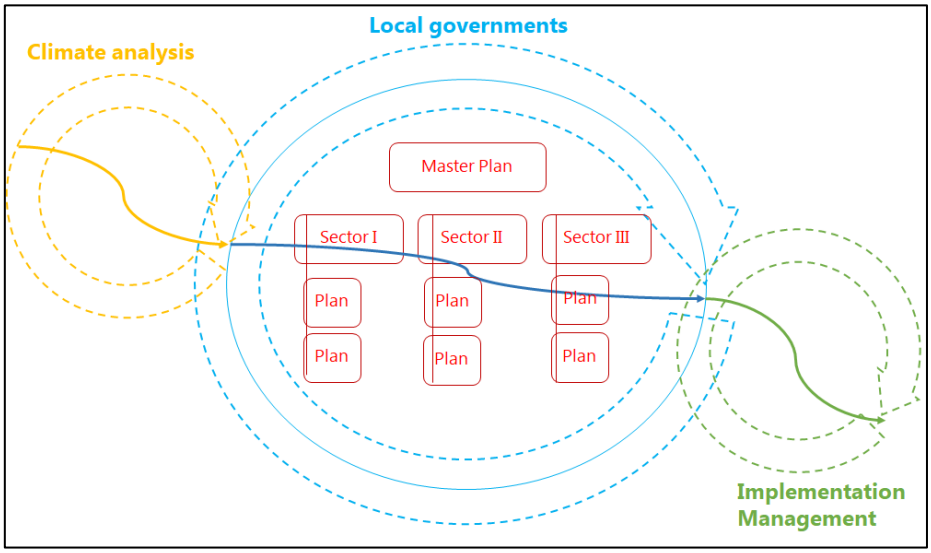

Figure 2. 2 - The analytical framework conceptual map

This framework draws on the literature reviews on the fields of CCA planning, policy, and mainstreaming, Climate Services, and co-production, which will be explained in the next chapter, 3.
The analytical framework of this research is based on a set of qualitative criteria and sub-criteria, summarized as follows:

- Credibility
    - Reliability
    - Accuracy
    - Legitimacy
- (Policy) Integration
    - Coordination-Harmonization-Prioritization
- Relevance and Consistency

Credibility

Credibility is the umbrella criterion – often used for climate information and services (see Chapter 3.3), and seldom for climate policy (Olazabal, Galarraga, Ford, Sainz De Murieta, & Lesnikowski, 2019) – that address the CC-related documents' analysis of this research.

Credibility (Bruno Soares et al., 2018; Cash et al., 2005; Heink et al., 2015; Kirchhoff, Esselman, & Brown, 2015), jointly with a set of sub-criteria, namely Reliability (Haasnoot, van 't Klooster, & van Alphen, 2018), Accuracy (Dessai et al., 2009), and Legitimacy (Adger et al., 2005; Cash et al., 2005; Heink et al., 2015; Street et al., 2019), makes the first part of the framework and assesses the climate-related information usefulness and how it flows into the local governments. The criteria were selected according to the climate information and services literature review (see Chapter 3.3).

Therefore, climate information and services are Credible if:

- *Reliable*
    - Variables: Which climate variables were included in the CC analysis?
    - Models and methodological approach: Which model(s) were used for the regional and local analysis?
        - Dataset for the CC analysis: is made of which type of data?
            - Historic series?
            - Which and How extreme events are tackled?
        - Downscaling: which types of downscaling approaches have been employed?
    - Timely: How many months/years did it take for making the CC analysis?
    - Time-managed: What is the time scale managed in the CC analysis (e.g. 1 decade, 100 years)?

- *Accurate*
  - Communication: Which tools were used to communicate climate information? (e.g. video, documents, maps, seminars)
  - Uncertainty embedding and communication: Was uncertainty accurately embed in the climate analysis? Was uncertainty properly communicated?
- *Legitimate*
  - Is the climate information accepted by the users?
  - What is the degree of involvement of the stakeholders (end-users)?
  - Was it tailored according to the end-user needs?

(Policy) Integration/Mainstreaming

In order to analyse the degree of integration of CCA within the local planning frameworks and based on a validated scholarship (Lafferty & Hovden, 2003; Runhaar, Driessen, & Uittenbroek, 2014; Widmer, 2018) the sub-criteria that will be used are coordination, harmonization, prioritization, as shown in Table 2.2.

Integration	**Coordination**	**Harmonization**	**Prioritization**
Characteristics	Cross-sectoral coordination to avoid contradictions and to set up the basis for synergies.	Creation of synergies and inclusion of CCA objectives on equal terms with sectoral objectives.	Favouring CCA objectives over sectoral policies; redesign and reorganization of policies and decision-making processes according to CCA goals
Degree	low	Medium	high

Table 2. 2 - Degree of integration: the set of criteria (Adapted from Widmer, 2018)

Coordination: it aims at avoiding conflicts, highlighting trade-offs among different plans and at preparing the field for synergies. It is considered the initial starting point.

Harmonization: information exchange and inter-departmental communication are established on a regular basis both within and across sectors. CCA is formally incorporated into the existing sectors.

Prioritization: it embeds a change of the current hierarchy of policy objectives from the perspective of CCA. Thus, CCA becomes the guiding objective for policy-making, interdepartmental cooperation is formally required, and conflict mediation mechanisms are established.

The typologies of mainstreaming considered are the normative, the organizational and the procedural (Persson & Klein, 2009). These categories are also categorized by Wamsler et al. as Programmatic, Organizational and Regulatory (2014).
The normative category relates to the development of strategies (e.g. comprehensive plan with CCA integration, CCA *ad hoc* Plan, climate-related DRR plan, the protocol of heatwaves emergency), political commitments, or legislative adjustments.
The organizational category focuses on the governmental and administrative structure, e.g.: the size of the staff, the establishment of specialized units across departments, the establishment of interdepartmental units, and stakeholder interaction.
The procedural category aims to alter current decision-making and information exchange procedures, setting up inter-departmental cooperation or consultation, making adjustments to existing or the implementation of new instruments across sectors (e.g. vulnerability assessments), and new or modified reporting and monitoring practices (e.g. new indicators).

Relevance and Consistency
Relevance (Brink & Wamsler, 2018; Hans-Martin Füssel & Klein, 2004; Kirchhoff, Carmen Lemos, & Dessai, 2013; Sillmann, Sippel, & Russo, 2019) and consistency (Kivimaa & Mickwitz, 2006; Mickwitz & Kivimaa, 2007; Uittenbroek et al., 2013) address to the CCA measures, plans, and indicators.
Relevance criterion is used to assess the relation of the CCA measures and plans with the CC information provided, and whether they are based on specific CC analysis.
Consistency criterion is used to assess whether the CCA measures and indicators are designed for tackling which CC peril and whether they are eventually susceptible to some CC perils.

- *Relevance*
    - How relevant are measures and plans to tackle CC?
        - Are the plans based on climate information?
        - Government and Department actions and measures are based on current (to-date) climate issues, CC futures, or both?
- *Consistency*
    - How consistent are measures and indicators regarding CCA?
        - To which CC-related peril(s)?
        - Are these measures susceptible to some other CC perils?
        - Do they have a target to reach? Is it an effective target for CCA?

2.4 Challenges, considerations, and limitations

Comparing cross-national policies in CCA might be seen as a comparison between "apples and oranges", as Dupuis and Biesbroek say (2013). Aware of the fact that whether on one hand comparative studies are warmly fostered in the field of CCA (Purdon, 2015; Vogel & Henstra, 2015; Vrolijks, Spatafore, & Mittal, 2011), on the other hand, due to the context-specificity and sensitivity of CCA it can be seen also as a risk. In this research, due to the refined and accurate case studies selection, the 2 cases can be considered similar. The difference lies in the fact that one is immature or even still an embryo, i.e. Turin, and the other is at the "infancy" moving towards the "adolescence", i.e. Barcelona. In fact, Barcelona has started tackling CC through planning two decades ago and CCA officially in 2013, while Turin has the characteristics of a "newcomer".
Two different policy phases were observed: in Barcelona, I observed a co-implementation process and in Turin, I observed a policy-making process. Therefore, Turin and Barcelona can be considered uneven cases that helped in answering the research questions. The observation of different phases of the CCA policy process helped in zooming in two different aspects.
The methodological data triangulation with secondary data analysis, interviews, and participant observation, demonstrated reliability and led to relevant findings. In the case of observations, this method was very helpful in "connecting the dots" found through interviews and secondary data analysis.

In the case of Barcelona, the difficulties found in receiving answers and availability from some of the municipal servants led to a set of interviews with some lacks. However, the in-depth semi-structured interviews made and the participation in the co-implementation phase compensated this lack.
A methodological approach that could have been useful and helpful in the case of Barcelona is the survey. An online survey based on mixed open and close structured questions could have helped in overcoming completely the lack of access to the municipal servants.
In the case of Barcelona's CC plan co-implementation, I interviewed 1 person per project and in total 10 out of 11 projects were interviewed. This helped in reaching consistent and pertinent findings. However, more interviews or focus groups with all the representatives of each organization involved could have helped in reinforcing the findings.
In the case of Turin, the participant observations were done during the policy-making process and were stopped *in itinere*. Therefore, it is a case partially investigated and it was, however, useful in aligning and reinforce some findings.
It wasn't possible to organize focus groups, which could have been an appropriate methodological approach and strategic in order to have the actors all together in once. In this case study, I found some difficulties in separating the research aims from the policy aims. I had to deal with different goals simultaneously. In fact, I provided to the policy entrepreneur and municipal servant two CCA-related diagnosis on-demand (see Appendix C) according to their needs and expectations.

In terms of communication, reading, listening and oral exchange, languages played an important role in this PhD Thesis.
At the beginning of this PhD journey, I spoke and read Italian, English, and Spanish. Meanwhile the research development I had to improve Spanish and to learn Catalan – the official languages of Barcelona, Catalunya. For more than 1 year I worked in 4 languages, i.e. Italian (for the Italian case study), Spanish and Catalan (for the Spanish case study), and English (for academic purposes).
It has been a tough, challenging journey – me and my four versions – but it worth it. Sometimes I missed some words in Catalan, other times I couldn't remember some technical words in Italian. It affected lightly the research, of course, but I was lucky that I always found patient interviewees which helped me in letting flow the communication.

Regarding the analytical framework and its qualitative criteria, Heink et al. (2015) describe credibility as a vague criterion and dependent on individual framing and thus require more specificity to be useful. Moreover, Leitch findings reveal that credibility and relevance are helpful when reflecting on the effectiveness of the science-policy interface, but they are difficult to apply as criteria when evaluating these interfaces (2019). These critics could be applied also to the other criteria.
However, aware of these critics and evidence, due to i) the purpose of the analytical framework, namely, to be used as a proxy, ii) to the exploratory approach basis, and iii) to the thorough selection of criteria and sub-criteria, this research analytical approach can be considered lowly dependent on the individual framing and proper for this type of research whose core aim is focusing on the policy arena, but also reflecting on the science-policy interface.
Climate information criterion and sub-criteria can be improved. Legitimacy and Accuracy overlapped in some cases. Reliability can be improved with more sub-criteria that can take into account other climate information production approaches, and not just the 'predict-and-provide'.
Policy integration and the sub-criteria worked properly confirming their usefulness (Persson & Klein, 2009; Widmer, 2018).
Relevance and Consistency might be improved adding sub-criteria, i.e.: describing the typology of the CCA measures, e.g.: Soft, Green, Grey; Incremental, Transformative; No-regret, Low-regret; reactive, proactive.
Other criteria can be considered for assessing the Science-Policy and Policy-Action interfaces. For instance, the co-production and the adaptiveness can be the analytical lenses that might be used and added in the analytical framework.
Generally, the set of criteria demonstrated to help explore the CCA mainstreaming field. For the purpose of this thesis, the analytical framework worked properly, accomplished the expectation, and it can be used as a proxy. Therefore, it is an approach that demonstrated its validity and can be used for other studies.

Chapter 3

Literature review

In this chapter four research fields were reviewed:

- CCA local planning
- CCA mainstreaming
- Climate information and services
- Co-production in planning and climate services

In the first section, 3.1, a state-of-the-art of CCA local planning is developed and the heterogeneous set of plans and strategies used for tackling CCA are listed. The set of planning instruments that were also included in the state-of-the-art of local CCA planning were EU-funded projects and city-to-city-learning (C2CL) programmes. Due to the case studies' context, namely Europe, especially the Southern region, a state-of-the-art of local CCA planning practices in the southern European countries (i.e. Italy, Spain, Portugal, France, Slovenia, Croatia, and Greece) is provided.

In the second section, 3.2, a literature review was carried with a systematic approach – explained in Chapter 2 – on CCA mainstreaming into local urban planning. The CCA mainstreaming research field was reviewed with a systematic approach in order to:

- find the most influential studies, and select the most representative definitions of CCA mainstreaming,
- select the empirical studies and find the geographical context where CCA mainstreaming is studied,
- find the studies that assessed the process of mainstreaming.

The first two reviews were planned since the beginning of the thesis, and the third (3.3) and fourth (3.4) ones, which are light overviews, were conducted after finding gaps from the first two literature analysis.

In the third section, 3.3, a light review was carried on the climate information and climate services (CS) in order to describe the origins and contents of these two fields.

These first three research fields' analysis were propaedeutic for the creation of the PhD thesis' analytical framework, explained in 2.3 section.

In the fourth section, 3.4, a light literature review was carried in order to describe the theoretical foundations of the co-production concept, and its application in the fields of CCA planning and CS.

Fifth and last section, 3.5, sums up the key results of the literature reviews, addresses the theoretical alignment of the two key concepts of this thesis, i.e. mainstreaming and co-production, and prepares for the second part of this thesis, which addresses the case studies' analysis.

3.1 Climate change adaptation planning

The concept of adaptation has been used in various research fields and disciplines (e.g. biology, ecology, geography). In the context of CC, adaptation has multiple meanings and can include various components, such as adaptive capacity, vulnerability, sensitivity, exposure (William Neil Adger, Brooks, Graham, Maureen, & Eriksen, 2004; Brooks, 2003; Garschagen, 2013; Tiepolo, Bacci, & Braccio, 2018; Tiepolo et al., 2019), and readiness (Ford & King, 2015). Moreover, there are complementary and overlapping fields that should be taken into account when investigating on CCA, and these are, i.e.: disaster risk reduction (DDR) (Djalante, Thomalla, Sinapoy, & Carnegie, 2012; Tiepolo et al., 2018; UN-ISDR, 2015; UNISDR, 2009) and resilience (Pelling, 2011; Pelling, O'Brien, & Matyas, 2015).

Adapting to CC, among the several definitions (e.g. IPCC 5th reports, EU CCA strategies), relates to the actions targeted at the vulnerable system in response to actual or expected climate stimuli (e.g. tornados, drought periods, storm surges, heatwaves) and their direct effects (e.g. insects migration and epidemiologic diseases) to moderate harm from CC or exploit opportunities (McCarthy et al. 2001). CC requires people – individuals, communities, and public or private organizations – to adjust ('adapt') autonomously[5] or by planning[6] not only to current and new hazards, and changing resources, but also to new regimes of knowledge, as well as to changes in access to and control over resources (Eriksen, Nightingale, & Eakin, 2015).

Another important aspect of adaptation is that it is *"...neither inevitable nor automatic..."* (Ford and King 2015, p.507). In other words, just because we have a strong adaptive capacity or we are highly resilient to climate-related hazards and perils do not mean we will adapt (Repetto, 2009). Furthermore, CCA is often considered as a dynamic iterative process, made of different states and transitions, aiming at a transformation, avoiding the collapse, and with two intermediary steps i.e. robustness and resilience (Solecki, Leichenko, & O'Brien, 2011).

3.1.1 Climate change adaptation, disaster risk reduction, and urban resilience

Framing the research on CCA at the local level in urban contexts, it appears clear that other complementary and related concepts should be taken into account. Within these global frameworks, CCA planning and implementation are frequently associated with or within other complementary objectives. As in the case of the Rockefeller Foundation, the "100 Resilient Cities" Programme frame the CCA

[5] A form of CCA that does not constitute a conscious response to climatic stimuli but is triggered by ecological changes in natural systems and by market or welfare changes in human systems. It is also referred to as spontaneous adaptation.

[6] A form of CCA that is the result of a deliberative policy decision, based on an awareness that conditions have changed or are about to change and that action is required to return to, to maintain, or to achieve a desired state.

issue under the Urban Resilience (UR) concept. Besides, in the case of UN-ISDR, CCA has been recently taken into account in its guiding schemes, i.e. Sendai Framework (2015), and projects jointly with its main objective, the DRR concept. Broadly defined, DRR and CCA are "*connected through a common approach: reducing the impacts of extreme events, and increasing the risk management capacity to disasters, particularly among vulnerable urban populations*" (Solecki et al., 2011). Along the past decades, DRR and CCA fields and their integration have been studied, "*yet progress has been slow and examples of effective integration, remain limited*" (Birkmann & von Teichman, 2010). Whether DRR is a concept with more than four decades of studies and practice (UN-ISDR, 2004), the notion of UR is newer and still not defined under a shared agreement by the scholarship. It is a 'buzzword' that has been used frequently when researching urban contexts (Meerow, Newell, & Stults, 2016). The concept of UR (Brunetta et al., 2019; Chelleri, 2012) embeds the idea that urban contexts need to be reactive to a wide range of stresses and to bounce back – or even bounce forward – from climate and/or non-climate shocks. In simple words, UR is *"… the ability … to withstand a wide array of shocks and stresses*" (Leichenko 2011, p. 164). Meerow et al. affirmed that "*…three [are] the … pathways to a resilient state: persistence, transition, and transformation*" and just Chelleri (2012) *"…explicitly identifies resilience as consisting of all three"* (2016, p.44) because UR *"… should be framed within the resilience (system persistence), transition (system incremental change) and transformation (system reconfiguration) views*" (Chelleri 2012, p.287). This view fits comfortably with Leichenko et al.'s framework on CCA, which sees CCA as a dynamic and iterative pathway as well as UR is. Moreover, both are often associated with flexible processes, network management and collaborative governance (Birkmann et al. 2010; Therrien 2010).

3.1.2 State-of-the-art of climate change adaptation planning

Nowadays, looking from the global perspective to the local scale, CCA, also considering its complementary concepts, are still not so common to find in city plans and urban policies, despite a consistent increase in the last years (Tiepolo et al., 2017). Most of the cities that tackle CCA through planning are large- and big-sized ones (Araos et al. 2016; Reckien et al. 2018; Tiepolo, Ponte, and Cristofori 2016), as shown in Figure 3.2. In the Tropical region, OECD and the BRICS countries have been playing a significative role in the climate planning with respectively 79% and 62% of medium to large-sized cities committed to the CC cause (Tiepolo et al., 2017). In terms of implementation, in the global north, besides many climate plans providing a framework for policy actions, their CCA and DRR measures have little impact because of several reasons, e.g. low CC awareness, low political commitment, scarce dedicated funds, and small dedicated teams (Bierbaum et al., 2013; Biesbroek et al., 2013; Biesbroek, Termeer, Klostermann, & Kabat, 2014; De Gregorio Hurtado et al., 2014; Markus & Savini, 2016; Runhaar et al., 2018; Tiepolo et al., 2016; Wheeler, 2008; Woodruff & Stults, 2016).

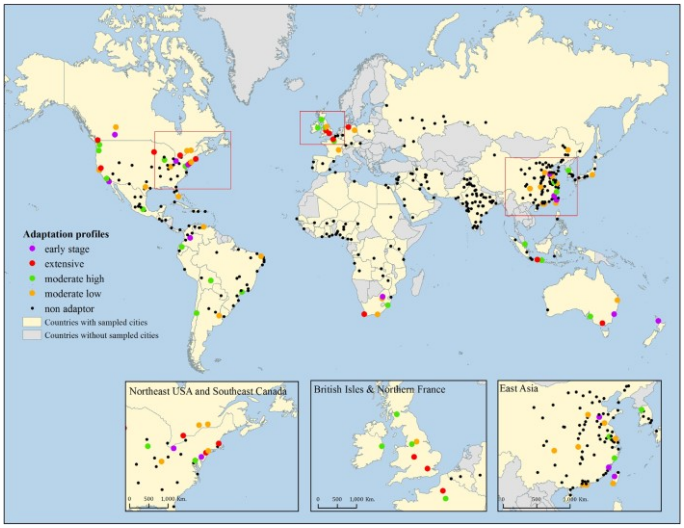

Figure 3. 1 - CCA profiles of large-sized cities (Araos et al., 2016)

The USA and North America, in general, have been the firsts to face CC with *ad hoc* plans and measures at the local level, mainly focussing on CCM (Wheeler, 2008). 10 years after Wheeler's paper (2008) USA increased significantly the number of cities tackling CCA with a dedicated plan (Woodruff et al., 2018).

More recently, other countries from Europe (e.g. UK), south-eastern Asia (e.g. Bangladesh), South-Saharan Africa (e.g. Mozambique), among the others, began to tackle this issue preparing climate-oriented plans, most of them starting from the national level. Whether the USA and some European countries are already at the second generation of local climate action plans, jointing CCA and CCM, most of the other countries seem to be still at the beginning, if considering just the local level.

Framing the CCA planning advances at the national level, countries of the Global South like Bangladesh, Malaysia or Philippines should be recognised as pioneers in the field (J. Ayers et al., 2014; Djalante et al., 2012; Saleemul Huq et al., 2003; Lasco et al., 2009; Pervin et al., 2013). Instead, referring to the Global North, UK national planning for CCA was recognised as the most advanced by several scholars (Benzie, Harvey, & Miller, 2011; Porter, Demeritt, & Dessai, 2015; Romsdahl, Kirilenko, Wood, & Hultquist, 2017). According to Tiepolo et al., as shown in Figure 3.2, only around the 25% of tropical and sub-tropical medium to large-sized cities have these measures and 25% of sub-tropical large-sized cities have them (2016).

Figure 3. 2 - The status of CCA-related plans and measures in tropical and sub-tropical regions (Tiepolo et al 2016)

Several are the ways that cities and local organizations have to tackle CC impacts and effects. According to Tiepolo et al. (2016, 2017), the climate issue is addressed by cities with different tools:

- municipal development / comprehensive plans,
- master plans,
- emergency/contingency plans,
- sustainable action and mitigation plans,
- smart city programmes,
- CCA plans,
- DRR and emergency plans,
- resilience strategies,
- land-use plans.

Building on this list, other planning tools have to be considered (see also Tab 3.1):

- Joint CCA+CCM Plans (Reckien et al. 2018)
- Environmental Programmes (Reckien et al. 2019),
- Departments' measures (Uittenbroek et al. 2014),
- pilot projects funded by supra-national organizations: either public (e.g. EU) or private (e.g. Rockefeller Foundations).

Cities are considered a sensitive context, although the effective number of urban systems actively addressing climate change is a minority as demonstrated by very recent scientific studies (Reckien et al. 2018; Tiepolo, Ponte, and Cristofori 2016; Tyler et al. 2016; Woodruff et al. 2018). Different international organization and alliances have been investing in the last decade in setting up climate transnational municipal networks (TNMN) and guiding schemes to encourage and support climate plans and policies at the lower levels (see Tab. 3.2). Among these:

- Multilateral and International Organizations, e.g. OECD, UN,
- International Political Institutions e.g. EU, with EU-funds (e.g. Horizon2020, LIFE+) and initiatives,
- International networks, voluntary platforms, and related initiatives e.g. ICLEI and the Compact of Mayors (CoM), Mayor Adapt,
- Private foundations e.g. Rockefeller Foundation with the "100 Resilient Cities" project (see Fig. 3.6 for the EU situation),
- Mixed partner and supporter alliances e.g. C40 cities.

In the European context, which has a long tradition of CC-related local planning (van Staden & Musco, 2009) the EU is encouraging the CCA mainstreaming (EEA, 2017; European Environment Agency, 2012b) in cities at least in two ways. First, through the CoM, a voluntary platform aiming at supporting both CCM and CCA, guiding EU citizens to receive and supply renewable energy, and offering financial guidance, fund assistance, knowledge and expertise. CoM after a successful engagement in mitigation plans (SEAP 2018-to date), started supporting CCA planning processes (2015-to date) through the Mayor Adapt. A second way is through specific funding programs as H2020 and LIFE+ which are supporting

(2009-to date) CC research and action in the most recent years (Fig. 3.4). Currently, the CoM of Energy and Climate (2017) is the reference platform and Figure 3.5 shows the number and location of the local governments that joined it. Southern Europe, especially Italy, Spain, and Greece, is the macro-region with more commitments. Instead, the local CCA planning state-of-art made by Reckien et al (2019), as shown in Figure 3.3, highlights that southern European countries have very few local governments[7]. Thus, these two maps show that south European municipalities are aware of and motivated to planning for CCA, and medium- to large-sized cities in the Euro-Mediterranean region are still a minority.

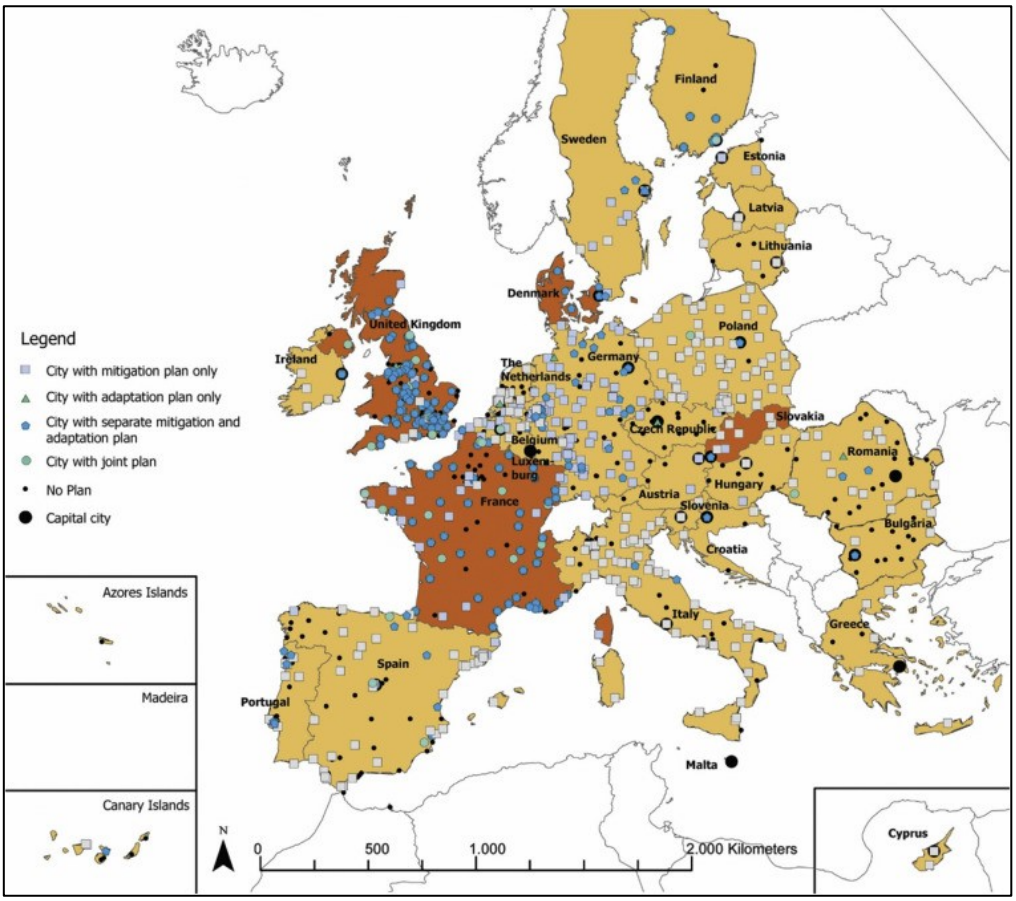

Figure 3. 3 - CC planning in EU cities (Reckien et al. 2018)

[7] Reckien et al (2019) considered in this study just the municipalities with more than 100.000 inhabitants.

Type	Focus	Examples	
		Name	Location
CCA *ad hoc* Plan	CCA	Cloudburst Plan	Copenhagen, Denmark
Joint CCA+CCM Plan	CCA and CCM	"Climate Action Plan"	Portland, USA
Master Plan with CCA integrations	CCA	"PlaNYC"	New York, USA
		"The London Plan"	London, UK
Comprehensive Plan	CCA	Puget Sound comprehensive plan	WA, USA
CCA *ad hoc* Strategy	CCA	"Estrategia Municipal de adaptaçao as mudanças climaticas"	Lisbon, Portugal
Sectoral plan	CCA	"Green City Clean Water Program"	Philadelphia, USA
Resilience plan and strategy	UR, CCA, CCM	"Estrategia de Resiliencia urbana"	Rio de Janeiro, Brazil
Local government departments' or measure	CCA	(No name) From Water municipal department (see Uittenbroek, 2014)	The Hague, The Netherlands
Risk management plan	DRR and CCA	Barangay DRR and management plan	Barangay,The Philippines
Project funded by international organizations (e.g. EU, OECD)	CCA	BlueAP	Bologna, Italy
Project supported by international alliances (e.g. C40, R100)	UR, CCA, CCM	100RC	Barcelona, Spain

Table 3. 1 - Urban planning and management tools for CCA (Made by the Author)

TNMN	Founded	Context	Goals
C40 Leadership group (C40)	2005	Global	CCM
100 Resilient Cities (100RC)	2013	Global	UR
Making Cities Resilient UNISDR	2013	Global	DRR
Asian Cities CC Resilience Network (ACCCRN)	2013	Asia	UR, DRR CCA, CCM
Covenant of Mayors	2008	EU	CCM
Compact of Mayors Mayor Adapt	2014 2014	EU EU	CCM CCA
Covenant of Mayors for Energy and Climate	2017	Global	CCA, CCM

Table 3. 2 - Examples of climate-related TNMN (Adapted from Haupt 2019)

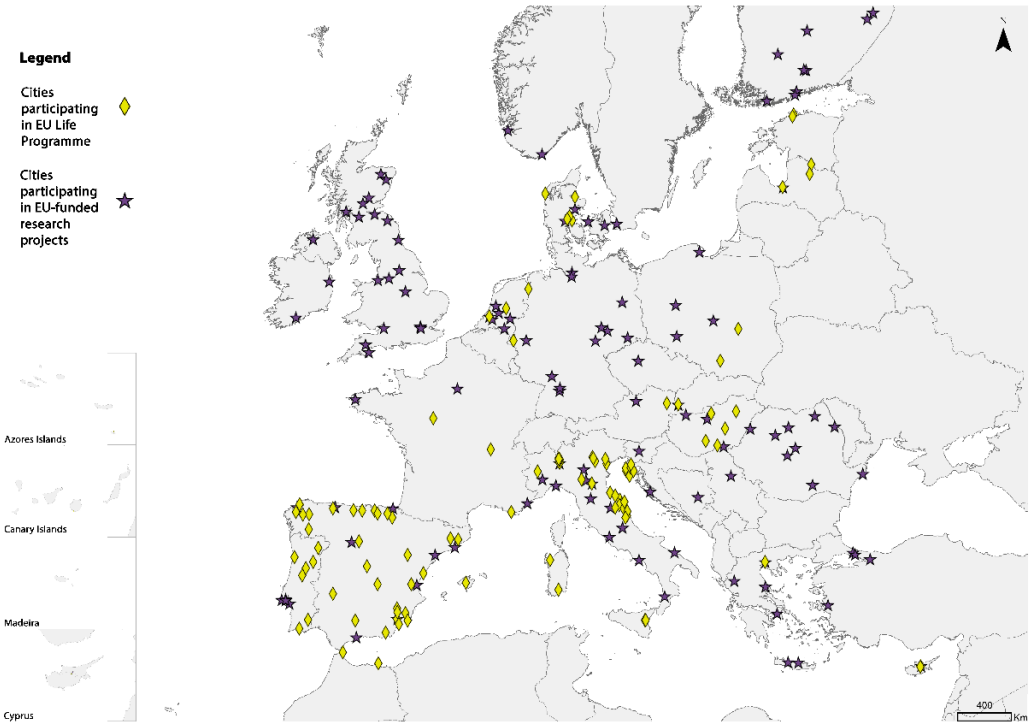

Figure 3. 4 - State-of-art of CoM (2017) signatory municipalities in EU (Made by the Author)

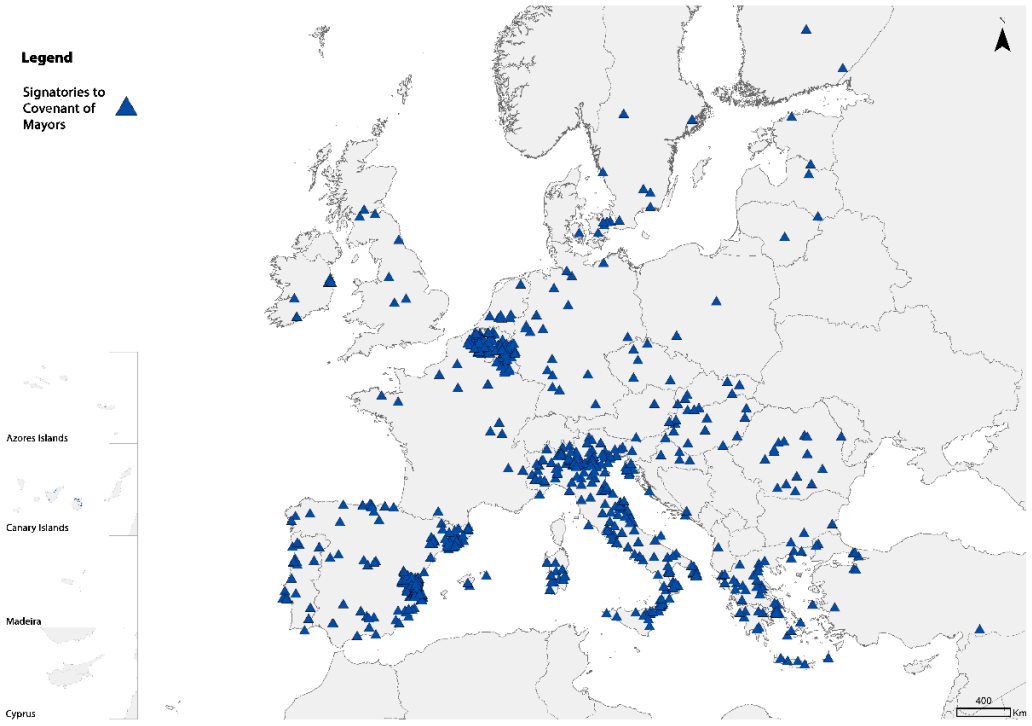

Figure 3. 5 - State-of-art of CoM (2017) signatory municipalities in EU (Made by the Author)

3.2 Climate change adaptation mainstreaming

The bibliometric analysis on CCA mainstreaming was made on a set of 202 documents (see Appendix B), which are the results of the query line search on Web of Knowledge (see Chapter 2). Along with the timeframe 2005-2018, CCA mainstreaming studies have increased (see Fig. 3.6) and the mainstreaming concept has been applied to different sectors:

- Forest (e.g. Clar and Steurer 2014; Reyer, Guericke, and Ibisch 2009),
- Agriculture (e.g. Hoffmaister and Román 2012; Howden, Crimp, and Stokes 2008)
- Water (e.g. Ziervogel et al. 2014)
- Environment (e.g. Chaney, 2016)
- Finance (e.g. Klein et al., 2007)
- Urban Planning (e.g. Uittenbroek, Janssen-Jansen, and Runhaar 2013; Wamsler et al. 2017)
- Media (e.g. Lyytimäki 2011)
- Disaster and Emergency management (e.g. Djalante et al. 2012; Rivera and Wamsler 2014)
- Public health (e.g. Panic and Ford 2013)

More than half of the documents reviewed are just theoretical, while the others, empirical, framed in a geographical context. As shown in Figure 3.7, the majority of the empirical studies are levelled at the National level (35), then 25 relates to the municipal level. Regional studies are 10 – including Province and County administrative levels –, 4 are the International ones (i.e. OECD, EU), and 7 are the sub-municipal ones (e.g. community-based or district/ward scale).

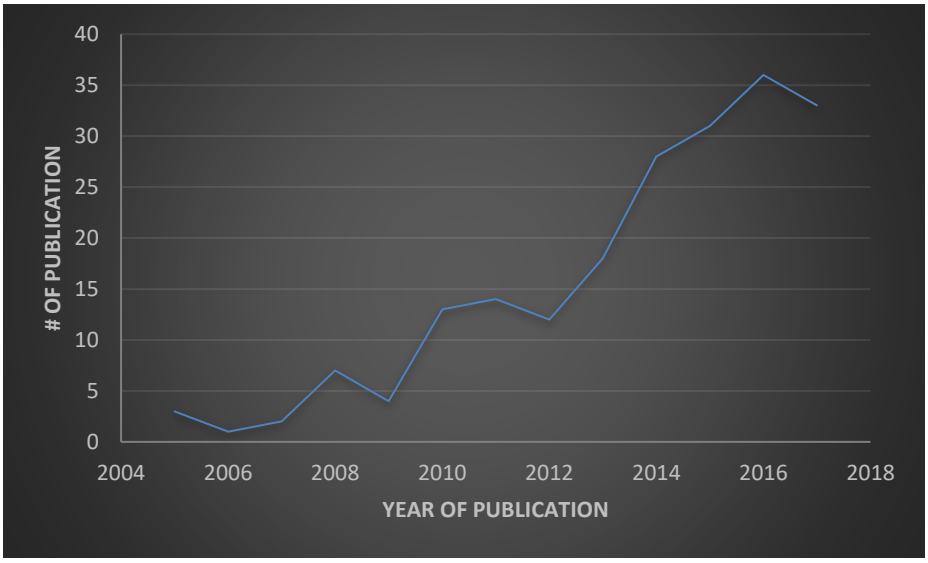

Figure 3. 6 – Papers published per year. Data from 2005 to 2017 (Made by the Author)

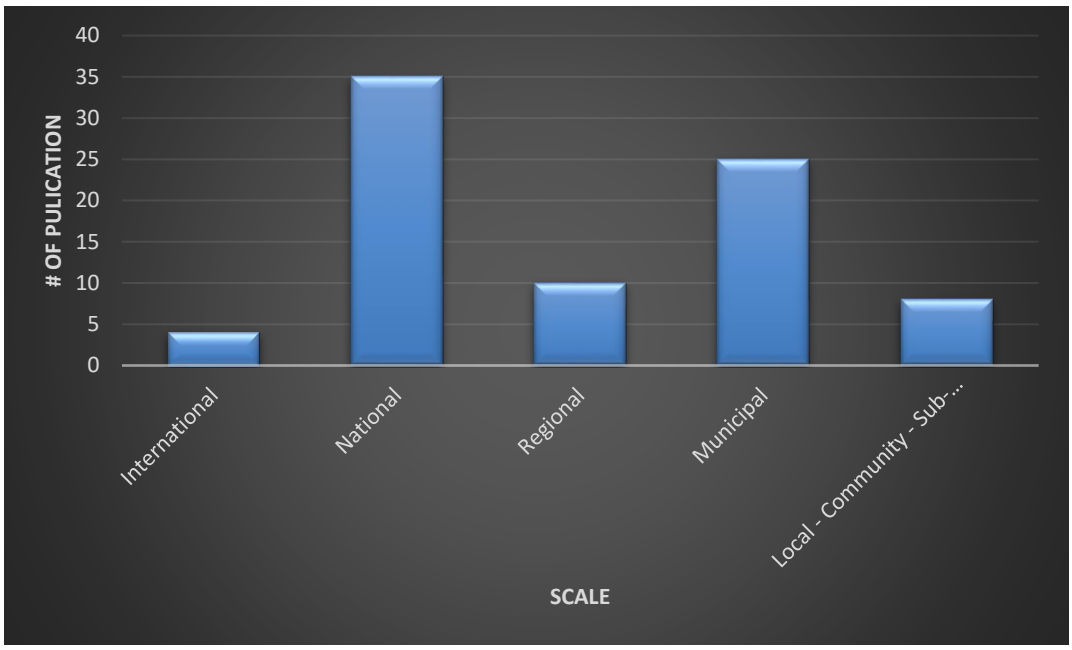

Figure 3. 7 - Occurrence of CCA Mainstreaming's levels

3.2.1 Research gaps

Mainstreaming concept, when framed in the CCA discourse, and in general, with CC, is considered an effective way to make CCA operative, and is increasingly taking importance in Academia and practitioners' global debate. In the last decade, international organizations (e.g. UN-Habitat, EU-EC, OECD, UNISDR) with the aim to foster governments to tackle CCA have increasingly used the term mainstreaming for calls for funding and guidelines when referring to the integration of climate-proofed actions into specific administrative levels and across their sectors. Even though these reports and guidelines are well written, and the quality of the contents is high, sometimes they lack in the definition of mainstreaming (IPCC, 2014b; UNEP, 2017) or, whether they define it, it is vague (European Environment Agency, 2012a; OECD, 2009; UN-HABITAT, 2015; UNDP & UNEP, 2011; UNISDR, 2009).

In the European context, European Environmental Agency (EEA) mentioned the mainstreaming in the 12/2016 and the 02/2017 (EEA, 2016, 2017) reports considering it as a way to link climate and non-climate policies and as a successful strategy when concerned into infrastructure and spatial planning.

Generally, most of the times in the grey literature mainstreaming is meant mainly as a synonym of integration and few times of incorporation and it is often tailored according to the policy sector(s) (e.g. Finance, Water management, Social care) involved or to the scale where it should act (i.e. International, National, Regional, Provincial, County, Metropolitan, Municipal, Neighbourhood/Ward). The International Institute of Environmental Development[8] is one of the most prolific publishers in the CCA mainstreaming field and, differently from the others organizations, provides complete information including definitions, approaches and

[8] https://www.iied.org/

analytical frameworks (Huq et al. 2003; Huq and Ayers 2008; Pervin et al. 2013). However, these working papers focus mainly on developing and least developed countries, and often at the National level. Whether on one hand, these documents are easy to access, albeit available mostly in English language, on the other hand, they are not exhaustive.

Similarly, in the academic literature there is still no widely conceptual agreement on what mainstreaming approach is, how to do it at the best (Wamsler et al., 2014), when it is performative and effective, at which time it happens (Klein, Adams, Dzebo, Davis, & Siebert, 2017), how could it be measured (Brouwer et al., 2013; Klein & Persson, 2009; Runhaar, 2016; Uittenbroek et al., 2013; Wamsler, Brink, & Rivera, 2013).

Due to these gaps, this research moved its first step to the academic literature to answer these questions:

- What does CCA mainstreaming mean?
- How CCA mainstreaming is assessed?
- Where local CCA mainstreaming have been studied?

3.2.2 What does CCA mainstreaming mean?

Many are the definitions of the mainstreaming concept, which were identified, reported integrally (see Annex I), and selected and listed in Table 3.3.

Mainstreaming concept has its roots in the social development discourse and was used firstly for gender-related issues (Jahan, 1995). Picciotto considers it a dynamic concept that suggests a "*deliberate perturbation in the natural order of things*" (2002, p.323). "*It subverts the status quo and yet it does not evoke chaotic change or painful disruption*" (2002, p.323).

Mackay and Bilton define mainstreaming as a "*social justice-led approach to policy-making in which equal opportunities principles, strategies and practices are integrated into the everyday work of government and other public bodies*" (Mackay & Bilton, 2003, p. 142). It "*should aim to transform the organizational culture of governments and public bodies and to improve the quality of public policy and of governance itself*" (ibid., p.142).

Mainstreaming is considered an iterative and erratic process (Uittenbroek, Janssen-Jansen, and Runhaar 2013). Besides, it is multi-sectoral and helps to create synergies among different policy sectors. Awareness of future CC impacts should be integrated and incorporated into local planning frameworks and this is also considered as a CCA mainstreaming objective (Schipper and Pelling, 2006). Klein et al. (2007) add that CCA mainstreaming aims at building capacity, but also focus on facilitating implementation.

Literature suggests that mainstreaming (and policy integration in general) can result in synergy effects; e.g. implementing CCA measures such as greener areas or more open water in city centres contribute to climate-proofing and improving environmental and spatial quality (Dewulf et al., 2015; Rauken et al., 2015; Storbjörk, 2010).

The mainstreaming is framed in a 2-dimension landscape: vertical and horizontal (Huq et al., 2003; Juhola & Westerhoff, 2011; Klein & Persson, 2009; Klein,

Schipper, & Dessai, 2005; Lafferty & Hovden, 2003; Nunan et al., 2012; C. Uittenbroek et al., 2013; Wamsler et al., 2014), as shown in the Fig. 3.8.

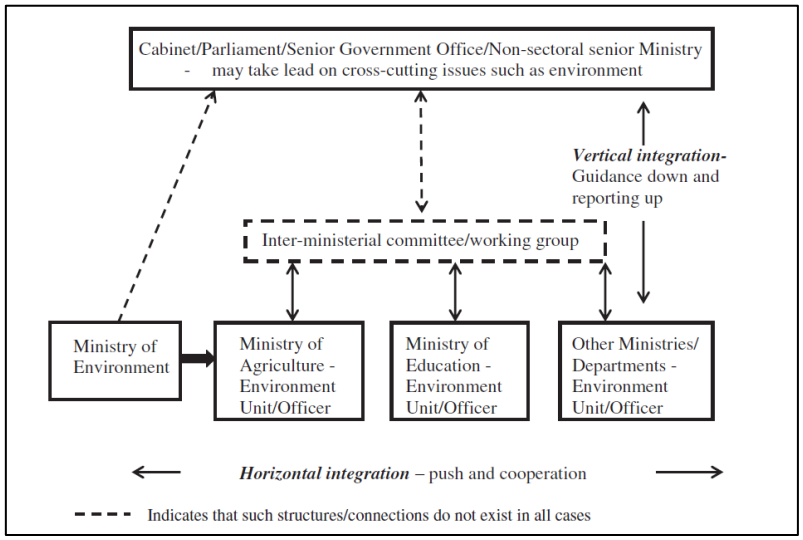

Figure 3. 8 - Vertical/horizontal dynamics of mainstreaming (Nunan et al., 2012)

Definition	Source
"*…adaptation tend to (…) modify (…) some existing (…) management strategy, (…) plan, and so on. This is commonly known as mainstreaming. Successful climate change adaptation and vulnerability reduction is rarely undertaken with respect to climate change alone…*"	(Smit & Wandel, 2006)
"*Mainstreaming involves the integration of policies and measures to address climate change into ongoing sectoral and development planning and decision-making…*"	(Klein, Schipper, & Dessai, 2005)
"*Common approaches to adaptation planning include "mainstreaming" or integrating climate adaptation into existing environmental, climate, or sustainability frameworks or sector-based plans or developing standalone adaptation plans*."	(Bierbaum et al., 2013)
"*Mainstreaming involves the integration of policies and measures that address climate change into development planning and ongoing sectoral decision-making, so as to ensure the long-term sustainability of investments as well as to reduce the sensitivity of development activities to both today's and tomorrow's climate*"	(Klein et al., 2007 citing Huq et al 2003)
"*…to integrate climate adaptation into existing policy domains such as spatial planning, water management, and public health*."	(Uittenbroek, Janssen-Jansen, Spit, & Runhaar, 2014)
"*In the literature on climate change, the integration of climate adaptation policies and measures into sectoral planning and decision-making processes is referred to as mainstreaming.*"	(Uittenbroek et al., 2013 citing Bouwer and Aerts 2006; Huq et al. 2003)
"*Mainstreaming refers to the incorporation of the challenges posed by climate change into the work of city authorities by formulating effective responses to it, which—to become sustainable—then need to be anchored in existing institutional structures, mechanisms and policy across sectors and levels.*"	(Wamsler et al., 2014 citing Wamsler, 2014, Kok & de Coninck, 2007, Moser, 2008)
"*…integration of climate resilience considerations into development planning objectives and processes from national to local scales recognizing that a transformative approach which*	(Archer et al., 2014 citing Jahan, 1995

positively impacts the development agenda, is preferable to a merely 'additional' approach…"	and Pervin et al., 2013)
"*…cross-sectoral coordination, which is usually understood as a prerequisite for effective mainstreaming…*"	(Lehmann, Brenck, Gebhardt, Schaller, & Süßbauer, 2015 citing Hunt and Watkiss 2011)
"*…mainstream adaptation within the existing urban planning and development arena rather than create a new institutional set-up…*"	(Sharma & Tomar, 2010)
"*Mainstreaming can be an important way to implement climate adaptation provided that local authorities have access to sufficient technical data and expertise.*"	(Hamin, Gurran, & Emlinger, 2014 citing Kok & deConinck, 2007)
"*...mainstreaming (...) has become much more popular among leaders in the USA and the UK as a method to integrate climate change response actions into broad governance activities, particularly with regard to climate adaptation.*"	(Haywood, Brennan, Dow, Kettle, & Lackstrom, 2014 citing Bierbaum et al., 2013; Wilbanks & Kates, 2010)
"*The alignment of climate adaptation with existing government priorities and policy, known as "mainstreaming", can meet multiple objectives and increase the efficiency of human and financial resources.*"	(Ziervogel et al., 2014 citing Pasquini et al., 2013, Uittenbroek et al., 2013)

Table 3. 3 - CCA mainstreaming definitions

It is used frequently as a way to tackle silos (Pasquini, Cowling, & Ziervogel, 2013; Pasquini, Ziervogel, Cowling, & Shearing, 2015; Ziervogel et al., 2014).
If on one hand, CCA mainstreaming can be criticized for embedding the risk for diminishing attention to CC, on the other hand, it can help remove contradictions and detect trade-offs and enhancing more efficient use of resources (Uittenbroek, 2014).
CCA Mainstreaming has roots in the Environmental Policy Integration (EPI) notion. EPI concept aims to incorporate environmental concerns in sectoral policies and to detect and avoid conflicts between environmental and other sectoral objectives (Adelle & Russel, 2013; Kivimaa & Mickwitz, 2006; Lafferty & Hovden, 2003).
In recent years, climate policy integration (CPI) has emerged as a specific form of EPI (Adelle & Russel, 2013; Jordan & Lenschow, 2010), where both CCA and CCM are considered (Runhaar et al., 2014). CPI and EPI are similar because they don't aim to create new *ad hoc* or dedicated plans/offices/programmes (Uittenbroek, Janssen-Jansen, and Runhaar 2013). CPI includes both CCA and CCM (Di Gregorio et al., 2017) and "*is a common policymaking mechanism in the European Union, the United Nations, and also in Sweden, [which] is often labelled [as] mainstreaming*" (Wamsler & Brink, 2014).

3.2.3 How CCA mainstreaming is assessed?

Some scholars frame the mainstreaming in a dichotomy (see Fig. 3.9), i.e. mainstreaming approach versus ad-hoc dedicated approach (Kalafatis, Grace, & Gibbons, 2015; Runhaar et al., 2014; C. Uittenbroek et al., 2013). Others rather approach it dividing it: i) in different categories (Klein & Persson, 2009; Persson & Klein, 2009; Wamsler et al., 2013); ii) in a spectrum (Haywood et al., 2014).

	Dedicated approach	Mainstreaming approach
Objective	Adaptation as main objective	Adaptation as one of the objectives
Policy process	Linear	Dynamic
Criterion for evaluation	Conformance	Performance
Framing of adaptation	Main objective (explicit)	Added value (implicit)
Political commitment	Direct	Indirect
Agenda-setting arena	Political arena	Policy department arena
Resources	New assigned resources supported by new organizational structures	Reallocating resources within existing organizational structures
Policy design	Specific policy	Synergies in policy objectives
Implementation	Fast	Erratic

Figure 3. 9 - The dedicated/mainstreaming dichotomy (Uittenbroek 2014)

Most of the authors analyse the CCA mainstreaming in a descriptive way (Ayers et al., 2014; Hjerpe & Glaas, 2012; Huq et al., 2003; Rauken et al., 2015; Storbjörk, 2010; Wamsler et al., 2014) without using a specific analytical framework made of indicators or criteria.

Research on CCA mainstreaming is often (Ayers et al., 2014; Cuevas, Peterson, Morrison, & Robinson, 2016; Huitema et al., 2016; Juhola, 2010; Lehmann et al., 2015; Storbjörk & Uggla, 2015; Uittenbroek et al., 2013) based on the barriers approach (Moser & Ekstrom, 2010). Moreover, a consistent number of scholars (Richard J.T. Klein & Persson, 2009; Runhaar et al., 2014; C. Uittenbroek et al., 2013) base their CCA mainstreaming analysis on EPI (Jordan & Lenschow, 2010; Lafferty & Hovden, 2003; Mickwitz & Kivimaa, 2007).

Uittenbroek, in her PhD Thesis (2014) took inspiration from the set of four criteria from Kivimaa and Mickwitz (2006), namely: inclusion, consistency, weighting, reporting. Besides, in the CPI field, a fifth criterion is often added to the four just mentioned that is coherence (Mickwitz et al., 2009).

Mainstreaming dimensions and related strategies.

Mainstreaming Dimensions[a]	Strategies	
Horizontal mainstreaming	(1) Add-on mainstreaming	Refers to the establishment of specific on-the-ground projects or programs that are not an integral part of the department's core objectives but directly target ecosystem-based adaptation or related aspects.
	(2) Programmatic mainstreaming	Relates to the modification of department's core work by integrating aspects related to ecosystem-based adaptation into on-the-ground projects or programs.
	(3) Inter- and intra-organizational mainstreaming	Promotes collaboration of individual sections or departments with other stakeholders (departments, organizations, committees, or governmental bodies) to inform, consult, advise or collaborate for shared knowledge generation, competence development and action-taking for advancing ecosystem-based adaptation.
Vertical mainstreaming	(4) Regulatory mainstreaming	Refers to the modification of planning procedures and related activities by formal and informal plans, regulations, policies and legislations that lead to integration of ecosystem-based adaptation.
	(5) Managerial mainstreaming	Refers to the modification of organizational management and working structures including related internal formal and informal norms and work descriptions as well as the configuration of sections or departments to better address aspects related to ecosystem-based adaptation.
	(6) Directed mainstreaming	Supports or redirects the focus onto aspects related to integrating ecosystem-based adaptation by providing topic-specific funding, promoting the initiation of new projects, supporting the education of staff, or directing responsibilities.

Figure 3. 10 - Mainstreaming dimensions and related contents (Wamsler et al., 2014)

Wamsler C. divide the mainstreaming into six categories (see Fig. 3.10), including the dedicated approach – "add-on" strategy – as one of the mainstreaming strategies

(Rivera & Wamsler, 2014; Wamsler, 2015; Wamsler et al., 2013). Instead, Klein R. and Persson A. divide the CCA mainstreaming into three categories, i.e. Procedural, Organizational, Normative (Klein & Persson, 2009), as explained in Tab 3.4.
Lafferty and Hovden (2003), as first, distinguished between these three degrees of (policy) integration, as illustrated in Table 3.4, which are:

- Coordination
- Harmonization
- Prioritization

This integration degree framework was used mainly by the scholars that used the Normative/Procedural/Organizational categories (Persson & Runhaar, 2018; Runhaar et al., 2014; Widmer, 2018).

Approach	Strategies
Normative	It refers to the development of strategies (e.g. Comprehensive plan with CCA integration, CCA Plan or Climate-related DRR plan), political commitments, or legislative adjustments.
Organizational	Focuses on the governmental and administrative structure, e.g.: the size of the staff, the activation of specialized offices across sectors and interdepartmental meetings.
Procedural	It aims to modify planning processes and official communication procedures, to set up cross-sectoral consultations, to set up new instruments (e.g. climate risk assessments), and to update the monitoring systems (e.g. new indicators or criteria).

Table 3. 4 - The three approaches of CCA mainstreaming, based on Klein and Persson 2009; Persson 2004; Persson and Klein 2009; Widmer 2018

3.2.4 Where local CCA mainstreaming have been studied?

The CCA mainstreaming empirical studies, as shown in the Fig.3.11, are balanced among Europe, Africa and Asia. The Americas have 15 studies and Oceania has the lowest position with just 2 papers. At the local level, the studies are monopolized by scholars (i.e. Wamsler C., Ziervogel, Uittenbroek CJ., Runhaar HEC, Huq S.) whose focus is on Sweden, South Africa, Netherlands, Germany, and India mainly (see Fig. 3.12).

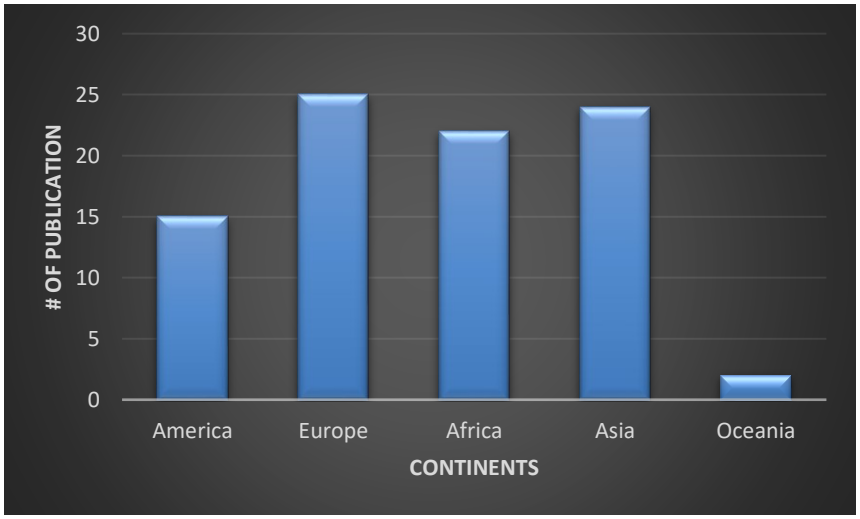

Figure 3. 11 - Occurrence of empirical CCA Mainstreaming per continent (Made by the Author)

Figure 3.13 shows a global map of local CCA mainstreaming focused publications and visualizes at a glance the monopolization by EU northern and central countries, North America, India, south-eastern Asia and South African countries. Big gaps are in the Asian continent, especially the middle east, north Africa and partially the sub-Saharan countries.
In the European continent, the Balkan countries are not studied at all, and south Europe has Italy, France (half central, half Mediterranean) and Spain with just 1 publication per country. Portugal and Greece haven't been studied in this field.

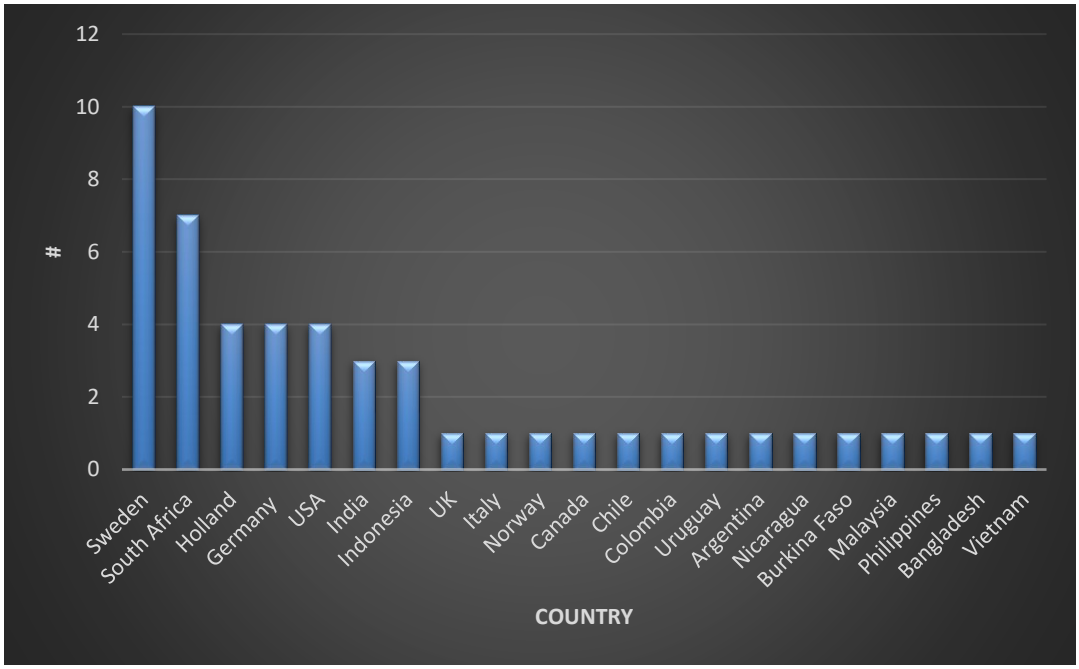

Figure 3. 12 - Occurrence of local CCA Mainstreaming per country (Made by the Author)

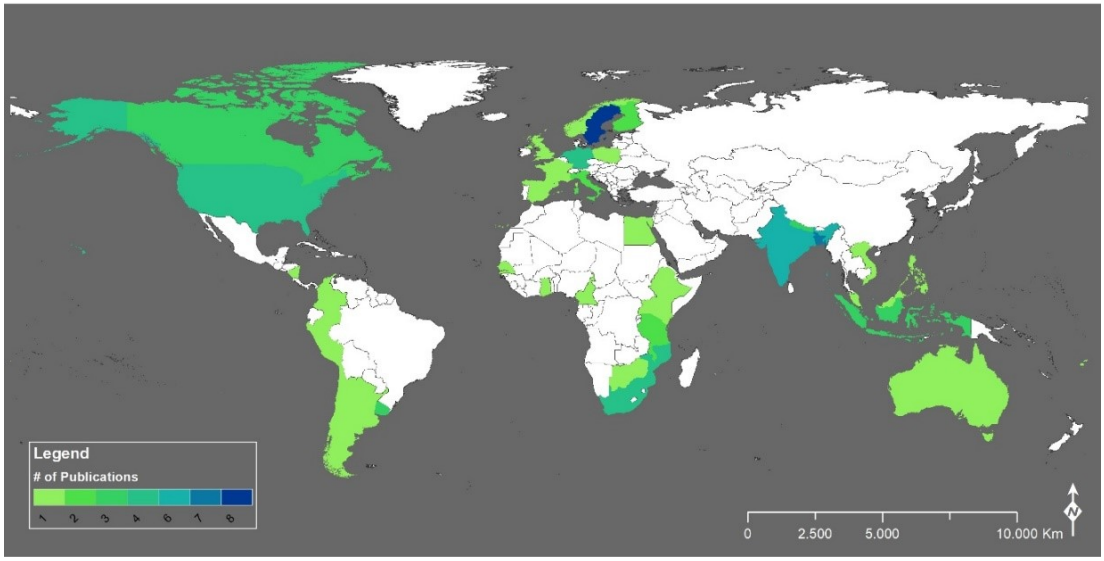

Figure 3. 13 - World map of the local CCA mainstreaming-focused publications (Made by the Author)

3.2.5 Final considerations and follow-ups

CCA mainstreaming is still a niche. The geography of this literature field is strongly monopolized by theoretical studies, and the empirical scholarship frames mainly their studies at the national level and the local level; studying Swedish, German, Dutch, South African municipalities, mostly.
Meanwhile carrying this review, at the beginning of 2018, a review paper (Runhaar et al.) whose goals were the same ones of my literature review was published and co-authored by the most important scholars of this niche. The results are similar with some nuances, which led to different conclusions.
The reviewing of Runhaar et al literature review helped refine the gaps in my systematic review. Runhaar et al. suggested to endeavour further research on outputs (e.g. plans) and outcomes (e.g. implementation of these plans). This view apparently lacks in not considering the climatic "entry points", e.g. funded projects, despite been mentioned in a pair of papers (Wamsler, 2015); and the input, e.g. climate information and services.
Therefore, I argue that mainstreaming of CCA into local planning framework should be considered as a series of processes and assessed as a whole (Persson & Runhaar, 2018), including the input, i.e. the climate information, and the wide spectrum of tools that local governments use or experiment nowadays.

This gap led to a further and deeper investigation in the complementary literature, finding that WoK and Scopus database's query combining "Climate Adaptation" or "Climate Change Adaptation" with "mainstreaming" and "climate services", produced zero results (see Fig. 3.14).

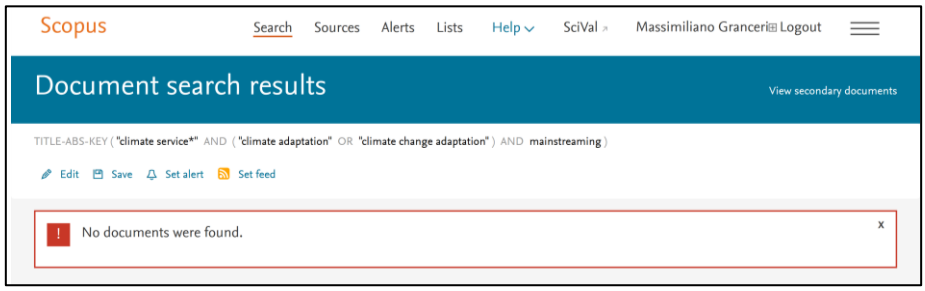

Figure 3. 14 - Screenshot of the query results on Scopus online database (made on May 2019)

With the addition of "climate information" the queries produced very few results (Ayers et al. 2014; Ayers et al. 2014; Kruse and Pütz 2014; OECD 2005). This highlighted that there is space for novel investigation at the edge of these two fields. Few are the examples of a combination of mainstreaming and climate information stays outside the urban CCA mainstreaming literature. Namely, Ziervogel et al that focused on the climate knowledge-policy interface in a rural context, combining the mainstreaming as one of the criteria with the co-production analytical lens (Ziervogel et al., 2016).
Another critic that arise from the literature review relates to the way CCA mainstreaming is assessed. The assessment of CCA is still a challenge and is mainly based on the "barriers" approach (Candel & Biesbroek, 2016; Runhaar et al., 2018).

In addition, Runhaar et al. (2018) recommended further research using the barriers and enablers approach. Nevertheless, this Thesis argues on the fact that this approach doesn't fit with the complexity of the issue investigated. Taking the side of Biesbroek et al., this approach reduces the comprehension of CCA policy- and decision-making processes. The barrier approach, which is based on a hyper linear and functionalist understanding (i.e. 1 input - 1 output), assumes that with no more barriers the policy and decision-making processes would adjust automatically to the changes that affect the system (2015). In contrast, CCA policy integration and planning should be seen as a mix of internal dynamics and processes, which are sensitive to internal knowledge (e.g. technicians from civil protection department), and to external inputs (e.g. CC scenarios, CCA good practices) coming through different entry points (e.g. EU-funded project, C2CL programme) from different actors and networks.

3.3 Climate information and services

3.3.1 Inherent challenges and gaps

"Adapting to what?" is the question that policy- and decision-makers – the users – ask for climate scientists and DRR experts for tackling CC. Depending on the availability of time, e.g. pressure from decision-makers, and the climate or weather data availability, e.g. historical series on specific climate variables, or models (see Box 3.1), climate scientists choose and deliver the climate information typology that best fit the context's needs. Climate information contains from historical climate and weather series to long-term projections, as conceptualised in Figure 3.15. Decadal predictions, which are framed between seasonal forecasts and projections (Christel et al., 2018; Meehl et al., 2009), represents a new type of information, albeit still at its research infancy as the expertise for this typology is currently limited (Smith et al., 2013).

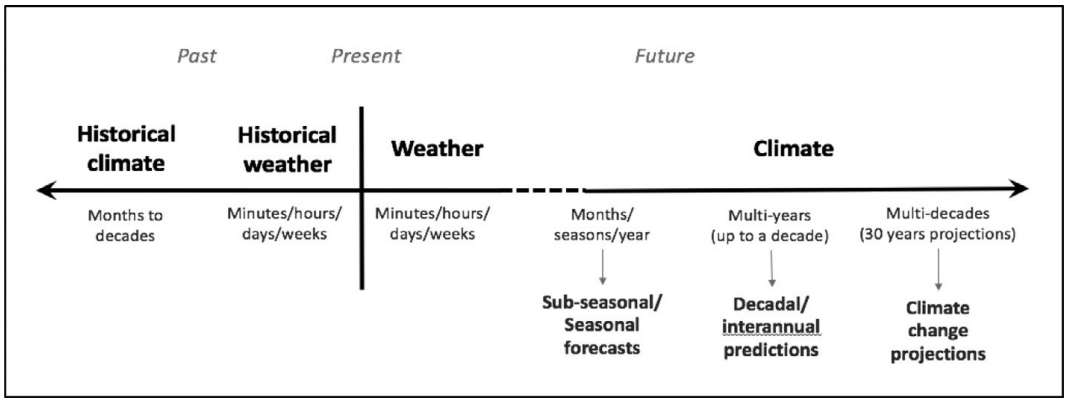

Figure 3. 15 - Main typologies of weather and climate information (Soares et al., 2018)

Planning for CCA means that the planned measures are designed for tackling the expected effects of CC that were made through forecasts, predictions, or projections. This implicitly assumes that the region concerned is already "adapted" to the historical – to-date – climate (Sobel and Tippett 2014).

Several times, mostly in the case of extreme events (e.g. strong winds, storm surges, cloudbursts, tornadoes) whose effects provide losses and damages, the aforementioned implication doesn't fit due to the rarity of the paroxysmal events. They are classified with a return period (see Box 3.1 for an overview) of e.g. 200 years or 500 years, longer than a human lifetime and the time in the office of a typical political leader (ibid). Even though in some cases CCA physical measures (e.g. big dykes) are made with the "too big to fail" approach (Chelleri, 2018) they remain very vulnerable to such strong events, *"having been constructed under the assumption (conscious or not) that such extreme events will not occur"* (Sobel & Tippett, 2018, p.8)

BOX 3.1 – Return period concept

The return period, which is also known as 'recurrence interval', has been used by experts and policy-makers to assess the severity of extreme events, e.g. earthquakes, tornadoes, floods. The notion is based on the magnitude-frequency principle and historical data records are the basis for the event occurrence probability analysis that serves for the risk assessments. Planners and policy-makers use frequently these assessments for developing risk-proof plans and management strategies.
The wider is the temporal scale of events records, the more accurate and precise is the assessment. However, extreme events, which have been considered hitherto rare by nature – but CC is increasing their frequency – haven't been observed and monitored enough to build any statistically rigorous statement or assessment.
For some purposes and some types of events, it is common to estimate hazard directly from historical observations. Records are often too short to characterize the extreme events that are of greatest interest by direct means, Good historical weather data are often not available for periods of even 100 years and hence, it is evident that we cannot estimate a 500-year flood basing on 70 years of data (Sobel & Tippett, 2018). In order to overcome this gap, a common method used to address this issue is the extreme value theory (ibid.). Indeed, the return period concept has started being criticized due to the above-mentioned lacks (Serinaldi, 2015).

Another inherent challenge of climate information creation relates to modelling (see Box 3.2). The simulation of changes in extreme climate-related events is a difficult problem because they are often non-linear, which means that are particularly hard to model (Mitchell, Lowe, Wood, & Vellinga, 2006). Furthermore, many of the processes which contribute to CC are currently insufficiently known and understood (IPCC 2018).
Usually, the production of climate information is made just by hard scientists or had science-based organizations and often provided with a top-down (Dessai & Hulme, 2004) and delivered through documents (e.g. reports, bulletins) using a hyper-technical glossary. Moreover, this top-down approach "*often require that organisations and decision-makers themselves discover and articulate latent risks to their assets and resources, operations, products or services provided, or populations of concern*" (Palutikof 2019 p.464). Sometimes, this information is gathered and then provided by knowledge brokers[9].
Climate Science carries several profession-related technical glossaries and a cascade of uncertainties (Wilby & Dessai, 2010), and the effective communication to the users, as passive receivers, often results in problems or reaches low effectiveness (Palutikof, Street, & Gardiner, 2019) Hence, the concept of Climate Services, CS henceforth, was created in order to overcome these problems between Science and Society.

[9] Knowledge brokers are intermediaries, either an organization or a person, that aim to develop relationships and networks with, among, and between producers and users of knowledge by providing linkages, knowledge sources, and in some cases knowledge itself to organizations in its network (https://en.wikipedia.org/wiki/Knowledge_broker - accessed on May 2019)

BOX 3.2 – Climate models downscaling

Downscaling is a procedure that processes large scale information and transforms it into predictions at the local scale. Downscaling CC information technics can be dynamical and statistical.
The dynamical downscaling approaches are computationally demanding and aim to provide accurate local climate characteristics. In simple terms, they treat high-resolution CC models on a regional scale, using lower-resolution data output as a boundary dataset.
Statistical downscaling is made of a two-step development, consisting of the construction of a statistical correspondence between large-scale forecasters and local-scale climate variables, and then ii) on the application of such correspondence to a global-scale climate model experiments that project local future CCs (Duvel, Camargo, & Sobel, 2017; Harris & Lin, 2013).
The primary tools for making predictive statements about climate change are dynamical models, also known as "climate models" or "earth system models."
Dynamical models have the great advantage that they can, in principle, represent behaviour outside the historical record, since the laws governing the system will presumably remain the same in the future as in the past even as greenhouse gas concentrations and other "forcing" change.
They have the disadvantage that their representations of the climate contain persistent errors, whose magnitudes might be significant enough to compromise their utility in risk assessment.
Dynamical models generally represent some kinds of extreme events well and others poorly. Heatwaves are represented quite well. Tropical cyclones and heavy rain events, on the other hand, are represented much more poorly. Some kinds of events, e.g. tornadoes, occur at such small scales that they remain inaccessible to any climate model, and can only be represented by some form of statistical downscaling (Sobel & Tippett, 2018).

According to the European Commission's Roadmap for Climate Services (2015), CS cover *"the transformation of climate-related data - together with other relevant information - into customized products such as projections, forecasts, information, trends, economic analysis, assessments (including technology assessment), counselling on best practices development and evaluation of solutions and any other services in relation to climate that may be use for the society at large."*
The main goal of CS is to transform and deliver climate science into bespoke, usable, useful, and context-tailored information products at the service of decisions for societal adaptation to CC (Bremer et al., 2019; Hewitt, Mason, & Walland, 2012; Vaughan & Dessai, 2014; Vincent et al., 2018).

The users of CS can be public or private organisations and actors (e.g. end-users, intermediary organizations, citizens) with diversified needs in the type of climate information they require.
An understanding of the chains that affect the flow of climate information, from those who develop and disseminate the service to those who receive it is important for the development of CS. These chains of information flow can consist of a multi-actor set, including intermediary organisations (also known as purveyors), whose objective is to bridge CC information between the experts that produce the

information and the end-users (Lourenço, Swart, Goosen, & Street, 2016; Vaughan & Dessai, 2014). Purveyors are often the ones committed to making risk and vulnerability analysis.
CS is an emerging field, made of good purposes, unclear extents, and still elitist attitudes. (Vaughan & Dessai, 2014). However, endeavours are mainly concentrated on improving the scientific prediction or observation systems whilst fewer efforts have been made for improving the usability of climate information (Kennel, Briggs, & Victor, 2016; Lemos, Kirchhoff, & Ramprasad, 2012). "*For an effective provision of CS, there is a growing consensus that user engagement and knowledge exchange across traditionally divided scientific-policy-practice communities is essential*" (Bruno Soares et al., 2018 p.7; citing cf. Hering, Dzombak, Green, Luthy, & Swackhamer, 2014; Lemos & Morehouse, 2005)
Complex problems, like CC, should account for different types of knowledge, e.g. indigenous knowledge, and, consequently, foster opportunities for interaction and co-production of knowledge (Kirchhoff et al., 2013). Therefore, users are no more considered as passive receivers of scientific information but actively involved in the knowledge co-creation and co-production process (Bremer & Meisch, 2017; Vaughan & Dessai, 2014; Vincent et al., 2018).

3.3.2 What makes useful and usable climate information?

Climate-oriented scholarship agrees on the fact that climate information and services have to be usable and useful (Bruno Soares et al., 2018; Christel et al., 2018; Dilling & Lemos, 2011; Kirchhoff, Esselman, et al., 2015; Lemos & Morehouse, 2005; Prokopy et al., 2017). Climate information and services are often analysed and assessed through the credibility criterion (Bruno Soares et al., 2018; D. Cash et al., 2005; S. H. Eriksen & Kelly, 2007; Olazabal et al., 2019; Street et al., 2019; Tiepolo et al., 2017). Saliency, Legitimacy (Cash et al., 2005; Cash et al., 2003; Haasnoot et al., 2018; Leitch et al., 2019; Olazabal et al., 2019; Preston et al., 2015) and Relevance (Heink et al., 2015; Vaughan & Dessai, 2014) are often added as sub-criteria of credibility or as joint criteria. Moreover, credibility is also joint with usefulness and usability (Klink et al. 2017); and with timely and accuracy (Lemos & Morehouse, 2005). In the case of climate information uncertainty and adaptive signpost, there are also three criteria taken into account, which are: Reliability – referable to climate models –, Convincibility and Trustwortyness (Haasnoot et al., 2018).
Credibility is a criterion that refers to scientific and technical believability, and in this research refers to the climate-related information received or experienced.
Pursuing salience means recognizing the complexities of policy environments, and legitimacy is about the stakeholder engagement and the acting as a general intermediary among different types of knowledge.
Legitimacy also refers to the acceptability or perceived 'fairness' to users and contributes to the acquaintance with and performance of the monitoring system and support for follow-up actions.

Leitch et al. use a set of criteria, i.e. credibility, saliency and legitimacy for analysing CCA signposts defining as important benchmarks of the effectiveness of the translation of science into policy or practice (2019). However, Heink et al. when referring to credibility, relevance and legitimacy, they are helpful when reflecting on the effectiveness of science-policy interfaces, but also vague and depend on individual framing (2015).
According to Vaughan & Dessai, the important aspects concerning the proper personalisation of CS are:

- the relevance of information (and perceived relevance),
- the accessibility to information, and
- the distributional impact on different users. Moreover, communication between the parties is important, but also transparency and flexibility (2014).

Furthermore, Fussel stated that the "*effectiveness of pro-active [CCA] often depends on the accuracy of regional climate and impact projections, which are subject to uncertainty*" (2007). Another important aspect that emerged recently after the last IPCC analysis (2018) relates to the casual communication of climate information (Wardekker et al., 2019). Therefore, the way the climate information and its inner uncertainties are communicated is critical and has to be taken into account. Finally, in the case of CS co-production, Vincent et al use four more criteria, which are Inclusiveness, Collaboration, Flexibility, and Time-managed. The latter relates to the output and the other three are called process principles (2018).

3.4 Civic engagement and co-production

Along with the development of the thesis, another concept arose, which is "co-production" – often called also "co-creation" (Mahmoud & Morello, 2018; Voorberg et al., 2015). Co-production is generally defined as the involvement of individual citizens and groups in public service delivery (Verschuere et al., 2012) or as "*the collaborative process of bringing a plurality of knowledge sources and types together to address a defined problem and build an integrated or systems-oriented understanding of that problem*" (Armitage, Berkes, Dale, Kocho-Schellenberg, & Patton, 2011). It is an approach that has been applied by several scholars (Albrechts, 2013; Bovaird & Loeffler, 2012; Olazabal et al., 2018; Verschuere et al., 2012; Voorberg et al., 2015) in different fields, e.g. urban planning, climate science, and sociology, with diverse aims and purposes, e.g. climate services (Bremer et al., 2019; Lemos & Morehouse, 2005), CCA (Wamsler, 2017), adaptive co-management (Armitage et al., 2008).
Regarding the CCA research field, and more specifically to urban governance, the related literature is growing, revealing multiple ways in which the civic takes part in the governance of urban CCA. As shown in the figure 3.16, Sarzinski categorizes in six variants the different ways of civic engagement – acknowledging their non-exclusive meaning and overlaps – including three variants of planning for CCA, i.e. traditional, non-governmental, and inclusive; and three variants of action on CCA, i.e. collaborative, non-governmental, and co-produced (Sarzinski 2015).

Type	Breadth (who)	Openness (when)	Intensity (how much)	Influence (what)	Goals (why)
Traditional government-led climate planning	Narrow to moderate	Low (planning only)	Low	Inform & consult	Instrumental
Non-governmental planning	Moderate	Low (planning only)	Low to moderate	Inform & consult	Instrumental & intrinsic
Inclusive planning	Moderate to broad; government-led	Low (planning only)	Low to moderate	Inform & consult	Instrumental & some intrinsic
Partnerships	Moderate	Moderate (decision & implementation)	Moderate to high	Consult & collaborate	Instrumental
Non-governmental provision	Broad	Moderate (decision & implementation)	Moderate to high	Empower	Instrumental
Co-production	Broad	High (planning, decision, implementation)	Moderate to high	Collaborate & empower	Instrumental & intrinsic

Figure 3. 16 - Types and characteristics of civic engagement in urban CCA (Sarzynski, 2015)

Participation has been alternatively termed "public participation," "citizen participation," "stakeholder engagement," "stakeholder involvement," "new public involvement," "community engagement," or "civic engagement." Nevertheless, the concept involves several distinctive elements that characterize how participation and civic engagement are structured: who participate, when happens, which targets, which tools and techniques are employed, what degree of engagement, and why the actors participate (Burton & Mustelin, 2013; Few, Brown, & Tompkins, 2007; Glass, 1979; Wamsler, 2017).
Co-production origins are in urban planning literature (e.g. Susskind and Elliott 1976 Whitaker 1980), and "*introduces into the neighbourhood, city or region new identities and practices that disturb established histories*" (Albrechts, 2013), combining scientific and indigenous knowledge, providing delivery of public goods, building resilient and mutually supportive communities (ibid.).

Besides, "*co-production implies the possibility that citizens might influence the execution of public policies as well as its formulation' and 'actors interact to adjust each other's expectations and actions*" (Whitaker 1980, p. 242).

In the context of CCA planning, co-production (science-policy and policy-action) presumes that both government and community participants contribute their knowledge and capacities and are involved in the planning and implementation of related service delivery or measures (Wamsler, 2017). It embeds principles of transdisciplinarity, which is an approach that enhances the effectiveness of science and democracy (Funtowicz & Ravetz, 1993). It aims to increase the degree of public engagement that it is usually activated through collaborations, consultations, and participation, and to support a transformative CCA (Pelling et al., 2015).

In the context of CS, co-production is still in its infancy. CS co-production is framed in the science-policy edge and within three dimensions: "*interdisciplinarity, interaction with stakeholders, and production of usable science*" (Lemnos and Morehouse 2005, p.58). It involves "*working iteratively and interactively toward collaborative learning*" (Nel et al. 2016, p. 178). However, CS field scholars "*are not drawing on the history and lessons learned from co-production from other fields, e.g. public services administration, science policy, and co-management*" (Vincent & Colenbrander, 2018).

3.5 Final considerations and preparation for the next part

This Chapter, 3., addressed the thesis' research fields literature and the results of these reviews are summarized in this section. Section 3.5.1 ponders on the alignment of the two main concept of this thesis, i.e. mainstreaming and co-production. Section 3.5.2 sums up the literature reviews' insights and prepares for the next part of the thesis, i.e. Part II.

3.5.1 Mainstreaming and co-production: a theoretical alignment

Mainstreaming and co-production concepts are still unknown in the field of CCA when applied together (Brink & Wamsler, 2018).
This thesis used the mainstreaming concept as the lens for understanding the key challenges for local CCA planning that was researched along the Science-Policy path. The co-production concept was considered along with the development of the thesis and appeared when researching the case of Barcelona.
From the theoretical perspective, the two concepts are different but are also complementarity, as shown in Table 3.5.

Characteristics	Mainstreaming	Co-Production
Change typology	Incremental	Transformative
Flow/Pace	Iterative and erratic	Iterative and cyclical
Approach(es)	Multi- and Inter-sectoral	Trans-disciplinary
Planning and Administration issues tackled	Silo mentality Conformance Specialization	Knowledge elitism Conformance Command-and-control mentality Predict-and-provide mentality Top-down
Ultimate goal	Total integration (Coordination-Harmonization-Prioritization)	Knowledge democratization

Table 3. 5 - Mainstreaming and Co-production theoretical alignment (Made by the Author)

Both aim to a change. The mainstreaming is considered by Picciotto as a "*deliberate perturbation in the natural order of things*" (Picciotto, 2002, p.323). It subverts the *status quo* and it "*does not evoke chaotic change or painful disruption*" (ibid.), meaning that it *"favours smaller adjustments over dramatic ones [and this] has been characterised as 'incremental'*" (Benzie et al., 2011, p.237). The co-

production on the other hand, instead, aims to provoke transformative changes (Wamsler, 2017).
From the perspective of the process flow, both are iterative. If on one hand the mainstreaming is considered erratic (Uittenbroek, 2014; Wamsler, 2017), on the other hand, the co-production acts through cycles (Jagannathan et al., 2020; Norström et al., 2020).
In terms of approach, the mainstreaming works with a multi- and inter-sectoral approach (Runhaar et al., 2018; Wamsler et al., 2013), and co-production rather employs a trans-disciplinary approach (Albrechts, 2013; Bremer et al., 2019; Wamsler, 2017).
Both concepts challenge and perturb the *status quo* of planning constituencies and administrative structures. The mainstreaming challenges the fundamental principles of the administrative structures, i.e. silo mentality, conformance, specialization (Bourgon, 2009; Uittenbroek et al., 2013). The co-production challenges the conformance mentality and the command-and-control approach. Moreover, at the Science-Policy interface, co-production challenges knowledge elitism, and the "predict-and-provide" and rigid top-down approaches in the climate information production and delivery (Bremer & Meisch, 2017; Bremer et al., 2019; Bruno Soares et al., 2018; Lourenço et al., 2016; Vaughan & Dessai, 2014).

3.5.2 Preparation for the Thesis' Part II

In this chapter four research fields were reviewed:

- CCA local planning
- CCA mainstreaming
- Climate information and services
- Co-production in planning and climate services

The CCA local planning review (3.1) showed the heterogeneous set of instruments used by cities for tackling CCA. The set of planning instruments that were also included in the state-of-the-art of local CCA planning were EU-funded projects and city-to-city-learning (C2CL) programmes. A further analysis was done on EU-based CC-focused city networks. The thesis focus on the EU and the case studies' frame on the specific southern European region led to the development of state-of-the-art of local CCA planning practices in the southern European countries (i.e. Italy, Spain, Portugal, France, Slovenia, Croatia, and Greece). Southern Europe, especially Italy, Spain, and Greece, is the macro-region with more commitments to the Covenant of Mayors for Energy and Climate. Instead, concerning the local CCA planning state-of-art, southern European countries have very few local governments tackling CCA. Southern European municipalities with a CCA plan only are medium- to large-sized cities, which are still a minority.

In the second section, 3.2, the literature review on CCA mainstreaming showed that this research field is still a niche. The geography of this literature field is strongly monopolized by theoretical studies, and the empirical scholarship frames

mainly their studies at the national level and the local level, studying Swedish, German, Dutch, South African municipalities, mostly. Southern Europe is barely studied.
A critic that arise from the literature review relates to the way CCA mainstreaming is assessed. The assessment of CCA is still a challenge and is mainly based on the "barriers" approach (Candel & Biesbroek, 2016; Runhaar et al., 2018), which carries limits and reduces the policy-making processes and the internal local dynamics as a simple input-output path.
The recent literature review carried by Runhaar et al. (2018) suggested endeavouring further research on outputs (e.g. plans) and outcomes (e.g. implementation of these plans). This view apparently lacks in not considering the climatic "entry points", e.g. funded projects, despite been mentioned in a pair of papers (Wamsler, 2015); and the input, e.g. climate information and services. Arguing on the fact that mainstreaming of CCA into local planning framework should be considered as a series of processes and assessed as a whole (Persson & Runhaar, 2018), research should include the input, i.e. the climate information, and the wide spectrum of tools that local governments use or experiment nowadays, i.e. C2CL programmes, International Funded projects.

In the third section, 3.3, a light review was carried on the climate information and climate services (CS) in order to describe the origins and contents of these two fields. Methodological and analytical approaches were reviewed in order to identify the set of criteria to employ in this research, i.e.: credibility, reliability, accuracy, and legitimacy.
These first three research fields' analysis were propaedeutic for the creation of the PhD thesis' analytical framework, explained in 2.3 section.

In the fourth section, 3.4, a light literature review was carried in order to describe the theoretical foundations of the co-production concept, and its application in the fields of CCA planning and CS – explained and theoretically aligned with 'mainstreaming' concept in section 3.5.1.

Finally, Chapter 3 prepares for the Thesis' Part II where case studies are analysed. It helped in defining the case studies' geographical frame and grounded the basis for the analytical framework, which was tailor-made in accordance with the research gaps to be fulfilled and the case studies' complexities.
Part II starts with the Mediterranean and south European climate framing and follows with a focus on the local CCA planning in southern EU. Case studies' peculiarities are detailed and their contribution for answering the research questions is explained.

PART II – CASE STUDIES ANALYSIS

The second part of the thesis shows the results of the research. Before approaching to chapters four and five, where the case studies' results will be explained, the characteristics of the Mediterranean climate and the two cities investigated i.e. Barcelona (ES) and Turin (IT) is briefly explained.

Climate change and local planning in south Europe

CC impacts, projected from all the emission scenarios, are expected to increase in terms of magnitude and rate all over Europe, and Southern Europe is a region where these impacts are expected to be more severe (Giorgi & Lionello, 2008).

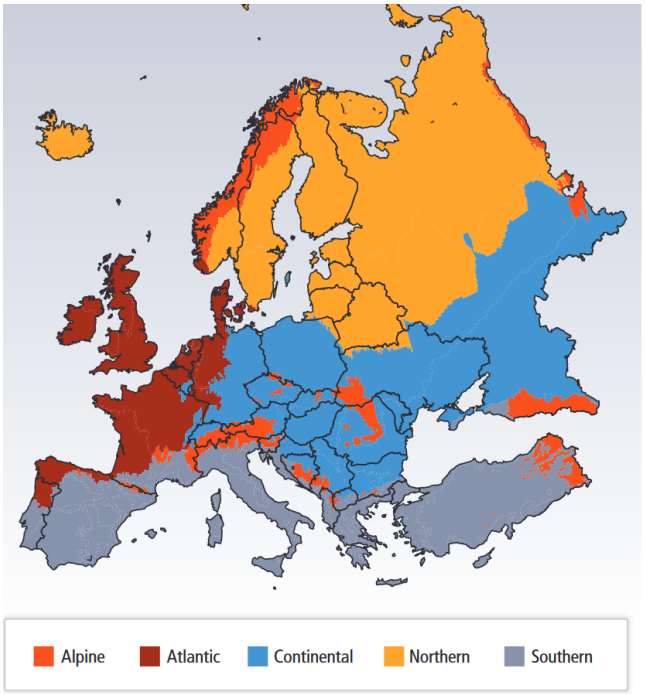

Figure 4. 1 - Regional climates in Europe (IPCC, 2014a)

Mediterranean area is defined as a CC hotspot (IPCC, 2018), both in terms of "*projected stronger warming of the regional land-based hot extremes compared to*

the mean global temperature increase" (Guiot & Cramer, 2016) and in terms of "*robust increases in the probability of occurrence of extreme droughts"* (IPCC, 2015). In the Mediterranean region, average annual temperatures are now 1.4 °C higher than during the period 1880-1899, well above current global warming trends, especially during summer. As for the future projections, the 2 °C global mean temperature target implies 3 °C warming in hot temperature extremes in the Mediterranean region. Depending on the RCP-based climate scenario and the season, a rise in temperature from 2 to 6 ° C by 2100 is expected in the Mediterranean (for summer temperatures: Fig. 4.2). High temperature events and heat waves are likely to become more frequent and/or more extreme (Jacob et al. 2014).

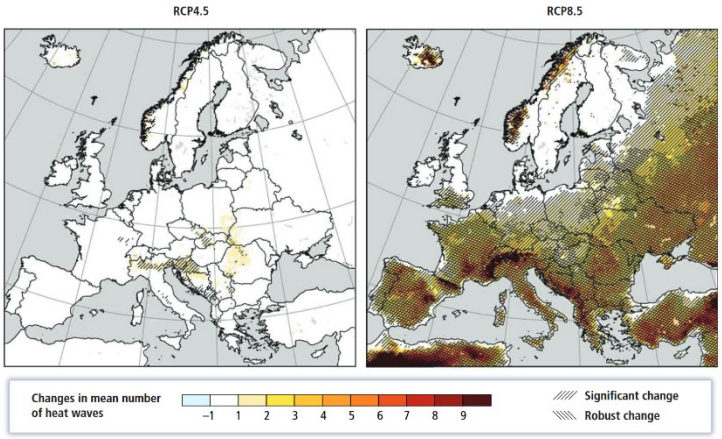

Figure 4. 2 - Heatwaves scenario during summer in the period 2071-2100 (IPCC, 2015)

The sea-level in the Mediterranean has risen between 1945-2000 at a rate of 0.7±0.2 mm/yr and the estimated rise during the last two decades was of about 3 cm/decade. The future total Mediterranean basin averaged sea-level rise has been estimated to be between 9.8 and 25.6 cm by 2040–2050 depending on the scenario (IPCC, 2015). The Mediterranean region has also increasingly suffered from strong wind events, storm surges, and mini-tornados (IPCC, 2014a). However, there is a lack of information for other storm types, such as strong tornadoes and thunderstorms. Moreover, due to the direct connection with the Sahara Desert, it happened several times that the region suffered from the combination of a heatwave and dusty wind (Perez et al., 2008; Zauli Sajani et al., 2011). Furthermore, another direct effect of CC, due to the widening of the sub-tropical area, is the vector- and water-borne diseases, which are becoming common threats in the whole Mediterranean region (Guzzetta et al., 2016; Marini et al., 2016; Millet et al., 2017).

Local adaptation planning in south Europe

South Europe context includes Portugal, Spain, France – the southern part –, Italy, Slovenia, Croatia, and Greece. France, due to their national plan's mandatory obligations (Reckien et al 2018), is the country with most CC-related plans, which are joint plans, including both CCM and CCA. However, they include an inferior number of CCA measures than CCM's (Reckien et al 2018). Still, it remains the southern European country with the majority of CCA-related plans. Spain has to-

date 8 active CCA-related plans (in the 4.3 figure Barcelona is not present because the source bases the study on plans on 2017). Portugal, which has a National programme on CCA local planning fostered by EEA grants, have started planning local CCA mainly around the Lisbon and Porto urban regions. Italy has just two active CCA-plans, i.e. Ancona and Bologna. Croatia has 1 (i.e. Zagreb), and Slovenia and Greece have no CCA-dedicated plan among their municipalities – with more than 100.000 (see the methodology of Reckien et al. 2019).

Case studies overview

Barcelona and Turin's municipalities are the case studies of this research, and Spain and Italy are the two representative countries of the southern European region.
Differently from the central and northern countries, Spain and Italy have few examples of CCA plans at the local level: e.g. Bilbao (Spain), Vitoria (Spain), Bologna (Italy), and Ancona (Italy). However, both countries have their municipalities with a strong will to commit to the cause and to plan for CCA, as shown in Figure 4.4[10].

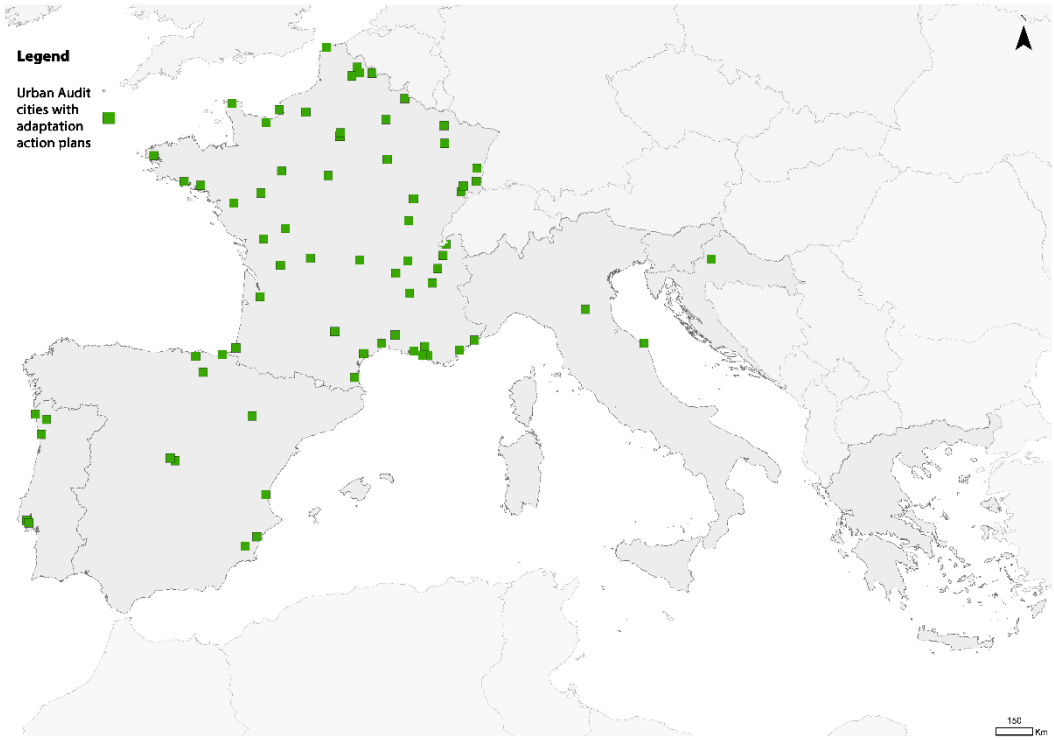

Figure 4. 3 - State-of-art of CCA-related local plans in South European countries (Source: Reckien et al 2018 – Made by the Author)

Spain has a National CCA Plan since 2006, while, Italy has a Strategy but not yet a National Plan (Pietrapertosa et al., 2019). In the Spanish case, the presence of a national plan didn't help for addressing CCA at the lower levels (De Gregorio Hurtado et al., 2014, 2015; Olazabal et al., 2014).

[10] Municipalities considered in this study have more than 100.000 inhabitants

In terms of sub-National levels, Barcelona and Turin are both consolidated cores of their surrounding metropolitan areas and capital cities of their Regions, Catalunya and Piedmont, respectively. Barcelona is a unique case because is the only one in Spain with a metropolitan agency. Turin has also a metropolitan administrative entity, but with reduced political power.

Cases	Barcelona	Turin
Inhabitants (Municipality)	1.604.555 (2018)	875.698 (2018)
Inhabitants (Metropolitan)	3.239.337 (2018)	2.277.857 (2017)
Climate-related hazards suffered to-date	Heatwaves, droughts, pluvial and marine floods, storm surges, strong wind, tornadoes, vector-borne diseases, critical infrastructure disruption, fires	Heatwaves, pluvial and fluvial floods, droughts, strong wind, mini-tornadoes, fires
CCA Phase	Implementation	Plan-making
Fund origin	Public (municipal), Public-Private (international projects)	Public (no ad-hoc funds)
CCA planning leadership	Municipal servant	Policy entrepreneur
Inter-municipal collaboration	No	No
CCA National plan	Yes: local CCA planning is not mandatory	No: stalled since 2016
CCA Regional plan	Yes: Strategy	No: work-in-progress as a strategy.
CCA Metropolitan plan	Yes: recently updated	No
1st CCA formal act	1998 (Water management plan)	2015 (Commitment to Covenant of Mayors and Mayors Adapt, then updated in 2018 to the Compact of Mayors)

Table 4. 1 - Overview of the case studies characteristics - Overview of the case studies characteristics

They are different in geo-morphological terms because:

- Barcelona is a coastal city of the Mediterranean Sea. It is a flat area with small hills, surrounded by two rivers – Llobregat in the south and Besòs in the north, and Serra de Collserola mountains protect the city at north-west,
- Turin is a river city, situated along the Po riverside and surrounded by two streams that connect with the Po river: Dora Baltea and Sangone. It is situated in the lowland of the Po valley, surrounded by the Alps, in a region that from the air and wind flow perspectives can be considered a *cul-de-sac*.

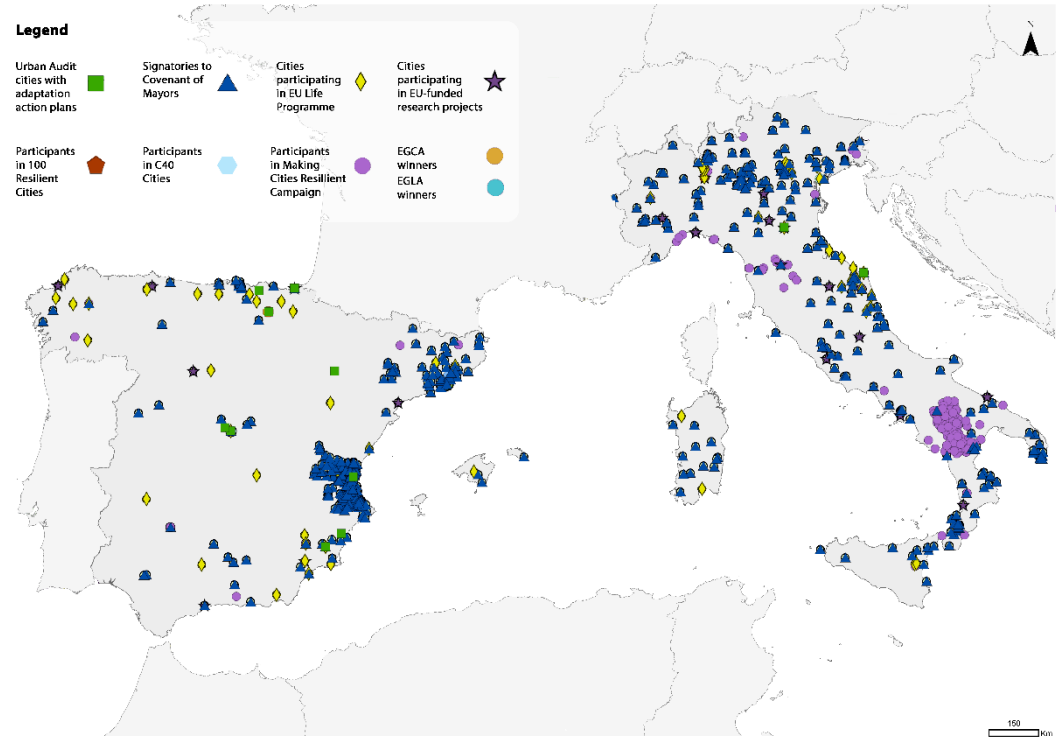

Figure 4. 4 - State-of-art of Italy and Spain CCA plans, commitments, and projects (Made by the Author)

Barcelona

Barcelona has a population of more than 1.6 million inhabitants that is settled in an area of 102.2 km^2. Its density – over 16,000 inhabitants per km^2 – makes it a compact and complex city (2018).

Barcelona municipality is part of the broader Barcelona Metropolitan Area (AMB), which is the administrative organization that takes 36 municipalities, has a total population of more than 3.2 million inhabitants, and control an area of 636 km^2. The city of Barcelona has ten sub-municipal districts and 73 neighbourhoods, which are administrated by the Barcelona City Council (BCC) (2018).

Barcelona is one of the most known Mediterranean cities because of its vibrant cultural activities and the quality of public spaces, but also because of its governance based on the 'Barcelona Model' (Marshall, 2000). The city of Barcelona has become an international benchmark in the way of making a city based on the development of a "Model". 'Barcelona model' origins are in the General Metropolitan Plan of 1976 and the generation of architects and spatial planners from the 80s, with its *momentum* in the 1992 Olympic Games and urban projects in the 90s and 00s (Calavita & Ferrer, 2000). This approach and the strategic planning made the metropolitan level that gave coherence among the several municipalities of the AMB and coordinated the individual projects that have been implemented at small scale, with the aim to plan and administrate the metropolitan area as a whole.

Turin

Turin is a city and an important business and cultural centre in northern Italy. It is the capital city of Piedmont and the Metropolitan City of Turin and was the first Italian capital from 1861 to 1865. The city is located along the banks of Po River, in front of Susa Valley, is surrounded by the western Alpine chain, and includes the Superga Hill. The population of the municipality is 875,698[11] (2018) and the Turin metropolitan area is around a population of 2.2 million[12] (2017).

Turin, both the municipal and the metropolitan levels, has been recognized as important grounds for planning experimentation in Italy and Europe. The series of comprehensive and strategic plans and large-scale projects that have been developed from the 1990s profoundly changed the city of Turin (Ponzini & Santangelo, 2018).

Turin is historically known as a one-company town, due to the automotive vehicle company FIAT. Today is a post-industrial shrinking city that has also created a new image of it through the 2006 Olympic Games, which branded the city as a cultural and creative, and triggered the thrive of new sectors, e.g. tourism (Vanolo, 2015).

In ecological terms, Turin, along the last three decades, has developed a more sustainable vision with a series of actions and projects addressing the regeneration and reclamation of brownfield, of degraded and peri-urban areas (Cassatella, 2016). However, the current presence of the number of heavy metals in the soils, where the industries were located, makes Turin one of the most polluted cities in Italy (Ajmone-Marsan et al., 2008; Madrid et al., 2006). In terms of contamination, the Turin area is also suffering from air-pollution (Eeftens et al., 2012). These two sources of pollution make Turin one of the most contaminated cities in Europe.

Turin municipality, as well as the all metropolitan area, is a territory with a network of green spaces that are well distributed. The idea of a 'Green city' has been conceived, planned and implemented along the last two decades due to a process of strategic planning and governance called "Corona Verde" (Cassatella, 2013). Regarding the period from the '90s on, Turin is also considered a good example in terms of land use planning (Caldarice & Cozzolino, 2019).

The role of Barcelona and Turin cases in this Thesis

Both municipalities, respectively coastal large- and inland mid-sized cities, employ a dedicated planning approach, with a difference in experience (Barcelona can be classed as relatively mature, whereas Turin is a relative "newcomer").

Barcelona is involved in several international networks and into a local CCA-related network, and currently taking part in an EU-funded project addressing CCA and UR. Likewise, Turin is involved in several international networks, in particular in a transatlantic C2CL programme. Turin also participated in an EU-funded project that tackles CCA and DRR, which triggered the current CCA policy-making process. In terms of civic engagement, Barcelona municipality designed the plan's

[11] See www.istat.it

[12] OECD estimates it at 2.277.857 – see www.oecd.org

goals and measures through an online public engagement process and has started co-implementing the CC joint Plan with external private and public actors – officially committed to the Barcelona's sustainability goals and part of the local sustainable-oriented network. Instead, Turin frames the policy-making process within the administrative boundaries involving five departments, and in parallel inviting the foreign municipalities of the C2CL programme.

Barcelona is a pioneer city for sustainability-oriented planning aiming to become a global CC planning champion. It is a city that has not suffered from inertia – a phenomenon that affected several local governments in south Europe (De Gregorio Hurtado et al., 2014; Olazabal et al., 2014). It has a high institutional capacity that is demonstrated by the innovative and progressist changes in the departments' organization (i.e. i) set up of the *Ecologia Urbana* department compounded by Urban planning, Environment, and Mobility former departments; ii) set up of the Resilience office – former TISU *Taules de Resiliència Urbana*).
It is a peculiar case because of its unicity regarding the metropolitan level. Barcelona is the only Spanish city with a Metropolitan Agency, namely *Agencia Metropolitana de Barcelona* (AMB), which has political power on municipal spatial planning. Moreover, AMB approved a CCA-dedicated plan (2014) before Barcelona's, which *de facto* benefited from it in terms of awareness and climate information production. This case study has also an on-going EU-funded project under the Horizon2020 framework called RESCCUE, which is a research project on CC resilience aiming at developing a multi-risk analytical and evaluative model.

Turin is a relative "newcomer" in the field of CC, especially concerning CCA, and has an ongoing dedicated plan-making process, which was triggered by a EU-funded project, namely DERRIS. It has also an intercontinental C2CL programme whose goal is CC-focused good practices exchanges between North Americans and European cities.

The inner cases of the two contexts are complementary and cover a wide spectrum of the current topical tools used at the service of CCA. From the "barriers" perspective (Eisenack et al., 2015; Moser & Ekstrom, 2010; Runhaar et al., 2018) Barcelona can be described as a city with plenty of enabling factors, whereas Turin can be classed as a city with several barriers to overcome. Employing this analytical approach, Barcelona would be considered as a good practice that reaches easily an effective CCA implementation, whereas Turin as a city with a scarce enabling environment for CCA. However, both cities have been facing and suffered from several climate-related hazards and threats, which are still partially or totally unsolved. Furthermore, the CCA objectives are still "sectoralized" in both cases and the degree of CCA implementation is still low.
Therefore, the inner cases complementarity jointly with the differences in terms of CC planning experience level and institutional capacity, make these two cases consistent offering a coherent and complete setting for answering the research questions of this thesis.

Chapter 4

Barcelona

In this chapter, the Barcelona case's findings will be described and analysed.
The objective of this chapter is to answer to the research questions through the analysis of the Barcelona City Council's (BCC) CCA policy, considering: i) the science-based CC analysis and assessments that fed the Climate-related plan, namely *Pla Clima*; ii) the participatory process for the design of the *Pla Clima*; iii) the *Pla Clima*'s co-implementation process.
Introductory section (4.1) will describe the CC impacts that Barcelona has suffered to-date (4.1.1) and will frame the CCA-related policy context in Spain, from the national to the local level (4.1.2).
The second section (4.2) will address the climate information inflows at the service of *Pla Clima*, both the first CC analysis (4.2.1) and the second one treated delivered by the purveyors at the service of the end-user (4.2.2). These are the climate-related information that has fed the CCA policy process in Barcelona municipality and here will be assessed through the Credibility criterion, jointly with Reliability, Accuracy, and Legitimacy sub-criteria. This section is important for answering the first sub-question of this thesis.
The third section (4.3) is about the *Pla Clima* and the objectives, measures and plans included. The 4.3.3 sub-section highlights the measures and plans included in the *Pla Clima* and their related department/office, and analyse the degree of integration of the CCA policy. The fourth section, 4.4, addresses *Pla Clima*'s co-implementation phase where 11 CC-oriented projects, funded by BCC, were analysed. Sections 4.3 and 4.3 are important for answering the second sub-question of this thesis
The fifth section, 4.5, concludes with the discussion (4.5.1) and highlights the case study's insights (4.5.2).

4.1 Introduction

4.1.1 Climate Change impacts and effects to-date in Barcelona

Barcelona area has a warm temperate climate – a typical Mediterranean climate. According to the Fabra Observatory in Barcelona, the annual mean temperature has increased significantly from 1950 to today, and the same increase has been registered for the annual maximum and minimum temperatures. As for annual precipitation, there is no statistically significant trend given the high seasonal variability, although a slight increase in intensity can be observed.
According to Catalonia's Meteorological Office (Servei Meteorològic de Catalunya, SMC henceforth), the Mediterranean area will become one of the Earth climates 'hotspots', which will suffer the most significant changes. The main risks forecasted for Catalonia and Barcelona, and which have actually been suffered hitherto, are the mean temperatures rise and consequent heatwaves and wildfires, rainfall pattern change and consequent floods, storm surges, strong winds, and droughts. Moreover, there are other hazards and threats to be added, which are sea-level rise, vector-borne diseases and the combined effects of periods of humidity or heatwave with air pollution.

Rainfall pattern change, droughts, and floods

Barcelona is a dense city – 15.700 inhab/km^2 (BCC, 2014) – and CC is one of the main threats, even more, when coupled with the increasing of impermeable surfaces, underground water discontinuities and sewer-pipes networks lack (Chelleri, 2018). Barcelona has been always exposed to flash floods and droughts, as most of the other part of the Mediterranean region.
The annual average reduction in rainfall, in general, will be from 5% to 15%, with possibly a slight increase in winter. This average reduction could reach 40% on the coast and in the summer. Downpours may become twice as frequent and their associated peak rainfall rates could increase by approximately 20%.
Historical data on the number of floods in the AMB during the period 1981-2010 says that the area of the metropolitan area of Barcelona, by location and characteristics, it is one of the areas of Catalonia where the risk of flooding is high. The historical data stand out especially in the municipality of Barcelona, as well as the coastal municipalities and the neighbouring municipalities on the Llobregat river and at some point, bordering the Besòs River. For the future, with the action of climate change, there is an increase in the extraordinary floods caused by intense short-term rains, especially on the coast (Estrategia Catalana de Adaptacion al Cambio Climatico).
The region of Catalonia suffered from 2007 to 2010 the worst droughts in 60 years (Chelleri, 2018) and the scenarios forecasted that these events may also double in

frequency and maintain their intensity for longer periods. Especially between the autumn of 2006 and spring of 2008, there was a period of considerable drought which seriously affected Barcelona and its metropolitan area. This sparked an intense debate about the classic water transfer solutions compared with those based on regulating demand and using alternative local resources. Effort and increased public awareness brought consumption down to 104 litres per capita, a figure very close to the limit of 100 recommended by the WHO. Shortly afterwards, the El Prat desalination plant was consolidated and entered into operation along with a pipeline connecting the Ter and Llobregat river basins. Therefore, the water provision is an issue that has to be tackled with a multi-scale approach involving the regional and watershed entities.

As for drought, the climatic factors that most influence it are precipitation and temperature, but humidity and wind are also important when evaporation and evaporation are present. The spring and autumn seasons are the most important to consider in terms of precipitation in Catalonia.

The management of water resources through the reservoirs has modified the impact of rainfall both temporarily and in different sectors. For this reason, more than talking about areas of involvement, we should talk about sectors of involvement. Land crops, forests and, in general, not artificially irrigated vegetation, are an exception, since the lack of rainfall affects them directly, as was seen in the last drought period (2004-2008).

An undeniable fact is that the intensity and duration of drought in the period 2004-2008 are well above that of previous episodes in the twentieth century.

Tornadoes, storm surges

Concerning tornadoes and hoses, it is notable that its evolution in Catalonia in the last 50 years shows a remarkable increase, greatly influenced by the increase in information. Tornadoes and storm surges cause significant material destruction, although in Spain they usually do not exceed the force 24. Sometimes they go with situations of heavy rain or stone.

The metropolitan area is one of the most affected areas for tornadoes in the last four decades in Catalonia since they are concentrated on the coast and particularly in the most populated areas. There is not enough information to conclude that windstorms have increased or are more intense than before. However, the models point to a potential increase in cyclones linked to these times that would arrive or be developed near Catalonia. It should be remarked that, in 2005, 5 cases were recorded in the area of Barcelona in one day, and in 2006, they took place in the September simultaneously to an episode of floods. The strong growth of the population's interest and the increase of information are a big factor in considering whether this positive trend is due to climate change. The seasonal distribution shows a positive trend in the months between August and November.

The biggest wind-related extreme events that produced also fatalities were the one in 2008, that happened in Sant Boi, and in 2013, that happened along the southern coast of Barcelona metropolitan region.

Extreme temperatures

In the case of extreme weather events and heatwaves, this is a risk of exclusively meteorological origin, and in this case, there is a greater agreement regarding its increase as a result of climate change.
The historical evolution of the Barcelona series indicates that the average temperature has been increasing. In the period 1780-2012, the increase was +0.07 ºC / decade, but if a closer period is analysed (1914-2012), the annual average temperature increase is still higher, with +0, 12 ºC / decade.
In the last 34 years, Barcelona has suffered more than 10 heatwaves.
There is also a tendency to increase all extreme high-temperature indexes raised in the Barcelona series:

- Positive trend greater than 3% / decade in the percentage of very warm nights.
- The percentage of very warm days shows an increase of 4% / decade,
- The number of tropical nights has grown rapidly since the '80s, with a trend that the coast can reach 5 days/decade.
- The evolution of the number of consecutive days per year with maximum temperatures above 25ºC shows an average tendency of 1.9 days/decade, while the number of days that exceed this temperature threshold tends of 2.7 days/decade.

As highlighted in the Second report on climate change in Catalonia, this increase has added an increase in vulnerability. Indeed, the community most affected by the heat waves is constituted by the elderly. In the metropolitan area of Barcelona, as in Catalonia, and in fact throughout Europe, it is expected to increase the average age of the population and, in particular, an increase in the population over the age of 65, who are the most vulnerable.
This increase, combined with the geographical distribution of this population and the means to which they can access to deal with situations like this, or more generally, resilience, will be definitive in the distribution of future risk.
In summary, the impact of extreme temperatures and heat waves will act directly on the health of the population, on the connotations of energy demand that it entails, on infrastructures, ecosystems and the degree of comfort of the population. All scenarios point to an increase in this risk, both in terms of vulnerability (the increase in the most vulnerable population) and its danger (the increase in frequency).

Public health impacts

The effects of CC on the pattern of temperatures, rainfall and changes in biodiversity will impact the population, economy, resources, governance, infrastructures, coastline and civil protection services.
People’s health will be affected due to the increase in frequency and intensity of heatwaves, made even worse by the urban heat island effect. This will affect air

quality and might intensify heart, respiratory and allergic complaints and the most vulnerable are the elderly and children. There'll be challenges for natural resources since forest fires are expected to get worse and might significantly affect the Collserola Nature Park. An overall reduction in biodiversity is also expected with even more opportunities for new invasive species and a larger reduction in endemic species, as well as changes for flora and fauna dependent on wetlands as their habitat is more likely to dry out.
Moreover, it'll be challenging for the preservation of resources such as water and energy. Current studies point to the demand for water rising by 5-12% due to a reduction in comfort, increase in evapotranspiration of vegetation, tourism, etc. Added to lower rainfall and smaller rivers, this will put a lot of pressure on available resources. Regarding energy consumption, the number of days of heating is expected to fall while the days that air conditioning is used will rise. The net change in energy demand is difficult to predict but there will be considerable changes in the patterns. The challenges involve guaranteeing energy supply and the ability of infrastructures to adapt to these changes in consumption patterns.
Waste-water infrastructures will be threatened because of the increase in intensity and frequency of torrential rainfall that could outstrip the capacity of treatment plants and lead to floods. The wastewater system needs to be expanded to be able to handle runoff, prevent floods and preserve water quality along Barcelona's coast.

4.1.2 Climate change adaptation planning in Spain

National level
The Spanish Office for Climate Change (*Oficina Española de Cambio Climatico* – OECC) was founded in 2001 and is the main institution that coordinates the national CCA policies and belongs to the Ministry of Agriculture, Food and Environment. It aims to mainstream CCA into the sectoral policies and planning and also grants funding to e.g. governments, non-governmental organizations, learning institutions, public and private entities.
OECC designed the National Climate Change Adaptation Plan (PNACC) that was approved in 2006. PNACC is the main CCA policy reference in Spain and sets the operative framework for CC projections construction, CC risks assessments production and CCA actions design. PNACC objective is to mainstream CCA into the existing planning processes and to achieve this, it supports the inclusion and participation of all institutions and stakeholders.
The Plan was adopted in July 2006 – submitted to the Council of Ministers in October 2016 – after a wide consultation process involving the main organizations and sectors dealing with CC. The process had wide participation, engaging representatives of the public administrations, non-governmental organizations and private actors.
The plan has been implemented through different operative programs. The last and third Program was approved in 2014 for 6 years (2014-2020). This program follows the previous ones and also introduced new approaches in impact, vulnerability, and

CCA assessments. It widened the sectors that have to be involved in the PNACC implementation adding to existing ones (i.e. marine and coasts, water, biodiversity) the new sectors (i.e. agriculture, tourism, forests and land desertification).

Regional level: Catalunya

At the regional level, the Autonomous Communities (AC) are implementing a relevant number of CCM and CCA measures, which are adopted by the Spanish National government for different sectors (Olazabal et al., 2014). As an AC, Catalonia has its government, namely the Generalitat, which is the highest authority within the Catalan territory, set up the Catalan Office for CC (*Oficina Catalana de Cambio Climatico* - OCCC).

OCCC designed two CCM plans (2008-2012 and 2012-2020) and the Catalan Strategy for CCA (*Estrategia Catalana de Adaptacion al Cambio Climatico* - ESCACC). ESCACC tackles 63 climatic impacts and 182 CCA measures were designed. Among the several impacts and sectors affected, water management is the most vulnerable sector (OCCC 2012).

Moreover, the government of Catalonia was coordinating also an EU Life + project called 'MEDACC – adapting the MEDiterrAnean to Climate Change', which aimed at designing and testing new measures to adapt agricultural, forest, and urban systems to CC.

Metropolitan level: Barcelona

The main urban planning tool in Barcelona is constituted by the *Plan Director Urbanistic Metropolitano* (PDUM)[13], 1976, which is a strategic planning tool, and by successive modifications thereof in those areas has required updates. Municipal planning is developed based also on the PDUM's related plans, which are the *Plans de Millora Urbana* and the *Plans Especials Urbanístics*. The PDUM becomes a tool at the metropolitan level, and it is important to keep in mind that the revision is currently being carried out and one of the aims of this new revision is to include and integrate CCA purposes.

The AMB has developed its metropolitan Plan for CCA (*Pla d'Adaptaciò al Canvi Climatic de area Metropolitana de Barcelona* - PACC 2015-2020) where 24 risks related to droughts, floods, marine storms, saline intrusion, forest fires, extreme climatic index evolution and extreme temperatures. This identification has resulted in 50 actions aimed at tackling CC from the point of view of CCA.

[13] In Spain, urban and spatial planning is an exclusive duty of regional governments, the so called Autonomous Communities. Basing on the National urban code, these regional governments define principles and guides for the municipal governments, which are delegated to plan and to manage their local administrative unit.

Figure 4. 5 - AMB's municipalities (Source: www.amb.cat)

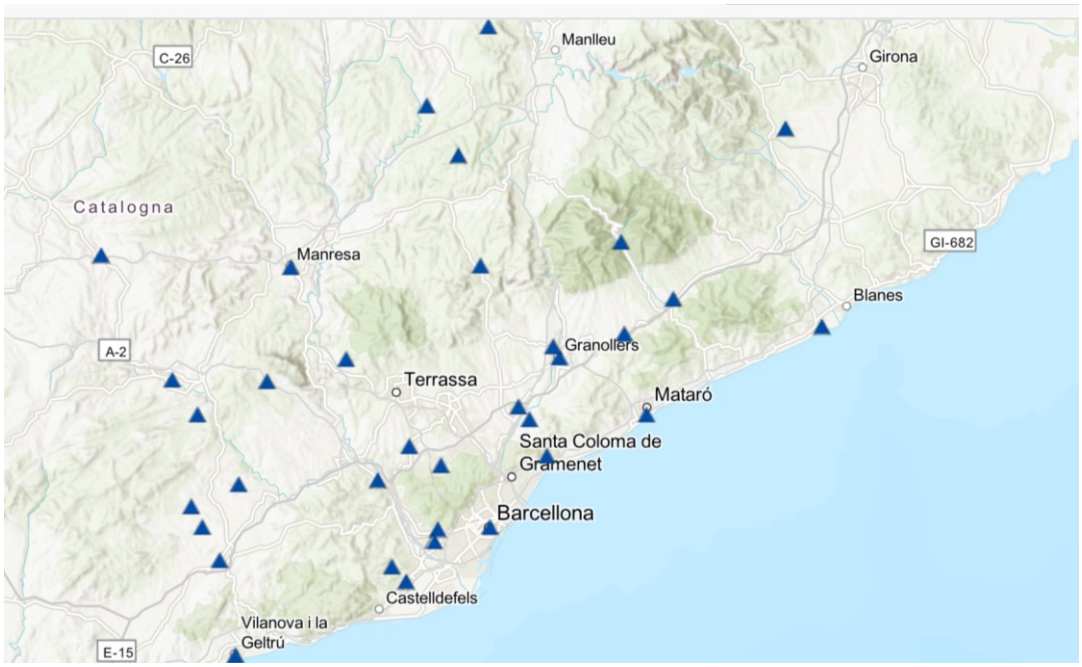

Figure 4. 6 - Municipalities of AMB signatories of CoM for Energy and Climate (a snapshot from www.eea.europe.eu)

The CCA metropolitan plan is not an isolated plan but rather it develops and complements a set of planning instrument of the AMB and its municipalities. The plan was set up in order to work in synergy with other existing plans and programmes, i.e. the *Pla de Sostenibilitat* of AMB (PSAMB 2014-2020), the *Programa Metropolità d'Educació per la Sostenibilitat* (PMES 2014-2020), the

future metropolitan mobility Plans, the future Urban Development Metropolitan Plan, the ESCACC (2013-2020).

Municipality	Type	Year	Name	Collaborators	CC
Badalona	EU-funded project	2016	Project BINGO	Aigua de Barcelona	CCA
Santa Coloma	Plan	2015	Pla local d'adaptació al canvi climàtic a santa coloma de gramenet 2016-2020	AMB	CCA
Santa Coloma	Plan	2009	Pla d'acció per a l'energia sostenible de santa coloma de gramenet	Diputació Barcelona, Covenant of Mayors	CCM
Sant Andria de Besos	Plan	2010	Pla d'Acció per a l'Energia Sostenible (PAES)	Diputació Barcelona, Covenant of Mayors	CCM
Hospitalet	Plan	2009	Plà d'acció per l'energia sostenible de l'hospitalet de llobregat	Diputació Barcelona, Covenant of Mayors	CCM
Igualada	Plan	2009	Pla d'acció d'energia sostenible d'igualada	Diputació Barcelona, Imis	CCM
Olesa de Montserrat	Plan	2014	Pla d'acció per a l'energia sostenible d'olesa de montserrat	Covenant of Mayors, SEAP+, IEEPEU	CCM
Prat de Llobregat	Plan	2016	Pla local d'adaptació al canvi climàtic del prat de llobregat 2016-2020	AMB	CCA
Cornella de Llobregat	Plan	2015	Pla d'acció per l'energia sostenible de cornellà de llobregat	AMB	CCA
Viladecans	Plan	2016	Pla local d'adaptació al canvi climàtic de viladecans 2016-2020	AMB	CCA
Sabadell	Plan	2009	Estratègia municipal per a la mitigació del canvi climàtic de sabadell 2008-2012		CCM
Sant Cugat	Strategy	2014	Estrategia local sobre el canvi climatic		CCA
Sant Cugat	Plan	2009	Pla d'Acció per a l'Energia Sostenible del municipi de Sant Cugat del Vallès Document I Avaluació d'emissions. Inventari		CCM
Terrassa	Plan	2009	Pla d acció per a l energia sostenible de terrassa	Covenant of Mayors	CCM
Manlleu	Plan	2016	Pla d'acció d'eficiència energètica i sostenibilitat - 2016		CCM
Manlleu	Plan	2009	Pla d'Acció per l'Energia Sostenible 2009 - 2020		CCM

Esplugues	Plan	2015	Pla local de adaptación al canvi climatic	AMB	CCA
San Feliu	Plan	2015	Pla local de adaptación al canvi climatic	AMB	CCA
San Just Desvern	Plan	2015	Pla local de adaptación al canvi climatic	AMB	CCA

Table 4. 2 – CC-related plans and strategies in the AMB's municipalities (Barcelona municipality excluded)

Municipal level: Barcelona

Barcelona municipality is not new in tackling CC. The city is aware and works in the field of CC since 1999. The first official document that explicitly dealt with CC through measures directly related to CCM, such as energy-saving and energy efficiency, was the Ordenança solar tèrmica (1999).

One year before, in 1998, the BCC approved the plan for the groundwater withdraw and supply (*Pla tecnic de aprofitament de l'aigua del subsol*, 1998), which aimed at more rational use of water resources, introducing criteria of environmental sustainability. The plan represented a proposal for the rational exploitation of the Montjuic aquifer and was framed in a broader context of improvement of the integrated water cycle management. Consequently, since 1998 BCC has started withdrawing groundwater, whose use has been always for non-human consumption, in a sustainable way reducing the need of being supplied by the other sources (e.g. Llobregat, Ter and Ebro basins) and started preparing for future threats for this field such as the CC issue. Despite the lack of explicit framing under CC effects, the groundwater plan of 1998 can be considered the first official document that anticipated CCA.

In 2002, the first plan related to CCM, namely *Pla de millora energètica* (2002-2010), was approved and almost 10 years later the second generation of CC plans had begun with the *Ordenança solar fotovoltaica* (2011) and with the *Pla de l'energia, canvi climàtic i qualitat de l'aire de Barcelona* (2011-2020).

BCC, before approving a specific plan for CCA, had been working on different studies and analysis on present and future's CC effects:

- "L'anàlisi dels plans d'adaptació al canvi climàtic" (2014)
- "Barcelona i el Canvi climatic" (2015)
- "Barcelona, ciutat resilient al canvi climatic" (2015)

Along the years, Barcelona has changed the internal administrative setting. In fact, since three political mandates (2009), BCC joint the Urban planning department with the Environment department under one unity called Ecologia Urbana. In the last and current mandate, the Mobility department was added in the Ecologia Urbana department (see Box 4.1).

BCC has also created and joined networks with other cities and local actors with the purpose of (co-)learning and to exchange good practices. From an international perspective, in order to be in contact with the organizations and cities that are leading champion initiatives in this field, and to foster the exchange of knowledge and share of good practices, some key collaborations have been

established. Fostering learning and collaboration with other cities has played a big part in the development of CC-related strategies, from the desire to share tools, methods, projects, experience.

BOX 4.1 - The municipal organization and the *Ecologia Urbana* Department

The today-called *Ecologia Urbana* department – once called *Habitat Urbà* – was set up for incorporating all those units in charge of planning and managing the municipal sub-systems (e.g. urban planning, waste, green and parks, coast and shores). *Ecologia Urbana* has been responsible for coordinating between urban planning, infrastructure and housing, as well as with Environment, Critical infrastructure and Telecommunication systems. The goal of *Ecologia Urbana* department was to be the backbone of the urban systems.

Urban planning changed and moved from its traditional nature of standard regulator to a more holistic and integrated vision of the city. This paradigm change led to innovative changes in terms of intra- and inter-organizational coordination and posed the basis for the integration and mainstreaming of new cross-cutting issues, as UR, CCM and CCA especially are.

With the view to coordinate all the coming cross-cutting issues and to manage projects and processes in an integrated way, a management board was established in 2009, called *Taula de Infraestructuras i Serveis Urbans* (TISU). "*From the creation of the TISU resilience board, Barcelona promoted in different international events this integrated projects management model, until been awarded in 2013 as "role model city" for infrastructures and services risks reduction policies from the UNISDR's Making Cities Resilient campaign*" (Chelleri, 2018). In the last years, a specific Resilience office was created whose goal has been to expand the scope of the TISU – now labelled as Resilience Boards – "*to a wider range of resilience-related projects*" (Filippi, 2018).

Meantime designing and approving plans and measures for tackling CCM and CCA, has worked in joining international and local commitments and agreements, which are:

- The *Compromís ciutadà per la sostenibilitat 2002-2012* (citizenship's pact for sustainability), updated later for the period 2012- 2022, and currently signed by more than thousand local entities, which are related to the *Xarxa Barcelona + Sostenible*[14] (Barcelona Network + Sustainable) and the Barcelona municipality.

[14] Barcelona + Sostenible is the network of more than 1,000 organizations committed to the environmental, social and economic sustainability that collectively build a responsible city with people and the environment. The network is made up of citizen entities, business and commercial organizations, educational centers, universities, professional colleges, unions and administrations. Each organization joins the Barcelona + Sustainable (B+S) network with the signing of the Citizen Commitment for Sustainability 2012-2022 and contributes to the transformation of the city with its actions. B+S members promote sustainability measures within their organizations, share good practices and develop projects with the other members of the network.

- The Covenant of Mayors, signed in 2008, signed in 2008, represents the main objective in terms of CCM, with a minimum of 20% reduction in GHG by 2020.
- The Mayors Adapt, which is an EU-based pact/platform, signed in 2014, which represents the main commitment for cities' CCA obliging the cities to approve a CCA local plan.
- The Compact of Mayors, signed in 2015, is a global agreement, beyond the EU, which implies the reaffirmation of the cities in respecting the main commitments, both on CCM and CCA, encompassing the Covenant of Mayors and the Mayors Adapt.
- The Declaration and Agreement of the Network of Cities and Towns for Sustainability supporting the Lima Meeting, signed in 2015.
- The Climate Commitment of Barcelona, signed in November of 2015, that was built on the Citizen Commitment for Sustainability 2012-2022.
- The Covenant of Mayors for Climate & Energy, signed in 2017, and merging the previous European initiatives to mitigate and adapt to climate change.

The city is an important partner of the C40 Network and also "*strategically offers to host and support financially the headquarter of the UN-Habitat City Resilience Profiling Program*" since 2013, "*and one year later awarded to become one of the Rockefeller Foundation's 100 Resilient Cities*" (Chelleri, 2018 p. 116). In addition, also UN International Strategy for Disaster Risk Reduction (UNISDR) – today called UN Office for Disaster Risk Reduction (UNDRR) –, as members of the 'Making Cities Resilient' campaign, has been part of the official Barcelona's relations and collaborations, and recognized the city as 'Role Model City for Infrastructures and Urban Services' in 2013. Barcelona is also part of an EU-funded research project, called RESCCUE – RESilience to Cope with Climate Change in Urban arEas – within the Horizon2020 framework.

4.2 Climate information and services for Barcelona municipality

The CC analysis was made by SMC and then the information produced was treated by a purveyor (intermediator), namely Barcelona Regional – a private company with public/municipal funds – and was done at the service of Pla Clima's process.
The production and delivery to BCC of CC projections and effects scenarios made by *Servei Meteorologic de* Catalunya (SMC) will be described in the 4.2.1 sub-section; the CC risk analysis made by *Barcelona Regional* will be described in the 4.2.2 sub-section.

4.2.1 Climate change projections

The SMC has been developing, since 2007, climatic projections regionalized at a high spatial resolution (<15 km). These first projections were based on the technique of dynamic regionalization with the mesoscale meteorological model MM5 (Barrera-Escoda A & Cunillera J, 2011). More recently, and along with the Barcelona Supercomputing Center, a new series of regionalized projections, computationally much more intensive, has been developed for the whole of the northwestern Mediterranean basin at 10 km of resolution until 2050 with the meteorological mesoscale model WRF to a MCCG of the CMIP3 (ibid).
With this background, the project "Generation of future regional climate scenarios" is proposed at a very high resolution (1 km) for the AMB (ESAMB strategy), with three main objectives in order to try to minimize the computational errors as much as possible in the global models:

- Make projections in more resolution than projections available so far and for more variables and climatic indexes
- Facing uncertainty based on the combined use of dynamic methodologies and regionalization statistics
- Use of the most recent results regarding climatic modelling created in the context of the CMIP5.

The Climate Change projections were made in two phases:

- Phase I: consisted of a dynamic climatic regionalization with a change of scale (the increase of the space resolution), using as a starting point the results of the ESCAT project. This is because these results were not adequate for the objectives set in the ESAMB project, it was necessary to apply a methodology to adapt them to a resolution compatible with the physical variability of the AMB. In the process of change of resolution, it was intended that features associated with the variability of mesoscale origin.

In this phase a multiple regression was applied between two main variables:

- Precipitation, and
- Temperature (maximum and minimum),

as well as static variables such as height above sea level, distance to sea or continentality, length and latitude. To calculate the parameters of the multi-regression it was necessary to use all mesh points in the domain of Catalonia.

- Phase II: generated future climate scenarios at very high resolution in the Metropolitan Area of Barcelona and is based on the concept of statistical regionalization. In this regard, having fundamentals differences from those of dynamic regionalization complements the results of Phase I. The meteorological variables and the climatic indexes that have been worked on in this phase are the same as in the previous phase, although now the projections do not depart from the physics of a mesoscale meteorological model exclusively, but of the climatic variability of the MCCG and the variability present in a high-resolution real-world climate (1 km) from the multiple regression of the historical data bank of the Meteorological Service of Catalonia. This choice to scale down at such local resolution was made because of the heterogeneous morphology of Barcelona metropolitan region.

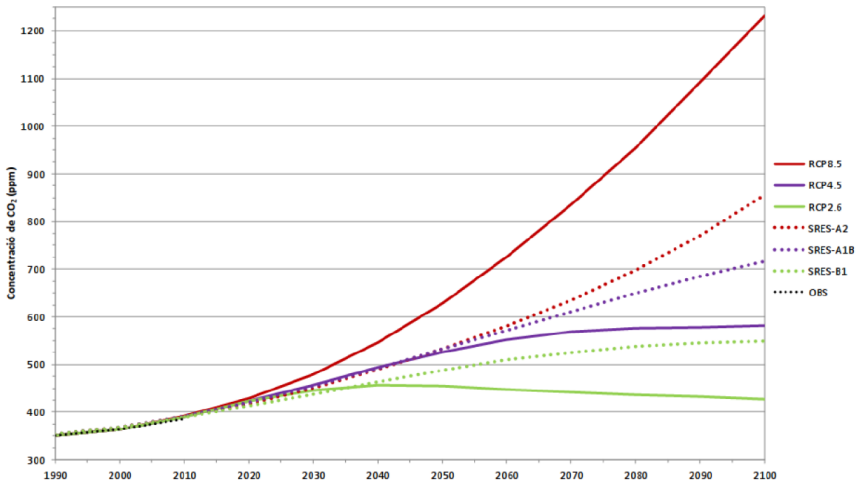

Figure 4. 7 – CO_2 concentration evolution according to RCP (1990-2100) (made by SMC - source: ESAMB, 2016)

Different emission concentration scenarios (RCP2.6, RCP4.5 and RCP8.5) were used (see fig. 4.7), giving the future projection of the different climate variables for 3 time periods: 2011 - 2040, 2041-2070, and 2071-2100. The reference or control period is 1971-2000. The AMB ceded the results of this study to the BCC to be able to enter them as starting data for the present "Study of the impacts of climate change on Barcelona" and to be able to carry out the analysis and the diagnosis of the different topics studied. The analysis of the BCC focused mainly on two of the three emission concentration scenarios studied: the so-called committed scenario (RCP4.5) and the so-called passive scenario (RCP8.5).

The RCP2.6 scenario was discarded in the analysis and diagnosis as it represented the emission rate in line with the goals of the 1992 Kyoto Protocol, where greenhouse gas concentrations they would remain almost as they are until the end of the 21st century. Therefore, this scenario is no longer possible.
The compromised scenario (RCP4.5) represents the emission rate if the Paris Agreement goals of 2015 were met. In this scenario, the green-house gases concentration would be higher than the current one by the end of the century, but the increase would be attenuated by 2030 to limit the maximum increase in global temperature on the planet to 1.5-2 ºC. The passive scenario (RCP8.5) represents the situation where the goals set in Paris would not be reached so that the GHG concentrations at the end of the century would be much higher than today. The global temperature increase would be well above 2 °C.
In terms of uncertainty, this analysis shows a lack in terms of inclusion and communication. Despite being communicated by the SMC officials to purveyors and CC plan coordinator, as confirmed in the interview, the degree of accuracy is very low.

Temperature
For the compromised scenario (RCP4.5) there is a predicted tendency of the temperature rise in the city of Barcelona for the next decades. As shown in Figure 4.7, starting from 1971-2000, SMC expects an increase in the average annual temperature of about 1.0 ° C for the three years 2011-2040, while for the period 2041-2070 this increase could be 1.6 ° C, therefore, the difference between the stages 2011-2040 and 2041-2070 would be +0,6 ºC. If we go further at the end of the century, in the period 2071-2100 the increase in average temperature would increase by 1.7 ºC, supposing an increase of 0.1 ºC concerning the period 2041-2070. Therefore, the highest temperature increases would occur in the middle of the 21st century.

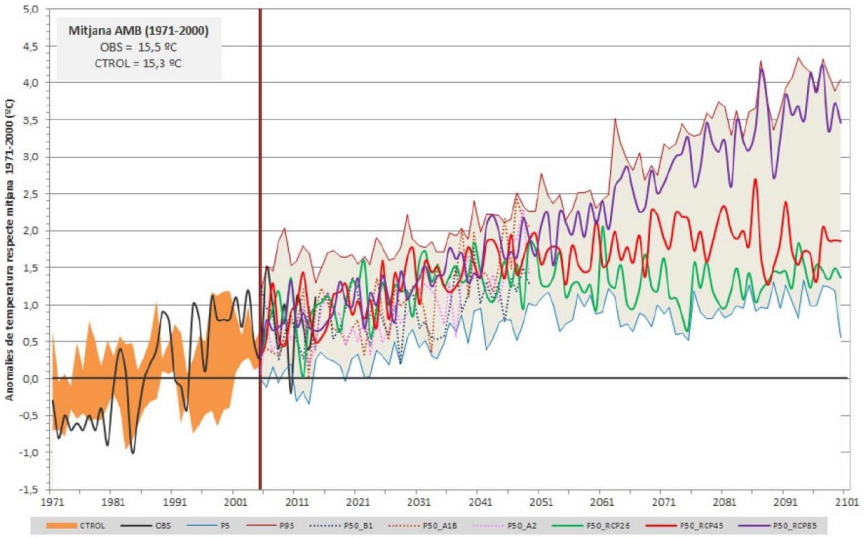

Figure 4. 8 – Projection of the annual average temperature (1971-2100) (Source: AMB, 2016)

Concerning the passive scenario (RCP8.5), an average annual temperature increase of approximately 1.1 ° C is expected for the period 2011-2040, basing on the reference period 1971-2000. In contrast, the average temperature increase for stage 2041-2070 can be around 2 ° C, with a rise of almost 0.9 ° C relative to the three-year period 2011-2040, so there would be an increase temperature highlight. For the period 2071-2100, it is expected that the average temperature in Barcelona may increase by 1 ° C over the three-year period 2041-2070, thus increasing by 3°C over the period 1971-2000. Therefore, although with the compromised scenario, a further increase in the average temperature in the city of Barcelona is expected in the middle of the century, with the passive scenario this rise would be more significant by the end of the century. In addition, the temperature increase under the passive emission scenario would be much higher than the compromised scenario, where the average annual temperature increase by the end of the century would be 1.7 ° C under the committed scenario (RCP4.5) and 3 ºC under the passive scenario (RCP8.5).

If we look at the average temperature trend for seasons with the committed scenario, then all the times of the year would also have the highest rise by the middle of the century.

The autumn months would see a further increase in average temperatures, where, by the end of the century, this increase could be between 2.1 and 3 ºC compared to the period 2071-2100. In contrast, summer would be the time of year with a slight increase in average temperature, with an increase of about 1.5 ° C by the end of the century.

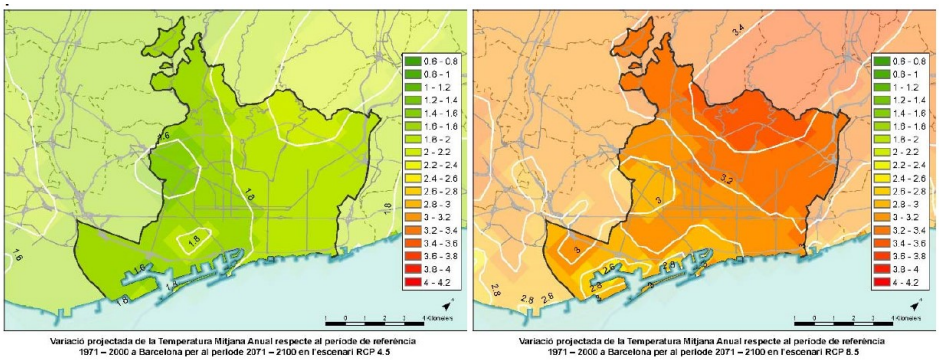

Figure 4. 9 – Maps of the annual average temperature projection in Barcelona for RCP 4.5 and 8.5 (Source: AMB, 2016)

In this same context, using the passive scenario as a reference, a similar pattern should be emphasized, albeit with higher temperature values. The autumn months would continue to see a greater increase in the average temperature in the city of Barcelona, where, by the end of the century, this increase could be between 2.9 and 4.3 ºC compared to the period 2071-2100. However, summer would still be the time of year with a slight increase in average temperature, although in this case, the increase in temperature by the end of the century could be between 2.0 and 3, 5 ºC.

Rainfall

A similar analysis has been performed for rainfall for the years 2011-2040, 2041-2070, and 2071-2100, referring to stage 1971-2000, and taking count the projections of the committed scenario (RCP4.5) and the passive scenario (RCP8.5). The projected evolution for the average annual rainfall in the area of Barcelona and surroundings, unlike the one we had found for temperature, does not show a clear trend in this century, with high variability for all the models and scenarios considered.

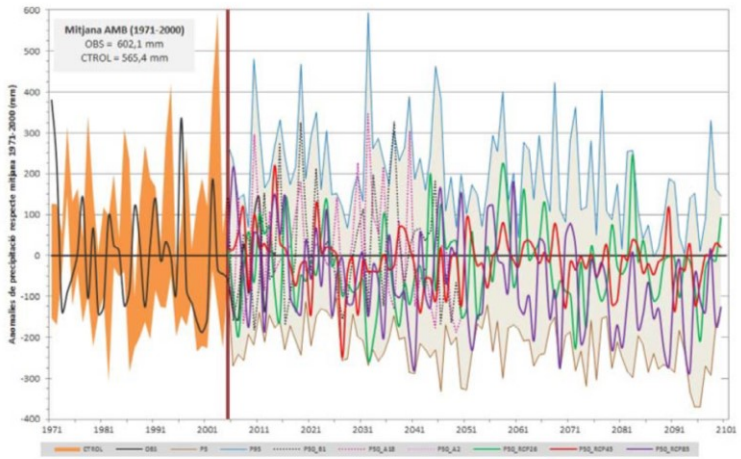

Figure 4. 10 – Projection of the annual average rainfall (1971-2100) (Source: AMB, 2016)

However, there is a higher frequency of dry periods from 2070 and a tendency to decrease in average annual rainfall, both in the committed scenario and in the passive scenario.

However, at a yearly level, a slight decrease in precipitation is projected throughout much of the Metropolitan Area. In general, as the century progresses and the severity of the scenario under consideration, the projected decrease in average annual rainfall becomes more important.

In this sense, for the period 2011-2040, there are few differences between the two scenarios considered. Towards the end of the century (period 2071-2100), the decline became very important and especially for the passive scenario (RCP8.5), a scenario in which in the metropolitan area there is a more than 19% decrease in average annual rainfall. Specifically, in the municipality of Barcelona is where the largest declines are located, reaching up to 30%.

On the other hand, the projections also show an increase in the probability of extremely rainy months (PMM> 200 mm), moving from an absence of these events during the reference period (1971-2000) to a small probability that these episodes happen in future.

4.2.2 Climate risk assessment and diagnoses

The risks and hazards that were taken into account in the Plan were analysed with the support of Barcelona Regional, which already did the vulnerability and risk assessments of the whole AMB at the service of 2005's metropolitan CCA plan. Barcelona Regional based the CC risk analysis on the SMC's CC scenarios and projections and divided the analysis into 9 categories:

- Heat islands
- Heatwaves
- Urban (pluvial and fluvial) floods
- Maritime floods (Storm surges)
- Biodiversity
- Fires
- Air quality
- Water cycle
- Energy flows
- Critical infrastructures

The climate-related hazards that were clearly defined and analysed were:

- Heatwaves and temperature rising
- Heavy rainfall and drought periods
- Sea level rise

Heatwaves

The parameters considered most representative (and with available data) were identified to analyse the degree of vulnerability in the different areas of Barcelona, which are:

- Vulnerable population (more than 75 years old)
- Buildings conditions
- Vegetation conditions
- Socio-economic conditions

They have been integrated into a single map to approximate the overall vulnerability of the city to the heat waves. The global vulnerability map (see Fig. 4.11) shows that there is a central part formed by the districts of *Sarrià - Sant Gervasi*, *Eixample*, *Les Corts* and part of Sant Martí less vulnerable and more vulnerable areas where The neighbourhoods closest to the Besòs sector and part of Horta are located, and much of the *Sants - Montjuïc* district.

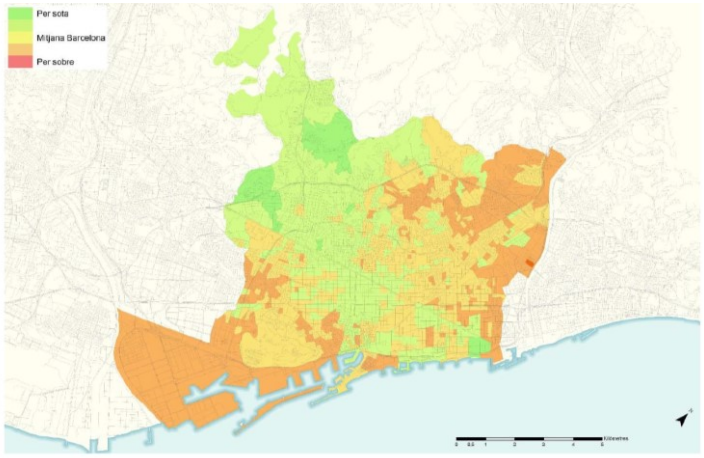

Figure 4. 11 – Vulnerability map of Barcelona for heatwaves (Source: Barcelona Regional, 2017)

The public spaces that were considered sensible to the heatwaves are (977 in total), e.g. social care offices, schools, first-rescue centres, health care centres, medical centres, public hospitality centres (see Fig. 4.12).

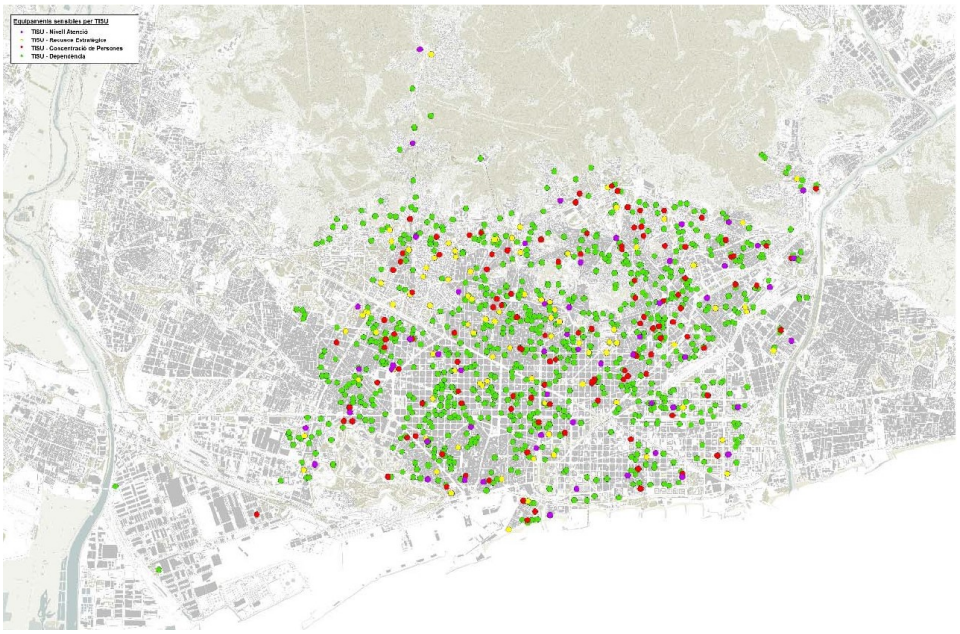

Figure 4. 12 – Barcelona public facilities for heatwaves (BCN Regional, 2017)

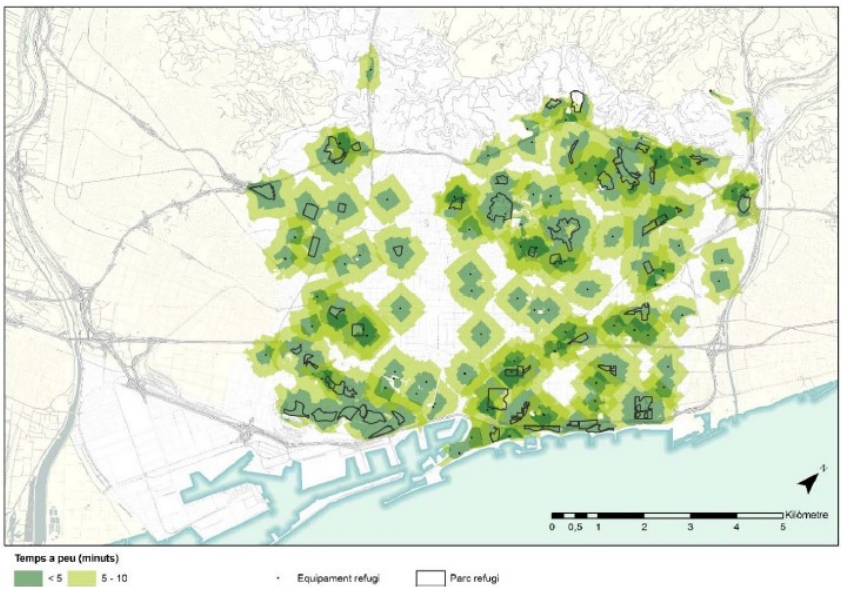

Figure 4. 13 – Displacement time to parks and public facilities (BCN Regional, 2017)

In order to tackle the heatwaves, they analysed also the facilities that might be used as climate shelters during prolonged hot days and nights.
Large public facilities have been chosen which may have better climatic comfort conditions, either because they have air conditioning or other cooling elements. The shelter facilities considered are the following:

- Public libraries
- Sport facilities
- Schools
- Parks.

In total, there are 77 shelter facilities in Barcelona, which are distributed relatively evenly throughout the city, except for some areas in the *Zona Franca de Sarrià - Sant Gervasi* and the *Eixample*, and 52 the parks. The population proximity to these shelter facilities has been analyzed (see fig. 4.13), taking into account the commuting time walking between the dwellings and the shelter equipment.

Rainfall

Analyzing the trend of average rainfall per season with the scenarios committed, the summer would show the largest decrease in precipitation, where at the end of this century it could rain in Barcelona almost 41% less than in the period 1971-2000. Moreover, the most significant decrease in average rainfall would occur in the middle of the century, with a decrease of 20% over the period 2011-2040.
Regarding the passive scenario, summer would still be by far the time of year with a greater decrease in precipitation, where at the end of the century it could rain in Barcelona by almost 61% less than in 1971 -2000. As shown in the Figure 4.14 In contrast to the RCP 4.5 scenario, in RCP8.5 the greatest decrease in precipitation would be more pronounced between the three years 2071-2100 with respect to the period 2041-2070 (reduction of 24%), than between the period 2041-2070 2011-2040 (14% reduction).

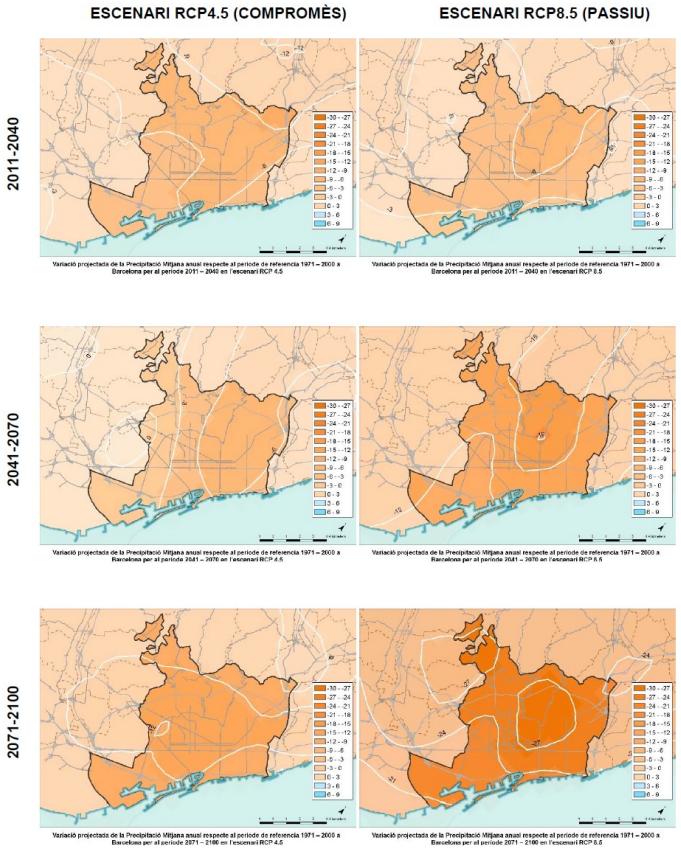

Figure 4. 14 – Rainfall annual mean projections in Barcelona with RCP 4.5 and 8.5 in the periods 2011-2040, 2041-2070, 2071-2100 (BCN Regional, 2017)

Marine floods and sea level rise

In addition to the increase in mean sea level, meteorological and astronomical factors are considered for the determination of the potential flood level, assuming a hypothetical case where all the effects could be added together. Taking into account these factors, and according to the estimated values, a maximum level of maritime floods for the period 2081-2100 is defined, which, concerning the current one, will mean a total increase of between 1,15 and 1, 33 m These levels were calculated based on the range of minimum and maximum variations in the regionalized mean sea level for scenarios RCP4.5 and RCP8.5.

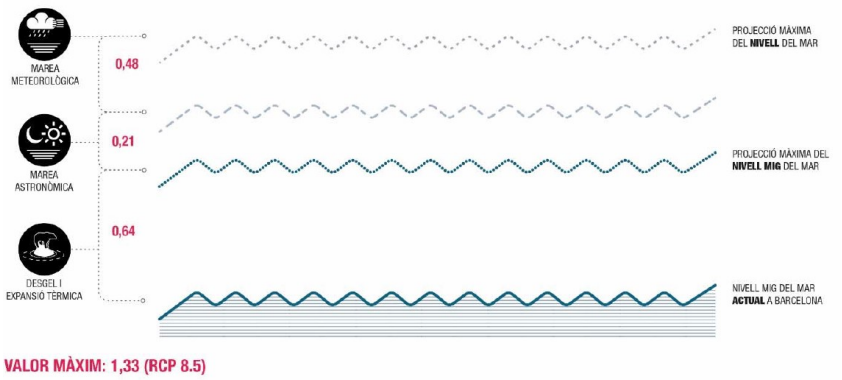

Figure 4. 15 – Sea level rise expected in Barcelona with the RCP 8.5 scenario (BCN Regional, 2017)

4.3 Pla Clima

The Pla Clima is the output of a long journey that has started in 2013, jointly with the Resilience strategy. The Pla Clima has been coordinated by the Strategic Planning office from the Urban Ecology department, and the Resilience strategy was coordinated, which is currently being under revision through the EU-RESCCUE project's progresses, by the Resilience office (ex TISU, see Chelleri 2018) from the Urban Ecology department.
Since January 2018, Barcelona has a plan, namely Pla Clima, that tackles CC comprehensively. Pla Clima was made after a series of processes where civil society was involved. The process that produced this output took seven months, from July 2017 to January 2018, and involved all the municipal sectors and more than 100 stakeholders. The risks and hazards that were taken into account in the Plan were analysed with the support of the AMB, which already had the vulnerability and risk assessments of the whole Barcelona metropolitan area (see the CCA Plan of AMB, 2015).
Based on the citizen commitment on the sustainability of the city (2012), the Pla Clima has the goals:

- Reducing the 45% green-house gases emission (reference period: 2005)
- Increasing of 1.2 km^2 of green areas
- Reducing the water consumption per person to the level of 100l per day

4.3.1 The pilot before the Pla Clima

Starting with the BCC's Climate Change Commitment, nine action-oriented project teams, formed by various Barcelona + Sustainable Network's organizations, were selected to be implemented. Between March and June 2016, several workshops were held aimed at all teams with a methodological guide to turn the first proposals into planned projects, from May each team independently decided on their work schedule, with the Support from the Barcelona + Sustainable Secretariat. This is the 1st attempt for CC-oriented implementation with civic engagement and was done without the provision of ad-hoc funds. It was a pilot and propaedeutic for Pla Clima's co-implementation phases. Among the 9 projects, shown in Table 4.3, just one related to CCA, i.e. green roofs, which triggered by the Barcelona's government measure on greening implementation enhancement and a call for funding (75% of the total green roof implementation costs) to retrofitting private buildings with green roofs.

Name	Project	Focus
4: Endorse yourself to Savings and Energy Efficiency	Prepare a guide that establishes comfort standards and define the criteria to promote energy-saving and efficiency strategies.	CCM
Passive reform and active awareness to	Program for energy efficiency and health through the reform of homes with low-cost	Climate Justice

deal with energy poverty	passive systems and recommendations for the adaptation of habits	
Cobertes mosaic Let's make our roofs sustainable	Transform covers into sustainable spaces that include green spaces, production facilities, renewable energy facilities and rainwater harvesting.	CCA
Safe and sustainable school paths	Promotion of sustainable mobility and safe access to schools on foot, by bicycle and public transport. Achieve school paths safer for families to believe and use.	Mobility
By bike at work	Promotion of sustainable mobility with a modal shift of labour transport through the lending of a fleet of bicycles for workers.	CCM
Green point 2.0.	Action for the Green Points to be spaces integrated into the daily lives of neighbours and become a point of reference for the exchange of knowledge, materials and products, the dissemination of waste prevention activities and repair workshops and information on waste management.	Circular economy
Sarrià residue zero	Action towards zero waste and the circular economy through the improvement of the separation of waste through the door-to-door collection, communication and awareness.	Circular economy
Together against climate change	A motivational, action-oriented and action-oriented training program aimed at cultural and educational agents, who emphasizes that climate change is a reality that will affect the quality of life of the people of Barcelona and what actions can be carried out by facing it up and adapt to it.	Education
Campaign # Commitment to Climate	Communication plan with serious messages at the same time as optimistic focused on the individual responsibility necessary in addition to international and city commitments.	Communication

Table 4. 3 - Projects involved in the pilot of the BCN+Sustanible network

4.3.2 Participatory processes for the Pla Clima design

Pla Clima is the output of a process where all the BCC's internal departments and 119 local stakeholders (e.g. private citizens, associations) participated in and that lasted from July 2017 to January 2018. After the first phase where the objectives, timeline and tools were presented, the second phase began and lasted three months. In this phase, the citizens and local organizations could upload their proposals through Decidim Barcelona, which is an on-line platform of participation open to all citizens of Barcelona. It belongs to the BCC and the Pla Clima was one of the first processes that took place online. It provided instructions for the process' audience to make contributions, explanatory videos about the Pla Clima, information on the meetings that took place, space to make proposals and supporting documentation. 112 proposals (see Annex II) were uploaded and then discussed and debated in the third phase, in October 2017.

From July to September 2017 the municipality led the public participation phase that was supported by the official municipal participatory platform[15]. 92 actors participated in the three events – a mix of local organisations, citizens, associations, private companies – and 112 were the proposals uploaded in the online platform[16]. 100 proposals were accepted and the climate focus that received more attention by the citizens was CCM with 46 proposals. Moreover, CCA proposals were 24; Citizen Action Enhancement received 27 ideas and; Climate Justice got 15 proposals (Granceri, 2018).
The 24 CCA proposals focused mostly on:

- Greening: 8 proposals addressed the importance of implement trees, parks and green areas in general,
- Water-sensitive greening: 2 are the proposals that aimed at tackling the water issue with greening solutions. 1 relates with the water-detention of greening solutions (e.g. rainwater garden) during flood events; 1 relates to smart devices that can capture and save rainwater (e.g. Sustainable Urban Drainage System - SUDS),
- Water drought management: 4 measures relate to the drought periods and the importance to prevent (i.e. research) and copy (i.e. protocols and communication) with this event,
- Buildings: 3 are proposals that relate to building energy savings and environmental comfort. 2 call for financial and technical support for buildings retrofit, 1 propose for the creation of a law that set time shift and the threshold for energy consumption,
- Emergency management: 7 are the proposals that relate with emergencies. 2 are for heatwaves management and measures at the service of workers (i.e. time shifts of work when temperature is above a certain limit); 2 calls for making emergency plans at district scale (i.e. heatwaves, floods, hurricanes), 2 calls propose to create new facilities or using existing ones for tackling heatwaves; 1 proposal highlights the importance to start tackling sea-level rise.

4.3.3 Output(s) and goals: Pla Clima as a climate umbrella

Pla Clima is an umbrella plan that contains a set of existing strategies and plans, and it designed also a set of new actions in order to achieve the objectives signed in the 2017's Barcelona Climate Commitment and the Pact of mayors for energy and the climate.
The Pla Clima is the first formal dedicated municipal act where CCA is defined, jointly with Resilience, as an objective. It is one of the four general objectives of the Plan – the others are CCM, Climate Justice, CJ henceforth (see Box 4.2) and

[15] www.decidim.barcelona
[16] https://www.decidim.barcelona/processes/placlima/f/109/?locale=es

Citizen Action Enhancement (CAE). Nevertheless, CCA issue has been cited and considered as an issue in the Barcelona's municipal planning framework for almost ten years (e.g. Green and Biodiversity Plan, Water security plan).
The Plan considers and integrates 33 existing plans, programmes, protocols and strategies, e.g. Urban mobility plan, Green Infrastructure programme, Water pipes infrastructure plan, Drought periods Protocol, Heatwaves prevention and preparedness plan. The aim was to frame them all in synergy with the Plan's objectives for 2030, which are: 45% GHG emission per capita reduction (considering the year 2005), reducing the water consumption to 100litres/hab./day and $1m^2$/hab. increase of green public space, eradicating energy poverty and enhancing climate-oriented citizens action through a fund of 1.2 million euros.

BOX 4.2 – Climate Justice in Barcelona

Debates about CJ have mainly occurred at the international scale and few scholars focused their research efforts on CJ at local urban scale (Bulkeley, Carmin, Castán Broto, Edwards, & Fuller, 2013; Bulkeley, Edwards, & Fuller, 2014). CJ builds upon the environmental justice concept (Schlosberg & Collins, 2014) that is considered trivalent, "requiring simultaneous attention to distribution, procedure and recognition as three facets of a rounded conception of justice" (Bulkeley et al., 2014 citing Scholsberg & Collins, 2004), and CJ in the urban context adds two principles: rights and responsibilities.
In the case of Barcelona, CJ revolves especially around the right (to well-living) to the city for the most vulnerable population (e.g. elderlies, low-income families) and the responsibility that the public organizations have in their regards. It is a concept that overlaps both CCA and CCM because it aims to protect the vulnerable and their livelihoods in order to tackle proactively the CC impacts (e.g. heatwaves, cold wavess) with energy-efficient building renewals and retrofits and enhancing the access to a clean and efficient energy provision. The latter sounds like a right to energy, which can be unaffordable for the population with economic vulnerabilities.

Barcelona's Climate Plan is partially framed under the Urban Resilience Strategy, which is the programme led by the Resilience office (see Box 4.1). The Urban Resilience strategy included the CC challenge and mentioned it as one of the three issues that the city has to tackle in order to be resilient – the other two are critical infrastructure and social care.
The main risks, which are officially stated in the plan are:

- heatwaves and mean temperature rising
- droughts
- floods
- sea-level rise (coastal stability)

In addition to these hazards, the other six interlinked issues and risks were taken into account:

- air quality
- fires

- biodiversity
- urban heat islands
- energy flows
- critical infrastructures

The official public actors that were involved in the state-of-art phase, where all the measures, strategies and plans related to CC were checked and highlighted. for the Pla Clima are:

- *Servei Meteorològic de Catalunya* (SMC): for the climate assessments and scenarios
- *Barcelona Cicle de l'Aigua* (BCASA): for the water cycle and the urban drainage
- *Agència de l'Energia de Barcelona* (AEB): for the energy production and provision
- *Agència de Salut Pública de Barcelona* (ASPB): for the heatwaves and vector-borne diseases.
- *Direcció General de Qualitat Ambiental i Canvi Climàtic de la Generalitat de Catalunya*: as an oficial actor from the regional administrative level
- *Centre de Recerca Ecològica i Aplicacions Forestals* (CREAF): for the wildfires
- *Agència Catalana de l'Aigua* (ACA): for the fluvial floods

The objectives

The objectives of Pla Clima that relates to CCA were divided per hazard to be tackled.

Common objectives

- Develop and incorporate a design guide for Sustainability and resilience criteria (based on Sustainable urban planning workshops) tailored to architects, engineers, and practitioners in general, as well as to key actors as research centres or universities (2020).
- Influencing in higher planning instruments, such as the Metropolitan Urban Plan and urban planning legislation (Town Planning Law) to incorporate urban standards that ensure the real presence of quality of green spaces, and ensure the infiltration of water in the subsoil, the protection of areas due to climatic risk or agricultural use on a metropolitan scale (2025).
- Categorizing the urban fabrics according to the CC risks that affect them and establishing correlations with the existing urban planning standards,

in order to incorporate corrective measures in the phase of planning revisions (2025).

- Rethinking and adapting the criteria in the protocols of projects and works and in the technical prescriptions of the urban space to ensure sustainability and resilience for new projects of urban transformation (2025).
- Incorporating CC criteria into the Special Plan for the Protection of the natural environment and the landscape of the *Serra de Collserola* natural park (2020).

Heatwaves

- Review the Action Plan to prevent the effects of the heat waves on health, in sight of the results of the climatic projections for Barcelona and incorporate the vision of the territory and the vulnerability.
- Establishing appropriate protocols for open-air or out-door work when temperature surpasses 30 ºC (2020).
- Identifying existing climate shelter spaces and potentials: public and private facilities and public spaces (such as parks and gardens) which can provide conditions of thermal comfort in extreme heat events- These spaces are linked to protocols of action for heatwaves, apart from quantifying the necessary additional resources (e.g. opening of parks 24 hours, use of patios of "greened" schools, etc.). Mapping the degree of coverage to guarantee one territorial equity and take into account the areas identified as most vulnerable to heat (2020).
- Prioritizing refreshing activities (more greening, reconversion of lakes and fountains to make them accessible, etc.) that are done in districts which house the most vulnerable population (2020).
- Learning more about how CC will affect the health and mortality of people in each neighbourhood, through the projected research project funded by "Climate-fit.city" involving ASPB (Barcelona's health service agency) and IS-Global (International Health research centre) (2025)
- Deepening in the knowledge of the urban climate with the implantation of a network of fixed meteorological stations (to collect data that is known to affect its effect on health or other sectors of interest) and specific timely stations (to evaluate the effectiveness of the applied measures, such as climatic variables measured before and after pilot interventions on urban space, especially in environments identified as more vulnerable) (2025)
- Creating the program "*Barcelona, Ciutat de ombra*", to intervene on the public space to generate shaded areas: increasing the green glaze or

through furniture elements, preferably multifunctional (such as photovoltaic energy generators), or ephemeral or seasonal textile items. Identify and map the itineraries. Encouraging shuttering in private free space (2025)

- Improving the thermal comfort of climate-friendly equipment and facilities, intervening in a priority manner for those who provide services to more vulnerable people (nursery schools, schools, residences, etc.), without implying an increase in energy consumption to the extent possible (using passive measures such as ventilation crossing, improvement of insulation, darkening) (2030)
- Creating new spaces for climate refuge (green spaces or equipment) to guarantee territorial coverage (2030)
- Improving the health services protocols to face the heat waves (2030)
- Intervening on pavements and pavement roofs to increase the reflectance index
- Approving an ordinance to encourage the productive roofs (urban gardening) for new buildings (2018)
- Approving a technical protocol for the retrofit of municipal buildings publics with green roofs, walls, facades (2018).
- Consolidating the green cover competition: one roof per district to fund and implement (annually).
- Writing the Green and Biodiversity Charter, to have a tool that gathers up the technical and environmental criteria for a climate-sensitive design that must be taken into account for the approval of new projects or the rehabilitation of existing spaces. It should define the climate-proof species (according to the resources demanded by the plants, the production of allergens and to avoid pests and diseases proliferation) and recommendations for enhancing more ecosystem services (2020).
- Analysing how CC will affect specifically each district to identify possible risks and vulnerabilities and define specific actions to respond, in collaboration with existing plans and theirs updates, such as the neighbourhood Plans or the Green plan of the neighbourhoods (2020)

Floods and rainwater management

- Creating rain gardens (sprinklers, accessible sources, lakes, pools, etc.) with playgrounds that combine permanent activities with ephemeral or seasonal activities (2030)
- Improving the rainwater detection and reuse in the existing buildings (2030)

- Reserve proper space in the soil and the subsoil to facilitate the provision of the necessary climatic services (an increase of water infiltration, improvement of soil quality to allow good growth of vegetation, etc.) (2025).
- Increasing the land permeability through the design of a Sustainable Urban Development Strategy that establishes a guide with design's recommendations, maintenance protocols. Monitoring and evaluating its effectiveness through proper indicators (2020).
- Fostering the use of drainage pavements, through innovative public procurement (2020).
- Reducing the water discharges to the sea during periods of intense rainfall and ensure adequate water quality in the marine environment (2030).

Droughts

- Incorporate updated climatic projections into future revisions of the Drought Status Protocol (2018).
- Use the pumping water off the pipe for underground facilities (underground, parking lots) to infiltrate the aquifer (2030).
- Exploit the resource of the Besòs river aquifer as drinking water and build a water purification plant (2030).
- Use regenerated water from Llobregat by the industrial pump of the Zona Franca Consortium to recharge the aquifer (2030).
- Enhance the use of grey water in new housing developments or rehabilitation and for industrial uses, and study it in future revisions of the Urban City Planning Order (2025).
- Ensure compliance with the water purification protocol in naturalized lakes to conserve and protect amphibians and aquatic flora (continuously).

Sea level rise

- Analyse social perception regarding the effects of climate change on the coast (extending the survey of users of the sites) to prioritize and redesign awareness-raising and communication activities on the beaches (2018)
- Deepening in the study of the vulnerability, perversion and marine flood (2019)
- Define the specific protection and use strategy in each beach according to the results of the studies (2020)

- Redefine the existing coastal uses to adapt to future needs and beach availability, and introduce Sustainability criteria in relation to the activities carried out for the beach stability (2020)

Public Health and Security (Vector-borne diseases and fires)

- Intensify the integral control to reduce pests (cockroaches, tiger mosquitoes, etc.) with the use of phytosanitary and biocides (2020)
- Consolidate programs for the control of arboviruses and other transmitted diseases by vectors and mosquito control protocols (ASPB – Barcelona's health service agency) (continuously)
- Find solutions to the problem of reproduction of mosquitoes in sewers and tanks.
- Continue with the fire prevention and extinguishing services, with special attention to areas most vulnerable to the fire hazard and the urban-forest boundary of the mountain areas (continuously).

What's under the umbrella and what's left outside?

Out of the 39 planning tools included in the Pla Clima, 17 tackles CCA.
Most of these tools relate with green and water management, except for the ones that focus on buildings' energy sustainability (*Pla pel dret a l'habitatge*), sea level rise (*Pla estratègic dels espais litorals de la ciutat*, and *Pla director del port olimpic*), socially vulnerable neighbourhood (*pla de barris*). The hazards that are mainly tackled are heatwaves, floods, and droughts. Sea-level rise is barely considered in the plans. The vector-borne diseases issue is tackled by the BCasa – municipal water management agency – with the water infrastructure plan, and by the Environment office, through the government measure for the glisulphatee eradication from the management of green spaces.

Plan/Programme	CCA	CJ
Pla integral del clavegueram de Barcelona (PICBA) (2006)	X	
Pla de gestió integrada del litoral (PGIL) (2007)	X	
Pla d'energia, canvi climàtic i qualitat de l'aire (2011-2020)		X
Pla de prevenció de residus municipals de Barcelona (2012-2020)		
Pla de Mobilitat Urbana (2013–2018)		
Pla del verd i de la biodiversitat de Barcelona (2013-2020)	X	X
Impulsar cobertes verdes a Barcelona (2014)	X	

Eradicació de l'ús de glifosat en els espais verds i la via pública municipal de Barcelona (2015)	X	
Pla de millora de qualitat de l'aire (2015-2018)	X	X
Programa de mesures contra la contaminación de l'aire (2016)	X	X
"Omplim de vida els carrers" amb la implantació de les Superilles a Barcelona (2016)	X	X
Resiliència urbana (2016)	X	X
Creació dels punts d'assessorament energètic i de garantia de subministraments bàsics (2016)		X
Transició cap a la sobirania 95ituación95 (2016)		X
Estratègia d'impuls del consum responsable (2016-2019)		X
Pla d'impuls de l'economia social i solidària (2016-2019)		X
Estratègia d'impuls de la política alimentaria (2016-2019)		
Estratègia de residu zero de Barcelona (2016-2020)		
Pla de barris de Barcelona (2016-2020)	X	X
Pla pel dret a l'habitatge (2016-2025)		X
Protocol per situacion de sequera (2017)	X	X
Programa d'impuls de la infraestructura verda urbana (2017)	X	X
Programa d'Impuls a la subvencion d'energia solar a Barcelona (2017-2019)		X
Democratització de la cura (2017-2020)		X
Desenvolupament del vehicle elèctric a Barcelona (2018)		
Pla d'estalvi i millora 95ituación95 dels edificis municipals (2017-2020)		
Pla director de l'arbrat (2017-2037)	X	
Estratègia de la bicicleta (2018)		
Pla director del Port Olímpic (2018)	X	
Pla tècnic per a l'aprofitament de recursos hídrics alternatius (2018)	X	X
Pla de cooperació per a la justícia global (2018-2021)		X
Pla estratègic dels espais litorals de la ciutat (2018-2025)	X	
Pla de prevenció per prevenir els efectes de les onades de calor sobre la salut (anual)	X	X

Table 4. 4 - BCC's sectorial plans and measures under the Pla Clima's umbrella and CC-related issues tackled

Except for the *Resiliencia Urbana* strategy – urban resilience strategy –, Pla de millora de qualitat de l'aire – air quality plan – and the *Pla Integral de clavegueram* – water infrastructure plan – the other tools aren't based or were not fed by a CC analysis.
In the case of the plans and actions that relate to greening, the technicians of the Environment office-based their actions' design on their multi-decadal CC-related experience.

Plans	Relevance	Consistency
Water		
Pla integral del clavegueram de Barcelona (PICBA) (2006)	Based on CC análisis (continuously updated)	Floods: High - The plan is constantly monitored updated (every year) - The solutions are based on grey infrastructure management and "too-big-to-fail" mentality (i.e. big-sized water tanks) - The most vulnerable areas of Barcelona (i.e. Raval district) are still affected Vector-borne diseases: High. Technical updates on going
Pla tècnic per a l'aprofitament de recursos hídrics alternatius (2018)	Based on CC análisis (continuously updated)	Floods: High - The plan aims to use groundwater from the urban hill (Montjuic) underground as a non-potable resource - The solutions proposed relates to SUDS and rainwater reuse
Greening		
Pla del verd i de la biodiversitat de Barcelona (2013-2020)	Based on previous 20 years of experience and testing of climate resilient species	High for heatwaves Technical updates for fire and vector-borne diseases
Impulsar terrats vius i cobertes verdes a Barcelona (2014)	Not based on CC analysis	Medium for floods High for heatwaves
"Omplim de vida els carrers" amb la implantació de les Superilles a Barcelona (2016)	Not based on CC Analysis	High for heatwaves Low for floods
Programa d'impuls de la infraestructura verda urbana (2017)	Based on previous 20 years of experience and testing of climate resilient species	High for heatwaves Low-medium for floods. The programmes focus mainly on trees and greenways

Pla director de l'arbrat (2017-2037)	Based on previous 20 years of experience and testing of climate resilient species	High for heatwaves Low for floods
Eradicació de l'ús de glifosat en els espais verds i la via pública municipal de Barcelona (2015)	Not based on CC	High for vector-borne diseases
Air		
Pla de millora de qualitat de l'aire (2015-2018)	Based on CC analysis	Low, almost nil. Brightly mentioned
Programa de mesures contra la contaminació atmosfèrica (2016)	Not Based on climate-related analysis	Heatwaves: Low. Barely mentioned
Emergency – Contingency		
Resiliència urbana (2016)	Based on CC analysis. Under revision through the EU-RESCCUE project	Heatwaves, Floods: High for heatwaves, and floods (included in the heatwaves and flood emergency plan). Tackles also direct effects i.e. critical infrastructure disruption and fires Medium for drought (included formally in the drought protocol) Sea level rise: low
Pla de prevenció per prevenir els efectes de les onades de calor sobre la salut (anual)	Based on CC analysis and direct experiences	Heatwaves: High.
Protocol per siituación de sequera (2017)	Based on CC analysis and direct experiences	Droughts: High.
Climate justice – Right to Energy		
Creació dels punts d'assessorament energètic i de garantia de subministraments bàsics (2016)	Not Based on climate-related analysis	Heatwaves, Coldwaves: Medium. Financial and technical assistance for the vulnerable people in accessing affordable energy and to retrofit their buildings/houses/apartments

Pla de barris de Barcelona (2016-2020)	Not Based on climate-related analysis	Heatwaves: Low-Medium The neighbourhood plans approved have very low consistency. The few solutions proposed relates to greening. Financial support for energy-saving retrofits is provided to those families with low incomes Emblematic is the case of Raval that suffer damaging floods, but the issue is not tackled in the plan
Coast		
Pla de gestió integrada del litoral (PGIL) (2007)	Not Based on climate-related analysis	Sea level rise (Beach stability): Low
Pla estratègic dels espais litorals de la ciutat (2025)	Not Based on climate-related analysis	Sea level rise (Beach stability): Low

Table 4. 5 - Relevance and Consistency of the plans and measures under the Pla Clima

In terms of emergency planning, Pla Clima included the *Pla de prevenció per prevenir els efectes de les onades de calor sobre la salut* - heatwaves effect prevention plan – and the *Protocol de sequera* – drought protocol. The urban resilience strategy is also an emergency planning tool and it tackles mainly heatwaves, floods, fires, critical infrastructure disruption, and also sea-level rise.
Other tools were not considered and included in the Pla Clima, unexpectedly, and they are:

- Flood emergency plan
- Wind emergency plan
- Air pollution emergency plan (considering heatwaves and prolonged wet periods
- Vector-borne diseases control and action protocols
- Fire emergency protocols

Regarding the vector-borne disease protocols and technical guidelines, they have not included ad furthermore they contrast with Sustainable Urban Drainage Systems and mostly with rain gardens – because they can detain rainwater for a prolonged period that is the perfect hub for mosquitos' proliferation.
Another critical aspect that wasn't considered is the Wind and so also the storm surges.

The integration among sectors and departments

The Strategic planning office, which belongs to the *Ecologia Urbana* department, was the pivot for the several departments and entities involved. The amount of climate-related information received by SMC and Barcelona Regional and the information exchanged with the officers and technicians led to a sense of

overwhelmingness for the Pla Clima coordinator, which was the one and only assigned to this task.
Most of the offices involved belong to the Ecologia Urbana department. The other ones that belong to BCC are the Social right department, the Civil Protection department, and the Mayor office. Outside the BCC the agencies that were included in the Pla Clima are BCasa – municipal water management agency – and the Agencia de Salut Publica de Barcelona – municipal public health agency.

Resilience office also plays a critical role but acted as a silo. In fact, it communicated mainly with Civil protection office (emergency planning) and BCasa (Water Agency) and pivoted the information to the Pla Clima coordinator.

Plan/Programme	Typology	Department/Agency	Office
Pla integral del clavegueram de Barcelona (PICBA) (2006)	Plan	BCasa (Agency)	/
Pla de gestió integrada del litoral (PGIL) (2007)	Plan	Ecología Urbana Medi ambient i serveis urbans	Oficina estratègica de l'àmbit litoral
Pla d'energia, canvi climàtic i qualitat de l'aire (2011-2020)	Plan	Ecología Urbana Mobilitat i Infraestructures	Agència de l'energia de Barcelona
Pla del verd i de la biodiversitat de Barcelona (2013-2020)	Plan	Ecología Urbana Medi ambient i serveis urbans	Direcció d'espais verds i biodiversitat
Impulsar terrats vius i cobertes verdes a Barcelona (2014)	City Council measure	Ecología Urbana Medi ambient i serveis urbans	Direcció d'espais verds i biodiversitat
Pla de millora de qualitat de l'aire (2015-2018)	Plan	Ecología Urbana Mobilitat i Infraestructures	Departament de Qualitat Ambiental
Programa de mesures contra la contaminació atmosfèrica (2016)	City Council measure	Ecología Urbana Mobilitat i Infraestructures	Departament de Qualitat Ambiental
"Omplim de vida els carrers" amb la implantació de les Superilles a Barcelona (2016)	City Council measure	Ecología Urbana Urbanismo	Departament de Prospectiva
Pla de Resiliència urbana (2016)	Plan	Ecologia Urbana Mobilitat i Infrastructures	Departament de resiliència
Creació dels punts d'assessorament energètic i de garantia de subministraments bàsics (2016)	City Council measure	Àrea de Drets Socials, Justícia Global, Feminismes i LGTBI	/
Pla de barris de Barcelona (2016-2020)	Plan	Gabinete Alcaldesa (Mayor office)	/

Pla pel dret a l'habitatge (2016-2025)	Plan	Àrea de Drets Socials, Justícia Global, Feminismes i LGTBI	Habitatge
Protocol per situació de sequera (2017)	Plan	Seguretat i Prevencio + BCASA (Agency)	Servei de prevenció i extinció d'incendis
Programa d'impuls de la infraestructura verda urbana (2017)	City Council measure	Ecología Urbana Medi ambient i serveis urbans	Direcció d'espais verds i biodiversitat
Pla director del Port Olímpic (2019)	Plan	Ecología Urbana Medi ambient i serveis urbans	Oficina estratègica de l'àmbit litoral
Pla tècnic per a l'aprofitament de recursos hídrics alternatius (2018)	Plan	BCASA (Agency)	/
Pla estratègic dels espais litorals de la ciutat (2018-2025)	Plan	Ecología Urbana Medi ambient i serveis urbans	Oficina estratègica de l'àmbit litora
Pla de prevenció per prevenir els efectes de les onades de calor sobre la salut (anual)	Plan	Seguretat i Prevenció + Drets socials	Servei de prevenció i extinció d'incendis

Table 4. 6 - BCC's sectorial plans and measures under the Pla Clima's umbrella and CC-related issues tackled

4.4 Pla Clima's co-implementation

BCC has allocated 1.2 million euros for the Pla Clima co-implementation for the period 2019-2030.

Every year, starting from 2019, the actors that belong to the *Barcelona +Sustenible* network can apply with a CC-related project to the Pla Clima's funds.
The first round of co-implementation process was observed and analysed for the period January 2018-December 2019.

4.4.1 Actors and funded projects

The first call of the Pla Clima's co-implementation received more than 50 proposals and 11 were selected.
From these 11 projects 10 were analysed (1 never participated actively in the meetings). Each project had a coordinator plus 3 or 4 more actors involved.
As shown in the fig. 4.7, 32 are the actors in total, which is a heterogeneous mix among private companies, foundations/associations/cooperatives, and public entities (universities, civic centres, research centres).
The process included three official meetings (March, June, and December 2019) and each project was assigned to an administrative officer and a technician, according to the focus and the aim of the project (e.g. green façade implementation project in a school with architecture heritage bond was assigned to the technicians and administrative officers from the buildings and heritage office).

Main Organization	Supporting Organizations	Project name	CC focus	Funds (€)
SOM MOBILITAT	BiciClot, SomEnergia, Associació Coordinadora d'Entitats per la Lleialtat Santsenca	Enfortiment de la mobilitat sostenible al districte Sants-Montjuïc	CCM	15.600,00
TARPUNA	Fundació Privada CIM, Associaciò Barceloneta Alerta	Espai d'Intercanvi de la Barceloneta-Punt Verd 2.0	CJ, CCM	20.000,00
AMPA IES MENENDEZ Y PELAYO	Associació Galanthus Natura, Fundació World Nature	MYP pel Clima - Creació d'un jardí vertical comunitari	CCA	14.880,00
FUN. PRIV. HABITAT 3 TERCER SECTOR	Ecoserveis, Green Building Council España	Reforma passiva i conciència activa per fer front a la pobresa energètica.	CJ, CCM	19.999,00
ASS.CATALANA	Aliança contra la pobresa	Pobresa energètica zero: Apoderament	CJ, CCM	19.841,00

ENGINYERIA SENSE FRONT	energètica – APE, Federació d'Associacions de veïns i veïnes de Barcelona (FAVB)	des dels barris		
INSTITUT QUATRE CANTONS	Societat Orgànica +10, Teresa Monleon Fernández	Blocs recerca i creació a l'Eso. Estratègies per transformar el teu Institut	CCA, CCM	20.000,00
ECO-UNION	Posidonia Green Project, Institut de Ciències del Mar	SomBlau - Comunitats pel Clima i el Mar	CCA	19.200,00
SOLUCIONS EIXVERD SL	Institut de Ciència i Tecnologia Ambiental (ICTAUAB), Alrun Jimeno (COAC), Lluïsa Arranz (Entorn XXI), Julio Bermejo (4A+A Arquitectura Ambiental)	Barreres i oportunitats cobertes mosaic	CCA	16.486,00
UNIVERSITAT DE BARCELONA	Institut de Salut Global Barcelona (ISGlobal), Ana Villagordo Vegara	CLIMATE CHANGE CHALLENGE. Big Data for the city.	CCM	20.000,00
LAVOLA 1981 SA	Twentic Tecnologias de la Informació y Comunicación, SL	Fem pinya contra el canvi climàtic	Citizen climate action enhancement	13.992,70

Table 4. 7 - Information about the projects selected for the Pla Clima co-implementation

4.4.2 A focus on the project's contents

Most of the projects aimed to implement non—structural measures.
The ones that aimed at structural changes were the ones that proposed CCA-related greening solutions. 4 out of the 11 projects related to CCA, whose objectives were to:

- Implement a green façade into a school garden (*MYP pel Clima – Creacio d'un jardin vertical comunitari*) aiming at tackling heatwaves,

- Design green spaces into a school playground (*Blocs recerca i creació a l'Eso. Estratègies per transformar el teu Institut*) aiming at tackling heatwaves,
- Design and create processes were to discuss about the CC issues related with the sea (*SomBlau - Comunitats pel Clima i el Mar*)
- Assess 10 projects for green roof design and implementation (*Barreres i oportunitats cobertes mosaic*)

In terms of CC understanding, the interviewees related mainly the CC effects with heatwaves, drought and floods, and in terms of CCA/CCM definition and difference, 3 out of 10 interviewees didn't state clearly the definitions and the difference between them.

Main Organization	Type	CC focus	CCA awareness and CC hazards	CCM/CCA awareness	Implementation
SOM MOBILITAT	Cooperative	CCM	Yes, relates to heatwaves and droughts	Understanding clearly the difference	Yes, Cargo bikes have started being used in the Sants and Clot neighbourhoods
SOM Energia	Cooperative				
Bici Clot	Private small business				
Associació Coordinadora d'Entitats per la Lleialtat Santsenca	Association				
Tarpuna	Cooperative	CCM CJ	Yes Relate just with heatwaves	Clear	Yes. Non-structural
Fundació Privada CIM,	Foundation				
ASSOCIACIÒ BARCELONETA ALERTA	Association				
AMPA IES MENENDEZ Y PELAYO	Foundation	CCA	Yes. Relates to Heatwaves and Floods	Understanding clearly the difference	Yes, structural. A vertical garden in the patio of a school building
Associació Galanthus Natura	Association				
Fundació World Nature	Foundation				
FUN. PRIV. HABITAT 3 TERCER SECTOR	Foundation	CJ, CCM	Not clear	Not clear	Yes, non-structural. Technical support for energy-saving given to 20 low-income families
Ecoserveis,	Private company				
Green Building Council España	Private company				

ASS.CATALANA ENGINYERIA SENSE FRONT	Association	CJ, CCM	Not clear	Not clear	Yes, non-structural. Meetings and awareness-raising in public and civic facilities about the technical assistance provided by the municipal energy office
Aliança contra la pobresa energètica – APE	NGO				
Federació d'Associacions de veïns i veïnes de Barcelona (FAVB)	Federation Association				
INSTITUT QUATRE CANTONS	School	CCA, CCM	Not clear	Not clear	Yes, non-structural
Societat Orgànica +10,	Private company				
Teresa Monleon Fernández	Private entrepreneur				
ECO-UNION	Cooperative	CCA	Clear Heatwaves Sea level rise Floods	Clear	Yes, non-structural.
Posidonia Green Project,	Cooperative				
Institut de Ciències del Mar	Research centres				
SOLUCIONS EIXVERD SL	Private company	CCA	Clear Heatwaves Floods Drought	Clear	No implementation. This project aimed to assess the call of 2017 for green roof implementation subventions
Institut de Ciència i Tecnologia Ambiental (ICTAUAB)	Research centre				
Alrun Jimeno (COAC)	Private entrepreneur				
Lluïsa Arranz (Entorn XXI)	Private entrepreneur				

Julio Bermejo (4A+A Arquitectura Ambiental)	Private entrepreneur				
UNIVERSITAT DE BARCELONA	University	CCM	Yes Project focus on Heatwaves	Yes, clear	No. The projects aim was to set up a challenge for university students on air pollution and temperature monitoring. Still on-going
Institut de Salut Global Barcelona (ISGlobal)	Research centre				
Ana Villagordo Vegara	Private entrepreneur				
LAVOLA	Private company	Citizen climate action enhancement	Yes Relates with floods, heatwaves, floods, droughts	Yes clear	No structural implementations
Twentic	Private company				
Tecnologias de la Informació y Comunicación, SL	Private company				

Table 4. 8 - Co-implementation CCA projects' characteristics and CC awareness (the organization in CAPITAL letters is the one that was interviewed)

During the meetings, the actors had to present and explain their progress to the other participants and to the Pla Clima coordinators.
The task they had to accomplish was to select three indicators from the 111 included in the Pla Clima. The actors of the CCA-related projects found difficulties in identifying appropriate indicators and this issue led to a further investigation on the CCA-related monitoring system, which will be addressed in the following section, 4.4.3.

4.4.3 On the Pla Clima's indicators: new challenges and same old monitoring system?

Most of the indicators are tackling heatwaves (and in general extreme temperatures, e.g. cold waves), droughts, and floods. In terms of droughts, the target to reach is the 100l/per day/per person – which is one of the Pla Clima goals. The greening solutions aim to increase the city of Barcelona of 1.2 km^2, but the indicators don't have specific and defined targets.
In terms of heatwaves and droughts, the indicators are generally consistent, except for someone, e.g. # facilities and infrastructures disrupted due to CC hazards,

building renewed, # building renewed or built with greywater reuse, and the surface of green spaces protected. The indicators for floods are generally lowly consistent. Sea-level rise indicators have a very low consistency.
Fires are barely tackled as well as vector-borne diseases. The former is monitored through the # of facilities and infrastructures disrupted due to CC hazards, the latter through # of interventions on insects' hubs.
Moreover, the # of SUDS projects implemented, and the # of rainwater gardens are conflictive with the vector-borne diseases – prolonged retained water on the surface might create the perfect hub for vectors, e.g. mosquitoes, carrying diseases.
Finally, strong winds and storm surges are not monitored at all.

Indicators	Consistency
Water	
Consumption per sector	Droughts: High
Consumption per habitant/day	Droughts: High
Consumption per use typology	Droughts: High
# building renewed or built with greywater reuse	Drought and Floods: Low-Medium Effectiveness is not measured
#SUDS*-based projects	Floods: Low-Medium Conflictive with vector- and water-borne diseases
% permeable surface	Floods: Medium-High
# rainwater gardens	Floods: Medium Conflictive with vector-borne and water-borne diseases
Built environment	
# apartments energy-efficiently renewed	Heatwaves, Cold waves: low-medium Better if put as a ratio with total buildings (per/district)
# implementation of energy-efficient spaces	Heatwaves, Cold waves: medium-high Better if put as a ratio
# sites supported by the PAE**	Heatwaves, Cold waves: low Doesn't mean that the building or the citizen adapted
# buildings renewed	Heatwaves, Cold waves: low
# building with A or B energy certification	Heatwaves, Cold waves: medium-high Better to put in a ratio
# green roofs built	Heatwaves, Floods, Droughts: medium for heatwaves and droughts Low for Foods
Surface (ha) of green roofs built	Heatwaves, Floods: medium
Green	
Total surface of green areas	Medium for heatwaves Low-Medium for Floods
Surface of green per hab.	Heatwave, Floods: Medium It'd be better to frame it per/district
% canopy area	Heatwaves: High
Population proximity to green spaces (% hab ≤ 5 minutes of walking)	Heatwaves: High
Surface of green spaces protected	Heatwaves: Low-Medium
% of flora species adapted to CC	Heatwaves: High
# urban gardens per district	Heatwaves: Medium-High
Public health and Critical infrastructures	
# interventions on insects' hubs	Vector-borne diseases: High It'd be better to frame it in a ratio with all the emergencies suffered
# facilities and infrastructures disrupted due to CC hazards	Heatwaves, Floods, Fires: Low

Ratio casualties/fatalities during heatwaves	Heatwaves: High
Climate shelters	
# climate shelters identified and enabled	Heatwaves: High
Scope of climate shelters (# hab.)	Heatwaves: High
Coast	
Metres of beach restored	Sea level rise: Low Strong wind and storm surges not considered
Volume of total beach	Sea level rise: Low Strong wind and storm surges not considered

Table 4. 9 - Indicators used for monitoring CCA implementation (*SUDS is the acronym of Sustainable Urban Drainage System; ** Punt d'Assessorament Energetic – Energy assessment sites)

4.5 Discussion and preliminary conclusions

Climate information and services

The Pla Clima was fed by a two-step climate-related analysis. In the case of CC analysis, the assessments and projections were produced with a predict-and-provide attitude and science-based approaches. The first one was made by the Regional Meteorological service (Servei Meteorologic de Catalunya - SMC) that downscaled – combining the statistical and dynamical approaches – with the aim to represent and take into account the heterogeneous morphology of the Barcelona geography, and then projected to Barcelona's area the IPCC's model basing on rainfall and temperature's historical series. This approach based on historical data can be considered a technical bias because other variables were excluded (i.e. wind, humidity) and because the historical series has a range of values (minimum and maximum) that constraints the projections to not overpass them (e.g. if 45°C is the maximum value registered, then the CC projections based on this maximum value won't overpass it). Hence, higher or lower temperatures couldn't be produced by the projections due to this inherent limit.The second one was made by a purveyor, i.e. BCN Regional, that elaborated the SMC's document and data and refined and downscaled furtherly their projections, adding a series of risk analysis (i.e. water cycle, floods, drought, fire, sea level rise). In this phase, the purveyor adjusted partially the technical biases carried in the first analysis.

Both phases used RCP scenarios 4.5 and 8.5. It took less than 1 year for the CC projections by SMC, despite demanding more time, and almost half year for the CC scenarios' development and delivery by Barcelona Regional. The time-managed was a long time-scale. The projections and analysis arrived until 2100 dividing the century into three parts 2011-2040 2041-2070 and 2071-2100. This shows that there is a discrepancy in terms of time-managed and time-planned: Pla Clima horizon is 2030.

Generally, the climate information that fed the CC policy-making process has a medium-high level of reliability. The climate information was communicated through documents with graphs, maps, and synthetic explanation, and also explained through face-to-face meetings with the Pla Clima's coordinator.

In the first phase, the SMC supported the comprehension of the CC projections' analysis with ad-hoc meetings with the coordinator of the CC policy-making and pivot with the end-users, i.e. the municipal servants. In the second phase, the purveyor's diagnosis was divided per 10 issues and produced a set of documents with analysis and maps of risks, the main ones: i.e. droughts, floods, heatwaves; and the other ones. i.e. fires, sea level rise, biodiversity loss, fires.

Uncertainty wasn't communicated properly in the written documents. Even though the SMC servants were aware of the inherent uncertainties carried by the models, the accuracy in the oral and written communication was very low.

In terms of legitimacy, the Pla Clima's coordinator was satisfied. However, the huge amount of complex information provoked an enormous sense of

overwhelmingness in carrying and communicating it. The downscaling of the models to the local investigated contexts were based on a dynamical downscaling through the historical series of temperature and rain. Variables like wind and humidity e.g. were excluded from the CC projections analysis of Barcelona because this type of information lacked.

Climate change adaptation policy integration

In terms of CCA policy integration, there is general coordination among departments and offices involved. The Strategic planning office was the pivot for the several departments and entities involved. The Resilience office also plays a critical role but acted as a silo. It communicated mainly with Civil protection office (emergency planning) and BCasa (Water Agency) and pivoted the critical information to the Pla Clima coordinator. In some cases, CCA is harmonized within specific sectors, i.e. Water agency, Public health agency, Environment office, Civil protection office. Nevertheless, most of the offices continue working independently without exchanging and receiving feedback from the other sectors.
The Pla Clima included 17 CCA-related planning tools but also didn't include critical CCA-related plans, i.e. flood emergency plan, air contamination emergency plan, wind emergency plan, and CCA-related existing protocols, e.g. vector-borne and fire. In the Pla Clima there are also some contradictions and conflicts, i.e.: vector-borne disease existing protocols and technical guidelines contrast with Sustainable Urban Drainage Systems and mostly with rain gardens – because they can detain rainwater for a prolonged period that is the perfect hub for mosquitos' proliferation.

Climate change adaptation measures

Most of the plans are to-date not updated with new CC-related analysis, with few exceptions i.e.: water management plan, urban resilience strategy. Most of the plans are not based on CC analysis and most of the measures tackle "just" past-to-present climate conditions. In terms of consistency, most of the measures relate to heatwaves, floods, and droughts. Greening was designed often as a heatwave solution. However, these measures, e.g. trees, are vulnerable to other hazards, e.g. drought, wind.
Among the objectives, the most innovative one is the climate shelter, like parks and public facilities were to gather the vulnerable population during hot nights' heatwaves. In terms of floods, big infrastructure, and grey infrastructure's – including the sustainable urban drainage systems devices – improvement are the main solutions for floods. In terms of droughts, the structural measures relate to the groundwater exploitation for non-potable use. Non-structural measures were as well consistent and aimed at raising awareness through campaigns about water consumption use, and re-use of commercial and industrial waters. Sea level rise measures were lowly consistent, which related to the addition of new volumes of sand. Storm-surges and wind – despite the wind emergency plan – were not tackled

at all. Vector- and water-borne diseases were mentioned by the BCC government measure on the glisulphate eradication from the green management – effective for creating a multi-species environment against pests and mosquitos.

Critical insights from the case study

The climate information creation and delivery carried a critical aspect: the CC uncertainties embedding and communication. Uncertainty was not accurately communicated in the documents and the meetings.
In terms of CC analysis' base data, key information was missing, i.e.: wind, humidity. The CC analysis and projection were based on just the available variables, i.e. temperature and rainfall historical, and therefore already experienced events, i.e. heatwaves, heavy rainfalls, droughts, but haven't yet been solved. This highlighted the fact that the CCA is oriented to just a few already existing and experienced hazards. Consequently, the message that was delivered to the policymakers and the citizens led to the design of the structural CCA measures with very few innovations, e.g. climate shelters. Most of the CCA measures are based on greening and grey infrastructure approaches – some of them carrying the water-sensitive principles (Ward et al., 2012).
Finally, the analysis highlighted the fact that top-down climate information production, carrying a predict-and-provide approach, despite passing through a purveyor (i.e. Barcelona Regional), hampered the CCA policymaking.

The climate information approach carried technical biases and was delivered just to one person – a bottleneck – i.e. the Pla Clima coordinator, which had to carry all this amount of technical information. This affected CC-dedicated policy-making and integration. The task to deal with a complex and huge amount of climate information and to communicate it to the municipal technician from different sectors seemed overwhelming for just one person. The coordinator was supported partially by the Urban resilience office, which dealt mainly with the civil protection office and the water infrastructure agency.
In terms of plans and actions that were not included in the Pla Clima, wind, flood, air contamination (heatwaves and wet period effects combined with air pollution) emergency plans were excluded from the Pla Clima umbrella. Existing vector-borne diseases (Public health municipal agency) and fire emergency protocols (Collserola park agency) were also not included.

In terms of CCA measures, the greening solutions are the main ones, which should achieve the Pla Clima goal of increasing the city of Barcelona of 1.2 km^2 of green spaces. Greening is considered as a one-size-fits-all solution. In fact, whatever type of solution, e.g. a big canopy tree, a small canopy tree, grass, bushes, green façades, is considered effective for tackling CCA in terms of heatwaves and floods. Moreover, these types of solutions might suffer from other CC effects, e.g. droughts and strong winds, which were not taken into account.

Grey infrastructure improvement is also another solution, e.g. big underground water tanks retrofit, pipelines enlargement, small water tanks on roofs for rainwater use, inlets removal and change, that aims to tackle droughts and floods.
Both greening and grey infrastructure solutions include water-sensitive approaches. Water-sensitive devices that aim to retain temporally water might create the perfect hub for vector-borne diseases proliferation, in case of prolonged wet periods.
Regarding the CCA monitoring system, most of these indicators are tailored for heatwaves, droughts and floods. Furthermore, the indicators used for monitoring CCA received critics from the co-implementation actors. The set of CCA-related indicators, which already existed and were selected from the existing sectoral plans, weren't updated or transformed in order to make them consistent for current and future CC.

BCC's Urban Ecology department engaged with the civil society and citizenship from the preliminary stage of the Pla Clima making until the implementation phase. The whole process of civic engagement was self-labelled by the municipality as a co-production process. This led to adding a research topic to this thesis and to researching its meaning in the fields of urban planning and CCA.
Barcelona municipality engaged with the civil society through the local network for sustainable development, i.e. *Xarxa Barcelona + Sostenible*, with the aim to pilot a CC-oriented participatory process. The call for CC-oriented projects produced at the end a selection of 9 projects. Despite being considered innovative and relevant to the CC issue, they couldn't be implemented due to the lack of ad-hoc funds.
This experience gave positive feedbacks from civil society engagement but demonstrated that funds are needed. This posed the basis for the co-implementation phase of the CC-dedicate plan.
During the CC policy-making process, civil society and citizenship were included in the design of the objectives and the measures. The interactions were done through meetings and the online platform of the Barcelona city council (www.decidim.barcelona). In this phase, which has the characteristics of public consultation, 90 entities participated and 112 were the proposals.
Until this point, the process didn't have the characteristic of a co-production. In fact, it was traditional government-led planning that "just" informed and consulted with the participants and that in the case of the Pla Clima's participatory session improved the inclusiveness.
In the phase of co-implementation, the process has started improving and approaching to the civil society with a "collaborative and empower" approach (Sarzynski, 2015). 11 projects have been selected for implementing some of the measures included in the Pla Clima and each project was assigned to an administrative officer and a technician officer of the municipality in order to collaborate and help the organizations in overcoming technical and bureaucratic impediments. The interactions were constant and useful between the municipal servants and the organizations and hence, this phase can be considered as a co-production.

On one hand, exchanges the technicians and bureaucrats helped the projects' enhancement, on the other hand, the phase of monitoring the projects implementation wasn't carried with the same flexibility. The organizations had to select three indicators in order to monitor their projects and the ones that related to CCA found difficulties in selecting three appropriate indicators. Even though they asked for creating new or modifying some of the existing indicators, the Pla Clima coordinators were firmly in maintaining their set of indicators. This demonstrated that the municipal servants are keeping with the command-and-control approach and the conformance mentality, at least from the CC monitoring perspective.

Chapter 5

Turin

5.1 Introduction

In this chapter, the Turin case's findings will be described and analysed.
The objective of this chapter is to answer to the research questions through the analysis of the Turin municipality CCA policy-making, considering: i) the science-based CC analysis and assessments that fed the Climate-related policy process; ii) the internal participatory process for the design of the CCA plan.
The introductory section (5.1) will describe the CC impacts that Turin has suffered to-date (5.1.1) and will frame the CCA-related policy context in Italy, from the national to the regional level (4.1.2).
The second section (5.2) will address the climate information inflows at the service of the CCA planning process, including the CC analysis made by *Agenzia Regionale per la Protezione Ambientale* (ARPA). These are the climate-related information that has fed the CCA policy process in Turin municipality here will be assessed through the Credibility criterion, jointly with Reliability, Accuracy, and Legitimacy sub-criteria. This section is important for answering the first sub-question of this thesis.
The third section (5.3) is about the CCA policy background (5.3.1), the CCA-dedicated policy-making process (5.3.2), and the new measures elaborated (July 2018) including the existing actions from the five departments (5.3.3). In this phase, policy integration criteria (coordination-harmonization-prioritization) and the CCA measures' criteria (relevance and consistency) were used for analysing the case and answering the second sub-question of this thesis.
The fourth section, 5.4, concludes with the discussion (5.4.1) highlighting the case study's insights (5.5.2).

5.1.1 Climate change effects to-date in Turin

In Piedmont region CC effects have been: an increased variability, with frequent "out of season" events and rapid alternation of extremes events, the intensification of intense events; changed condition of the mountain in particular at high altitudes, which determined a series of impacts induced on the agroforest-pastoral activity. An increase in temperatures, in particular of the summer maximum and autumn temperatures, which cause an increase in conditions favourable to the propagation of forest fires and threaten the most durable water reservoirs - the glaciers, snow and permafrost.
Urban areas have suffered, in particular, from the effects of heatwaves on health, which increased in terms of mortality and morbidity; in a prolonged and early period of pollination with the onset of new cases of allergies and with the spread of vector-borne diseases due to the prolonged heat and wet period (Marini et al., 2016). Moreover, heat waves also have an impact on the management of urban green areas and water availability, increasing the stress to water provision for public, commercial, and industrial purposes.
Turin area, which is mainly a plain region with also a hill and the main river Po and two other streams, has suffered a series of climate-related impacts along the last years:

- Pluvial floods
- Fluvial floods
- Cloudbursts and Hailstorms
- Droughts
- Heatwaves
- Strong winds and mini-tornadoes

Regarding the wind-related extreme events, during 2017 June there were a series of extreme wind and mini-tornadoes events (Fig. 5.2.a). The regional agency of Piedmont Region called ARPA, created and forwarded a bulletin regarding the alert underestimating the entity of these events. However, the expected entity and severity for these events were low (Fig. 5.2.b).
In terms of temperature, Turin has seen along the last 50 years of an increase of max and mean temperatures (see Fig. 5.1).

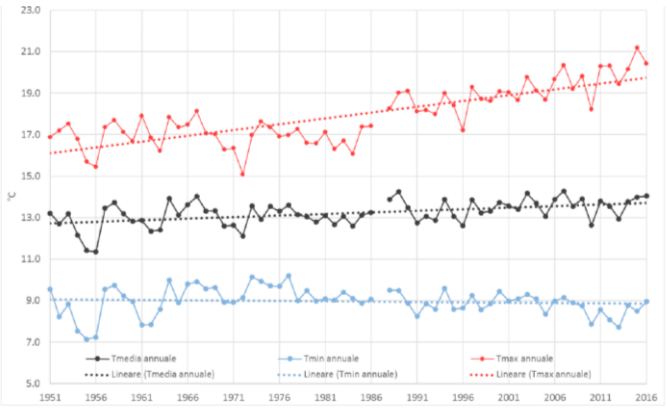

Figure 5. 1 - T max (in red), mean (in black) e min (in blue) per year in Turin from 1951 to 2016 (ARPA 2018)

It is topical to observe how the effect of the increase in heating is also reflected in the shape of the frequency distribution of the temperature itself, thus modifying not only the average value but also the extremes. Comparing, for example, the distribution of the maximum daily summer temperature of the period 1981-2016 with that of the period 1958-1980 shows an increase in the median and all the higher percentiles: of the 95th percentile of about 1°C and 99 ° percentile of about 1.5°C (Figure 5.3). The 50th percentile value (equal to 27.6 ° C) in the most recent distribution occurs only 32% of days and no more than 50%. The 95th percentile value (equal to 33.2 ° C) and the 99th percentile value (equal to 35.99 ° C) are 89% and 98% of the days respectively.

Figure 5. 2 – On the left: Fig.1.a[17] - A car hit by a tree that fell down after a strong wind event– On the fight: Fig. 1.b[18] - The ARPA bulletin the day before the strong wind event foreseeing low degree of risk of these events

[17] http://www.ecodallecitta.it/notizie/387748/maltempo-e-danni-a-torino-con-vento-a-78-kilometri-allora-in-centro-citta/ downloaded 30th June 2018

[18] http://www.arpa.piemonte.it/arpa-comunica/file-notizie/2017/bollettino-allerta-28-giugno downloaded 30th June 2018

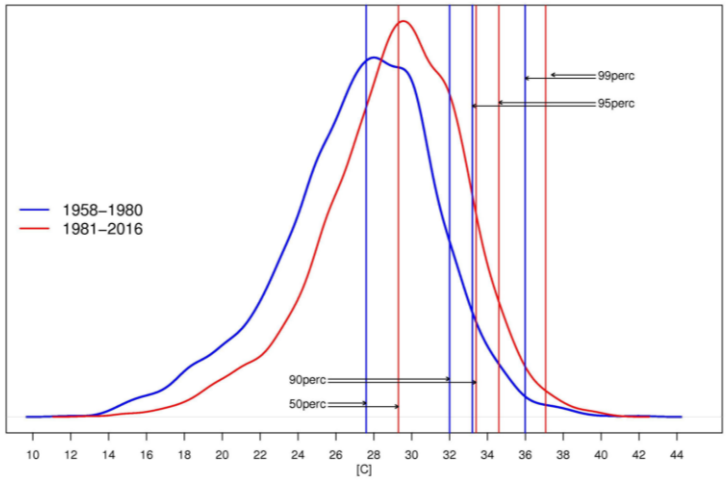

Figure 5. 3 - Distribution of maximum temperature values in the summer period in Turin in the period 1958-1980 (blue) and 1981-2015 (red). The vertical lines represent the percentiles (50 °, 95 ° and 99 °) of the two distributions (ARPA 2018)

In terms of rainfall pattern change, the analysis of average annual cumulative precipitation anomalies on Turin calculated from 1951 until 2016 compared to the 1971-2000 period does not indicate a clear and statistically significant trend, rather periods of several consecutive years are observed below the reference standard, alternated with others in which the contribution of precipitation during the year is positive.

From the point of view of intense rainfall, comparing the highest percentages (95 ° and 99 °) of the daily rainfall distribution from 1951 to 2016, we observe a slight tendency to increase extreme values more marked for the 99th percentile (Figure 5.4).

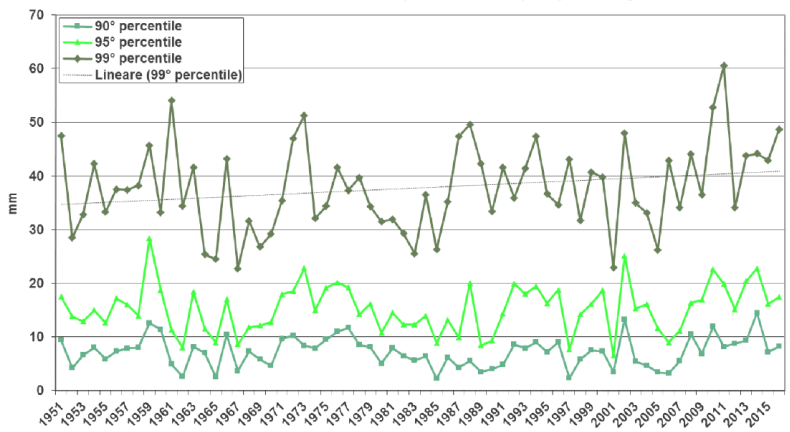

Figure 5. 4 – Trend of 90th, 95th and 99th percentile of daily rainfall in Turin from 1951 to 2016 (ARPA 2018)

5.1.2 Climate change adaptation planning in Italy

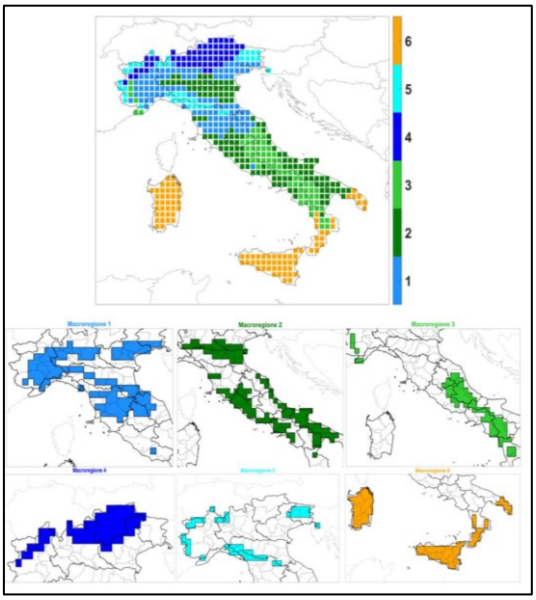

Figure 5. 5 – Division of Italy in climatic zones (CMCC, 2017)

Turin is included in the macro-climate category 'Prealps and Northern Apennines' (see fig. 5.5). This area is characterized by high values for winter and summer rainfall trends and by high values, compared to other areas, for extreme precipitation phenomena. It is the second area with the highest number of summer days or with the number of days in which the maximum temperature has a value higher than the threshold value considered (95th percentile) (CMCC, 2017).

National level: Italy and the Minister of Environment, Territory, and Sea

Italy has a National Strategy for CCA (Strategia Nazionale per l'Adattamento al Cambio Climatico – SNACC), which is approved, and a National Plan for CCA still stalling. The Minister that design and coordinate the climate-related issues is the Environment, Territory, and Sea Minister.

The National Strategy for Adaptation to Climate Change (2014) was approved in October 2014. The National Strategy for CCA gives an overview of the impacts of CC, identifying a set of actions and CCA measures to address these impacts. The Italian National strategy mirrors almost in all the sections and aims the European CCA Strategy.

In 2017 the Italian National CCA Plan in October 2017 closed a public consultation aiming at collecting comments and integrations from stakeholders, which, still, hasn't been approved. In the case of the Plan the process of consultation followed a more oriented 'top-down' approach, involving sectoral scientific communities only after the publication of a first plan proposal.

Big efforts were done to the CC analysis and scenarios, made by the *Centro Euro-Mediterraneo per il Cambio Climatico*, while, less endeavour was done for what concerns the local and regional planning systems. Indeed, the "ghost" National Plan

didn’t include the potential implications with the legal framework of regional planning and the urban, peri-urban and rural governance (Pietrapertosa et al., 2019).

Regional level: Piedmont

With the DGR (Decreto Generale Regionale) n. 24-5295 of 3 July 2017, the Piedmont Region undertook to elaborate the Regional Strategy on Climate Change, which provides for the preparation of a guidance document for the various sector policies (Plans and Programs), towards strategic objectives, already existing of the Region, to affect both the causes and the effects of CC. To this end, a Working Group was set up that was made up of officials from different regional offices, which makes use of the scientific contribution of ARPA Piedmont.
The Group's objective, coordinated by the Environment, Government and Land Management Department - Strategic Planning and Green Economy Sector, was to plan the activities to be implemented and to establish the group's management tools.
The regional strategy of CCA that the Regional Council set up, aimed to identify the sectors in which the potential impacts of the current and future climate changes are more relevant and to include the principles and the objective of the SNACC (Strategia Nazionale per l’Adattamento ai Cambiamenti Climatici) in the future regional sector planning.
The wide spectrum of the sectors involved requires close coordination between the regional directorates involved and the activation of a tool for the active involvement of stakeholders and civil society. The Regional Strategy on Climate Change intended to be a transversal instrument that does not replace or add to the planning or planning tools already in place within the Piedmont Region itself but is instead proposed as the frame of reference to which these regional instruments will refer to CC.

5.2 Climate information for Turin municipality

This section addresses the production and delivery to Turin municipality of CC analysis made by *Agenzia Regional Protezione Ambientale* (ARPA) – Regional agency for Environmental protection – at the service of the Plan-making process. ARPA treated and elaborated the climate information and CC scenarios made by *Centro euro-Mediterraneo per i Cambiamenti Climatici* (CMCC) – Euro-Mediterranean centre for CC – at the service of the Italian National Plan for CCA. ARPA acted as a sort of purveyor because processed the CMCC data and projected locally to the Turin area.
The ARPA information is not an assessment, but just CC analysis based on CC projection with a temporal scale that reached 2100. No spatial applications were made or produced (e.g. risk maps on the Turin municipal area)
Temperature and Rainfall are the historical data that was used as a base for the CC projection. The wind was included in the historical analysis, not in the projection.
Through the use of climate modelling (global and regional) and taking into account the socio-economic development scenarios and the hypotheses on the greenhouse gas mitigation actions that will be undertaken, it is possible to outline future scenarios relating to climate variables. The simulations are affected by uncertainties, dictated by the limited capacity of the models in explicitly describing all the processes and interactions between the variables that influence the climate, including the feedback mechanisms, the accuracy of the socio-economic scenarios, the relevance and the timing with which mitigation measures will be implemented, as well as other factors that are difficult to predict, such as population growth, migrations, lifestyle changes, technological evolution ... Nevertheless, it is important to have estimates, even quantitative, on climate change, in order to assess impacts, define punctual enforcement actions and prioritize prevention and protection measures to be undertaken. It is important that the future projections of the climatic variables are validated over a period called "control" with respect to the observed data and appropriate corrections are made so that the representativeness of the model is assured, at least in the control period. The application of the correction techniques also to the future period constitutes a further arbitrariness that is attributed to the scenarios, increasing their uncertainty.
In this report the high-resolution simulations obtained with the COSMO-CLM regional climate model (8 km horizontal resolution) produced by CMCC were used, the same simulations used for the National Plan for Adaptation to Climate Change. Using these scenarios, together with the application of systematic error removal techniques, it was possible to carry out assessments on the climate trend in Turin in the coming decades, until the end of the century. The simulations use the elaborations carried out by the IPCC and the two RCP 4.5 emission scenarios (intermediate, with significant mitigation actions, which foresee a stabilization of the concentration of CO2 in the atmosphere after the middle of the century) and the RCP scenario 8.5 (without mitigation actions), taking into consideration the time period from 2017 until 2100.

After an analysis of the validity of model data in the reproduction of past and present climate, the data of the RCP4.5 and RCP8.5 scenarios were examined, focusing in particular on Turin.
The mean average, minimum and maximum temperature values of the control period 1971-2005 and the following thirty years of years 2011-2040, 2041-2070 and 2071-2100 were calculated. The analyzes reported were obtained by applying a bias correction to the model data to eliminate the systematic error present. This correction provides excellent results both for the average values and for the extremes of the distribution.
Figure 5.6 provides an overall view of the trends annual average, maximum and minimum temperatures from 1971 to 2100 provided by climate modelling. As can be seen from the graph, temperatures tend to increase until the end of the century, with a more pronounced trend for maximum temperatures. This increase and the growth rate remained significant until the end of the century, in line with the emission scenario which does not provide for the stabilization of the concentration of CO2 in the atmosphere during the 21st century.

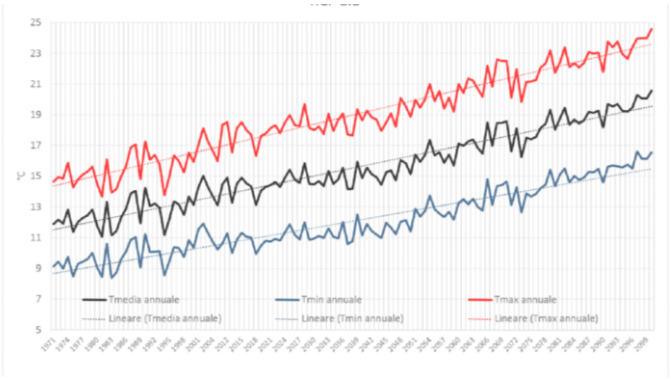

Figure 5. 6 - annual average, maximum and minimum temperature trends and respective trends of the RCP scenario 8.5 (ARPA, 2018)

The precipitation data of the RCP8.5 scenario were used to evaluate the trend of the number of days with precipitation> = 1mm,> = 5mm,> = 10 mm and> = 20 mm in the period 1971-2005 (control period) and in the periods 2011-2040, 2041-2070, 2071-2100 (Figure 5.7).
In terms of mean and strong wind, data were used from three monitoring stations of the ARPA network located in the city centre, *Via della Consolata*, Alenia and *Giardini Reali*, considering the data from the moment of their installation. Analyzing the 10 minutes averaged wind distribution, we find that most of the values are below 18 km / h and on average 30% of the values correspond to wind calm (<0.3 m / s).
To consider the extreme values of the wind speed measured by the stations, the percentiles (90^{th}, 95^{th} and 99^{th}) of the hourly burst and the maximum hourly burst were calculated for each year. The highest values at the Turin's *Alenia* station where the maximum annual gust time is always above 18 m / s (65 km / h), reach peaks of 28.6 m / s (103 km / h). Differences are thus highlighted in the different areas of Turin, but trends are not deduced, given that the time series are relatively short.

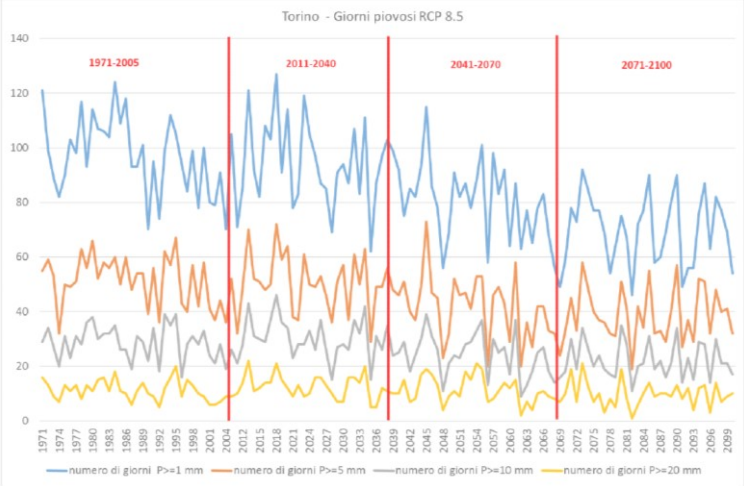

Figure 5. 7 - Number of days with precipitation> = 1mm,> = 5mm,> = 10mm and> = 20mm according to the RCP8.5 scenario

5.3 Climate change adaptation policy-making process

5.3.1 Background and aims

The trigger: EU-DERRIS project

Introduction to the project
Turin is the first Italian municipality to join DERRIS[19] (DisastEr Risk Reduction InSurance - LIFE14 CCA / IT / 000650), which is a project aimed at preventing and reducing risk in small- and medium-sized enterprises (SMEs) deriving from environmental catastrophes related to climate change such as floods, landslides, drought, typhoons.
The DERRIS project is led by the Group Unipol (Insurance and Bank Group) together with other partners, i.e.: City of Turin, Cineas, ANCI and *Coordinamento Agende* 21. The project aimed to implement a series of actions in order to transfer the expertise in assessing and managing risk, and to design and distribute the tools to minimize damage both at the individual company level (such as the corporate adaptation plan) and the business district (such as the Integrated District Adaptation Plan), which will be tested with local private companies – 30 small to medium-sized Enterprises in the Turin area and then disseminated on the whole Italian context. DERRIS foresees an initial investment of 1.3 million euros, partly co-funded by the European Commission within the Life+ program. Specifically, the project aimed to achieve these objectives:

- 1 tool for self-assessment of risks deriving from climate change,
- 1 financial instrument to support adaptation measures to climate change,
- 1 model of Public-Private Partnership for climate resilience,
- 30 Business CCA plans;
- 1 integrated CCA district plan.

In April 2016, a call was launched entitled "*Torino che Protegge*" that aimed to involve 30 SMEs from the municipal area in a process aimed at evaluating and reducing their exposure to climate and climate risk by implementing solutions to preserve the value of the company over time. All SMEs were called to participate, located in the 6 areas identified above, interested in the project and that had some specific characteristics. From October 2016 to March 2017, the companies participating in the pilot experiment joined a series of training meetings and received free technical support from the project experts, in particular:

[19] www.derris.eu

- a timely assessment of its vulnerability to weather-climatic events through two surveys by experts to identify the potential risks to which the company is exposed,
- technical assistance for the identification of risk reduction measures that can be undertaken,
- a training course aimed at creating an internal expert in Risk Management,
- the possibility of contributing to the development and testing of the IT risk self-assessment tool developed by the project partners.

DERRIS project can be considered as an entry point for the CCA issue in the Turin municipality. It can be considered the incipit of the CCA-dedicated policymaking process. In fact, after this experience, the Turin municipality, through the Environment department, to set-up an inter-departmental process whose aim was to create a CCA planning tool, either a Plan or a Strategy.

Inter-departmental policy-making process

From June 2018 to-date in Turin municipality the Environment department is leading an internal process of CCA policy-making, called Climate working group, involving 5 departments, i.e.: Environment, Urban Planning, Mobility, Social policies, Innovation (see Fig. 5.8).
The official public actors that were involved in the state-of-art phase, where all the measures, strategies and plans related to CCA were checked and highlighted for the CCA planning process are:

- *Regione Piemonte*
- *Agenzia Regionale Protezione Ambientale* (*Regione Piemonte*)
- SMAT (*Società Metropolitana Acqua Torino*)

The political entrepreneur with the support of a technician organized and coordinated the formal and informal meetings.
The working group aimed to meet formally eight times, every two/three month approximately, and in each meeting tackling a specific hazard.
The risks and hazards that were taken into account for the policymaking process are:

- Floods
    - Pluvial and Fluvial
- Heatwaves
- Droughts
- Wildfires
- Landslides (as a direct consequence of intense rainfalls)
- Hailstorm

Before the meetings, the Environment officer with the political entrepreneur met with the sectors that already tackled the specific climate issue, e.g. heatwaves, intending to gather all the existing related plans and measures.

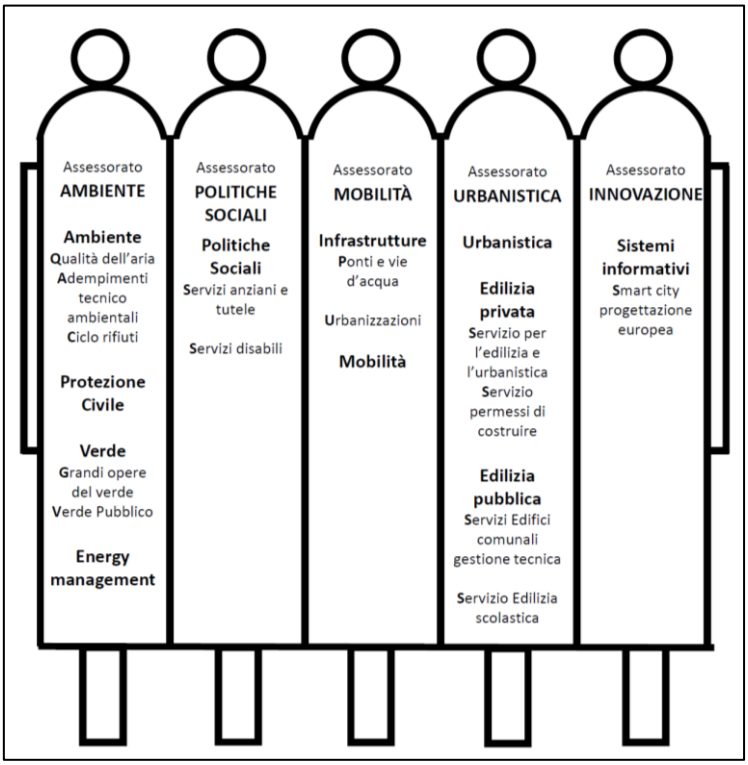

Figure 5. 8 - The departments and related offices involved in the CCA planning (Source: Città di Torino)

Along the process of CCA policy-making, a CC-focused city-to-city learning programme, the Transatlantic City Lab (see Box 5.1), was carried. It consisted of four official meetings, three in Turin and one in Portland, and it was considered as part of the CCA working group process.
The new CCA plan will focus on:

- Safeguarding the quality of life in the city
- Protecting people's safety
- Protecting public and private goods
- Safeguarding natural resources
- Guaranteeing of continuity and quality of public services and private economic activities

The main aim of this inter-departmental process has been to prepare a CCA plan that can integrate into the local planning framework of the Turin municipality including the sectoral plans and actions. In order to integrate this CCA policy with the existing and on-going plans, this process aimed also to update the:

- Master plan accordingly with the CCA-related needs
- Sustainable mobility plan
- Civil protection plans

- Sustainable Energy Action Plan,

and integrate the new CCA plan with new planning tools that will be designed:

- Green Infrastructure Strategic Plan
- Air quality plan
- Zero waste strategy (circular economy plan)

BOX 5.1 – GMF's Transatlantic Cities Lab: Portland and New Orleans practices

The German Marshall Fund of the United States of America (GMF) fosters transatlantic cooperation at the international, national, and regional levels. GMF has several programs and one of these is specifically dedicated to the city and regional planning, namely the Urban and Regional Policy Program (URP). Within this URP Program, a city-to-city learning network has been framed, which is the Transatlantic Cities Lab.

The Transatlantic Cities Lab (TCL) on Urban Metabolism and Sustainability pursues the aim of supporting Torino's policy deployment and innovation in this field as a means to achieve the city's climate goals. For this, the GMF supported by the *Compagnia di San Paolo* of Turin convened a one-year transatlantic peer-to-peer learning workshop titled "Urban Metabolism and Sustainability: Exploring Climate Adaptation Strategies for Torino" between the city of Torino and the city of Portland (Oregon) – which was the core good practices' city –, Oakland (California) and New Orleans (Louisiana) as well as experts and practitioners in the U.S. and Europe experienced in leading the energy, environmental and governance transformation on the local scale. Under this framework, participants shared their expertise on four priority areas of climate action in Torino (sustainable mobility, waste reduction, food policy and energy) for the city to reinvent its development pathways and core metabolism.

The workshop explored planning strategies and policies that can support Torino's climate agenda by providing a new framework of reassessing the urban metabolism functioning and the pressures generated by its urban development processes and connected the city to best practices on these topics.

The kick-off workshop took place on June 22-23, 2017 in Turin, where the Turin municipality met with Portland and Oakland municipalities. The American municipalities showed and presented their approaches in tackling the CC issue. Portland was selected as the good practice and the process of exchanges and practices sharing took almost two years (June 2017 – February 2019). The municipality of Turin, visited Portland in 2018 with the aim to see how the Climate action plan of Portland works (2015 to-date). Portland municipality visited Turin twice and the second time was in late 2018. In the second meeting, Portland showed their CC policy integration strategy, including the 2035 Comprehensive Plan (2016). They explained also how they coordinated the Climate action plan with the Transportation Plan and the Strategic Plan. The key sectors that were involved in the policy- and decision-making process, were: Transport, Water, Stormwater, and Parks.

The Climate action plan, which was updated in 2017, focuses its efforts mainly on CCM. CCA has a less objectives than CCM, rounding mainly on Greening solutions (i.e. Green Infrastructure and greenways plan) and non-structural

actions (e.g. emergency and disaster preparedness). Concerning the monitoring system, Portland attempted to create indicators for CCA-related issues but found difficulties in defining a thorough monitoring system.
Based on the CC preparation strategy (2014) including the CC risk vulnerability assessment, the Climate action plan tackles these climate hazards: extreme rainfalls producing floods, droughts and directly impacting on the land stability (e.g. landslides), extreme temperatures involving heatwaves and wildfires.
In January 2019 the municipality of New Orleans with a group of professionals that worked in the Katrina hurricane's (2005) post-disaster and recovery plans, presented the practices and actions implemented.
This workshop focused mainly on the civic engagement aspect, explaining i.e. how to set up a participatory process with the local population, how to make the citizens proactive and provide critical and useful climate-related information.

5.3.2 Measures designed against heatwaves and floods

This sub-section outlines the CCA measures, which tackle heatwaves and floods, designed by the CCA process coordinators (June 2018) that were:

- gathered by the CCA process coordinators, from the departments' meetings and working group events,
- shared by the Turin municipality servants during the city-to-city learning programme with Portland's peers,
- taken from the documents delivered by the Author, whose focus was the CCA plans from the Global North (see Appendix C)

Common measures

Urban code and rules

Review of the PRG: the introduction of guidelines that recognize the introduction of design solutions to reduce urban heat islands. Executive Urban Tools allow direct intervention in portions of land to be transformed by increasing green-lined areas, reducing land use and increasing permeable areas.

Coordination and Policy integration

Inter-departmental Working Group: a support team able to ensure initiatives to prepare and monitor the Adaptation Plan. Through the interdisciplinary involvement and goal-sharing of all sectors, it aims to integrate the CCA issue with general planning.

Vertical Integration: Integrated working methodologies and the construction of institutional vertical relations between state and region can ensure a participatory process. The relationships will be hierarchical but define common intervention plans.

Horizontal Integration: the participatory process takes shape through institutional relations that are at the same level. The parties involved express integrated policies

and working methodologies, as in the case of the active international experience between Turin municipality and the city of Portland.

Capacity building

Professional update: the activation of a specific training and update programme related to public and private construction is aimed at promoting the implementation of innovative technical solutions.
Building technical manuals: The ability to guarantee technical building design manuals can promote new and effective solutions that can counteract the negative effects caused by high temperatures.

Emergency management

- Support public events: Civil Protection presence to public events during heat periods
- Municipal Emergency plan update: The recognition in the municipal emergency plan document of the heatwave as a climate risk to be managed allows you to activate the procedures necessary for the management of events related to change climate change.

Media

- Activating a comprehensive preventive communication campaign for citizens: information for citizens is provide for raising awareness of risks livelihoods, workplaces and standard commuting paths, that can increase the response to extreame events.
- Heat and rainfall alert bulletins spread: Heat alerts delivered to the relevant Functions and Support Facilities allow timely and up-to-date information, which is essential for any actions to be taken. The bulletin is also published on institutional platforms in order to ensure the usability of information by citizens.
- Raising CC-related awareness: preparation of the population for appropriate proactive actions and reactons is a central action to ensure the protection of citizens from extreme events.

Heat waves

Urban code and rules

- Review of the Environmental Energy Annex to the Building Regulations: the review of the document allows to ensure in new buildings and, above all, in building renovations the adoption of rules sensitive to the topic of climate change.

Emergency management

- Heatwaves Emergency Plan: In order to identify the necessary interventions to reduce vulnerability, the activation of the Hot Emergency Plan, operational in the summer months and aimed at the elderly population through communication about the projects available.

Media

- Citizens preparedness: activities to spread information on the issue and the solutions to be adopted for citizens' and administrative services' security, that will allow adequate information and a proactive response to the different high temperatures-related risks.
- Social support strategies for the most vulnerable people: social policies are designed to fortify the effectiveness of the social network of proximity to the most fragile sections of the population. The identification and improvement of strategic territorial nodes that can ensure support and protection of the local community allow dealing with extreme events with greater incisiveness.

Emergency management

- Heatwave Emergency Plan: In order to identify the necessary interventions to reduce vulnerability, the activation of the Heatwave Emergency Plan, operational in the summer months and aimed at the elderly population through communication about the projects available.

Green infrastructure

- Green Infrastructure Strategic Plan: Through the development of the Green Infrastructure Strategic Plan in coordination with the Green Planning Adaptation Plan, it is possible to integrate the design guidelines on green adaptation to climate change.
- Increase the number of trees in the city: the increase in plant cover is guaranteed through initiatives of citizen involvement through operational measures of action of the existing urban green and new realization and diffusion of the themes linked to the importance of the role that trees play in the urban ecosystem.
- Tree increase: the planting of new plants along the city's walking and parking routes allows to increase the shading on the streets and buildings, thus decreasing the surface temperature.
- River parks: the recovery of riverbanks through the construction of river parks to be integrated into the system of existing parks linked to the Turin City of Water project allows increasing the capital of sweet mobility that binds to the green and blue areas Piedmont city.

- Tree management: Arboreal heritage maintenance activities and measures must be accompanied by the most effective arboriculture techniques that ensure the best results in terms of health and safety.
- Shade trees: the preservation of the canopy and its shading properties must take place through pruning techniques designed to ensure the safety of public spaces and the benefits of the tree system.
- More resistant tree species: the study and research of tree species with the greatest capacity for resistance and adaptation to extreme climatic conditions to enrich the green heritage with elements that can cope with stressful conditions that characterize the summer period.
- Private-listed census extension: the integration of private greenery through a census that can diversify private green assets and related functions allows to define more effective measures. The possibility of having a comprehensive picture of urban trees allows precise quantification of the ecosystem services that they can provide.

Fresh surfaces

- Fresh flooring: cooling the flooring through innovative materials and solutions promotes the decrease in local temperature generating a local benefit in the area of intervention and general reducing the island effect of heat.
- Blue cooling solutions: the inclusion of the aquatic element in urban furniture solutions and public places of use and meeting can mitigate the negative effect of high temperatures.
- *Toret*[20] relocation: the planning and accommodation of public urban fountains, according to a fair distribution and real use, must meet the areas of rest and greater vulnerability of the city.
- Drainage areas: The creation of surfaces capable of draining the rain and rain that accumulate along the traffic roads are accompanied by the arrangement of green solutions and ensures the mitigation of urban temperature by means of the dual benefit of greenery and increased water run-off.
- Green rails: The transformation of areas subject to the passage of public trams to green tracks in areas that can accommodate the transformation reduces surface temperatures.

[20] Toret: water mister with a bull-shaped tap

- Temporary covers: in periods of high temperatures, solutions are expected to be temporarily inserted to ensure shaded areas in the squares and parking areas most at risk.

Public buildings and schools

- Green roofs: The conversion of the top areas of public and private building heritage by the construction of green roofs increases the thermal insulation capacity of the artefact.
- Green walls: through careful analysis and choice of solutions that can guarantee the least maintenance interventions it is possible to realize technological or traditional measures of equipment of vertical green capable of guaranteeing thermal insulation. An additional benefit is related to ventilation in cases where it is feasible to create a gap located between the green wall and the building.
- Reflective paintings: The use of materials, such as paintings or membranes, with a high SRI (solar reflectance index) on the roofs of buildings, making possible to have a positive impact on the thermal comfort of the residents.
- Cooling public buildings: in conjunction with the extraordinary maintenance works, the insertion of cooling systems is proposed to ensure increased comfort during the hottest days.
- Shielding system: Analysis, design, and implementation of solutions that can provide shields against heatwaves, that allows lowering the temperature and reducing the energy demand for air conditioning necessary to cool it down.

Mobility

- Local Public Transport (LPT) priority: Reducing journey times for local public transport allows for benefits that can generate a virtuous circle. More efficient means generate greater use of public travel provision by citizens, which reduces the use of private vehicles and again affects the improvement in travel times for the city. The traffic lights are the priority of ensuring priority and regulating public transport traffic.
- LPT conditioning: ensuring the conditions of thermal comfort on public transport during the hottest hours of the summer periods is aimed at discouraging the choice of the private vehicle by the citizen the hours of greatest concentration linked to high temperatures.
- Covered LPT stops (e.g. bus stop): Public transport stop cover allows for shading for citizens while waiting for transport.

- Greening LPT surrounding area: the creation of strategic green areas located in conjunction or near local public transport stops, able to provide places of shelter from high summer temperatures and able to accommodate water management systems rain.
- Comfort stops LPT: actions and measures that allow the ventilation and/or spraying of rest areas increasing the well-being of people waiting.
- Local Public Transport stop redesign: A new design of the stops, especially the older ones, is able to positively affect the ups and downs of public transport thus decreasing the waiting time at a stop.
- Shaded bike lanes: The creation of shaded bike lanes encourages the use of the bicycle even in the hottest hours of the day.

Climate shelters

- The hill as a refuge area: the construction of rest areas and shelter in the hilly area of the piedmont capital allows the enhancement from the point of view of mitigation of extreme temperatures, but also affects the perception of the territory as a place of shelter from heatwaves. To this end, the action is needed on the guarantee of access routes and the presence of services related to areas designed for people's parking.
- Horizontal signage areas: the placement in the TPL rest areas of maps that indicate to citizens the location of urban green areas and climate shelters, combined with the access and connection modes to reach them, favours access and enjoyment of city dining spaces.

Floods

Urban code and rules

- Revision of Building regulations and codes: the re-discussion of the document aims to encourage the implementation of adaptation measures proposed by private entities.
- Regulation for stormwater drainage: research and analysis of the optimal solutions, in terms of practicality and cost, of stormwater drainage. A regulation envisages the adoption of alternative conveyance solutions in the city's whitewater network.

Capacity building

- Sample of possible solutions for designers: the definition of a selected collection of design support actions, available to public bodies and private

citizens, allows to make available to professionals in the sector possible solutions to be adopted to cope with the increase in heavy rains.

- Training and internal sharing of the solutions already adopted: to pool the experiences acquired and increase collective knowledge is proposed the internal sharing of the solutions adopted by the city, also on an experimental basis. Good practices, but also negative attempts, increase the ability to best deal with present and future threats.

Monitoring

- Mapping of the main critical areas: the definition and integration of the maps present that document the most critical areas to the risk of flooding, as well as flooding caused by intense precipitation events or due critical infrastructure in the area, allows you to know the most sensitive areas. The identified areas become the subject of more intense monitoring and care, depending on the type of event. Maps become central to the location decision for the construction of artefacts and connecting infrastructure.
- Preventive measures hilly areas: visual monitoring and reconnaissance activities of hilly areas ensure the reduction of risks for residents of the hilly territory of the municipality of Turin. With special attention of the areas close to the dwellings, checking possible future criticalities related to land slides.
- Economic reporting related to extreme events with damage to public greenery and municipal buildings: the analysis and assessment of the cost incurred due to the damage caused by extreme weather events and the potential one related to the trend that sees the increase in the frequency and intensity of the same in the future define the economic impact that they have on the City. The planned measure is also able to indicate the cost of not implementing adaptation measures.
- Monitoring of the inlets and periodic cleaning: the monitoring of the status of the city's inlets allows the best organization regarding the periodic cleaning that allows the function of drainage during the rains. Reducing the malfunction due to the accumulation of leaves and, in cases of carelessness, waste reduces the regular runoff of stormwater in the white net.

Media

- Define a structured procedure of communication and behaviour (during or an event or *ex-post*): public information of events that took place in the municipality, such as falling trees or closing green areas equipped for situations of ineligibility, helps to spread self-protection modes and help the discussion about the problems for the search for the best measures. By

publishing data and releases, it is possible to raise awareness and promote the adoption of behavioural practices that reduce the risk.

- Communication activities on new solutions for the disposal of rainwater: transparent communication of actions and devices prepared for the proper disposal of rainwater makes the citizen more aware of the opportunities and critical issues present. Disclosure activities aim to spread the objectives that move the experimentation of the design solutions adopted.

Emergency management

- Defining an internal operational procedure for managing on-time emergency events: the procedure and coordination of the immediate handling of rapid events allows the timely management of the critical issues that affect the territory. It proposes the definition of the methods and procedures to be followed to interface with the Civil Protection, the Municipal Police Operations Centre, the Fire Department, the Bridges Service and the waterways, identifying who is responsible for the intervention.
- Broadcasting system: The definition, design and subsequent activation of an alert system that can send an alert communication to people who are present near risk-prone areas. The pointed information of a possible imminent risk affecting a given area is of utmost importance in order to ensure the reduction of damage caused to citizens.
- Civil Protection exercises: Planning and providing support for civil protection activities related to behavioural exercises in situations characterized by flooding or heavy rain increase the sensitivity of all public and private actors.

Nature-based solutions and green Infrastructure

- Green Infrastructure Strategic Plan: the preparation of the plan in parallel and coordination with the adaptation plan for green planning becomes a key tool of urban design and management for change climate change.
- Road drainage with greening: The implementation of green stormwater drainage areas along with the grey infrastructures, represented by the urban road network, reduces the load on the white-water disposal network.
- Rain gardens: locating in the urban texture green areas designed for the collection of rainwater and their subsequent outflow contributes to the decrease in the load generated by white water on the disposal network during weather phenomena.
- Removal of impermeable spaces: the increase in permeable spaces of the city allows the absorption by the soil of part of the water that accumulates during rain events.

- Use of draining materials: at the end of the testing phase it is proposed the use of materials conducive to reduce the formation of surface runoff, inserting in the areas of transformation identified materials to increase the capacity site drainers.
- Adaptation of the inlets: regular cleaning and maintenance of the inlets reduce the malfunction due to the accumulation of foliage that can cause problems during the most intense rains. It is also suggested, in cases where possible, to replace the older ones with simple wolf-mouthed grids that reduce the risk of clogging created by the leaves.
- Stormwater collection: the ability to collect the weather water collected on the roofs of buildings allows to reduce the load on the sewer and save, through its reuse, drinking water for multiple uses. The construction and support for the creation of green roofs promote water collection while ensuring numerous climate and thermal comfort benefits to the building concerned.
- Facilitation/incentives: providing incentives for those who do not discharge white water into the disposal infrastructure and therefore fostering its reuse in different sustainable ways. The benefit guaranteed to the public drainage system is supported by concessions meaning a reduction of taxes.

Waterways interventions

- Removal of hazardous and disruptive elements from riverbanks: the removal of conditions along with river riparian spaces that become objects of disturbance to public well-being and safety, such as unregulated gardens, activities un-authorized deposits and housing settlements, reduces flood risk exposure.
- Inspection of the buried sections of hillside rivers: regular maintenance and control of the buried water infrastructure.
- River cleaning: The removal of debris, branches and timber that creates barrage reduces the risk of clogging that does not allow the correct run-off during rain events.

5.4 Discussion and preliminary conclusions

Climate information

The CCA policymaking process in Turin was fed by the Climate analysis made by ARPA. ARPA based this analysis on the CMCC's projections made at macroregional level (North Italy) for the Italian National Plan for CCA.
The model used by CMCC was the COSMO and the ARPA's analysis downscaled it at the Turin scale. The variables used were Temperature and Rainfall basing the projections on the historical data series. Wind variable was included in the analysis but due to the lack of data and the few monitoring stations available in the Turin area, wind trends were just analysed and not projected. The time managed for the projections is the whole century (until 2100). Both phases used RCP scenarios 4.5 and 8.5.
In this case, no climate-related risk analysis was done. The document delivered to the Turin municipality showed the effects of CC using graphs with no maps. The document and its insights were presented at the first meeting of the interdepartmental process. The uncertainty of CC analysis was mentioned neither in the document nor in the presentation.
The creation and the delivery of this information follow the rigid top-down and predict and provide approach. The information passed through a limited number of people, i.e. 2: the political entrepreneur and the public servant that coordinated the CCA policy-making process and this represent a bottleneck. No one of the end-users interviewed, namely, the public servants of Turin municipality, read the document, but most of them attended the oral and visual presentation.
The whole process of creation and delivery of CC-related information lacks in terms of reliability, accuracy, and legitimacy. The most critical aspects of this issue lie on the exclusion of certain variables from the analysis, on the absence of a climate-related risk assessment with spatial analysis on the Turin region, on the absence of the uncertainty awareness and communication, and on the exclusivist creation of the climate information and rigid top-down delivery.

Climate change adaptation policy-making and integration

The Environment department, which is the one in charge of the CCA issue, plays the role of pivot between the other four departments involved. A policy entrepreneur, that led the CCA policy-making process with the political mandate of the Mayor and the Department's director (a politician), and a municipal servant are the coordinators of the CCA plan-making process.
Environment, Mobility and Urban planning departments tackle CCA through independent actions, which were designed and implemented reactively, and pilots (e.g. green roofs, sustainable urban drainage systems). Civil Protection, that is part of the Environment department, is updating the Emergency plan, which didn't include heatwaves, but instead already included wind and tornadoes events.

Green and Tree management offices are tackling drought periods since decades and the office in charge of parks and trees is the one that most worries about strong wind and tornadoes. There are no measures ad-hoc for tackling this hazard to-date.
Social care office has a strong link with the local public health agency. They are committed to helping the most vulnerable citizens from heatwaves effects, since 2004.
Urban Planning department's director wasn't present during the inter-departmental meetings and urban planning servants weren't present so often in the meeting as well. In fact, Urban planning department behaved as a silo and also didn't agree with the Environment department in including the CCA issue into the revision of the Master plan. Consistent effort was done by the political entrepreneur in institutionalizing the goal of integration of CCA in the Turin's planning framework despite the Urban planning department hampering.

Climate change adaptation measures

The existing sectoral plans and actions weren't based on CC analysis. The only plan that is being updated with new CC issues to be tackled is the general emergency plan (currently under revision). Sectoral actions made independently by the offices and departments are based on current (to-date) climate-related hazards experiences, and each office has their priorities, i.e. Trees and Parks office needs to deal with strong winds and droughts, Green management has to deal with drought, Social care needs to deal with heatwaves, Urban planning offices and Mobility offices deal mainly with fluvial and pluvial floods.
The actions and measures considered in this research that was collected and proposed during the policymaking process, which was observed by the Author until May 2019, relate to heatwaves and floods. The CCA structural actions proposed rounds two general approaches: the greening, with a water-sensitive approach, and the grey infrastructure. There are also non-structural actions that relate to the use of indoor and outdoor public spaces during heatwaves, the improvement of the alert system, and the creation of norms and laws for a more effective and integrated CCA planning. A strong emphasis was put also con the CCA integration into the local planning framework, setting up a permanent inter-departmental working group and improving the vertical and horizontal coordination.

Insights from the case study

The climate information produced and delivered by the ARPA to the Turin municipality was based on a few variables, i.e. rainfall and temperature. Strong winds were considered but not analysed and projected to the future time scales.
As well as the Barcelona case, the climate information in Turin passed through a bottleneck, and this fact combined with the rigid top-down and predict-and-provide approach take the form of a path dependency. The communication of more extreme temperature periods, heavy rainfalls, and droughts periods in the future, which are extreme events already experienced, led to the design of CCA measures that are not

innovative. In fact, most of the structural solutions are nature-based measures – greening solutions – and grey infrastructure. Greening as well as the Barcelona case, is considered a one-size-fit-all solution and was not taken into account the fact that such CCA measures carry vulnerabilities to certain climate-related hazards, i.e. droughts and strong winds.

In terms of CCA policy integration, the CCA working group triggered a process of coordination between the departments and offices involved that were not accustomed to cross-sectoral integrations. In order to make the CCA-oriented coordination lasting, regardless the possible future political changes, e.g. new elections and new governments, a preventive measure was designed, which is the institutionalization of a permanent working group's table.

PART III – DISCUSSION AND CONCLUSIONS

Chapter 6

Discussion

Local CCA planning has a series of gaps that haven't been fulfilled, e.g. CCA planning often doesn't reach the implementation phase, the CCA issue is not integrated into the local planning frameworks, CCA-related plans – especially the dedicated ones – often don't work in synergy with the other plans, CCA find difficulties in taking pace, and the CCA objectives and plans also disappear after a political mandate.

The literature of CCA mainstreaming, especially in the recent review carried by Runhaar et al (2018), focuses only on the outputs (e.g. plans and programmes) and outcomes (e.g. CCA measures implemented) of the CCA policy integration processes, and the analytical approaches used are often on barriers and drivers (Moser & Ekstrom, 2010) or are just a mere description of objectives, tasks and resources allocation and distribution.

A critic of this research that arose from the systematic literature review - outlined in section 3.2 – relates to the analytical approaches, especially to the one on the barriers. Building on Biesbroek et al critics (2014), this thesis argues on the limits of this approach and called for the elaboration of new analytical frameworks that detect policy integration dynamics and include climate inputs – climate-related information – (e.g. CC projections, CC scenarios assessments), which have been excluded to-date from most of the studies on CCA mainstreaming.

Climate information jointly with its conceptual evolution, i.e. climate services (CS), is a critical aspect of the CCA planning and mainstreaming. Academic literature of these fields has recently started criticizing the studies that tackle the CC issue with just science-based approaches – what Vaughan and Dessei call "knowledge elitism" (2014). CC with the un- that embeds, i.e. unpredictability, unexpectedness, uncertainty, and unknowingness, challenge the aims of CC scientists, which always seeks for the achievement of perfection of models, projections, although basing their studies on materials (e.g. historical weather series) and concepts (e.g. return-period) that have limits. Moreover, climate-related information, also in the form of services, are often produced with a "predict-and-provide" mentality (Soares 2016)

by knowledge elites or experts and delivered with a rigid top-down approach (Vaughan & Dessai, 2014).
Due to these gaps and critics, the purpose of this research was to focus on the challenges that local CCA planning faces:

- from the initial phases when the climate-related information is produced and delivered,
- through the design and integration of CCA policy objectives within the local planning frameworks,
- until the phases of implementation and monitoring system setting.

For this purpose, this thesis, which used the 'mainstreaming' as the research lens and used a tailor-made analytical framework consisting of a set of qualitative criteria: Credibility – Reliability, Accuracy, and Legitimacy –, Policy Integration/Mainstreaming and, Relevance and Consistency, aiming to understand the key challenges for local planning in reaching CCA policy integration and implementation.
The Discussion chapter is divided into two sections:

- 6.1 is the section where the research questions will be answered,
- 6.2 section recaps the insights of the previous sections and highlights the lessons learned that feedback the research fields of CCA planning and mainstreaming. Potential follow-ups in research and recommendation for policy-makers and planners are also addressed.

6.1 Key local planning challenges for integrating and implementing climate change adaptation

This section explores the challenges of integrating and implementing CCA derived from case studies' analysis. It is split into two parts: the first one addresses the climate information and services (6.1.1), the second one addresses the climate information impact on policy-making and integration (6.1.2).

6.1.1 Climate information effects on climate change adaptation planning and policy integration

On the credibility of climate information and services

Climate information credibility in Barcelona and Turin cases was conditioned by several technical and communicative gaps and biases.

In both cases the production of the climate information was science-based and expert-led, embedding a "predict-and-provide" mentality, and the delivery of this information was done with a top-down approach. In both Barcelona and Turin cases, the CC analysis was produced by entities that belong to their Regional agency. In accordance with the analytical framework used in this thesis, the findings regarding climate information will be discussed in terms of Reliability, Accuracy, and Legitimacy.

Reliability

Regarding the data and the sources used for the CC analysis, there is a critical aspect, found in both cases, that relates to the official CC projections that were based on just two variables, i.e. temperature and rainfall. Wind and humidity were excluded in the projections due to missing data in the historical series, which are usually the base information for the climate modelling and projections. In the case of Turin, the wind was mentioned at least in the historical trends but due to the availability and quality of the monitoring system, it could not be possible.

Despite the evidence that both Barcelona and Turin have suffered from extreme wind, tornadoes, and the combination of air pollution with a prolonged period of humidity, the variables were not properly communicated. Due to these technical choices and constraints, a bias was produced that led to the provision of a limited CC analysis.

In the case of Barcelona, the sea level wasn't included as well in the first analytical phase, but in the second analytical phase carried by the purveyor, despite embedding conceptual and methodological lacks, the sea level rise was considered and projected in a time-lapse of three decades. Nevertheless, this CC effect remains underestimated and perceived as a taboo (Keys et al. 2019).

CC analysis and assessments were done with projections and the time-managed is almost 100 years. This highlights a discrepancy with the time horizons of the plans (e.g. 2030 for Barcelona).
This poses a focus on the need to provide CC analysis that considers also the current tendencies of CC (IPCC, 2018) and the current policies of EU that are fostering high-end scenarios (i.e. RCP 8.5) research and action projects (Capela Lourenço et al 2018). This evidence conveys the debate also to the reliability of the models and scenarios used, which were RCP-based using the 4.5, the 6.5 and the 8.5 – the high-end – scenarios.

Accuracy

Regarding the CC analysis and the degree of uncertainty that CC carries, the accuracy in the explanation of uncertainty was low. It was barely written in the documents and not properly communicated to the end-users and also to purveyors.
In terms of communication of the climate information, the effort was medium, for Barcelona, and low, for Turin. In both cases, the documents used a technical glossary with graphs and histograms.
In Turin case, the Regional Agency provided a document, whose information is based on the statistical downscaling approach, with just graphs and no maps.
In the case of Barcelona, the purveyor made a climate risk assessment, based on the rainfall and temperature variables, and provided a set of 10 diagnostic documents containing risk maps and focusing each on a topical aspect, i.e. water cycle, urban floods, marine floods, heatwaves, critical infrastructures, urban heat island, fires, biodiversity, air quality. This helped in the internal communication between the climate plan coordinator and the municipal servants, and the communication during the civic engagement processes.

Legitimacy

In both cases the legitimacy of the CC analysis is medium-high. In both cases, the climate knowledge producers prepared a document with the information that the end-users requested.
In the case of Barcelona, the CC diagnosis passed through a purveyor – a public-private company that belongs to the Barcelona City Council – that analysed the CC assessment and produced a series of projections with a higher spatial resolution. This step sounds like a climate service because the technical document produced by the meteorological service of Catalunya was elaborated and the CC scenarios were applied at the spatial scale including all territory of Barcelona municipality. This diagnosis was tailored accordingly to the need of the end-users, which were represented by the Climate Plan coordinator. This step increased the legitimacy of climate information in the case of Barcelona.
In the case of Turin, the CC analysis was delivered by the Piedmont Regional Agency climate experts to the CCA planning coordinator along the inter-departmental process. A preliminary analysis was explained in the first session of the process through a visual and oral presentation.

Another critical finding in both Barcelona and Turin cases relates to the flow of climate information into the local government. The amount of CC-related technical information was delivered to a few people, and therefore can be considered as a passage through a bottleneck. Therefore, in both cases, one CCA planning coordinator had to assimilate science-based hyper-technical documents that were explained through oral and visual presentations or just by face-to-face clarifications. In the Barcelona case, this led also to a sense of overwhelmingness.
Once assimilated this information, in both cases, the coordinators met with the municipal servants for communicating the insights of the analysis, delivering the documents and for exchanging with them about the on-going plans and actions that are managed in their departments.
In the case of Turin, no one of the interviewees read the CC analysis document. Nevertheless, at least they participated and attended the CC analysis' presentation of the Piedmont Regional Agency climate expert, which elaborated the document.
This doesn't mean that there is the culpability of either the regional agency or the municipal servants. Indeed, these finding highlights once more the fact that:

- the elitist approach (Vaughan & Dessai, 2014) used for producing climate knowledge, and
- the top-down and rigid way (Coulter et al., 2019) for the delivery of the climate information, which passed through a bottleneck,

affect the credibility and more specifically the accuracy and the legitimacy of the climate information.

The climate information that fed the CC-oriented processes drove, in both cases, to a similar pattern. In both cases, the message delivered to the municipalities was that the main issues that the cities are going to face are heatwaves, droughts, and floods. The exclusion from the CC projections of certain variables, i.e. wind, sea-level rise, and humidity, can be considered a form of technical bias that led to the consequent exclusion from the CCA planning of their related extreme events.
In the case of Barcelona, the intermediary step – Barcelona regional agency that acted like a purveyor – between the regional agency and the municipality helped in widening the CC issue transforming it from an oligo-threat issue to a multi-threat issue.
The purveyor focused the climate risk assessment on the temperature and rainfall variables, which tackled heatwaves and fluvial and pluvial floods. Moreover, it made further analysis also on the urban water cycle, air quality, biodiversity, wildfires, marine floods, and vector-borne diseases. These diagnoses helped in making the state-of-the-art of the public organizations of Barcelona regarding how they tackle CC-related issues, which are mainly emergency management measures, e.g. protocols, alerts.
In terms of marine floods, both storm surges and sea-level rise are tackled lightly. The climate information was not reliable in this case and there were no measures proposed for tackling both threats.

The effects of climate information on climate change adaptation planning and measures

The credibility of this climate information affected both the CCA policy integration and the relevance and consistency of the measures proposed.
In terms of solutions designed and proposed, both Barcelona and Turin cases showed that the CCA objectives and measures focused mainly on: i) greening through nature-based solutions, for talking heatwaves, floods, and droughts; and ii) water (blue) and grey infrastructure improvement, for floods and droughts.
Most of these physical solutions proposed are tackling CCA through green, blue, and grey solutions. For the ones that relate with the heatwave emergency plans, both cases proposed also the use and the retrofit of public spaces, indoor or outdoor, for tackling heatwave periods, daily and nightly.

Greening has been proposed as the main and the 'one-size-fits-all' solution and it is considered the *panacea* for tackling CCA. If on the one hand, these solutions are relevant for some climatic threats, i.e. heatwaves and floods, on the other hand, they can be highly vulnerable to other hazards or can cause disservices.
Greening solutions, i.e. trees, especially the ones with a big canopy area, are highly water demanding, as stated clearly by local technicians and policy documents in both cases, and vulnerable to droughts (Reyes-Paecke, Gironás, Melo, Vicuña, & Herrera, 2019) and wind-related threats (Sobel & Tippett, 2018). However, both cases have a long-standing effective tradition of water management and supply that lower the risk for the urban vegetation watering. Barcelona has the local groundwater reservoir dedicated for non-potable use – e.g. greenways and parks management – and drought periods imply negative effects mostly on the potable water supply.
Moreover, greening solutions in their water-sensitive version (e.g. rainwater gardens, bioswales) can help in the flood management. However, they can be the perfect hub for water- and vector-borne diseases during prolonged wet periods (Marini et al., 2016; Millet et al., 2017; Muñoz et al., 2011; Napp et al., 2019). This issue also can happen to grey solutions, e.g. inlets that detain stagnant rainwater.
Both cases show greening solutions' vulnerability to droughts and strong winds and that vector-borne diseases are triggered by water-sensitive devices.
Regarding the former, CCA solutions carry trade-offs – they can be effective for some hazards and vulnerable for other ones – and the latter highlights that CCA solutions can provide not only services but also disservices – triggering CC-related threats.

Spotlighting on the main threats considered, i.e. heatwaves, floods, and droughts, both cities have already suffered from these hazards along the last decades. The need to keep the focus on these issues demonstrates that both cities haven't completely adapted to the past-to-current CC. Planning a city for CCA implicitly embeds the assumption that the urban system is already adapted to past-to-present CC. Hence, both cases showed that Barcelona and Turin have a CCA deficit.

Regarding the variable excluded or just barely considered in the climate analysis, in the case of Barcelona this led to the exclusion from the Pla Clima of the wind and air contamination emergency plans, which are managed by the civil protection office. In the case of Turin, this led to the initial exclusion of the winds and the mini-tornadoes from the hazards that have to be tackled by the CCA policy-making process. Moreover, the vector-borne diseases' issue, which has been mentioned as an existing problem (Guzzetta et al., 2016) by the Regional agency in its visual and oral presentation, was neither considered nor mentioned in the climate analysis. Consequently, it was neither stated not mentioned among the threats that Turin municipality has to plan for and to tackle.
These findings show that CCA is a multi-hazard issue whose risks are interrelated among them. The complexity of the CC effects, the availability of data, and the lack of a policy engagement in the creation and delivery of climate information affected the CCA planning.

6.1.2 Climate change adaptation policy integration through dedicated planning approaches

The current use of dedicated approaches for tackling CCA at the local level is still high, especially in the EU. Both Barcelona and Turin cases applied this dedicated approach that aimed at creating a new planning tool that can work in synergy with the existing sectoral plans and actions. Barcelona did it and created the Pla Clima, and Turin is still in the CCA-dedicated plan-making phase.
Turin CCA policy-making process was observed since the beginning, April 2018, until May 2019. The process continued and this makes the Turin case analysis partial.

These two cases' approaches should not be defined as classic stand-alone tools, but rather as CCA-dedicated strategic umbrellas under which existing sectoral plans and measures are framed and integrated. Both cases had coordinators that acted as pivots between climate information providers and the municipality, and between the actors in the municipality i.e. servants and politicians.
In both cases, several municipalities' departments were already tackling certain climate-related hazards through their on-going sectoral plans, actions and protocols. For Barcelona, in terms of CCA policy integration, three entities work in synergy: the Environment office, the Water agency, and the Public health agency. The degree of integration among them is medium, which means that they coordinate and harmonize the CCA issue among them from the flood and vector-borne diseases perspectives. Instead, the civil protection office wasn't directly involved in the CCA plan making, despite the set of CCA-related emergency plans. The emergency issue has been carried by the Resilience office, which is the charge of the CCA issue of the Pla Clima and has been the pivot between the Pla Clima coordinator and the civil society office.
In the case of Turin, municipal servants from the departments involved into the policy-making have started tackling CCA with pilots (e.g. sustainable drainage

devices implemented in a street, green roof in a civic building, rainwater infrastructure retrofit) or with extraordinary maintenance (e.g. improving the water drainage systems of roofs and buildings).
The municipal servants, except the one of the Urban planning department, joined the inter-departmental meetings since the beginning and many of them stated the importance to communicate and create synergies between departments. The Urban planning department behaved as a silo since the beginning: it didn't take part in the first inter-departmental meetings because it was assumed that the CCA issue belonged just to the Environment department. Moreover, it also hindered the integration of CCA into the Master plan revision process.
Along the inter-departmental process, they joined also the city-to-city learning programme's meetings and events. Portland municipality, that was considered a good practice by the city-to-city learning programme's organizers, namely the German Marshal Foundation, shared their CCA-dedicated plan achievements with the Turin municipal servants and politicians. Both processes have helped in raising awareness of the CCA issue and the CCA policy-making process helped create the basis for the CCA policy integration, which is still at the beginning of the coordination.

This dedicated approach helped in rising CCA awareness of politicians and civil society. On the other hand, findings confirmed the risk that a CCA-dedicated plan can be perceived, especially from the municipal servants and technicians, as the n^{th} new tool that overlaps with the existing and on-going ones, and add-on new goals and tasks not integrated within the existing planning framework.
In terms of effectiveness, a CC- or CCA-dedicated new sectoral plan acts as a palliative. Hence, it might help in starting to deal with the issue superficially, but it does not help to tackle CCA in the long-term.

Spatial planning systems and CCA governance

Spain and Italy – the countries to which the case studies of this thesis belong – together with France, Portugal and Greece, are part of the "Urbanism" planning tradition group (Giannakourou, 2005; Janin Rivolin, 2018; Rivolin & Faludi, 2005). These countries with similar planning and administrative systems (Dasí, González, & Madariaga, 2005; Giannakourou, 2005) often result in a rigid and formal model of regulation. They are typically characterized by low legalistic flexibility so they have been included in the group of the so-called 'Mediterranean Syndrome' of governments (Giannakourou, 2005 citing La Spina & Sciortino, 1993).
In this setting, local governments are dependent on the central national power, and in the case of CC-related planning, municipalities have found difficulties in designing long-lasting policies due to lack of consistent national planning. In terms of CCA national policies, Spain has a National CCA plan, which was updated twice, but it is not mandatory, and Italy has a National CCA plan stalled since 2017. CCA is a multi-level issue and the Italian and Spanish National bare policies conditioned the CCA policy-making and integration at the lower levels. In the case of Barcelona, the Regional and Metropolitan levels played a key role in preparing the groundwork

for the local CCA planning. In the case of Turin, the Regional level was designing the CCA regional strategy and helped in framing the municipal CCA planning.
Regarding the CCA mainstreaming into local planning frameworks of Barcelona and Turin, the results confirm that both planning and administrative systems are still locked-in the 'command-and-control' approach (Roo, 2017), especially in Barcelona case when looking at the co-implementation phase and the monitoring system design. This approach emphasizes the conformance mentality, that is in line with the rigid regulative frameworks of southern European countries, and the technocratic *modus operandi* (de Roo & Silva, 2010). This is particularly clear in the case of Turin, especially when looking at the CCA policy-making process whose actors involved belonged just to public organizations.
Both cases also highlighted a strong vertical political authority and the presence of silo mentality – Turin for the Urban planning department and Barcelona for the Resilience office. The vertical integration of CCA into higher and more powerful plans, i.e. Master plan, is still a challenge. Barcelona has started incorporating the CCA issue into the master planning revision debates, whereas Turin's CCA integration process was hampered by the Urban planning department's resistances. Hence, case studies' findings also highlight difficulties in horizontal coordination, especially in the Turin case.
Mainstreaming is also criticized because its application into existing logics and structures, if not addressing the political dimensions of CCA, perpetuates the risk to reproducing the business-as-usual approaches to planning and development, in the name of CCA (Scoville-Simonds, Jamali, & Hufty, 2020). Regarding the case studies, findings confirm that the adaptiveness of local planning and administrative frameworks is still low, and several business-as-usual approaches are still perpetuated. However, attempts of unlocking technocratic patterns of rigid control and regulation have been employed, which posed the ground for effective CCA mainstreaming in the medium terms.

6.2 A Research and Practice Agenda for local climate change adaptation mainstreaming and planning

This section addresses the key learnings in the CCA mainstreaming and planning fields (6.2.1) and provides insights and tips for practitioners and policy-makers (6.2.2).

6.2.1 Research learnings

Research on climate change adaptation mainstreaming

The analytical framework application demonstrated that climate information production and delivery have to be considered always when researching on CCA mainstreaming because they play a critical role in the CCA policy making. Due to a series of inter-locked causes, climate information production and delivery can affect negatively the CCA understanding, policy integration, and implementation.
Mainstreaming of CCA into local planning framework should be considered as a series of processes and assessed as a whole (Persson & Runhaar, 2018), including the input, i.e. the climate information, and the wide spectrum of tools that local governments use or experiment nowadays. In fact, CCA mainstreaming is not a linear process, but rather an iterative and erratic journey and should not considered just as a mere list and allocation of resources, objectives and instruments.
Furthermore, findings confirm the other argument regarding the barriers/enabler approach, which is too simplistic and doesn't explain why CCA find impediments in the integration into local planning frameworks and in reaching effective implementation (Biesbroek et al., 2013). Hence, this thesis argues that what is actually mainstreamed into the policy-making processes and the local planning frameworks are the climate information and services. More research is needed in this research niche, enlarging the spectrum of climate information approaches – not just the predict-and-provide. Hence, other ways and approaches of climate knowledge production and delivery should be investigated under this lens. Finally, findings on the Barcelona case, concerning the civic engagement in CCA policy processes, highlighted the need to endeavouring research on both mainstreaming and co-production, confirming and reinforcing what stated by Brink & Wamsler (2018).

Research on local climate change adaptation planning

Research on CCA-related plans

According to the findings of this research the CCA-dedicated planning approach has started making efforts for supporting the integration of CCA including the set of existing and on-going planning and policy tools. Still, the evidence that the climate information affects and hampers the CCA planning and policy-making processes make the dedicated planning approaches not totally responsible for the

CCA integration and implementation gaps. Nevertheless, more research is needed to understand the relation between climate information creation and delivery, approaching with policy or civic engagements, at the service of different planning tools, considering the whole spectrum of planning tools, and especially the ones that act at higher levels than the sectoral ones, e.g. local comprehensive plans, municipal development plans, master plans.
From the temporal perspective, there is a need for greater attention to climate change consequences and adaptation over near-term time horizons, highlighting the need to create and delivery not just one-shot stand-alone CC projection analysis, but also climate prediction (Meehl et al., 2009), which work in the near-term horizons (e.g. one or two decades), and researching on it as well.

CCA conflicts, trade-offs, and disservices

The findings showed that the CCA measures proposed to tackle mainly few climate-related hazards, namely heatwaves, floods, and droughts. These measures are mainly aiming at greening the city through nature-based solutions and at making its water-related grey infrastructure more efficient. Nevertheless, the measures' effectiveness can be consistent for some hazards but vulnerable to other ones. In the case of nature-based solutions, i.e. trees that are the main solution for tackling heatwaves are extremely vulnerable to droughts and wind-related extreme events (e.g. strong winds and storm surges). This finding calls for research in the CCA measures conflicts and trade-offs with the wide spectrum of climate-related risks.
Furthermore, green and grey solutions embedding a water-sensitive approach can provide disservices. In case of prolonged wet periods, due to the "tropicalization" of the Mediterranean region, these devices can provide a perfect habitat for vectors, e.g. insects, that may carry diseases. Therefore, this finding spots the attention to endeavouring further research on CCA services and disservices.
CCA measures' inner conflict, trade-offs, and disservices are to-date a field not yet explored, which are forms of maladaptation and can be included in this research field (Magnan et al., 2016; Parsons, Nalau, Fisher, & Brown, 2019).

Research today on CCA: towards a transdisciplinary approach?

What is the role of Science for tackling CC and especially CCA?
Scholars are questioning whether Science is "of CCA" or "for CCA" (Preston et al., 2015; Swart, Biesbroek, & Lourenço, 2014). Building on Preston et al (2015) and Swart et al (2014), this thesis ponders on the role of CCA research and its ultimate goal. From this, two questions arise:

- Do the academic research endeavours have to be at the service of Science? Therefore, researching and communicating what is true and creating new knowledge validated by peers.
- Do the academic research endeavours have to the service of the "Adapters" (e.g. decision-makers, citizens, private companies)? Therefore, researching and communicating what works and what does not.

Building on Armitage et al., the two approaches differ from each other because the Science of CCA is reckoned as a process of teaching and educating and the Science for CCA as a process of learning (2008).
There is evidence that critical information is omitted when moving through the Science-Policy interface. Indeed, science-based climate information is not exhaustive (Keys et al., 2019; Preston et al., 2015) and the lack of accuracy, legitimacy, and policy and civic inclusion in the creation hamper the CCA planning and hence its implementation.
This thesis investigated also on the notion of co-production, which will be pondered in deep in the conclusions, that is a concept that embeds characteristics of transdisciplinarity that has started being applied in the Climate service (Bremer et al., 2019) and the CCA planning fields. It fits perfectly within the Science for CCA debate and can be applied at the service of both Science-Policy and Policy-Action interfaces.
Building on Preston et al. (2015) Science of and Science for CCA should achieve alignment and synergy, despite remaining a challenge. Planning for CC challenges not only governmental organizations but also educational and research organizations (e.g. Universities). This spotlights on the need to reflect on the role of the research enterprise and its openness to the non-academic entities through the use of trans-disciplinary approaches, e.g. co-production (Bremer et al. 2018) and post-normal science (Dankel, Vaage, & van der Sluijs, 2017), and actors, e.g. facilitators and boundary managers (Graham & Mitchell, 2016; Kirchhoff, Lemos, & Kalafatis, 2015; Preston et al., 2015; Therrien, Jutras, & Usher, 2019).

Analytical framework's potential applications

The analytical framework created and used in this thesis for researching on CCA mainstreaming was useful and supported answering the research questions.
The inclusion of the co-production concept along with the thesis development, and its consequent investigation, highlighted the need to improve the analysis of the policy and civic engagement at the Science-Policy and Policy-Action interfaces. New criteria and sub-criteria can be added, e.g. adaptiveness and the inner sub-criteria of learning and innovating capacities (Armitage et al 2008, Folke et al 2005) and the co-production criterion (Sarzynski 2015).
The framework can be used also for other cases with different:

- Climate information production and delivery approaches (less rigid or with technical and civic knowledge engagement),
- Planning tools not formally dedicated to CCA, where CCA objectives are incorporated, e.g. local comprehensive plans, master plans, strategic plans.

In line with the need to standardize procedures for integrating CCA into decision-making processes of both public and private organizations ("ISO - ISO 14090:2019 - Adaptation to climate change — Principles, requirements and guidelines," 2019), the analytical framework can be applied also in other setting and contexts, differing from governments, i.e.:

- Private organizations (e.g. donors, insurance companies, regional professional *consortia*, energy companies)
- Universities considering the educational curricula (Davidson & Lyth, 2012; E. Hamin & Marcucci, 2013; Molthan-Hill, Worsfold, Nagy, Leal Filho, & Mifsud, 2019)

6.2.2 Insights and tips for planners and policy-makers

Local CCA planning has several key challenges that affect its ultimate goal, the implementation. This thesis posed the attention to the climate information production and delivery and with this suggest the planners and the policy and decision-makers widen their scope and include in their tasks the climate- and the weather-related information detection.
The multi-risk nature of CC obliges the policy-makers in engaging more with the climate information producers. The best-case scenario will be a climate service co-produced by policy-makers, civil society, public servants, multi-disciplinary research group, and the climate knowledge producer. They may gather together in institutionalized cyclical meetings within a boundary organization (e.g. Living Labs) and will co-produce a set of climate-related information (Coaffee et al., 2018; Normandin & Therrien, 2016; Normandin, Therrien, Pelling, & Paterson, 2019; Therrien, Jutras, & Usher, 2019).
Both cases, Turin and Barcelona, showed that just a "one-shot" and stand-alone analysis has lacks that hamper the CCA policy-making and its integration within the local planning frameworks. The Earth climate, due to its inner uncertainties and to the continuous increasing of green-house gases emissions, is still changing – in worse – and this obliges the decision-makers in keeping continuously in contact with the climate knowledge producers, i.e. Academics, Knowledge brokers, CC risk analyst, Meteorological agencies. An intermediary, which can be an organization that acts as a knowledge broker (e.g. consortium, research centre) or a neutral arena (e.g. living lab), is a useful option. Indeed, the case of Barcelona showed that the purveyor – the intermediator – helped in improving the reliability, accuracy and legitimacy of the climate information. CC projections are important but embed technical biases and mismatches with the time managed by the planners. For this, climate predictions can be added in order to have climate information and services more precise and accurate in the near-, medium-terms.
Another important issue that arose from the case study analysis relates to the CCA measures inner conflicts and disservices. This thesis addressed the CCA measures consistency and certain types of measures, i.e. greening and water-sensitive solutions, are effective to certain climate hazards (e.g. floods, heatwaves) but can also be vulnerable to other climate hazards (e.g. winds) or even triggers of climate-related threats (e.g. vector-borne diseases). Therefore, due to the complexity of CC and the consequent difficulty in designing effective CCA measures, it is

recommended to consider CCA measures, since the pre-planning phase, as vulnerable assets.

Who leads the local CCA planning?

This thesis showed that there are conflicts between departments, especially with the ones that act as silos – neither sharing information nor participating in the other departments' initiatives. Therefore, this thesis encourages joining the forces between departments supported by:

- A co-leading approach, involving more key departments (i.e. Urban planning, Environment, Civil Protection) in the leadership of the CCA policy making,
- Basing the policy-making on the information from the servants and technicians that mostly tackle extreme events in practice, e.g. Civil protection, Water Agency, Public health, Green and tree management,
- A permanent roundtable that gathers every two/three months all public actors – internal actors of local governments, public offices, and agencies that are in charge of climate-related issues.

What type of plan fits better the CCA needs?

The CCA-dedicated approach demonstrated to be helpful but with reserves.
Aware of the fact that cities are tackling CCA incorporating it into other non-dedicated plans (Tiepolo et al 2017), this thesis posed the attention on the fact that a CCA-dedicated plan can be a strategic pivot to let enter the CCA issue into the local planning framework in order to mainstream it with the *conditio sine-qua-non* to make the consequent effort to integrate it at higher levels, e.g. Master Plan, Comprehensive Plan, Municipal Development Plan.
In case of difficulties of making this vertical integration, this thesis suggests keeping the CCA-dedicated plan alive and update it constantly jointly with the existing and on-going sectoral plans and programmes. New CCA-dedicated plans may be considered as 1.0 versions that will be improved and updated (e.g. 1.1, 1.2, etc.) until reaching the next levels (e.g. 2.0, 3.0).
The joint theoretical application of mainstreaming with co-production allowed to consider also the strategic planning approach. Nevertheless, these approaches are not yet confirmed to-date by science-based evidence as effective for CCA. Due to these gaps, it might be useful to adopt these approaches as a learning process and co-lead the CCA strategic plan-making with an academic organization, which will both support and study the policy and decision-making processes.

Chapter 7

Conclusions

Local CCA planning has a series of gaps that this thesis addressed, i.e.: CCA planning often doesn't reach the implementation phase; CCA objectives are often not integrated – mainstreamed – into the local planning frameworks especially when policy and planning dedicated approaches are employed; CCA objectives and measures find difficulties in taking pace and becoming long-standing; the role of science-based climate information in CCA mainstreaming as well as CCA co-production are aspects in need of further investigation.

Investigating the key challenges for local CCA planning through exploring the different stages of policy-making processes and the Science-Policy interface, this study identified the impediments that hamper CCA policy integration and implementation. In order to investigate these issues, the theoretical lens through which this research was conducted is the concept of 'mainstreaming'. Aware of the limits of the "barriers" approach, this research called for the elaboration of new analytical framework tailored for detecting policy integration dynamics and including climate information and services, which have been excluded to-date from most of the studies on CCA mainstreaming.

Two municipalities promoting CCA-dedicated policies and plans were analysed, Barcelona (ES) and Turin (IT). Accordingly, this research contributes to the CCA planning and mainstreaming fields by investigating, reporting on the experience of and analysing mid- to large-sized cities, and this dissertation's conclusions are tailored for these city typologies.

Climate information and services

Case study findings show that climate information and services, when produced and delivered following a rigid top-down and "predict-and-provide" approach, carry technical biases and gaps that affect local CCA planning. This research found that science-based climate information and services, although reliable, cannot be exhaustive and effective if not accurate in the communication and legitimated by the end-users needs. In both cases, climate information and services were created

and delivered with no local technical consultation or civic participation. In fact, due to data availability and to the lack of policy and civic engagement, critical information remains "off the radar". Moreover, the CC analysis, using a hyper-technical glossary, which was delivered and eventually communicated just to a few people, i.e. CCA plan coordinators, hampered both the CCA policy-making and the CCA policy integration processes. Thus, exclusive expert-led production of climate information passing through a bottleneck led to a pattern that looks like a path dependency.

CC analysis including just temperature- and rainfall-based projections, which are the best known variables, due to the presence of historical datasets, communicates the message that in the years to come heatwaves, floods, and droughts will be more severe and frequent. These are events that have already occurred and both municipalities have suffered from them without solving them completely. This highlights the fact that in both cases the municipalities have not completely adapted to the past-to-date climate conditions. Planning for CCA means assuming implicitly that we are already adapted to past-to-present climate conditions, whereas the reality proves that there is a CCA deficit in both case-study cities.

Climate change adaptation measures

The measures designed and planned for tackling CC mainly consist of greening solutions and grey infrastructure enhancement. Both CCA solutions are consistent for tacking droughts, floods, and heatwaves, and greening solutions are considered the *panacea* and proposed as a 'one-size-fits-all' solution. However, the multi-risk nature of CC obliges us to consider several climate-related risks – as a compound – and their direct effects. In fact, heatwave-, flood-, and drought-focused solutions might be neither effective nor useful for tackling other extreme events, e.g. winds, tornadoes, storm surges, vector-borne disease, and the sea-level rise. For example, greening solutions i.e. trees, are hampered by strong winds, tornadoes, and storm surges. Similarly, green and grey water-sensitive solutions e.g. rainwater gardens, bioswales, and inlets, during prolonged wet periods are the perfect hub for mosquitoes that are disease-carrying vectors. This research therefore focuses its attention on the consistency of certain CCA measures, on the conflicts and trade-offs between CCA measures and CC hazards, and on the disservices that certain CCA measures might provide. The inner conflicts, trade-offs, and disservices of CCA measures are unexplored fields, which can be included in the maladaptation research field.

Climate change adaptation dedicated plans and policy integration

Empirical findings from both municipalities showed that CCA-dedicated policy and planning approaches affected CCA integration into the local planning frameworks. Both cases' planning processes aimed at producing a strategic umbrella, rather than a "stand-alone" plan, under which existing sectoral plans and measures are framed and coordinated. This approach helped in raising awareness of the CCA issue and laid the foundations for the CCA policy integration in both cases, with some differences. In the case of Barcelona, some municipal departments and offices have

a long-standing tradition of coordination and, thanks to this existing relationship, have started harmonizing CCA measures and objectives, enhancing CCA integration. In the case of Turin, the CCA policy making was hampered by several internal impediments. CCA policy integration into the planning framework had to face the long standing administrative characteristics of vertical political authority, implying in some cases the presence of silo mentality, and low level of coordination among departments. Nevertheless, these impediments have been started solving due to the CCA strategic umbrella approach.

Concerning the choice of designing a new dedicated and sectoral plan, findings also highlighted some drawbacks. If on one hand, the dedicated approach helped in raising CCA awareness, on the other hand, CCA-dedicated plans may look, especially from the viewpoint of municipal technical staff, as the n^{th} new tool that overlaps with the existing and on-going plans, and 'add-on' new goals and tasks not integrated within the local planning framework.

The dedicated approach applied to CCA mirrors the long-standing characteristic of local governments to specialize and consequently to 'add-on' new sectors, plans, offices, and procedures. Case study evidence shows that this approach is limited by its inherent propensity to "sectorialize" a cross-sectoral issue and thus ends up having the characteristic of a palliative. Indeed, whilst it might help in starting to deal with the issue, although in a 'light' and superficial way, it does not lead to effective CCA integration. Moreover, if managed by just one department and limited staff it carries the risk to disappear easily as well as the CCA objectives.

The approaches employed by both municipalities, framing the plans as strategic umbrellas, supported the inclusion of CCA objectives in the local planning frameworks and enhanced coordination between departments. Still, there is evidence that climate information affected and hampered the CCA planning and policy-making processes. In both cases, the CC-dedicated plans and processes are conditioned by the climate information, which hampered the CCA policy integration and makes dedicated planning approaches not totally responsible for the low degree of CCA integration. Therefore, further endeavours are needed to understand local CCA planning processes, by using the 'mainstreaming' lens, including different approaches of stakeholder engagement from the pre-planning phase, i.e. climate information production and delivery. It is also necessary to investigate other planning tools, especially the ones that act at higher levels than the sectoral ones, e.g. local comprehensive plans, municipal development plans, master plans.

Barcelona case: civic engagement and co-production

The design of CCA measures was carried out mainly through internal municipal consultations, i.e. exchanges among department officers.

In the case of Barcelona, there was also a public consultation for co-designing CC-related measures, and a co-implementation phase. The findings showed that the administrative culture of the municipalities is still locked-in to the conformance mentality and a command-and-control approach. Regarding the monitoring system of Barcelona's plan, the indicators for CCA are lowly consistent, and during the co-

implementation phase they didn't match the needs of the CCA-oriented project actors. Therefore, CCA monitoring is still a challenge and further research endeavours are necessary to make it more consistent and able to avoid maladaptation.
Barcelona case investigation also led to further findings, which prompted theoretical reflection on CCA co-production and mainstreaming. However, the gaps in the joint application of the both concepts in CCA planning still remain.

Methodological learnings and limitations
This research demonstrated that CCA mainstreaming should be considered as a series of processes and assessed as a whole, including the input, i.e. the climate information, which plays a critical role in CCA policy design and integration. Hence, this thesis argues that what is actually mainstreamed into the policy-making processes and the local planning frameworks is the climate information and it is recommended to always consider this aspect when researching the CCA planning field.

This research also has some limitations. The number of case studies is limited, i.e. two, and this has conditioned the generalizations of this dissertation's contributions. The methodological data triangulation with secondary data analysis, interviews, and participant observation, demonstrated reliability and led to relevant findings. In the case of observations, this method was very helpful in "connecting the dots", which were provided through interviews and secondary data analysis. However, other methods can be added in future research in order to enhance the research and provide a more thorough documentation of science-policy and policy-making dynamics. A method that could be added is the survey. In the Barcelona case, an online survey based on mixed open and close structured questions could have helped in overcoming the lack of access to municipal staff. Furthermore, it was not possible to organize focus groups in either case, nonetheless this method is appropriate for detecting the dynamics between municipal departments and could have been useful in bringing together and consolidating the views of different actors and a diversity of perspectives.
Based on the research results, the analytical framework proposed and applied in this research, which might also be improved with further criteria, is a valid and useful tool for researching the issue of CCA mainstreaming and led to consistent findings. This exploratory research also paved the way for a better understanding of the joint application of co-production and mainstreaming concepts in CCA planning research. Co-production and adaptiveness (e.g. learning capacity, innovation capacity) can be the analytical lenses that might be used and added to the analytical framework of this research.

For the purpose of this thesis, the analytical framework provided good results and data, provided a structure for critical comparative analysis, accomplished expectations, and can be used as a proxy. It is an approach that demonstrated its validity and is recommended to be used in future studies. The framework can be used for studying different governmental levels (e.g. national) and organizations

(e.g. private companies), investigating different climate information production approaches (e.g. public consultation, co-production) and different planning tools (e.g. master plan, comprehensive plan). This analytical framework can be also used by policy-makers, planning practitioners, donors, and evaluators. In fact, it can work as a road map for monitoring the progress of CCA processes.

Implications and practical recommendations

Critical attention was posed to climate information and services production and delivery. In particular, this thesis recommends that planners and policy and decision-makers should widen their scope and include climate- and the weather-related information detection and production into their planning processes' tasks. Furthermore, due to the multi-risk nature of CC, policy-makers are encouraged to engage more with climate experts and risk analysts. An intermediary, which can be an organization that acts as a knowledge intermediary (e.g. consortium, research centre) or a neutral arena (e.g. living lab), is a useful option. Moreover, CC projections are important but may embody technical biases and temporal mismatches with planning and management processes. For this, short-term future climate information, i.e. forecasts and predictions, can be added in order to increase the climate services reliability and accuracy.

Another important issue that arose from the case study analysis relates to the CCA measures inner conflicts and disservices. This thesis addressed the CCA measures consistency and certain types of measures, i.e. greening and water-sensitive solutions, are effective to certain climate hazards (e.g. floods, heatwaves) but can also be vulnerable to other climate hazards (e.g. winds) or even triggers of climate-related threats (e.g. vector-borne diseases). Therefore, due to the complexity of CC and the consequent difficulty in designing effective CCA measures, it is recommended to consider CCA measures, since the pre-planning phase, as vulnerable assets.

This thesis showed that municipal departments tackle the CCA issue independently, and some do not coordinate or may even act as silos. In order to overcome this impediment to CCA integration, this thesis encourages 'joining the forces' among departments through a co-leading approach. This implies that more departments should lead CCA policy-making processes, with more importance given to the offices that mainly tackle climate-related events, e.g. Civil protection offices, Water agencies, Public health departments and agencies, Environmental departments. It is recommended to institutionalize a permanent roundtable, involving all local government departments as well as external public offices and agencies that tackle CC effects – permanent roundtables should gather all actors every two/three months.

In conclusion, the CCA-dedicated approach demonstrated itself to be helpful for local governments but with reservations and limitations. This thesis highlighted that a CCA-dedicated plan, if set as a strategic umbrella, can be pivotal in introducing the CCA issue into the local planning framework in order to then mainstream it with the *conditio sine-qua-non* of making the consequent efforts to integrate it at higher

levels, e.g. Master Plan, Comprehensive Plan, Municipal Development Plan. If this vertical integration is not applicable, it is suggested keeping the CCA-dedicated plan or strategy alive and updating it constantly and jointly with the existing and on-going sectoral plans and measures. In particular, it is highly recommended, whatever planning approach is used, to keep the CCA issue alive and therefore considering plans or strategies that incorporate CCA objectives as living planning tools.

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Appendix A – Interviews structure

In total 34 in-depth interviews were realized; 13 for Turin case, 21 for Barcelona case. All of them were key actors of the CCA planning processes and were asked semi-structured questions. The interviews were carried out between April 2018 and July 2019 and were conducted *in-situ* or via phone. The ones contacted via phone were already known beforehand or were met in person after the interview. The interviews were conducted in Italian for the Turin case, and in Spanish and English for the Barcelona case.

For what concerns the profile of interviewees, most of them are public officials from organizations having direct competences on climate-related issues. Given the focus of the research, interviews were mainly addressed to members of the technical stuff, and not to political representatives. In the Barcelona case, there is another category of interviewees that is composed by practitioners and citizens that participated to the co-implementation phase of Pla Clima.

For Barcelona, the interviewees were 10 public servants – 6 from Barcelona municipality, 1 from Barcelona municipal public health agency, 1 from Barcelona municipal water infrastructure management agency, 1 from Barcelona metropolitan body, 1 from Catalan Meteorological Agency –, 1 employee from Barcelona Regional, 9 practitioners, and 1 citizen representing a group of 7 people that are part of a Primary School Association.

Code	Organization	Role	Date (dd/mm/yyyy)
B01	Barcelona municipality	Pla Clima coordinator	10/11/2018
B02		Pla Clima co-implementation coordinator	05/07/2019
B03		Environment office technician	23/11/2018
B04		Civil protection office technician	22/11/2018
B05		Sustainable office technician	13/06/2019
B06		Urban planning office technician	25/01/2019
BM1	Barcelona Metropolitan agency	CCA plan coordinator	19/11/2018
BH1	Barcelona public health agency	Vector-borne control officer	23/01/2019
BW1	Barcelona water infrastructure agency	Offices coordinator	20/11/2018
BA1	Meteorological agency	CC scenarios officer	03/12/2018
BR1	Barcelona Regional	Technician	19/11/2018
BC01	SOM Mobilitat	Project coordinator	19/02/2019
BC02	ASSOCIACIÒ BARCELONETA ALERTA	Project coordinator	22/02/2019

BC03	AMPA IES MENENDEZ Y PELAYO	Project coordinator	15/02/2019
BC04	FUN. PRIV. HABITAT 3 TERCER SECTOR	Project coordinator	28/05/2019
BC05	ASS.CATALANA ENGINYERIA SENSE FRONT	Project coordinator	25/02/2019
BC06	INSTITUT 4 CANTONS	Project coordinator	14/05/2019
BC07	ECO UNION	Project coordinator	21/02/2019
BC08	SOLUCIONS EIXVERD SL	Project coordinator	26/03/2019
BC09	LAVOLA	Project coordinator	22/02/2019
BC10	Ana Vilagordo Arquitectura	Project coordinator	09/05/2019

In the case of Turin, the interviewees were 13, i.e.: from the Turin municipality 1 politician, 1 political entrepreneur and 10 municipal servants; from the ARPA, the regional agency for environment protection, 1 officer that was the coordinator of the CC analysis.

Code	Organization	Role	Date (dd/mm/yyyy)
T01	Turin municipality	CCA planning coordinator – Political entrepreneur	09/10/2018
T02		CCA planning technician	09/10/2018
T03		Public building office technician	11/04/2019
T04		Mobility office technician	10/04/2019
T05		Urban planning office technician	10/04/2019
T06		Civil protection office responsible	11/04/2019
T07		Environment office technician	10/04/2019
T08		Tree management office technician	22/04/2019
T09		Streets and Transport office technician	10/04/2019
T10		Social care office technician	17/04/2019
T11		EU-funded projects technician	10/04/2018
T12		Environment Department Head – Politician	08/05/ 2019
TA1	Agenzia Regionale Protezione Ambientale Piemonte	CC analysis coordinator	24/10/2018

Dialogue with selected stakeholders has been carried out through semi-structured interviews, lasting on average 1 hour. When necessary, questions have been adapted or specified to acquire more detailed information, or other questions have emerged during the interaction. Also, they have been slightly changed according to the profile of the interviewed.

The following table indicates the general interview structure.

In both cases, the in-depth semi-structured interviews' questions policy makers and municipal servants focused on:

- CC hazards and CC analysis reading and perception
- CCA understanding and perception
- Sectoral CCA measures planned and implemented
- Policy and planning coordination between sectors and organizations

- Perception of CCA-dedicated policy and planning processes

CC hazards and CC analysis
- Did you read the CC analysis documents? - What did you understand from the analysis?
CCA understanding
- What does CCA mean for you? - Which hazards have to be tackled for an effective CCA?
Sectoral CCA measures
- Have you designed and planned CCA in your department/office? - Which measures and plans are tackling CCA? Which hazards are tackled?
Policy and planning coordination
- Do you coordinate with other offices/departments/agencies? - How do you collaborate with them? Do you meet formally or informally? - Do you have official procedures that relate with the CCA issue?
CCA-dedicated planning perception
- Do you consider CC- or CCA-dedicated plans useful and needed? - Do this approach work in synergy with your sectoral measures and plans?

For both cases, the actors involved the CC analysis and assessments were interviewed using the same structure, as shown below, based on the climate information reliability, accuracy, and legitimacy.

Reliability
- Which variables did you take into account for the CC analysis/assessment? - Which models you used? - How did it take for making the analysis? - What is the time scale managed? Why did you choose this approach?
Accuracy
- How did you communicate the analysis? - Did you embed and explained the degree of uncertainty in the analysis?
Legitimacy
- What was the perception of the end-users? - Did you involve the end-users in the CC analysis production? - Did you tailor the analysis according to the end-users' needs?

In the case of Barcelona's co-implementation, the interviewees were the 10 leaders of the projects funded by the municipality. 10 out of the 11 projects were considered, the one missing never answered and never appeared in the internal meetings. The interviews conducted for this set of actors were made of open questions that round on the interviewees':

- Awareness of CC effects and perception on Pla Clima's climate information
- CCA understanding and CCA/CCM definitions
- CCA relation with their projects
- Perception on the indicators provided by the municipality

Awareness of CC effects
- Did you read the CC analysis? - Are you aware of CC effects? Which are the hazards that relate with CC?
Perception of Pla Clima
- Did you read the Pla Clima?

- How does the Pla Clima relate with CC? - Are the goals coherent with the current CC effects?
CCA and CCA/CCM understanding
- What is your definition of CCA? - Could you explain the difference from CCA and CCM?
CCA relation with their projects
- How CCA relate with your project?
Perception on the indicators
- Do you think that the Pla Clima's monitoring system include useful indicators for monitoring CC and CCA? And for monitoring your project?

Appendix B – Climate change adaptation mainstreaming bibliography

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Appendix C – Turin case. International climate change adaptation good practices

◀ Adaptation strategy
Paris, 2007 (2015 updated)

	Building	Street/quarter	City level
PROACTIVE MEASURES	Insulate buildings Cooling systems (e.g. heat pumps) Sun screens, blinds and shutters Provisions for heat disposal (e.g. chimneys) Building orientation (reduce sun exposure) Heavy building materials (high solar thermal mass) Green roofs (i.e. plant cover) Green facades (i.e. plant cover) Increased reflecting levels of roofs (albedo) Insurances (building owner)	Open water, fountains mistress Vegetation (cooling due to evaporation) High albedo pavement instead of asphalt Creating optimal shading in: - building orientation - compact building and - (big leaf) trees Orientation and profile of streets regarding wind direction (affecting wind speed and urban ventilation)	Conduct research on heat stress Anticipate possible peaks in deaths and hospitalisations (access to/capacity of medical care)
REACTIVE MEASURES	Cooling (air conditioning) Medical care (building owner)	Replacement of vulnerable groups Monitoring and inspection Warning systems and disaster contingency plans Wetting streets and roofs Information campaigns Move to cooler areas	

▲ Pla clima
Barcelona, 2018

◀ Climate Adaptation strategy
Melbourne, 2017

August 2013
during a 10 days heatwave
more than 60.000 casualties
in France, Italy and Spain

POSTER 1
Climate adaptation for heatwaves

Gruppo di Lavoro Inter-Assessorile della Città di Torino
per la Strategia di Adattamento ai Cambiamenti Climatici

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CITTÀ DI TORINO

Building	Street/quarter	City level
Downpours Waterproof building, for example Floor above street level High thresholds No crawl spaces Waterproof plaster and membranes on walls Waterproof floors Green roofs (i.e. plant cover) Green facades (i.e. plant cover) Water drainage (drainage in gardens, gutters etc.) Unpaved gardens (infiltration, water retention) **River flooding** 'Floating' buildings Pile-dwellings **River flooding and downpours** Insurances (building owner)	**River flooding** Enhancing capacity of sluices and weirs Elevate urban areas Additional flood defences (dykes or buildings) or reinforcing existing ones Replacement of vulnerable buildings and infrastructures Disaster contingency plans (e.g. temporary dykes) **Downpours** Seeping water 'screens' Water permeable pavement instead of asphalt and other measures for better infiltration and water outlet Lower water tables Separation of rainwater and sewage water plumbing Rainwater detention devices **River flooding and downpours** Monitoring and inspection Warning systems Evacuation plans Extra green space Water storage facilities (open water such as pools) Increase sewer capacity or enhanced maintenance Drainage systems Dry pumps and other provisions for water discharge and clean-up	**River flooding** Options for water storage and retention in or near city Evacuation plans Ban on building in flood-prone areas Compartmentalisation **River flooding and downpours** Conduct research Information campaigns

PROACTIVE MEASURES

REACTIVE MEASURES

◀ Climate change adaptation strategy Rotterdam, 2013

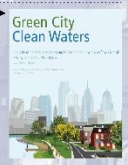
Plan New York City, 2011 ▲

Adaptation strategy ▲ Lisboa, 2017

▲ Climate action plan Portland, 2015

▲ Climate adaptation plan Copenhagen, 2011

Green city, Clean waters ▶ Philadelphia, 2015



July 2011
a night cloudburst flooded Copenhagen with 1.040 M$ losses and damages

POSTER 2
Climate adaptation for floods

Gruppo di Lavoro Inter-Assessorile della Città di Torino
per la Strategia di Adattamento ai Cambiamenti Climatici
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