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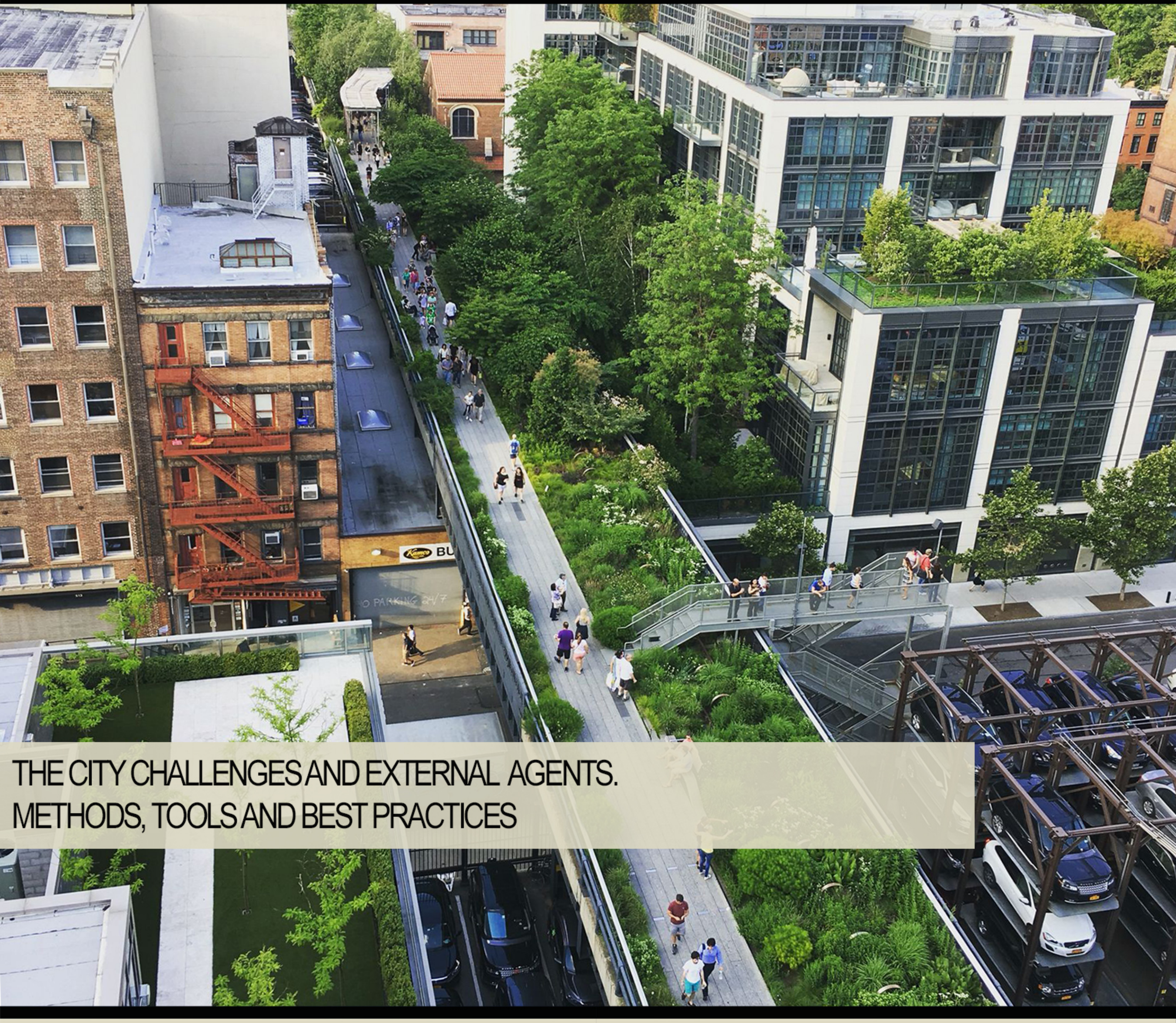

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METHODS, TOOLS AND BEST PRACTICES

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Fostering the climate-energy transition with an integrated approach

Synergies and interrelations between adaptation and mitigation strategies

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Abstract

Cities have a key role in tackling the challenges related to climate change and they constitute an ideal framework to engage with low carbon and green agendas, and to transform the built environment with resilient and inclusive measures.

In this paper, the relationship between adaptation and mitigation strategies has been investigated, to evaluate the possibility of combining them in planning policies and design practices. To this end, recent studies and European policies are reviewed to examine the interrelation between adaptation and mitigation strategies, and to explore to which extent a more integrated approach is foreseen towards urban transitions. The review allows an assessment of synergies, trade-offs and conflicts between adaptation and mitigation in urban practices and highlights several win-win solutions, such as Green Urban Infrastructure and climate sensitive design. However, the analysis indicates a lack of guidance and coordination, leading to the tendency to consider separately adaptation and mitigation, both in policy and in practice.

The study intends to provide an overview of the interrelations and to present the gaps in current processes, with the aim of fostering a more integrated approach at the local level and of implementing more efficiently low carbon and adaptive solutions.

Keywords

Mitigation; Adaptation; Urban design; Climate policies; Integrated approach.

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1. Introduction

Tackling climate change has recently become a priority for the European Union and for the United Nations, with ambitious programs to reduce carbon emissions and to drive towards sustainable development. The European Union set long-term and short-term targets: reducing carbon emissions by 40% by 2030 and reaching carbon neutrality by 2050 (European Commission [EC], 2018). As highlighted in the Pact of Amsterdam and in the Paris Agreement, cities have a key role in contributing to this challenge. Cities are responsible for around 70% of greenhouse gas emissions due to the extensive use of energy in the building and transport sectors (Grafakos et al., 2019). Additionally, they are vulnerable to the effects of climate change, such as floods and heat waves. Therefore, cities have been implementing actions to respond to these challenges, and they have been self-organizing with climate plans, due to the European and international support for bottom-up approaches (Reckien et al., 2018).

According to the United Nations Framework Convention on Climate Change (UNFCC), mitigation and adaptation address different issues of climate change: the former aims at reducing the causes, while the latter seeks to decrease the impacts. Both policies are necessary to effectively tackle climate change and, even though there is a tendency to consider them separately, many interrelations between their strategies exist in cities. Several studies have investigated the relationships between the two policies and have identified, in different urban scales and components, their synergies, conflicts and trade-offs.

However, despite many studies have highlighted the possibilities of combining mitigation and adaptation in urban areas, an integrated approach is still undeveloped. Thus, urban policymakers acknowledge that, to implement adaptation and mitigation actions, they need to integrate them (Creutzig et al., 2020), but few efforts have been made for an integrated approach (Reckien et al., 2018, Pietrapertosa et al., 2019). A recent study of Reckien et al. (2018) analyzed 885 European cities' climate plans and showed that 66% have a mitigation plan, 26% have an adaptation plan, and 17% have a combined plan.

Landauer et al. (2018) concluded that the lack of combined approaches is due to lack of legislation or guidelines. Other studies (e.g. Klein et al., 2005; McEvoy, 2006) argued that mitigation and adaptation have many differences concerning spatial and temporal scales, and actors and sectors involved. Considering the local scale ideal to combine place-specific policies, national and supranational ones, and to translate policies into specific actions, the study draws upon policies and strategies for urban adaptation and mitigation, to identify practices that combine the challenges in the built environment.

The practice of urban and building design is framed by strategies, laws, regulations and operating rules, including building and energy codes, that often separated the design of a building from its surroundings and limited cross-scale interactions. In the design practice, more attention should be paid to consider the influence of microclimate on a building, or the materials of a building on the local microclimate. In city planning, environmental performances, such as retention capacity and temperature regulation, should be integrated in the plans and regulations. Hence further effort is needed to mainstream combined approaches for climate action at the urban scale.

The purpose of this paper is to identify successes, gaps and challenges to respond to the climate-energy transition in the urban environment with an integrated approach, and to try to make steps forward in the assessment of a combined approach.

The method of the research is presented in section 2. Section 3 provides a literature review of recent studies focusing on this topic and presents a re-elaboration of synergies, conflicts and trade-offs of the design practices in the built environment. Section 4 describes the current policy references and resources on adaptation and mitigation in urban areas and identifies ongoing attempts to integrate the two policies. The case study of the city of Stockholm is introduced in section 5 to provide an example of integration between adaptative and mitigative actions in urban planning. The identified successes and gaps for a combined approach are presented in Section 6. Finally, Section 7 reports some conclusions and recommendations for future works.

2. Method

As a first step of the study, interactions between urban adaptation and mitigation strategies are identified. Many examples of positive and negative interrelations are collected from the literature (e.g. Landauer et al., 2015; Grafakos et al., 2018), referring to the terminology given by Klein et al. (2003). Considering that many sectors influence adaptation and mitigation policies (e.g. mobility, constructions, energy production), in this study we focus only on built environment and measures that transform its surfaces.

Based on the literature, we provide a list of urban practices contributing to adaptation and mitigation and we try to define the drivers of conflicts, trade-offs and synergies between them. Measures with different scales are selected, ranging from building-scale, developed in specific projects (e.g. green roofs, insulation), to the urban one (e.g. wetlands, parks), which are normally implemented by local plans.

Urban practices related to adaptation and mitigation are generally regulated by planning polices and urban development management tools, which are guided by planning instruments, and by programs addressing environmental issues ranging from the European level to the local one. To have an overview on how to address climate-related challenges in the urban environment, the study analyses the European climate adaptation, mitigation and urban policies, to identify strategies or guidelines for integrated approaches. Specifically, the policy analysis aims at identifying potentials and constrains to integrate adaptation and mitigation, scale-related and cross-sector issues, administrative priorities and processes, and limitations.

Finally, the case study of Stockholm in Sweden is presented, by examining interrelations and policy coordination between mitigation and adaptation, and by identifying adaptation strategies influencing mitigation and mitigation strategies affecting adaptation.

By providing a collection of key interactions between urban mitigation and adaptation, and presenting the climate policies and their integration in the urban development plans, we try to contribute to the ongoing debate and stimulate more efforts for climate integrated approaches to practitioners and decision-makers.

3. Interrelations between adaptation and mitigation strategies

To tackle the challenges related to climate change, urban areas should contribute to reduce greenhouse gas emissions and to become more prepared to extreme events. To this end, the climate-energy transition in cities is possible by engaging in mitigative and adaptive actions. Adaptation and mitigation strategies are complementary actions to avoid serious impacts of climate change and they can be combined to create a mix of long-term and short-term effects against it. However, adaptation and mitigation strategies may lead to conflictual situations and incompatible actions. Hence, efforts are required to develop and to implement strategies that facilitate successful integration.

The separation of the approaches led to the mitigation and adaptation dichotomy, which is characterized by 3 main differences. The two policies have incompatibilities concerning the spatial and temporal scale: benefits of mitigation are evident in the long-term and at the global scale, whereas adaptation has immediate effects, which can still be effective in decades, and they are place-specific (IPCC, 2007). Another difference emerging is that they involve different stakeholders: mitigation deals primarily with energy and transport sectors, while adaptation, operating from national to single building scale, deals with more sectors and beneficiaries. The third type of incompatibility is related to the extent to which the costs and effects of the policies can be evaluated: while mitigation is estimated in terms of CO_2-equivalents, adaptation benefits are difficult to express in a single metric and they depend on the social, political and economic contexts (Klein et al., 2005).

Klein et al. (2007) defined the different interactions resulting from the integration between adaptation and mitigation: the ideal scenario is to obtain a successful integration, thus generating synergies or co-benefits; while differences in policies objectives or scale's priorities may cause conflicts or trade-offs, especially when they are not coordinated by a common vision.

Urban practice	Driver of conflicts	Description	Source
Green Urban Infrastructure (GUI)			
Urban greening	Physical space request	high demand of space (against M)	Grafakos et al., 2018
Wetlands (storm water system)	Physical space request	high demand of space (against M)	Landauer et al., 2015; Grafakos et al., 2018
Building and Infrastructures (BI)			
Urban densification	Physical space and perviousness request	less drainage, UHI, flood risk; more air cooling (against A)	Landauer et al., 2015; Grafakos et al. 2018
Ventilation	GHGs emissions; lack of energy efficiency	high demand of energy (against M)	Grafakos et al., 2018
Water Management (WM)			
Water pumping	GHGs emissions; lack of energy efficiency	high energy demand (against M)	Grafakos et al., 2018; Grafakos et al., 2019
Flood protection with walls	GHGs emissions	emissions through material production and biodiversity loss	Grafakos et al., 2018

Tab.1 Measures leading to conflicts between adaptation and mitigation

Based on the literature review, a list of measures leading to conflictual interrelations between adaptation and mitigation is provided in Tab.1. A source of potential conflict is the land-use patterns: climate change mitigation is driven by the idea of densification, while a key point of adaptation is the use of open spaces and less densely built environments (Hamin & Gurran, 2009). For example, higher density of urban areas reduces the need to travel and offers more possibilities to develop energy efficiency measures, reducing carbon emissions. However, these mitigation strategies conflict with the demand for space required by adaptation, such as green spaces to retain water or to create cooler microclimates (McEvoy, 2006). According to Dymen and Langlais (2013), the dense city concept may lead to several conflicts of interests with handling of storm drainage, preparedness to drought, retention of environmental qualities, microclimate comfort, and liveability, which all require physical space. Trade-offs are thus necessary to implement open spaces that provide several ecosystem services.

Grafakos et al. (2018) highlighted that some adaptation strategies, such as water pumping or walls for flood protection, conflict with mitigation since they require high energy use or emissions during construction.

Moreover, several studies (McEvoy, 2006; Laukkonen et al., 2009; Landauer et al., 2015) state that other reasons for a negative interrelation between the two policies is the lack of coordination and of monitoring, leading to scarce balance of interests. Setting a common vision based on sustainable development at the local scale could be a guide to ensure proper choices in urban planning (McEvoy, 2006) and to prioritize the measures needed (Laukkonen et al., 2009).

Trade-offs are defined as "a balancing of adaptation and mitigation when it is not possible to carry out both activities fully at the same time, e.g. due to financial constraints" (Klein et al., 2007, p.749). Trade-offs may have a positive or neutral meaning, hence the ability to negotiate them is essential. According to Grafakos et al. (2018), negotiations are necessary in decisions between "soft" or "hard" engineering, and in situations where the temporal scale of implementation causes uncertainties, such as planning, financial, or data related. Due to the interaction between different scales and sectors, some measures that generally produce positive effects in terms of adaptation and mitigation can require some negotiations. For example, implementing Green Urban Infrastructures (GUI) provides many benefits from social, environmental, health and economic points of view and generates many synergies between adaptation and mitigation. However, Demuzere et al. (2014) identified some trade-offs: maintenance and construction activities cause greenhouse gas emissions, fertilization reduces run-off capacity, tree shade in cold climates reduces solar radiation, thus increasing heating demand. In such cases a common vision and coordination between sectors and stakeholder is helpful to avoid conflicts.

The positive interaction between adaptation and mitigation results in synergies or co-benefits. In some of the analyzed articles, the two terms are used as synonyms; in others (e.g. Klein et al., 2007), a distinction is made: "co-benefits" are measures beneficial for both policies, whereas "synergies" consist of a greater effect of the combined measures, than the sum of their effects if implemented separately. Since the purpose of the study is to investigate the opportunities for integrated approaches in planning policies and designing practices, in this paper, we will not make a distinction between synergies and co-benefits.

Despite the dichotomy between adaptation and mitigation, local measures have shown several win-win solutions in different sectors, with which both climate policies are achieved. A detailed list of specific urban design solutions providing synergies between adaptation and mitigation is shown in Tab. 2, and is divided by the following sectors: Urban Green Infrastructure (GUI), Building and Infrastructure (BI), Energy Sector (SE), and Water Management (WM).

First, GUIs lead to many synergies, developing climate resilient urban areas and reducing emissions (Demuzere et al., 2014, Shirgir, 2019). GUIs are multifunctional and multiscale green and blue spaces (e.g. forests, green roofs, wetlands) that provide cross-scale provisioning, regulating, and cultural ecosystem services (Demuzere et al., 2014). The European Commission (EC) recognized the value of GUI and of its ecosystem services for the cities, and supports the re-naturalization of built environment through nature-based solutions (EC, 2015; EC, 2016).

(a) (b)

Fig. 1 (a) Green roof with energy production in Basel (Source: Stefan Grossert) and (b) roof-top farming on top of the Dakakker office building in Rotterdam (Source: Ossip van Duivenbode).

Demuzere et al. (2014) categorized the services and benefits of GUI that are beneficial both for mitigation or adaptation: CO_2 reduction via photosynthetic uptake during the day and its release during the night; thermal comfort and reduction of energy use, by lowering air temperature through shading and evapotranspiration; improvement of air quality and reduction of flooding problems by infiltrating water and by bioretention; improvement of air quality due to pollutants absorption.

However, the cooling effect strongly depends on the water of the vegetation: if during heat waves there is no water available, the cooling effects is not relevant (Viguié, 2020).

For example, green roofs reduce carbon emissions and temperatures in buildings, they adapt to higher temperatures, and collect rainwater, preventing flooding during heavy rains (Laukkonen et al., 2009). Moreover, they can be integrated with other functions and lead to several co-benefits, such as production of renewable energy or production of food (Fig. 1).

Urban practice	Drivers of synergies	Source
Green Urban Infrastructure (GUI)		
Green roofs and walls	Temperature reduction (A), water retention (A), carbon sequestration (M)	Landauer et al., 2015
Parks, urban forests	Reducing temperature (A) and carbon sequestration (M)	Landauer et al., 2015
Shading buildings with trees	Energy efficiency (M) and reduce need for air conditioning (A)	Gupta & Gregg, 2013; Landauer et al., 2015
Urban agriculture	Reduce need for transportation (M), reducing carbon footprint (M), increase permeability (A), food production (A)	Grafakos et al., 2019
Wetlands (storm water system)	Flood protection (A), carbon sequestration (M)	Landauer et al., 2015, Grafakos et al., 2018
Building and Infrastructures (BI)		
Passive cooling of buildings with night ventilation	Indoor comfort (A) and reducing energy needs (M)	Gupta & Gregg, 2013; Landauer et al., 2015; Grafakos et al., 2018
Building orientation, window performance, insulation	Indoor comfort (A) and reducing energy need (M)	Gupta & Gregg, 2013; Landauer et al., 2015; Grafakos et al., 2018
Increasing resilience of building fabric / adaptive skins	Resilience of the building (A) and energy efficiency (M)	Landauer et al., 2015
Climate sensitive design	Climatic comfort (A) and energy saving (M)	Landauer et al., 2015
Albedo	Minimize the effect of solar radiation (A, M)	Gupta & Gregg, 2013; Landauer et al., 2015
Multiservices infrastructures	Regulating and provision services (A,M)	Hamin & Gurran, 2008
Reuse, recycling	Reduce carbon footprint (M), improve adaptive capacities (A)	Hamin & Gurran, 2008; Thornbusch et al., 2013
Energy Sector (ES)		
Local energy sources, district heating/cooling	temperature comfort (A), energy efficiency (M)	Landauer et al., 2015; Grafakos et al., 2018
Alternative energy sources - RES	reduce transportation and operational energy use (M)	Landauer et al., 2015
Alternative energy sources - smart grids	reduction GHG emissions (M), reduction risk of power shortages (A)	Grafakos et al., 2018
Energy efficiency in buildings	Energy saving (M), enhance building adaptive capacities (A)	Landauer et al., 2018
Water Management (WM)		
Water saving	Adapt to less precipitation (A) energy saving (M)	Grafakos et al., 2018

Tab.2 Measures leading to synergies between adaptation and mitigation

Second, Building and Infrastructures (BI) is another category in which many synergies and co-benefits between adaptation and mitigation occur, particularly in case of passive building design. In this case, the main strategies that simultaneously achieve mitigation and adaptation are energy efficiency urban systems, by reducing waste heat and carbon emissions; measures on form and orientation of buildings, which maximize energy saving and ventilation and reduce the use of heating or cooling systems; design surfaces of building fabric that are heat resistant and climate resilient (Rosenzweig et al., 2015).

Transforming the built environment is particularly challenging, since the retrofitting measures should be also climate adaptive (Grafakos et al., 2018). However, many passive measures, such as improving insulation or increasing the albedo, besides reducing energy needs, also have an impact on the indoor comfort, improving existing conditions.

Third, the Energy Sector (ES) has many sources of synergies: the implementation of measures can contribute to reduce carbon emissions or energy use and to improve temperature comfort or adaptive capacity of the energy infrastructure. For example, the use of alternative energy sources (RES) and decentralized systems (smart grids) locally produced contributes to reduce transportation, operational energy use and risks of power shortages (Landauer et al., 2015).

Finally, synergies and co-benefits may be achieved in Water Management (WM) by using Blue and Green Infrastructure solutions to filtrate and reduce run-offs, such as wetlands, retention areas, green riparian zones, and by adopting solutions to save water consumptions (Grafakos et al., 2018).

According to the analyzed studies, significant opportunities to combine mitigation and adaptation measures take place when dealing with urban regeneration and energy retrofitting. Moreover, building regulations support both safety, energy efficiency, thermal comfort, thus requiring consideration of cross-cutting issues between the two strategies. Strategic planning and urban design should seek to simultaneously address resilience and energy transition and to promote win-win solutions.

4. European efforts for an integrated approach

As previously discussed, many opportunities are available to generate synergies and to combine the effects of adaptation and mitigation in urban practices. It is therefore interesting to analyze and understand if an integrated approach is supported from a policy perspective. For this purpose, we investigated adaptation and mitigation policies focusing on built environment, and urban policies that deal with climate change challenges (Tab.3). The analysis allowed us to provide a general framework, to identify cross-cutting goals and direct reference to an integrated approach as well as gaps.

According to the literature reviewed, developing plans or projects with an integrated approach is convenient, as well as necessary to tackle climate challenges. However, the process might be not simple and clear in all steps, since mitigation and adaptation emerged in policy as two different strategies and have been separately institutionalized. Landauer et al. (2015) collected studies that identified potentials for cross-cutting goals and synergies between the objectives of the two strategies in the policy level. These include, for example, urban regeneration as a bridge for the dichotomy, building retrofitting and regulations to create synergies between adaptation and mitigation, and supporting behavioral change and actors' inclusion.

EU Mitigation strategies for the built environment are contained in various policies sectors: in "Climate action policies" (specifically as "Greenhouse gas emission reduction", "Energy efficiency", "Renewable energy" policies), in "Energy policies" (as "Energy strategy", "Energy efficiency" and "Renewable energy" policies) and in "Environment policies", precisely in "Urban environment" for which the 7th Environmental Action Programme helps cities to manage their areas in a sustainable way.

The three main strategies to mitigate climate change are energy efficiency, use of renewable energy and greenhouse emission reduction, as mentioned in the climate and energy packages. The first, 2020 climate and energy package (2009), provided by European Commission (EC), aims to reach the 20% energy goals by 2020[1]. The second, the 2030 climate and energy framework (2014) is the framework that defines the energy targets by 2030[2], with the goal of reaching climate neutrality by 2050 as indicated in the EU vision "A clean planet for all" (2018). The strategy outlines a road to the decarbonization of Europe's energy supply and to a climate neutral economy by 2050, which requires a deep transformation in energy, building, and transport sectors as well as in society.

1 20% cut in greenhouse gas emissions, 20% of EU energy from renewables, 20% improvement in energy efficiency compared to the levels registered in 1990

2 40% cuts in greenhouse gas emissions, 32% share for renewable energy, 32.5% improvement in energy efficiency compared to the 1990 levels

Date	Name	Type	Objectives
		Climate mitigation (energy efficiency, renewable energy, greenhouse gas emissions)	
2009	2020 climate and energy package	legislation	20% cut in greenhouse gas emissions, 20% of EU energy from renewables, 20% improvement in energy efficiency
2014	2030 climate and energy framework	framework	40% cut in greenhouse gas emissions, 32% share for renewable energy, 32.5% improvement in energy efficiency
2017	Strategic Energy Technology (SET) plan	plan	transition towards climate neutral; collaboration; improving technologies
2018	A clean planet for all	vision+directive	energy efficiency target for 2030 of at least 32.5%, climate neutral by 2050
2020	European green Deal	strategy	long-term low greenhouse gas emission development strategies
		Climate adaptation	
2013	EU Adaptation Strategy	strategy	promoting action by member states climate-proofing action at EU level Better informed decision-making
2018	Evaluation of the EU adaptation Strategy	report	adoption of comprehensive adaptation strategies by Member States, Provide LIFE programme, Covenant of Mayors, knowledge gap, Climate-ADAPT, climate proofing of the common agricultural policy, the cohesion policy and the common fisheries policy, resilient infrastructure, Promote insurance and other financial products
		Urban policies	
2013	7th Environmental action Programme, PO 8: Sustainable cities	action programme	policies for sustainable urban planning and design: take in consideration environmental issues; raise awareness; involve local actors
2016	Pact of Amsterdam - Urban Agenda for the EU	urban agenda	better regulation; better funding; better knowledge
2018	Regional Development and Cohesion Policy 2021-2027 - post2020 Cohesion Policy	investment policy	key investment priorities; tailored approach; flexible framework; improve investments
2019	Seville Commitment	commitment	implementation of 2030 SDG

Tab.3 Overview of the European environmental policies and urban policies

Precisely, the mitigation goals regarding the built environment consist of the modernization of the building sector, which currently accounts for 40% of energy demand (European Commission, 2018) and the increase of building renovations, by promoting highly energy efficient and decarbonized buildings, sustainable renewable heating, and user engagement.

Adaptation strategies are contained in the "Climate action policies", with which EU promotes actions to help countries dealing with future and inevitable impacts of climate change. Adaptation policies are not detailed as the mitigation ones: EU Adaptation Strategy (2013), in which "action 3" specifically refers to adaptation in cities and which was updated in 2018, invites member States to adopt national strategies to become climate-proof and to have better informed decision-making. EU has recognized the importance of further effort and guidance in adaptation from the European level and, for this reason, added it in the primary future research interests (Horizon 2021-2027).

Besides defining the above-mentioned objectives, EU promotes voluntary programmes and initiatives aimed at mainstreaming and sharing adaptation actions between cities (e.g. Climate-Adapt, Covenant of Mayors) and at supporting bottom-up approaches for more resilient infrastructures, for climate-proof action integration in every sector, and for bridging the knowledge gap.

As highlighted in the New Urban Agenda and in the Paris Agreement, cities will have a key role in contributing to sustainable development and they will tackle many environmental and societal issues. The key role of urban areas in these future challenges is acknowledged both by EU and UN, that signed the Seville Commitment in

2019, recognizing the importance of implementing the 2030 SDGs. In 2013, EU adopted the 7th Environmental Programme, in which "Sustainable cities" were a specific priority objective. The document defines policies for sustainable urban planning and design taking in consideration environmental issues, it raises awareness, involves local actors, and it proposes a low carbon economy. In 2016 EU made the effort of combining all the challenges involving urban areas in one document, the Pact of Amsterdam or Urban Agenda for EU, addressing an integrated and coordinated approach to EU policies. In the Pact of Amsterdam both mitigation and adaptation are relevant, and they are part of the twelve priority actions.

In the Urban Agenda for EU, the climate adaptation action plan provides future design, implementation and monitoring actions, and revision of the existing EU legislations. According to the document, climate adaptation - which in Europe is mainly related to increasing temperatures, precipitation, extreme precipitation events, floods and water scarcity - is weakened by lack of knowledge, awareness, resources, conflicting priorities and coordination. Even though currently still around 75% of European cities are without an adaptation plan (Reckien et al., 2018, Pietrapertosa et al., 2019), the role of Europe was essential in raising awareness and increased voluntary commitment (Reckien et al., 2018). EU adaptation action plan aligns with several statements of the New Urban Agenda (2016) in risk and vulnerability reduction by building resilience and responsiveness, and it specifically refers to Goal 11 of the Sustainable Development Goals (SDGs) to "make cities and human settlements inclusive, safe, resilient and sustainable".

The energy transition action plan promotes clean, secure, affordable energy systems, to be achieved through socially inclusive and progressive policies. The plan considers trade-offs and synergies with other environmental priorities, namely "clean air" and "climate adaptation": only a coordinated approach will meet the decarbonization and environmental targets. The role of cities in energy transition is to decarbonize heat systems and to retrofit buildings through local and renewable energy sources and to promote a clean and sustainable transport system. The goal is to reach the previously mentioned European targets, and to drive the energy transition with a flexible, decentralized, demand-led and zero carbon system that manages both heat and power. EU energy transition plan is coordinated with EU climate adaptation plan to ensure resilient cities and supports the use of actions that generate co-benefits. Finally, the energy transition plan links to the Paris Agreement, to limit increasing temperatures, and to the New Urban Agenda and UN SDGs in several goals: Goal 7 Affordable and clean energy, Goal 9 Industry, innovation, and infrastructure, Goal 11 Sustainable cities and communities, Goal 12 Responsible consumption and production, Goal 13 Climate Action.

According to EU climate adaptation, mitigation and urban policies, there is coordination between measures, and it is clear the common vision for future urban developments, based on increased resilience, quality of life and health. Cross cutting goals can be identified in strategies of energy efficiency, to reduce emissions and to reduce probability of blackouts during heatwaves events, of standards and of regulations for buildings which have to be prepared for extreme events and to reduce carbon emissions, and of behavioral and awareness change.

The Green Deal (2019) is a fundamental part of EU strategy to tackle climate-related challenges and to implement UN 2030 SDGs, and it shows the EU effort to transform the economy towards carbon neutrality. The document, as well as all the previously mentioned policies, supports integration between adaptation and mitigation, however a guidance for this purpose does not exist yet. For example, in 2015, the initiatives Covenant of Mayors (initially only on mitigation) and Mayors Adapt were merged into Covenant of Mayors for Climate and Energy, highlighting the importance to adopt decarbonization and adaptation plans in municipalities. Integrating adaptation and mitigation is also acknowledged in the "Guidebook to develop a Sustainable Energy and Climate Action Plan" by the Joint Research Centre and in the new strategic document of the Joint Programming Initiative [JPI] (2019). According to the documents, the policies should ensure that neither mitigation nor adaptation being deprioritized in the cities' climate response plans.

From a policy perspective, there is awareness of the need for combined approaches between adaptation and mitigation and there is considerable action and participation among politicians and citizens, however, further effort is required to implement integrated approaches (JPI Urban Europe, 2019) and further guidance is foreseen to mainstream them.

5. Interactions in urban planning: case study of Stockholm

To further understand the interrelations between adaptation and mitigation in city planning and urban practices, we present the example of the city of Stockholm. The city was elected Green European Capital in 2010 but adopted the first environmental program in 1976 (City of Stockholm, 2014b). We examine this city to find out (1) the policy development of adaptation and mitigation and (2) the interrelations between them.

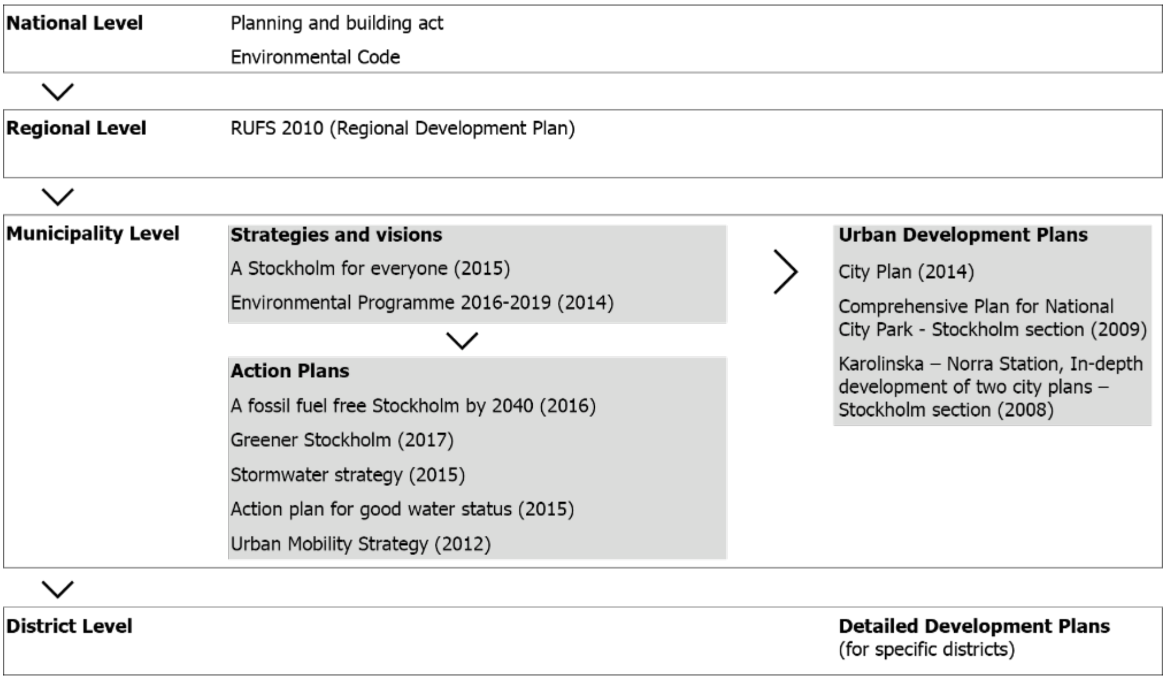


Fig.2 Cross-scale and cross-level structure of Stockholm policies influencing adaptation and mitigation strategies.

The city signed the Covenant of Mayors in 2009 and defined specific targets of emissions reductions within 2020, 2030, and of climate adaptation. In 2009, the city published "Stockholm Climate Initiatives", to set out the ambitious initiatives to reduce climate impacts. As mentioned in the "Action Plan for Climate and Energy" and in "Adapting Stockholm to climate change", the city needs to cope with warmer temperatures, increased precipitation and more frequent downpours, while preserving the quality of environment and the good status of water. The main effort of Stockholm is to combine the urbanization related to increasing population with the sustainable and environmentally friendly vision of the city. Hence, the City pointed out possible trade-offs between the need of densification, mitigation and adaptation, and declared the importance of preserving the green areas as a contribution to reduce the effects of future climate (City of Stockholm, 2009, p. 12, City of Stockholm, 2014a, p.27). The city of Stockholm updated its climate targets and implemented new programmes according to the vision "A Stockholm for everyone" and to the SDGs, defining the city goals for urban and environmental development. The former indicates the ambition to become climate-smart and resilient, while letting the city grow and be an attraction for more people. Specifically, it remarks the importance of creating new climate friendly neighborhoods, of adapting the existing built environment to cope with climate change, and of improving the blue and green infrastructure to ensure several ecosystem services. To fulfil this program, the city relies on currently poorly developed areas, such as brownfields, on the creation of a flexible structure that can adapt to changes and on the coordination between different sectors. The latter (Stockholm Environment Programme 2016-2019) constitutes the backbone of the 2040 vision from the environmental point of view, by developing missions such as sustainable energy use, environmentally friendly transport, sustainable land and water use with targets and sub-targets and by keeping together climate mitigation, adaptation and energy goals. The structure of built environment and transport system must facilitate low carbon emissions, sustainable energy use, mixed-use development, slow mobility, preservation of ecosystems, healthy water and safety in vulnerable areas.

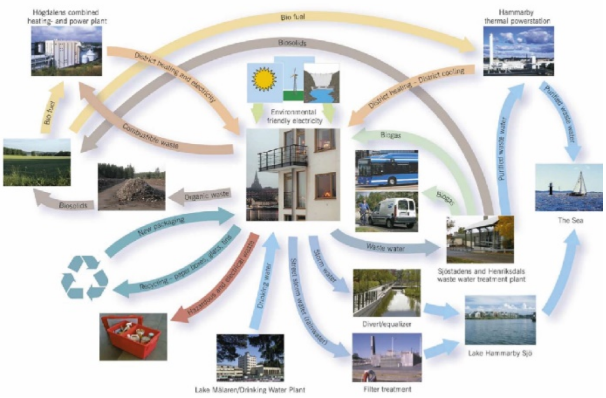
The vision of the city and the environmental program are further developed and deepened by specific Action Plans (e.g. Fossil fuel free Stockholm by 2040, Urban Mobility Strategy, Greener Stockholm, Stormwater strategy, Action plan for good use of water), and they are coordinated by a comprehensive document, the "City Plan".

As mentioned in the Planning and Building Act (chapter 3, section 2), the City Plan defines the direction of the long-term development of the physical environment and provides guidance on how to use, develop and preserve land, water areas and built environment. Moreover, the City Plan is further developed in detailed plans for specific areas, which define urban planning binding rules.

The structure of the urban development documents and environmental programs allows coordination between different sectors, city departments and scales (Fig.2).

The City Plan gives indications to avoid the conflict while meeting the demands of climate change and reducing energy impacts. For example, to avoid using cooling systems during summer, passive solutions such as screening of sun's rays and natural ventilation should be preferred to cool down the environment (City of Stockholm, 2014a, p. 12). It defines standards to avoid uncontrolled densification in existing neighborhoods and highlighted the importance of safeguarding green areas to achieve simultaneously several ecosystem services and sustainable stormwater management (City of Stockholm, 2014a, p.101).

(a)



(b)

Fig.3 (a) Stormwater management in Hammarby Sjostad (Source: Madeleine d'Ersu) and (b) environmental and infrastructural model of the neighbourhood, developed by Fortum, Staocholm Water Company and the Stockholm Waste Management Administration (Source: Bumpling AB).

"One starting point for city planning is to improve the green infrastructure and to build green solutions, such as ecosystem services, into new urban environments. In high-density areas, it is important to ensure that different functions are met within the same space." (City of Stockholm, 2014a, p.27)

Further synergies may be identified in the Hammarby Sjöstad (Fig.3) and the Stockholm Royal Seaport districts projects, both proposing climate proof and climate friendly dwellings.

Hammarby Sjöstad is a former industrial area and, after remediation, it has been developed as a residential district that merges several infrastructure systems (e.g. technical, mobility, green and blue) in a sustainable way. Hammarby Sjöstad reduces emissions by lowering heat consumption, having efficient electricity systems and using renewable energy sources (bioenergy and re-use of waste to produce heat and electricity). Besides energy, the district is designed to harvest and filter wastewater and stormwater, by creating simultaneously attractive open spaces, and its dense settlement structure is characterized by green courtyards and green roofs.

In Stockholm Royal Seaport, nature and urban environment will be merged to create an inclusive and healthy lifestyle and to reduce climate impact. To wave together urban planning issues and sustainability goals, the city proposed the Sustainable Urban Development programme (2017), a policy document that defines urban planning principles in each implementation phase and sustainable targets to monitor throughout the process. For example, buildings must have a low climate impact and be designed with at least a 100-year perspective and be energy efficient and have resource efficient operations. Moreover, blocks will be used to reinforce the green infrastructure in the area, through green courtyards and green roofs, to contribute to a sustainable stormwater management and increased microclimate comfort.

6. Discussion

As previously discussed, fostering an integrated approach between adaptation and mitigation is possible and convenient, due to the presence of several win-win solutions in practice, and due to the attempts to unify climate-related actions in urban environment in policy. Particularly, both literature and policy reviews identify unused areas' regeneration and building retrofitting as occasions to combine adaptation and mitigation strategies. Thus, if adaptation actions are easier to achieve in newly built areas, actions aiming at transforming already anthropized spaces require more efforts (Zucaro and Morosini, 2018). Moreover, a lack of coordination between different sectors and within different scales, leads to conflicts or trade-offs.

Considering cities and local communities as an ideal framework for implementation of measures, we seek to contribute to the integration of mitigation and adaptation by defining good practices and limitations in the current processes.

Choices about adaptation and mitigation are essential nowadays in cities to avoid serious impacts of climate change. Hence, a taxonomy of interactions between adaptive and mitigative measures is presented, by focusing on the drivers of synergies, trade-offs or conflicts.

To avoid negative interactions or to catalyze positive one, cross-scale and cross-level coordination is essential, and it requires strategic plans and a structured system of interventions. To implement these features in urban planning, an assessment of successes and gaps in the current processes towards an integrated approach is provided. The successes, both in policy and in practice, are driven by the shared vision of sustainable development, which helps to define priorities and to solve conflicts while considering environmental, climatic, and social aspects. Moreover, the coordination between different levels of governance and the presence of cross-cutting goals facilitates the common vision. Negative conditions of current processes appear in cases of silo-thinking or lack of cross-scale coordination, thus generating cross-scale, political or economic conflicts and leading to scarce balance of interests. Based on the analysis and according to several studies (e.g. Molinaro, 2020; Biesbroek,2009), the role of coordination and integration between mitigation and adaptation is related to spatial planning, specifically at the urban or metropolitan scale. However, a limitation highlighted in literature is the obsolescence of some systems of spatial planning, which are not capable of reflecting the complexity of urban challenges.

The results of this study show that models or tools for urban planning are necessary to connect different sectors and scales under the view of a long-term scenario, such as a city plan that coordinates different environmental challenges and cities priorities. Limited consideration of adaptative and mitigative actions in the urban plans and lack of information represent a significative gap in urban planning knowledge.

Cross scale coordination, from local to European policies, is needed to better manage conflicts between short term and long term social and economic conflicts with short term finances. Different planning departments' and sectors' goals could be unified in a policy document that highlights priorities and clears conflicts or trade-offs. Moreover, the above-mentioned policies should be integrated in the urban development plans defining the binding requirements, to facilitate the transition from vision to action.

An urban programme that embraces these aspects helps to choose multifunctional solutions and to solve trade-offs. For example, designers should avoid adaptation strategies which rely on high energy use and should prefer solutions based on low carbon energy resources and on low levels of emissions (Barbhuiya et al., 2013). Similarly, they should propose mitigation strategies that acknowledge future effects of climate change (e.g. heavier precipitations, increasing temperatures) and consider the interrelations between the single building and the urban fabric in retrofitting projects.

Hence, despite the synergies between many solutions, prioritizing and evaluating solutions might be useful to solve possible conflicts. A recent study from Viguié (2020) showed that little effect is achieved in reduction of air conditioning use in Paris by creating parks and green spaces, a greater impact can be reached by improving building insulation, the greatest impact is a behavioral change. It is important to plan cross-scale interactions and combined urban and building design practices to effectively achieve mitigation and adaptation benefits.

Moreover, when defining future projections, it should be considered that the increase of temperatures will not be determined only by emissions, but also by future population growth and the relative urbanization. In their study, Garshasbi et al. (2020) proved that in Sydney plantation of trees will only compensate population growth. Therefore, to reduce annual energy needs, further strategies, such as increasing albedo of urban surfaces or water base technologies, are necessary, as well as building adaptation strategies.

This study could contribute to make local practitioners and decision-makers aware of how climate policy processes are influenced by scales and sectors interactions. The paper intends to highlight the interactions between urban planning and project practices, by focusing on plans and guidelines at the city level and on measures to transform urban surfaces. However, further studies are necessary on energy and climate implications in urban environment to better understand scale-interactions and to enhance solutions with synergies. To better understand limitations in current planning practices, examination of interrelations and coordination in more case studies, stakeholders' interviews and analysis of economic processes might be a useful asset.

Based on the results, upgrading regulations and guidance at the city level constitute the opportunity to develop new tools that will enable implementation of adaptive and mitigative solutions. An urban plan that combines adaptation and mitigation measures in accordance with the city vision is a good guideline to solve trade-offs between sectors and stakeholders. Moreover, it increases awareness about co-benefits of measures and guides in the definition of solution for specific areas.

7. Conclusion

The study discusses the relationship between adaptation and mitigation strategies and investigates the opportunities for integrated approaches in planning policies and design practices. Focusing on the studies in the urban field, the current state of research and the European policies are examined, to understand to which extent the interrelation between adaptation and mitigation has been studied and with which outcomes.

The paper illustrates an assessment of the synergies, trade-offs and conflicts between specific measures of adaptation and mitigation and reveals several win-win solutions with the use of green and blue infrastructures and sustainable building design. Based on the findings, it can be concluded that the local scale has a great potential to combine adaptation and mitigation strategies and to strengthen co-benefits for a more sustainable built environment.

Despite the opportunities to combine mitigation and adaptation strategies in urban environments, urban and climate policies show a lack of guidelines and coordination between policy sectors to achieve an integrated approach. For this purpose, more guidance for the processes and better awareness of interrelations between solutions is necessary for designers. Recently, several cities are adopting joint plans which combine different environmental programmes or are supporting the regeneration of neighborhoods with adaptive and mitigative solutions, and they might constitute an example to facilitate a joint approach. To provide an example, the case of Stockholm is presented, showing the integration between urban development and environmental challenges in terms of urban planning. Based on the findings, examining interactions and coordination between urban planning tools provides knowledge to better understand the relations between decision making and climate-related practices. However, further studies are necessary to understand more in detail the limitations of current processes.

Further research of spatial, jurisdictional and management scales' interactions is therefore needed to foster an integrated approach that considers the interplay between policy and practice at the local scale. Particularly, it might be useful to develop methods and tools for integrated climate policy in the cities to overcome the separation between policies and align the needs of urban development and environmental issues.

Finally, experimenting implementation and evaluation solutions in which adaptation and mitigation are joint might help to mainstream and provide guidance for more integrated approaches.

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Image Sources

Fig.1: (a) Stefan Grossert and (b) Ossip van Duivenbode.

Fig.2: Authors' elaboration.

Fig.3: (a) Madeleine d'Ersu and (b) Bumpling AB.

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