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Task 6.1: Adaptation enablers identification and selection

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List of Acronyms

BEI – Baseline Emission Inventory

CoM – Covenant of Mayors for Climate and Energy

EC – European Commission

EEA – European Energy Agency

EU – European Union

IPCC – Intergovernmental Panelo on Climate Change

JRC – Joint Research Centre

RVA – Climate Risk and Vulnerability Assessment

SECAP – Sustainable Energy and Climate Action Plan

UNFCCC – United Nations Framework Covention on Climate Change

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Introduction

According to the IPCC Assessment Report 6 (2022): "*Human-induced climate change, including more frequent and intense extreme events, has caused widespread adverse impacts and related losses and damages to nature and people, beyond natural climate variability*". Furthermore, "*global warming is increasing multiple climate related hazards and related risks to ecosystems and humans*", "*the level of risk is strictly dependent with the adaptation efforts"* and *"several risks can be moderated with adaptation*". However, the planning and implementation of adaptation actions are often constrained by financial, technological, institutional, informational, behavioural or socio-cultural barriers. The adaptation enablers are factors that assist the implementation of adaptation, by removing barriers, through shifts in thinking, social norms, behaviours, resource use and institutions. Due to the uncertainty connected to climate change scenarios and the difficulties in defining long-term transformative adaptation solutions, adaptation enablers can be effective in fostering the definition and implementation of adaptation, also leading to autonomous and spontaneous adaptive behaviours by both public authorities and private citizens. Adaptation enablers can be the drivers of the dissemination and effective implementation of adaptation policies, paving the way to increasing the resilience of the local communities to the ongoing and expected impacts generated or increased by climate change. However, the conceptualization and the identification of adaptation enablers is still in progress. Moreover, enablers emerge as a site and sector specific dimension (IPCC, 2022), requiring specific assessment of the most recurring attributes and indicators to evaluate and identify these elements in the Italian context, in particular related to the public sector planning activity.

This report is aimed at investigating the concept of adaptation enabler, presenting the theoretical framework, framing the recurring dimensions and related attributes according to the scientific literature, and exploring these enabler conditions into two practical case studies. The document is structured over three main parts: i) a conceptualization of the adaptation enabler dimension, analysing both institutional documents and the scientific literature; ii) a review of the most recurring attributes and indicators used in the literature; iii) the application of the identified attributes to case studies.

1. Adaptation enablers conceptual framework

1.1. Definitions

The concept of adaptation enabler has been discussed by both research organisations and international institutions as a key factor to increase the pace and the effectiveness of adaptation planning and implementation. IPCC (2022) presents the adaptation enabler issue as a relevant component of a climate resilient development process to support sustainable development. The EU Mission on adaptation (2020) highlights the importance to create the enabling conditions to facilitate adaptation transformative changes, especially focusing on inclusive and deliberative processes, access to data, strengthening education and circular local economies and mobilising funds and resources. UNFCCC Parties in the Global Stocktake emphasize the need to strengthen policy guidance, incentives, regulations and enabling conditions to reach the scale of investments required to achieve a global transition towards low greenhouse gas emissions and climate-resilient development and encourages Parties to continue enhancing their enabling environments (UNFCCC, 2023).

The IPCC Glossary (https://apps.ipcc.ch/glossary/) defines the term "enabling conditions (for adaptation and mitigation options)" as: "*Conditions that enhance the feasibility of adaptation and mitigation options.*

Enabling conditions include finance, technological innovation, strengthening policy instruments, institutional capacity, multi-level governance, and changes in human behaviour and lifestyles". The WGII AR6 defines enablers as "*conditions for implementing, accelerating and sustaining adaptation in human systems and ecosystems*" (IPCC, 2022). In the IPCC framework, adaptation enablers are defined as those conditions or properties creating an environment conducive to promote or advance the adaptation process. Enablers are positively associated with the likelihood that adaptation planning occurs, and strategies will be put into practice (IPCC, 2022). Brullo et al (2024) consider enablers to be factors that create or promote opportunities for adaptation to be implemented. Mu et al (2020) define adaptation enablers as factors and conditions that stimulate collective abilities and efforts to adapt to current and future climate change. EEA (2024) made a survey asking EEA member states to identify challenges and enablers and it presents adaptation enablers as areas in which there is greater potential to invest in time and resources to be able to upscale and accelerate the implementation of adaptation action. Thus, the concept of adaptation enabler has a quite general meaning. Adaptation enablers are defined as conditions, factors or properties that stimulate, promote opportunities, advance or are more generically positively associated with adaptation planning. The enablers are also generically related to the whole adaptation process, considering both the design of adaptation strategies, the implementation of policies and the governing of the process through time. Furthermore, they are related to both human (i.e. public administrations and communities in general) and natural systems.

The WGII AR5 (IPCC, 2014) refers to these enabling conditions using the term "adaptation opportunities", whereas, in literature, the terms "adaptation drivers", "enabling factors" or "determinants" are interchangeably used (Brullo et al, 2024). Adaptation opportunities are defined in the IPCC glossary as "*factors that make it easier to plan and implement adaptation actions, that expand adaptation options, or that provide ancillary co-benefits*". Alternatively, literature focuses on the related concept of the adaptation barriers. The IPCC characterizes the adaptation barriers (synonymous with adaptation constraints) as "*factors that make it harder to plan and implement adaptation actions or that restrict options*". Moser and Ekstrom (2010) define barriers as obstacles that make adaptation less efficient, less effective or may require changes that lead to missed opportunities or higher costs. Barriers can arise from three sources: the actor(s) making adaptation-related decisions, the context (for example, social, economic or biophysical) in which the adaptation takes place or the system that is at risk of being affected by climate change (called 'system of concern'). Moser and Ekstrom (2010) identify four categories of barriers most encountered in the local urban context: institutional, attitudinal, financial and political. Biesbroek et al. (2013) identify seven barrier categories: (i) conflicting timescales, (ii) substantive, strategic and institutional uncertainty, (iii) institutional crowdedness and institutional void, (iv) institutional fragmentation, (v) lack of awareness and communication, (vi) motives and willingness to act, and (vii) lack of resources.

1.2. Categories and attributes

There is a growing literature on the concept of adaptation barriers and enablers, and there are various papers trying to identify methodologies and attributes to characterise and assess the enabling environment for adaptation policies. The attributes and indicators used to assess these drivers are numerous and they change depending on the context and on the sector considered. Sustainable development is considered as an overarching solution to increase the capacity to plan and implement climate change adaptation policies. Sustainable development is associated with increasing opportunities for research, training, and education as well as for enhancing access to expertise and tools for risk assessment activities and decision support. Other recurring enabling factors are governance, finance, knowledge and capacity, whereas the cultural, social, political and economic differences can influence individual and collective willingness and capability to act. IPCC (2022) identifies three main groups of enabling conditions: governance (legislation, regulation,

institutions, litigation), finance (needs, sources, intermediaries, instruments flows, equity) and knowledge (capacities, climate services, big data, Indigenous/local knowledge, co-production, boundary organisations). Even though the main categories of adaptation enablers are similar between different regions, sectors and communities, the way they manifest is context dependent (IPCC, 2014), depending on its social, cultural and institutional characteristics. Therefore, IPCC suggests being cautious in making assumptions on the effectiveness of adaptation enablers attributes and indicators in a specific context.

Brullo et al (2024) conducted a systematic literature review on adaptation enablers. The review has been carried out in 2023, taking in consideration the papers published between 2013 and 2023, the most significant period for the adaptation enablers scientific framework in terms of number of publications. 100 papers among the 144 papers considered in this review are dedicated to the agriculture sector. The remaining 38 papers describe the enablers of adaptation among various actors working at different scales and sectors, allowing for a clearer analysis of patterns in the research. The local level is the most recurring setting, where most of the case studies is dedicated to local governments and to local community. In contrast, the literature provides little evidence about what drives adaptation at the level of individuals, in the private sector, in regional or provincial levels of government, and among national governments. Brullo et al (2024) organise in categories the various enablers identified in the literature. The ten most recurring categories are: Proactive leaders, sufficient resourcing, adaptation knowledge, coordination, institutional support, risk perception, social capital, effective communication, participation, trigger events.

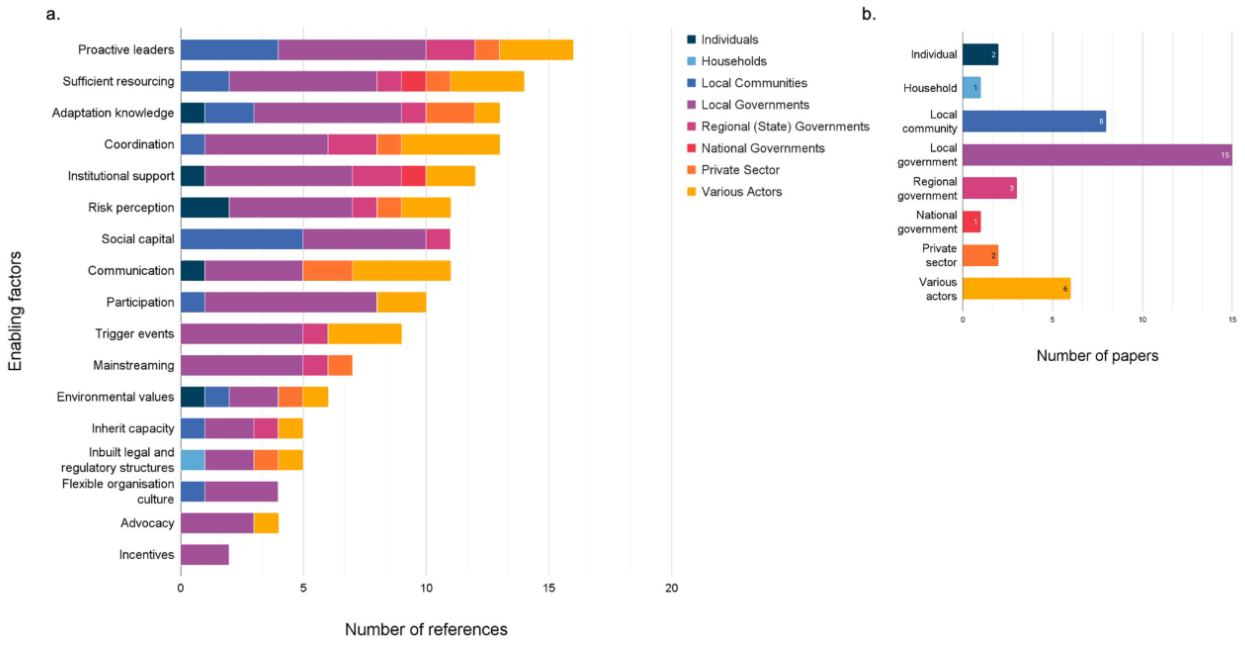


Figure 1: Enabling factors identified in the literature review (Brullo et al, 2024) and organised by actors and administrative level

Another systematic literature review on barriers and enablers for adaptation policies has been published by Rogers et al (2023), specifically focusing on the municipal level. Employing a Systematic Quantitative Literature Review method (Pickering & Byrne, 2014) they undertook a critical analysis of 131 peer-reviewed articles, published between 2005 and 2020. Among the 131 articles reviewed, 112 (85%) explicitly identified and/or explored a range of enablers to, or drivers of, municipal adaptation. Articles revealed 43 different enablers or drivers to municipal adaptation, grouped into two general dimensions representing the "authority to adapt" (describing the political will and legal requirements) and the "capacity to adapt" (presenting the

local resources in terms of finance, skills and also organisational culture or processes). Furthermore, the different enablers are organised over 7 categories: i) Information, knowledge, and communications – e.g. emphasizing adaptation co-benefits and synergies for enhanced salience, active communication and scenario planning (or similar) with community, using substitute frames for climate change; ii) Authority to adapt – e.g. political support (will & commitment), presence of an 'adaptation champion', a statutory requirement for municipal adaptation, community expectation to act; iii) Active professional networks and external collaboration – e.g. active regional collaboration, support from research/academic institutes, dense professional networks; iv) Supportive organizational culture – e.g. collaborative (non-siloed) culture in a municipal administration, a staff position to lead adaptation mainstreaming across the administration, proactive and reflective planning culture; v) Enabling organizational processes – e.g. adaptation embedded in municipal processes, portfolio proximity to decision makers, builds on existing policy and plans; vi) Enhanced access to funding – e.g. funding from other levels of government or donors; vii) Other enablers or motivators – e.g. presence of a trigger event or experience with climate impacts, effective use of financial arguments in decision-making, recognition to be seen as a climate leader

In this section we present a summary of the adaptation enablers discussed in literature with the aim to describe each dimension and to identify recurring attributes and related assessment methods. We organise the different attributes over the categories identified by the literature review on adaptation enablers by Brullo et al (2024), and we focus on the drivers of adaptation for the public sector, in the attempt to highlight the elements fostering the adaptation policy planning and implementation.

A first category of enablers collects factors presenting the essential role of politicians and public administration officials in pursuing the pace of adaptation policies. The "proactive leaders" category refers to both political will and to the proactivity of officials in designing and implementing adaptation policies. Political leadership emerges as an essential factor for making climate adaptation a priority on the agenda of the public administration, to decide the allocation of human resources and of funding (EEA, 2024). Throughout the interviews conducted by Measham et al (2011), the opinions and value system of the mayor, as well as the CEO or general manager, were recognised to be essential to promote or to hamper the definition of adaptation policies. According to the literature, this category is particularly significant at the individual or local government level, and it is focused on officials committed, dedicated, and motivated to pursue adaptation, because they understand the impact of climate change or are engaged in research on climate change. The role of these actors is essential as an adaptation enabler because they can be the trigger for an adaptation planning process, to develop a first set of adaptation policies, strategies and guiding documents. Proactive leaders are considered a catalysing condition (see chapter 2.3) by IPCC (2022). IPCC includes among the catalysing agents: policy leaders, city officials, including mayors and other executives; but also, mobilisations for environmental justice causes or social movements communicating the urgency of climate action. However, where administrative cycles may be relatively short, maintaining political support and commitment over successive terms becomes essential (EEA, 2024). Thus, even political stability is considered a significant enabler for adaptation, as it creates a stable operating environment that gives governments the ability to make decisions and see them through. The importance of proactive leaders is related both to public administration officials, but also to charismatic leaders or local communities' movements leading the promotion of adaptation through bottom-up approaches. There is vast literature presenting the role of agency and leadership in urban climate governance. In a case study focused on Norwegian municipalities (Dannevig et al, 2013), successful adaptation planning processes emerge where administrative employees are engaged in the adaptation topic and particularly interested in the consequences of climate change, recognising that adaptation is inevitable and necessary to integrate mitigation efforts. Patterson (2021) highlights the

importance of change agents, especially when combined with political pressure and knowledge on climate change impacts and risks. Moser and Ekstrom (2010) focus their analysis on adaptation barriers, and they identify the lack of leadership as one of the most significant crosscutting and recurring barrier. This barrier is particularly relevant in initiating the process and sustaining momentum over time. The prominent role of the "municipal champions" in fostering adaptation is also highlighted by Dilling et al (2017), who conducted a survey, interviewing officials from municipalities in the United States. Aylett (2015) presents the results of a survey focused on enablers and challenges to the governance of adaptation at the local level and even though leadership is the area where the fewest number of respondents report significant challenges, 54% of respondents reports significant challenges resulting from a political focus on short-term goals. A lack of leadership from senior management, the mayor, and other elected officials were identified as significant challenges by roughly one third of respondents (at 33% and 30% respectively). Public official's leadership emerges as a significant driver even in the paper by Birchall et al (2023) focused on regional governments in Canada and based on interviews on institutional barriers and drivers. The proactivity of public administrations may be motivated by ideology and political beliefs, such as the presence of parties close to environmentalist or ecologist positions. Ideology-driven policy diffusion occurs when groups of actors—such as political parties, advocacy networks, or transnational movements—promote the spread of policies across different jurisdictions based on shared ideological principles or policy beliefs, rather than on instrumental or pragmatic considerations (Schoenefeld, 2022). However, the application of values and beliefs within the climate change adaptation framework remains very much open. The politicization of adaptation is not evident and, according to literature, adaptation is less politically driven than climate change mitigation (Giordono et al, 2020). Moreover, Remling (2018), argues that the European Commission is framing adaptation as a more technical, nonideological issue. On the other hand, other authors highlight that adaptation is focused on distributional issues, or conflicts about the different solutions to implement in responding to climate change effects (e.g. the choice between structural and non-structural measures to face flood events).

Another recurring dimension refers to the availability of resources to design and implement adaptation policies. Brullo et al (2024) group these elements under the category "sufficient resourcing". Literature considers a wider array of resources, not limited to the economic dimension, but referring to human, natural and technological resources as well, even though financial resources are considered the first determinant to stimulate adaptation. There are different possibilities for adaptation funding, including public, private and alternative source of finance specifically dedicated to adaptation (UNFCCC, 2024). According to AR6 (IPCC, 2022) adaptation finance constitutes a crucial enabling condition and it shapes of the solution space, together with other enabling conditions (such as proper planning, implementation and governance), which contribute to the access and use to these financial flows, ensuring the planning of proper adaptation solutions. Financial resources are also especially relevant for the local governments. Local administrations consider the lack of funding for implementation as the most relevant challenge for the mainstreaming of adaptation policies (Aylett, 2015). The European Environment Agency (2014) highlighted that national financial support can drive local and regional adaptation whereas a lack of resources, including finance, was identified as one of the major barriers to adaptation. However, literature findings suggest that economic resources are not sufficient by themselves in promoting adaptation and that they are best considered to be important among a larger set of conditions that contribute to an enabling environment for adaptation. Porter et al (2015) highlighted the importance of funding and of dedicated local staff as a key driver to foster the implementation of adaptation at the local level in UK. In terms of human resources, Reckien et al (2015) found that the current level of adaptive capacity is one of the main drivers of adaptation at the local level (besides the signing of the Covenant of Mayors and the population size). Moser and Ekstrom (2010) emphasize the lack of resources as one of the most important barriers to adaptation policy-making processes. Similarly to the literature on

enablers, they consider a wide array of resources, not limited to the financial ones: technology, staff expertise, information resources, time. In the analysis conducted by Berrang Ford et al (2014) on the correlation between adaptive capacity and the implementation of adaptation policies at the national level, the results highlight a dominant role for institutional determinants of adaptive capacity in driving adaptation action. The strong and most consistent predictor of variation in national adaptation is their measure of good governance, based on the Transparency International's Corruption Index (CPI), a composite measure ranking countries based on how corrupt their public sector is perceived to be. The Environmental Sustainability Index is another indicator used by Berrang Ford et al (2014) to characterise the institutional determinants leading to the implementation of adaptation policies. The Environmental Sustainability Index creates a participation score ranging from 0 (no participation) to 1 (full participation), based on the level of participation in the UNFCCC and Kyoto Protocol, Vienna Convention and the accompanying environmental treaties. Points are allocated based on signature, accession, ratification without signature, ratification with signature, acceptance, approval, or succession. Previous research on primarily high-income countries found the ESI was statistically associated with adaptation outcomes in the health sector. These institutional determinants emerge as a driver for other related adaptation drivers (such as the technological readiness, represented by Internet users and mobile cells subscriptions), meaning that good governance capacity can be a predictor of an enabling environment, leading to national adaptation action. The relevance of resources emerges as a driver of adaptation even in the paper by Araos et al (2016). Here they assess adaptation policies by large cities among 80 countries, and they find that wealthier cities are more likely to implement adaptation. This relation could also be influenced by the fact that wealthier municipalities could have better institutions and skills for the reporting of their initiatives, compared to poor municipalities. The relevance of resources emerges also in the paper by Birchall et al (2023) (economic resources) and Hamin, E. and Gurran, N. (2015) (financial and human).

A third category is focused on the pillar role of the adaptation knowledge. Here the focus in on the presence of information and data on both the climate related risks and the adaptation options, their effectiveness and their economic efficiency (Brullo et al, 2024). Moreover, here the focus is placed both on the availability of these data and information and on the dynamics regarding the transfer of adaptation knowledge (by engineers, consultants, academics), such as the presence of training courses or other programs that empower the capacity of individuals working on climate change. Trained people are better equipped in searching information on climate change and in designing adaptation solutions. According to IPCC (2022), enhancing climate change literacy on impacts and possible solutions is necessary to ensure widespread, sustained implementation of adaptation by state and non-state actors. Ways to enhance climate literacy and foster behavioural change include access to education and information, programmes involving the performing and visual arts, storytelling, training workshops, climate services and community-based monitoring. Furthermore, the focus here is also on the channels and procedures to integrate the adaptation knowledge in the decision-making processes, enhancing the full potential of the collected data and information. Cornell et al (2013) present the concept of knowledge system, defined as a set of interacting "*agents, practices and institutions that organize the production, transfer and use of knowledge*". This definition emphasises the social nature of knowledge and the importance of the link between knowledge and action, rather than presenting knowledge simply as information about past, present and future states of the world which can be of use to decision makers (IPCC, 2022). It was well established in AR5 (IPCC, 2014) that a good knowledge system for climate decision-making is rooted on "*information on climate, its impacts, potential risks, and vulnerability*" which can be easily and effectively *"integrated into an existing or proposed decision-making context*" (IPCC, 2022). Moreover, learning can be both applied to the knowledge on the impact of climate change but also to the diffusion of information and data on adaptation policies that proved effective in a similar context in response

to similar climate change related effects. Municipalities can be more likely to adopt adaptation policies when extreme events manifest in neighbouring municipalities, and when these municipalities have adopted such policies, suggesting learning and diffusion effects. Information on the implementation and related effectiveness of adaptation solutions can flow through many different channels and networks depending on whether there is geographic proximity between administrations. However, empirical evidence of learning in adaptation policy diffusion seems not as frequent as one might expect (Schoenefeld et al, 2022), even though because the assessment of the effectiveness of adaptation policies and related benefits remains quite challenging to both public administrators and technical agencies or scientific institutions. However, the importance of knowledge is also recognised by the literature focused on adaptation barriers. Moser and Ekstrom (2010) consider the lack of information about the problem, solutions and their implications as one of the most recurring barriers to adaptation policymaking processes. However, whereas uncertainty has often been claimed to be the major barrier to the implementation of actions, studies have shown that improved quantity and quality of climate information, and greater certainty, do not automatically lead to locally adapted and appropriate actions (Tribbia and Moser 2008). For example, Porter et al (2015) analysed the adaptation policies planned and implemented by local authorities in UK and they didn't notice a significant influence by scientific knowledge (even from reliable entities) on the implementation of adaptation. In the survey by Aylett (2015) the formal climate education and the training programs were ranked as relatively ineffective by the local public officials, apart for African and Asian cities, who reported greater success from formal education and training programs for encouraging different departments to engage with climate change (whereas the most important factors were the presence of networks and interdepartmental working groups between the different sectors). Measham et al (2011) emphasise that the need for information varies not only due to the adaptation issue in question but also due to the specific location, priorities and existing capacity of different councils. Their findings show that, "*in the case of sea-level rise and storm surge implications or planning, the information needs are quite specific and can be addressed through detailed hazard mapping in partnership with external technical support to provide best available estimates. In other instances, such as the effect of climate change on bushfire risk, councils did not need further detailed information. A workshop on this topic was sufficient for them to recognise that the frequency and intensity of this hazard may increase*" (Measham et al, 2011). Thus, the presence of knowledge on climate related impacts and on adaptation policies is not considered a direct predictor of adaptation planning and implementation by itself but its relative importance depends on the local context, the sector and the specific climate change impacts to address. Furthermore, as well as for other enablers, this driver can be especially effective when integrated with other enablers or when the knowledge is specifically tailored on the local needs and integrated into effective mechanisms of knowledge transfer and communication.

Another group of drivers for adaptation is represented by elements describing the presence of coordination between different levels of government or between different sectors of the same administration. Both horizontal and vertical coordination between and within levels of government have been shown to be a key driver of system change, enabling consistent and efficient adaptation action (IPCC, 2022). Horizontal coordination requires those responsible for different policy areas within an administrative level to exchange information and adjust their activities to ensure that adaptation efforts result in coherent action (EEA, 2024). Climate change causes impacts on different sectors, and the integration of needs and priorities from different sectors and governments is usually considered essential to design and implement effective adaptation policies. Moreover, the presence of competing priorities (e.g. health, housing, sanitation …) is considered an important challenge to the definition and implementation of adaptation policies (Aylett, 2015). Adaptation represents only one priority among many competing interests for local government planning, thus coordinated policies can be effective in fostering adaptation, leading to designing win-win strategies for

different sectors of the administration (Measham et al, 2011). On the other hand, vertical coordination mechanisms refer to institutions and processes that support the integration of adaptation through multiple administrative levels within a country (EEA, 2024). The vertical coordination and cooperation with regional authorities is particularly relevant to small municipalities, which may need additional support to secure funding and set adaptation goals (EEA, 2024). However, methods to coordinate policies among different levels of government and to support local authorities may be different depending on the context and on the country size. EEA (2024) shows differences between Germany and Denmark, where the first one utilises regional conferences to disseminate knowledge at regional and local levels, while the second one contacts municipalities directly. Defining clear roles and responsibilities for different actors can allow lower levels of government to be more proactive, helping to share the risks of action and inaction and to promote knowledge dissemination. Many forms of climate adaptation are likely to be more effective, efficient and equitable when organised collectively and with multiple objectives. According to Rogers et al (2023) the most frequently identified enabler of municipal adaptation is the proactive emphasis on adaptation co-benefits and salient key messages that draw attention to the synergies between adaptation and wider municipal priorities. Aylett (2015) presents a survey to communities around the world that were currently members of ICLEI – Local, with the aim to investigate their governance structure and the challenges and enablers to their policymaking processes for adaptation. The two most relevant strategies to mainstream climate change adaptation are "creating informal channels of communication" and "cultivating personal contacts and trust" between person or team responsible for climate planning and staff within other local government agencies. Other relevant factors are the definition of cross-cutting climate adaptation policies able to meet other existing sectoral goals and the creation of interdepartmental climate change working groups. The importance of initiatives that build internal networks between local government agencies (and, specifically, those that encourage informal relationships of trust) confirms the key role that personal ties play in creating the conditions necessary for shifts in policy direction within complex urban systems.

The presence of institutional support on adaptation emerges as another recurring enabler of adaptation policies. The presence of political support and of shared goals, policies and priorities is considered a relevant driver, fostering the definition and implementation of adaptation. The institutional support can manifest over different solutions: such as the definition of an overarching normative framework on adaptation, a unambiguous mandate to develop adaptation policies, a technical support by delivering approaches, tools or dedicated human resources for the development of adaptation policies. The definition of a national research institution on climate change impacts and data collection is another example of institutional support to regional and local administrations. Based on the analysis of the Covenant of Mayors (CoM) reports' data, technical support may affect the effectiveness of the entire process of CoM implementation at a local level, particularly in the case of small municipalities (Santopietro and Scorza, 2021). In Bowen et al (2013) the definition of the National Climate Change Committee has been perceived by the member of the health sector as a key change that enabled adaptation activities. In this case, the prime Minister was named Honorary Chair of the committee, and this choice represented a symbolic action increasing the importance of this new institution and enhancing the full potential of the institutional support by the national government. According to IPCC (2022), institutional frameworks, policies and plans that set out adaptation goals, define responsibilities and commitment devices, coordinate among actors and build adaptive capacity are essential to facilitate sustained adaptation actions. Instruments such as behavioural nudges, re-directing subsidies and taxes and the regulation of marketing and insurance schemes have proven useful to strengthening societal responses beyond governmental actors. According to Schoenefeld (2022), a possible motivation for adaptation policy diffusion is connected to established and expected rights and duties. A first category can be called "*coercion*", and it is referred to a hierarchical legal framework or on the willingness to join some

international organisations or networks where some requirements must be observed to join the network. A legally binding framework for adaptation does not yet exist. UNFCCC continues to have a limited legal power, whereas the European Union has mainly focused on the national level, launching the EU Climate law in 2021, requiring the national governments to design adaptation strategies and to monitor (and communicate) the implementation of adaptation commitments. In some cases, this obligation has been transferred to local municipalities also. This happened in Denmark, where, according to national regulations, the municipalities are required to develop adaptation strategies, although these legal obligations are quite rare in the adaptation policy framework. The financial incentives are instead a more common tool to foster the diffusion of adaptation strategies and plans. The 2021 EU Adaptation Strategy confirms and extends the EU funding to support the local implementation of adaptation measures in Europe.

Furthermore, according to literature (Brullo et al, 2024; Dilling et al, 2017), people, institutions and organizations who are aware to be exposed to climate related risks are most likely to take actions to reduce their vulnerability. Risk perception combined with the presence of structured knowledge on climate change and a sense of urgency emerges as a significant enabler, facilitating the development of adaptation. Moser and Ekstrom (2010) identify low risk perception as one of the potential barriers to the planning and implementation of adaptation policies. Simonet and Leseur (2019) engaged public administration officials in a survey. The “elected officials’ awareness of climate issues” emerged as the most mentioned dimension driving the promotion and the implementation of adaptation. The presence of so-called catalysing conditions, such as extreme events, can be a significant factor triggering the perception of climate related risks, and thus the definition of adaptation measures. Experiential learning on both the effectiveness of adaptation and on the effects of climate change is an important driver for adaptation policies. Communities are more inclined in implementing adaptive behaviours when they are more used to respond to climate variability and to have feedback on their actions. Extreme events can change the risk perception of people, motivating a shift toward more significant efforts on adaptation. These events can be relevant for the risk perception of both citizens, public administration officials and professionals. Mo Madsen et al (2019) assess the effects of the extreme cloudburst event of 2011 in Copenhagen on the adaptation policymaking process in the municipality. This event pushed professionals to adopt an expanded institutional risk frame, considering increased public and political risk perceptions and launching a new technological trajectory. However, the occurrence of extreme events can be a relevant driver for adaptation especially when combined with the presence of environmental values or place attachment. Amundsen (2015) analysed place attachment as a driver of adaptation, focusing on a case study in the coastal communities in Northern Norway. Considering the results from the interviews, place attachment seems to be an important driver of adaptation, more than the knowledge and fear about climate change impacts.

Another recurring enabler is connected to the role of social capital and the presence of social networks. Social capital is the value people get from their social networks — such as trust, support, information, and cooperation that come from relationships. According to literature, two different social capitals exist: bonding and bridging social capital. Bonding social capital refers to the strong ties within close-knit groups, such as family and close friends, that create trust, loyalty, and mutual support. In contrast, bridging social capital involves weaker ties that connect people across diverse groups, providing access to new ideas, resources, and opportunities. While bonding strengthens group identity and cohesion, bridging expands networks and fosters inclusiveness. Both forms are essential, as they complement each other in building resilient and connected communities. Both bonding and bridging networks emerge as significant drivers to enable adaptive behaviours and policies. A bonding social capital is shown to be important in building community resilience to climate shocks. Bonding social capital also helps foster collective action by increasing

participation, cooperation, and problem solving. Bridging social capital was shown to be important in systems of government, where networked individuals and organisations enable cooperation, knowledge sharing, and skill transfers that help promote adaptation. Partnerships and networks can also help overcome human, financial, and knowledge resource. According to a survey over urban adaptation and mitigation plans in Europe (Reckien et al, 2015), the signing of the Covenant of Mayors is among the most significant drivers for adaptation, and also the C40 and the ICLEI memberships are positively correlated with the planning and implementation of adaptation policies.

The presence of effective communication strategies, tools and processes is considered another relevant driver for adaptation. Giordono et al (2020) focus on the enabling conditions at the municipal level in the US, where the coverage by local media of an extreme weather event emerges as a determinant factor to stimulate adaptation policy response, more than the political orientation of the community or its environmental values. Straightforward and well-structured communication on adaptation and climate change is considered particularly relevant to engage stakeholder and to alleviate opposition to change.

Stakeholder participation is another recurring driver for adaptation. It is considered an enabling factor especially at the local level. Active engagement (not basic consultative processes) can improve the quality of the decision-making process, facilitating the integration of different perspectives, experiences and knowledge. Moreover, this engagement can also build capacity and ensure the legitimacy and ownership of adaptation measures. Citizens can provide important information about the local impacts of climate change and the appropriateness of specific adaptation measures (EEA, 2024), improving the tailoring of the adaptation strategies on local needs and priorities. Participation can be aimed at different phases of the decision-making process. Participation in knowledge co-production processes can lead to decisionmakers and stakeholders feeling deeply engaged and empowered. The collaborative nature of these processes plays a pivotal role in mitigating conflicts and fostering the creation of multi-scale partnerships. It also allows for a better inclusion of issues related to environmental justice, just transition and the concerns of vulnerable groups of people (EEA, 2024). A participatory process requires a rigorous approach and specific solutions to improve the effectiveness of the engagement of the community on the decision-making process: i) policymakers should be committed on the participatory process; ii) public officials should be skilled in participatory planning processes; iii) citizens should have space and influence on the outcomes of the process; iv) the public officials should clearly define the space they will allow for participatory governance; v) the engagement of socio-economically vulnerable groups is crucial to ensure equitable outcomes, even though broad groups of stakeholders and particularly hard to engage groups such as youths or the disadvantaged citizens, may require new forms of involvement, tailored to their needs (EEA, 2024). Puig et al. (2025) emphasise the importance of engaging citizens and local communities in designing adaptation policies and they present five conditions essential to have a successful engagement of populations in citizens' assemblies: (i) a clear mandate and a well defined scope; (ii) a truly representative selection of members; (iii) openness about the decision making process of the assembly; (iv) access to scientific, legal and policy expertise; (v) and agreed-upon procedures for how the assembly's recommendations will be considered by decision-makers. In addition, reliable and long-term financing to implement the assemblies' recommendations is required. Both the EEA and the paper by Puig et al. (2025) emphasise the importance of clearly defining the outcomes of the process and the boundaries of the citizens participation, the necessity of considering vulnerable citizens and people affected by the decision when selecting the composition of the assembly and the relevance of knowledge and skills on participatory processes but also on the topic of the engagement. The engagement of marginalised people is recognised to be particularly relevant in the adaptation sector, where policies still fail

to reflect the priorities of many people, lacking a focus on gender and age diversities, on indigeneity, disability, asexuality and race (Araos et al., 2021)

Even though the main categories of adaptation enablers are similar between different regions, sectors and communities, how they manifest is contextually dependent (IPCC, 2014). The relevance of a single driver is influenced by different aspects: (i) the geographical scale (e.g. national, regional, etc.); (ii) the sector; (iii) the social and cultural context; (iv) the time of the analysis (e.g. connected to the temporary needs of a community) (Porter et al, 2015); (iv) the interaction between the different enablers (IPCC, 2022); the policy making stage (Rogers et al, 2022). Moreover, the literature shows that political action is rarely driven by a single factor or event. Overall, multiple factors interact or act in combination to produce an enabling environment to increase the pace and the effectiveness of action in the face of weather- and climate-related risk (Dilling et al, 2017). The existing literature suggests that to promote adaptation a combination of enabling conditions must be facilitated to create an enabling environment. This was demonstrated, for example, by Birchall and colleagues highlighting the need for other enablers alongside financial resources. The survey conducted by Dilling et al (2017) over 60 US municipalities suggest that multiple factors interact or act in combination to produce an enabling environment for action in the face of weather and climate related risk. Moreover, various enabling factors are connected. For example, the presence of adaptation and climate change knowledge is considered relevant but it is strictly connected with other dimensions, such as the presence of officials with competencies and professional skills to understand the climate information (connection with the "sufficient resourcing" determinants), the presence of effective channels to mainstream the knowledge inside the decision making processes (connection with the "coordination" determinants), the reliability of the climate knowledge (perhaps promoted by a public national research institution - connection with the "institutional support" drivers), the presence of effective communication channels to increase the awareness of officials or local communities (connection with the "effective communication" determinants), the presence of local environmental values or place attachment, increasing the propensity to protect the local community and increase local resilience.

In Table 1 a synthesis of the most recurring adaptation enablers is presented. The table presents the main category of the enabler, a brief description of the category, examples of indicators from the literature.

Table 1: Adaptation enablers categories and methods to assess their relevance

Adaptation enablers			
Category	**In brief**	**Indicators**	**References**
Proactive leaders	Public officials interested on climate change issues and committed, dedicated and motivated to pursue adaptation (but also bottom-up processes leaded by local communities)	• *Assessed through interviews with local officials and stakeholders*	Brullo et al, 2024; Dannevig et al (2013) ; Patterson (2021); Hamin, E., & Gurran, N. (2015)
Sufficient resourcing	Larger set of resources, not limited to economic dimensions, but related to both financial, human, natural as well as technological resources	• National/regional financial support dedicated to adaptation planning and implementation • Municipal budget dedicated to adaptation policies • Local staff/officials dedicated to climate change adaptation planning duties • Good governance, based on the Transparency International's Corruption Index (CPI) • Good governance, based on the Environmental Sustainability Index (i.e. level of participation in environmental treaties, such as UNFCCC, Kyoto Protocol and Vienna Convention) • Wealth – GDP/head (even though this can be related to the fact that wealthier municipalities could have better resources and skills for the reporting of their initiatives)	Brullo et al, 2024; UNFCCC, 2024; IPCC, 2022; Reckien et al, 2015 ; Porter et al (2015) ; Hamin, E., & Gurran, N. (2015)
Adaptation knowledge	Presence of knowledge on climate related risks and on possible adaptation options. Focus both on the presence of data and on the dynamics regarding the circulation of knowledge inside the public administration (e.g. training activities). The focus here is on the concept of knowledge system, defined as sets of interacting "agents, practices and institutions that organize the production, transfer and use of knowledge" (Cornell et al., 2013). However, according to case studies (Tribbia and Moser 2008) the presence of knowledge on climate related impacts and on adaptation policies is not a direct predictor of adaptation planning and implementation and, as well	• Presence of training courses on climate change issue and adaptation • Knowledge on the effectiveness of adaptation solution (this indicator can be influenced by the interaction with other public administrations, through international networks dedicated to climate change issues or through the geographical proximity to other public entities already committed on adaptation)	Simonet and Leseur (2019); Brullo et al, 2024 ; IPCC, 2022; Cornell et al., 2013 ; Tribbia and Moser 2008; Dannevig et al, 2013 ; Porter et al (2015); Hamin, E., & Gurran, N. (2015)

	as for other enablers, this particular driver can be particularly effective when integrated with other enablers		
Coordination	Horizontal and vertical coordination between and within levels of government (e.g. defining clear role and responsibilities, paving the way to local "bottom-up" policymaking). The coordination among between governments can help share the risks of action and promote knowledge sharing	• *Assessed through interviews with local officials and stakeholders. It usually refers to the presence of a multi-level governance*	Brullo et al, 2024; IPCC, 2022
Institutional support	Political support by other level of government, the presence of National research institutions on climate change and adaptation, the political stability of a public administration	• Presence of a national institution on climate change impacts research and data collection • Presence of a national or regional adaptation strategy to support the definition of local adaptation policies	Brullo et al, 2024; Patterson (2021)
Risk perception	Awareness on high climate related risks (or the knowledge on the effectiveness of specific adaptation solutions). Who knows and understands the causes and the consequences of climate change is more likely dedicated to seeking to implement change. This finding is denied by other papers focused on climate related risks. Moreover, similarly to other drivers, this enabler is significantly dynamic, influenced by the presence of external factors, such as trigger events or the presence of windows of opportunity.	• *Assessed through interviews with local officials and stakeholders.*	Brullo et al, 2024
Social Capital (networks)	Presence of networks between communities or public administrations can improve cooperation, knowledge sharing, and skill transfers that help promoting adaptation	• Covenant of Mayors • C40 • ICLEI • Climate Alliance	Schoenefeld et al, 2022;
Effective communication	Clear, accessible and effective communication on climate risks and adaptation to alleviate opposition to change	• *Assessed through interviews with local officials and stakeholders.*	Brullo et al, 2024
Participation	Active engagement of local communities (not basic consultative processes) can improve the quality of the decision-making process, facilitating the integration of different perspectives, experiences and knowledge	• *Assessed through interviews with local officials and stakeholders.*	Brullo et al, 2024
Environmental factors	The environmental characteristics of a territory can influence the propensity to design and implement adaptation measures. These dimensions seem to have an impact as adaptation enablers when	• Low elevation coastal zone • Proximity to coast <= 10 km • Median city centre altitude above sea level [m]	Reckien et al, 2015

	they influence the risk perception of the local community, whereas, according to a European case study, the presence of these external factors seems to be by itself ineffective on the adaptation process	• Total number of hours of sunshine per day • Average temperature of warmest month [°C] • Average temperature of coldest month [°C] • Number of days of rain per annum • Rainfall [Liter/m2] • Proportion of green space area [% of city area] • Relative green space to which the public has access [m², per capita]	
Others…		• Population or population density • Experiential learning on past events or adaptation achievements • Environmental values • Potential synergies between adaptation and mitigation policies, where mitigation policies can be a forerunner of adaptation in a local administration • Smart cities index[1] • Political pressures coming from decision making arena or societal demands (instead of more rational explanations, such as the response to climate risks or to extreme weather events) • Socio-economic conditions of local communities/citizens (unemployment rate, median population age) • ESPON Climate Indices: Aggregated impact, combined adaptive capacity, aggregated vulnerability, combined mitigative capacity	Schoenefeld et al, 2022; Patterson, 2021 (i, ii, iv); Posey, 2009 (v)

[1] https://www.smart-cities.eu/

1.3. Catalysing conditions

IPCC (2022) distinguishes two related concepts: the enabling conditions and the catalysing conditions. While enablers make adaptation more feasible and effective, catalysing conditions provide an impetus for action. Catalysing conditions motivate and accelerate the decision-making processes on adaptation, "*leading to more frequent and potentially substantial adaptation*". These later conditions include a sense of urgency, system shocks, such as those from natural disasters, policy entrepreneurs and social movements. Catalysing conditions serve to overcome the inertia that often operates as a barrier to action.

There are different categories of catalysing conditions. Firstly, IPCC (2022) focus on the sense of urgency. In literature, urgency is defined primarily through objective and subjective time pressure, including the recognition of the costs of delaying action and the importance of using windows of opportunity during which new forms and higher levels of response are possible. Extreme weather events may for example stimulate policy-making by increasing internal problem pressure through highlighting vulnerabilities and the severity of climate change (Giordono et al, 2020). However, very high levels of urgency can be a barrier to effective action because last-minute actions to reduce risk during crises can create haste and panic, often leading to insufficient deliberation. In these cases, decision makers fail to consider a full range of alternative actions, make rash choices and poorly mobilise available resources.

Another catalysing condition is represented by the presence of windows of opportunity: these are time-bounded periods during which conditions are present for advancing and often accelerating climate adaptation strategies. Windows can open due to (i) extreme weather events (e.g. reconstruction after a flood event), (ii) political shifts (new institutions, new laws and regulations, and presence of a new policy entrepreneur or new policies), (iii) relevant and achievable policy goals and (iv) emergence of new knowledge.

A third dimension presented by IPCC refers to climate litigation on adaptation. These climate ligations can be (i) petitions to act (e.g. from farmers to the government with the aim to force decisions); (ii) failure to act by public authorities; (iii) failure by private sector to consider climate change adaptation in their business practice; (iv) youth public trust or human rights claims.

1.4. Summary

Adaptation enablers are conditions, factors or properties that can enhance the feasibility of the adaptation policies, referring both to the design phase, the implementation and the governing of the process. Adaptation enablers emerge as site and sector specific dimensions and can be connected both to public administrations and local communities and citizens. Moreover, enablers are dynamic, changing according to the ongoing barriers and needs of the local communities. Enablers can be organised over different categories, spanning from institutional characteristics (e.g. good governance and proactive leaders), socio-economic dimensions (e.g. risk perception and vulnerabilities to climate change related risks) and local environmental features (e.g. memory of extreme events or average temperature in the urban context). The literature on adaptation enablers emphasizes the effectiveness of these dimensions in increasing the pace of planning and implementation of adaptation actions; however, a combination of different enablers seems to be necessary in order to create an enabling environment and to enhance the implementation of adaptation commitments. In the last Assessment Report (AR6), IPCC separated the so-called catalysing conditions from the adaptation enablers dimension. While enablers make adaptation more feasible, increasing the possibilities to adapt, catalysing conditions are triggers, providing an impetus for action.

2. From theory to practice

According to the literature review by Brullo et al (2024), the understanding of how adaptation is enabled is constrained by the relatively small number of empirical studies that explain actual instances of adaptation.

In this section the categories of enablers identified in the previous chapter are applied and tested in real case studies, verifying the presence of these elements inside the adaptation policy-making practice. In the first case study, we present a study on the enablers and barriers to adaptation policies at the national level. The study is focused on the drivers and constraints discussed by national governments in their National Communications to UNFCCC. According to Brullo et al (2024), there is a need for further research that can explain the factors and processes that enable adaptation in institutions that are not 'local', in regional/provincial and national governments. Therefore, even if the preliminary stage of this case study, this analysis can introduce promising elements to understand the functioning of barriers and enablers in the UNFCCC environment. The second study is instead dedicated to the municipal level, and it is focused on the socio-economic, institutional and environmental conditions behind the definition of an adaptation plan inside the Covenant of Mayors framework. In the first study the analysis is focused on self-declared considerations, whereas, in the second study, the analysis is developed through a quantitative econometric assessment method, using a set of indicators applied as proxies for enablers categories. Even though these are just a first stage preliminary studies, some interesting indications emerge on the functioning of enablers and the interactions among different drivers, opening new research questions and promising research developments.

2.1. Adaptation enablers and barriers in the development of national adaptation policies

2.1.1. Introduction

National governments are essential institutions for fostering adaptation commitments, supporting local authorities, providing a scientific knowledge framework and allocating resources or designing funding schemes to improve the effectiveness and the pace of adaptation. 87% of countries has a national adaptation planning instrument in place, but progress towards complete global coverage has slowed significantly over the last four years. Economic development is not the sole motivation hampering the definition of adaptation policies. A significant number of countries that have not yet initiated a process for developing a national adaptation planning instrument are facing considerable development challenges, such as internal fragility, conflict and geopolitical tensions (UNEP, 2024). Under such circumstances, adaptation struggles to become a priority of the public administrations.

According to the literature review by Lee et al (2022) there are critical limitations in the existing literature on barriers to national adaptation policy. The volume of research is very small, particularly considering the rapid progress with national adaptation policies and plans since IPCC AR4 (IPCC, 2014) and their recognised importance. There is a need for more research on drivers and barriers to national adaptation policy that acknowledges their differing importance and priority for actors at different levels of governance and for different sectors, to identify the most common and significant dimensions with the aim to focus on these aspects inside the national policymaking processes. Even in the adaptive capacity literature, the national level is poorly investigated. Adaptive capacity characterises the resources and the willingness of institutions and

communities to adapt to climate change. In the literature review by Chapagain et al (2025) and Siders et al (2019) the assessment of adaptive capacity at the national level is developed in 3% and 2% of analysed papers respectively.

UNFCCC Parties have to periodically submit National Communications (https://unfccc.int/topics/adaptation-and-resilience/workstreams/adaptation-communications) where they present their advancements in adaptation policies. In these documents, Parties should also discuss the barriers and enablers to the planning and implementation of adaptation policies, focusing on their domestic experience and looking at their specific needs. National Communications thus contain self-reported evaluations by national governments. Even though the evaluations on barriers and enablers are generally not supported by data and other quantitative information, these National Communications are effective representations of site-specific needs, priorities and possible drivers to adaptation policies. Moreover, they can provide knowledge and data to characterise changings in adaptation needs and in the importance of specific enablers through years.

In this paragraph we present the preliminary results of a study on National Communications, analysing the barriers and enablers presented by Parties.

2.1.2. The adaptation communications

The Adaptation Communication was established by Article 7, paragraphs 10 and 11, of the Paris Agreement (UNFCCC, 2015).

> *"10. Each Party should, as appropriate, submit and update periodically an adaptation communication, which may include its priorities, implementation and support needs, plans and actions, without creating any additional burden for developing country Parties.*
>
> *11. The adaptation communication referred to in paragraph 10 of this Article shall be, as appropriate, submitted and updated periodically, as a component of or in conjunction with other communications or documents, including a national adaptation plan, a nationally determined contribution as referred to in Article 4, paragraph 2, and/or a national communication."*

The purpose of the National Communications is to increase the visibility and profile of adaptation and its balance with mitigation, strengthening adaptation action, providing input to the global stocktake, and enhancing learning and understanding of adaptation needs and actions.

The structure and the contents of National Communications were identified by the Decision 9/CMA 1, titled "*Further guidance in relation to the adaptation communication, including, inter alia, as a component of nationally determined contributions, referred to in Article 7, paragraphs 10 and 11, of the Paris Agreement*". This document contains the guidance for preparing and submitting an Adaptation Communication. It outlines the general modalities for submission, recommends timelines, outlines how the adaptation communication relates to other documents containing adaptation information, and identifies the specific types of information that Parties may include. Inside the chapter dedicated to the implementation of adaptation actions and plans, the UNFCCC Parties should discuss the "*barriers, challenges and gaps*" related to the implementation of adaptation.

The repository of the National Communications to the UNFCCC can be found here https://unfccc.int/ACR

2.1.3. Methodology

Firstly, we have collected the National Communications published on the UNFCCC repository. Secondly, we have read and analysed each document, with the aim to isolate the sections explicitly dedicated to the presentation of the specific barriers and/or drivers of adaptation at that specific national level context. In order to analyse the barriers and enablers presented in the National Communications we have used the categories identified by the literature review of Brullo et al (2024). Thus, we have prepared a dataset collecting all the barriers and enablers and we organised these factors through the main categories identified in Brullo et al (2024). Lastly, according to the dimensions presented in the National Communications, we have identified enablers sub-categories, to better cluster and assess the dimensions presented.

Table 2: Categories and sub-categories of adaptation barriers and enablers

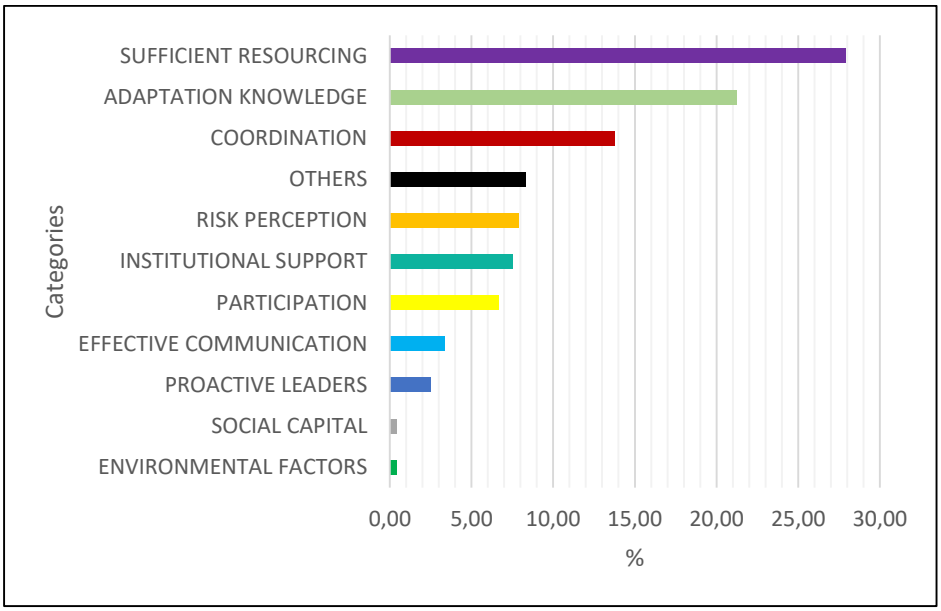
Category	**Attributes used for National Communications analysis**
Proactive leaders	* Political will * Public officials' proactivity
Sufficient resourcing	* Technological resources * Institutional capacity * Financial resources
Adaptation knowledge	* Adaptation knowledge * Climate change knowledge * Monitoring * Risk assessment
Coordination	* Horizontal coordination * Vertical coordination * Mainstreaming
Institutional support	* Normative framework * Technical support * Financial support
Risk perception	* Adaptation awareness * Climate change awareness
Social Capital (networks)	* Adaptation networks
Effective communication	* Climate change communication * Adaptation communication
Participation	* Civil society * Stakeholder engagement
Environmental factors	* Environmental resources
Others…	…

2.1.4. Results

The UNFCCC repository for the National Communications collects communications from 65 countries. In some cases, the National Communication on adaptation is a stand-alone document dedicated to the monitoring and reporting of adaptation, whereas, in other cases, the Adaptation Communication is contained inside the monitoring of the Nationally Determined Contribution. The 61% of these National Communications (40) includes a description of enablers and/or barriers to the adaptation process. The focus is mainly on barriers.

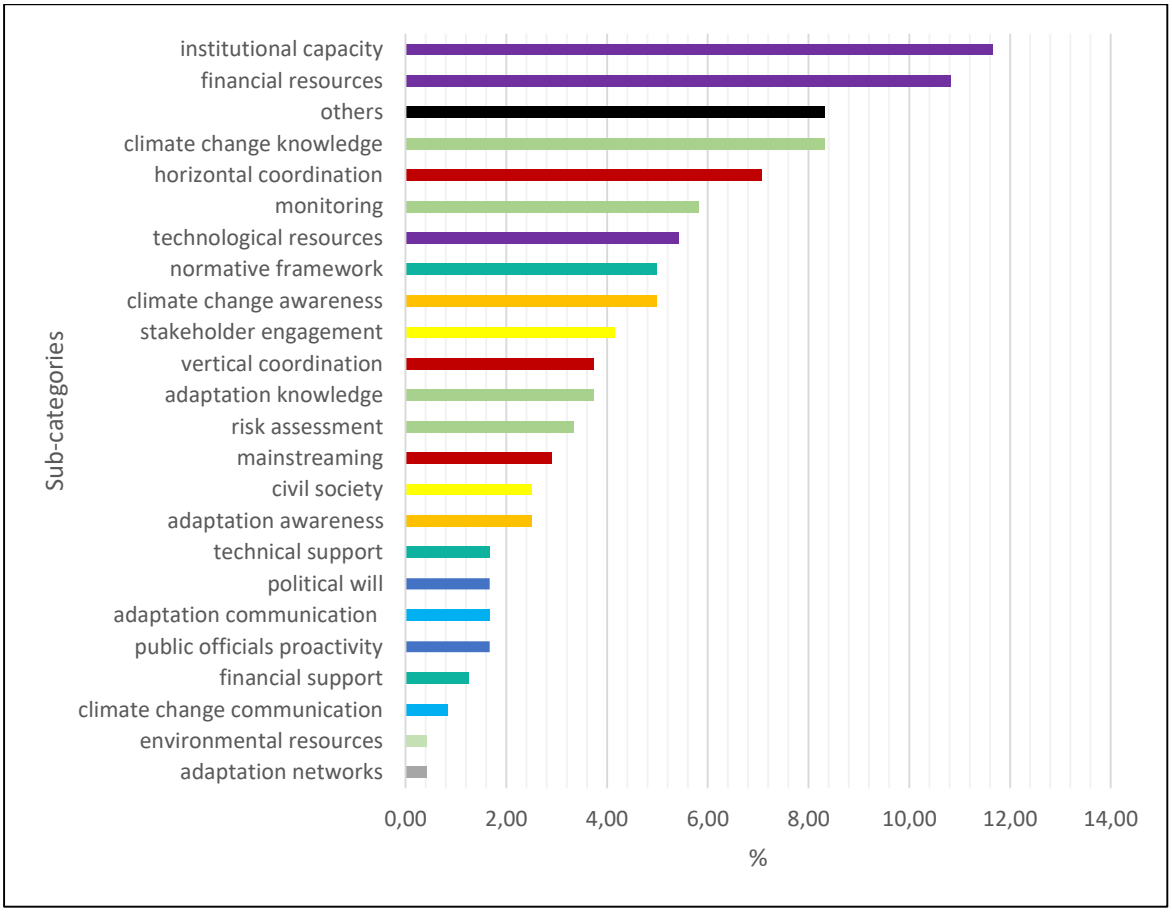
225 barriers and 15 enablers have been presented in the National Communications, an average of 6 factors for each country. The 89% of these factors comes from non-Annex I Parties[2].

Figure 2: Adaptation enablers categories in the National Adaptation Communications



[2] https://unfccc.int/process/parties-non-party-stakeholders/parties-convention-and-observer-states

Figure 3: Adaptation enablers sub-categories in the National Adaptation Communications



The National Communications by UNFCCC Parties emphasize the importance of resources and knowledge on the impacts of climate change and on the benefits of adaptation policies as potential drivers to the development of adaptation policies. Here some examples of sufficient resourcing barriers and enablers at the national level:

"Lack of technical competencies to interpret the local climate change projections"

"Lack of specialized technical capacities needed for planning and implementation, and lack of stand-alone capacity building programs"

"Further capacity and human resources are needed to locally identify hazards and vulnerabilities"

"Lack of facilities, tools and equipment"

"Difficulty in project monitoring due to paucity of funds"

"Improved governance and institutional capacities: Building the needed institutional capacities to reform, analyse, coordinate and regulate climate and sustainable development action is essential" (enabler)

The sufficient resourcing category gathers up a plurality of dimensions, referred to both the presence of trained and skilled officials, to the presence of tools and equipment, to the availability of funds to design, implement and monitoring the projects on adaptation.

The adaptation knowledge category relates to the relevance of data and information on both the impacts of climate change and on the effects of adaptation policies (e.g. quantitative assessment of the effectiveness of measures, knowledge on traditional adaptation policies, evidence on benefits of adaptation compared to the costs) and the presence of tools and systems to monitor the local effects of climate change and collect data to inform policies (e.g. software, modelling skills, data collection and management systems, standard operating procedures for data recording).

Here examples on the adaptation knowledge category:

"Enhanced Monitoring and Transparency Clarity and effectiveness of action can only be guaranteed through a robust monitoring and transparency framework"

"For the effective implementation of the Adaptation Plan, it is crucial to quantitatively ascertain and assess the effectiveness of climate change adaptation measures, such as how much each measure has contributed to the avoidance and reduction of damage from climate change impacts"

"Establishing a comprehensive central repository for accessing and archiving documents (project reports, research etc.) that can help in the sharing of knowledge and lessons and also accelerate the dissemination of climate information, vulnerability, and risk assessments, as well as multi-scalar adaptation initiatives"

"Limited understanding and awareness of climate change impacts and adaptation approaches"

The adaptation knowledge category collects various dimensions, such as the presence of monitoring tools and programs on the impacts of climate change and on the benefits of adaptation policies, the presence of knowledge on climate change trends and future scenarios and the assessments of the effectiveness and economic benefits of adaptation actions.

Half of the factors presented by the National Communications refers to these two categories. Focusing on the sub-categories, the institutional capacity (i.e. the competencies and the skills of the public administration in designing adaptation solutions or in developing climate change adaptation proposals), and the financial resources are the most important attributes. In the institutional capacity the focus is mainly on capacity building and training. The pivotal role of the institutional capacity is consistent with Berrang Ford et al (2014), which analyse the correlation between adaptive capacity and the implementation of adaptation policies at the National level. Their results highlight a dominant role for institutional determinants of adaptive capacity in driving adaptation action. Economic resources are the second most recurring driver, with a focus on external donors, such as other countries or international organisations and funds. The reliance on external financial resources can be partially explained by the predominance of National Communications (85%) coming from Non-Annex I parties. These results are consistent with the Adaptation Gap Report (UNEP, 2024). However, according to UNEP (2024) low economic development and lack of financial resources are not the sole barriers hampering the definition of adaptation policies, but also the presence of solid institutions and the capacity of public officials are recognised to be an important factor to determine the pace of adaptation.

The third group of enablers is represented by the importance of coordination, among both different sectors of the same public administration or between different administrative levels (e.g. coordination between the regional and urban level). Some examples of this category are:

"Review all relevant policies and legislation for integration of climate change action in line with CC Policy for effective integration and implementation of NAPs, NDCs and other sectoral strategies" (enabler)

"Enhance coordination of climate change adaptation" (enabler)

"Planning for coordinated response to climate change and disaster risk reduction activities need improvement"

"Utilize the Local Government structures and the National Decentralization Policy: Effective adaptation planning can only happen when local governance and decentralization structures are utilized" (enabler)

The systematic literature review by Lee et al (2022) presents similar results. The paper is dedicated to identifying the most recurring barriers to adaptation at the National level, considering peer review papers. The articles report on similar barriers to the national adaptation policy, most often on resource barriers (16 of 18), fragmentation barriers (12 of 18), and barriers related to lack of awareness and communication (12 of 18). Our results confirm that financial barriers are the most common form of resource barriers, frequently reported in the literature since the early 2000s. Fragmentation is also particularly important and it collects different categories: i) poor integration of adaptation policies across government departments (sectors); ii) poor integration of adaptation policies across jurisdictional levels; iii) poor integration of relevant knowledge; and iv) poor involvement of stakeholders. Poor integration of adaptation policies across jurisdictional levels and poor involvement of stakeholders were the most frequently highlighted dimensions in the review by Lee et al (2022). In our case study, the lack of coordination and communication between different sectors is viewed as the most relevant coordination issue and the fourth most important sub-category overall. Frequently, the presence of competing priorities and interests inside a public administration emerges as one of the most significant barriers to the adaptation policymaking process. Thus, the coordination between different sectors can be an effective strategy to identify cross-cutting policies and win-win solutions, emphasising co-benefits for different sectors and concurrently reaching different development priorities, additional to adaptation needs.

On the contrary, some barriers and enablers are rarely mentioned. The relevance of international networks to commit on adaptation policies and share experiences on adaptation implementation is mentioned just by one country, whereas the importance of proactive leaders and political will represents just the 2% of all the barriers and enablers presented. The importance of effective communication represents just 2.5% of the presented factors (and half of the reported communication barriers comes from a single country), and the relevance of the engagement of stakeholders and civil societies is mentioned in the 6.7% of cases. Probably these results are partially influenced by the perspective of these adaptation communications, focused on national government needs and priorities. The presence of participatory processes or the participation in national or international networks on adaptation might be more relevant for the local level. A similar motivation can justify the low relevance assigned to proactive leaders. According to the literature, this category is particularly significant at the individual or local government level, not limited to public administration officials, but also referred to charismatic leaders or local communities' movements leading the promotion of adaptation through bottom-up approaches.

If we consider Annex I and non-Annex I countries separately, some differences emerge. Adaptation knowledge and coordination are the most frequent categories among the Annex I countries, representing the 50% of the stated factors. Participation, effective communication, social capital and environmental factors are not mentioned in the communications. The differences between Non-Annex I parties and Annex I parties are presented in Table 3. Compared to Non-Annex I countries, Annex I countries give more relevance to: i) the presence of coordination between different sectors of an administration or between different administrative levels; ii) the preferences and wills of the public administrations; iii) the presence of knowledge on both the impact of climate change and the benefits of adaptation measures. While Non-Annex I countries particularly

focus on the need of sufficient resourcing (almost 30% of the stated factors), for the Annex I countries this enabler is just at the third place (at the level of risk perception and proactive leaders).

Table 3: Categories of adaptation enablers inside the adaptation communications: comparison between Annex I and non-Annex I countries

	Non-Annex I	Annex I
Environmental factors	0.5%	0.0%
Social capital	0.5%	0.0%
Effective communication	3.7%	0.0%
Proactive leaders	1.4%	11.5%
Participation	7.5%	0.0%
Risk perception	7.5%	11.5%
Institutional support	7.9%	3.8%
Others	7.9%	11.5%
Coordination	12.6%	23.1%
Adaptation knowledge	20.6%	26.9%
Sufficient resourcing	29.9%	11.5%

There are differences even among the sub-categories. Annex I countries give more relevance to vertical coordination, climate change awareness and public officials proactiveness, whereas Non-Annex I countries give more emphasis to institutional capacity, technological resources and to the normative framework.

Table 4: Sub-categories of adaptation enablers inside the adaptation communications: comparison between Annex I and non-Annex I countries

	Non-Annex I	Annex I
Adaptation networks	0.5%	0.0%
Environmental resources	0.5%	0.0%
Climate change communication	1.0%	0.0%
Public officials proactivity	1.0%	8.7%
Financial support	1.5%	0.0%
Political will	1.5%	4.3%
Technical support	1.5%	4.3%
Adaptation communication	2.0%	0.0%
Adaptation awareness	3.0%	0.0%
Civil society	3.0%	0.0%
Risk assessment	3.0%	8.7%
Vertical coordination	3.0%	13.0%
Mainstreaming	3.6%	0.0%
Adaptation knowledge	3.6%	8.7%
Climate change awareness	4.6%	13.0%
Stakeholder engagement	5.1%	0.0%
Normative framework	6.1%	0.0%

Technological resources	6.6%	0.0%
Monitoring	6.6%	4.3%
Horizontal coordination	7.1%	13.0%
Climate change knowledge	9.1%	8.7%
Financial resources	12.2%	8.7%
Institutional capacity	13.7%	4.3%

The categories developed by Brullo et al (2024) are effective in categorising most barriers and enablers mentioned in the National Communications. However, approximately 10% of factors can't be easily included in these categories. Here some examples of these factors: social resistance; external factors such as the political instability or the COVID-19 crises; the presence of social inequalities; the lack of a climate-adaptive development process; the high cost of transformational measures; a weak gender mainstreaming in the adaptation policymaking.

Berrang Ford et al (2014) analyse the adaptation policies reported by national governments (117) in their National Communications to the UNFCCC. They looked at the determinants of adaptive capacity in literature, and they tested possible correlations between these dimensions and the implementation of adaptation. Results highlight a dominant role for institutional determinants of adaptive capacity in driving adaptation action. The strong and most consistent predictor of variation in national adaptation is their measure of good governance based on Transparency International's Corruption Perceptions Index (CPI). High performances in their environmental sustainability index are another determinant significantly correlated to the implementation of adaptation. In this analysis there is a dominance of institutional factors over the other enablers and even the economic factors are effective in combination with the quality of institutions.

Furthermore, some clarifications on this National Communications review are needed. Here the focus is on self-declared considerations. Thus, this represents the perception of national needs by public officials or the political will of a national government. Therefore, these barriers and enablers are not necessarily directly connected with the pace of adaptation policies design and implementation, but they are more directly related with the beliefs and priorities of the national governments or public administrations' officials. In some cases, the national government might have underestimated the importance of some barriers and enablers, while focusing on other needs and priorities. Secondly, the majority (94%) of the factors relates to barriers, whereas the adaptation enablers are reported by just few countries. Even though the adaptation enablers are often considered the counterparts of the adaptation barriers (i.e. obstacles that can be overcome with concerted effort, creative management, change of thinking and related shifts in resources, land uses institutions etc.), there could be differences between these two dimensions. Thirdly, in line with literature findings, adaptation barriers and enablers seem to be strictly connected and influenced by the administrative level and by the social, economic and institutional context. Moreover, adaptation enablers can also vary according to the transitory needs of a public administration (e.g. the need of information on climate change impacts, the need of resources to implement commitments, …).

2.1.5. Summary

According to the review by Brullo et al (2024) the analysis of adaptation enablers at the national level is quite limited. The assessment of enablers is usually dedicated to the local level, even though national governments are essential to accelerate the pace of adaptation policies, enhancing an enabling and conducive environment for adaptation policies. In this first case study we have applied the adaptation enablers categories to the

analysis of the National Communications on adaptation to the UNFCCC. National Communications were instituted by the Paris Agreement and are mandatory for the countries inside the UNFCCC framework. Countries must regularly present the status of their adaptation policies, also specifying the barriers or enablers for the development of their adaptation commitments. In this first preliminary analysis, we have evaluated 65 National Communications, collecting 225 barriers and 15 enablers. The institutional capacity and the presence of economic resources are the most frequent factors, confirming a result recurring in the adaptation literature. The presence of knowledge and data on climate change impacts is the third most mentioned category, whereas the importance of coordination stands out among the most mentioned factors. Adaptation is usually considered limited by the competing objectives of the different sectors of a public administration; thus, the presence of coordinated policies can be effective in identifying win-win solutions and cross-cutting policies, with the aim to increase the pace of adaptation emphasising the capacity of adaptation policies to contribute to other development goals. This case study is based on self-assessments by national government's officials. In a refined version of this work, these self-evaluations may be integrated by more quantitative data, considering also the evolution of needs through the years.

2.2. An assessment of socio-economic, institutional and environmental drivers behind the definition of adaptation policies inside the Covenant of Mayors framework

2.2.1. Introduction

Cities have been recognised as one of the most relevant actors for reaching climate change adaptation goals. The urban environment is considered a hotspot of the climate change impacts, and local administrations have the responsibilities to prepare the communities in facing these climate related hazards, improving their resilience and adaptive capacity, especially focusing on the most vulnerable. According to these motivations, the identification of the specific enablers for the municipalities and the characterisation of the most effective enabling environment for adaptation is particularly relevant for enhancing the resilience to climate change of local communities.

In order to assess the functioning of adaptation enablers, we have analysed the evolution of the signatories to the Covenant of Mayors for Climate and Energy, collecting data on the design of adaptation plans within this international framework. Later, we have characterised these municipalities according to both institutional, geographical and socio-economic characteristics, following the indications collected from the literature on the most significant adaptation enablers for European public administrations. Lastly, we have applied an econometric approach to identify interdependencies between these factors and the occurrence of adaptation policymaking processes.

2.2.2. Covenant of Mayors for Climate and Energy

The Covenant of Mayors was launched in 2008 with the aim of bringing together European municipalities to increase commitments and efforts in terms of climate change mitigation policies. In 2014, based on the experience of the Covenant of Mayors and acknowledging the vulnerability of urban areas to the unavoidable impacts of climate change, the EC launched Mayors Adapt, a similar voluntary initiative with a focus on climate adaptation. In 2015, the Covenant of Mayors for Climate and Energy was launched, with objectives co-decided by the cities through a consultative process: i) -40% reduction in greenhouse gas emissions by 2030; ii) having an integrated approach between mitigation and adaptation; iii) and guaranteeing access to safe, sustainable and available energy for all. With regards to the adaptation pillar, the Sustainable Energy

and Climate Action Plan (SECAP) should include the assessment of climate risks and vulnerabilities within the territory, at least one adaptation goal and a set of actions (including at least three key actions) to increase the resilience of the local authority sectors and vulnerable groups. In June 2016, the Covenant of Mayors joined the Compact of Mayors, a global agreement between networks of cities to adopt effective and transparent mitigation and adaptation policies. This initiative gave birth to the Global Covenant of Mayors for Climate and Energy, with more than 11,300 cities around the world committing to mitigation and adaptation policies and to the promotion of clean energy accessible to all. The municipalities engaged in this network are also committed to publicly providing data on their policies through the Cities Climate Registry portal. Consistently with the new CO_2 reduction target set by EU in the Climate Law (2021), the Covenant of Mayors raised the ambition of its mitigation objective. The new goal is now at least -55% reduction in greenhouse gas emissions by 2030 and the climate neutrality by 2050.

The text of the Covenant of Mayors reads: "*Our vision is that, by 2050, we will all be living in decarbonized and resilient cities with access to affordable, secure and sustainable energy. As part of Covenant of Mayors – Europe movement, we will continue to (1) reduce greenhouse gas emissions on our territory, (2) increase resilience and prepare for the adverse impacts of climate change, and (3) tackle energy poverty as one key action to ensure a just transition*" […]. Local authorities joining the Covenant of Mayors for Climate and Energy initiative commit to submitting an action plan within two years of the formal signing to the initiative. The action plan identifies mitigation targets and adaptation goals and is based on a Baseline Emission Inventory (BEI) and a Risk and Vulnerability Assessment (RVA) which provide a baseline assessment of the emissions and vulnerabilities across the municipality. Signatories also commit to reporting on progress on these actions every two years. In order to guarantee that the submitted action plans are aligned with the Covenant principles, the Joint Research Centre (JRC) evaluates the submitted action plans, following a set of eligibility criteria and providing a feedback report within six months from the submission.

The eligibility criteria are the following ones:

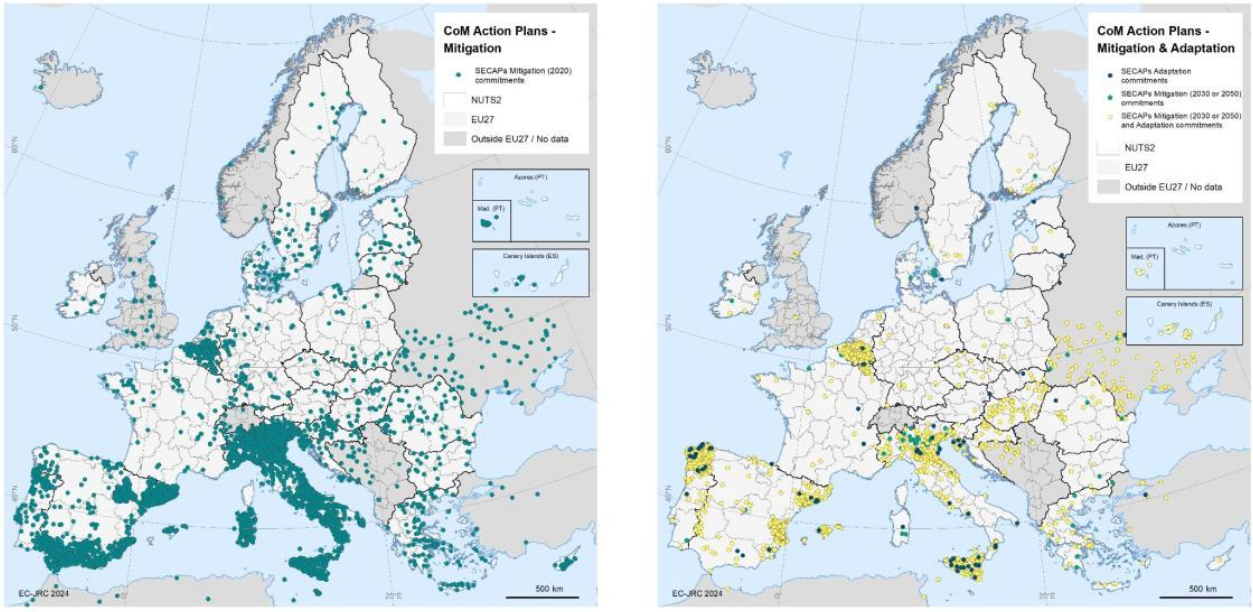
- The action plan must be approved by the Municipal Council or by an equivalent body.
- The action plan must clearly specify the Covenant mitigation target (i.e. at least -55% CO2 emission reduction by 2030) and the adaptation goal.
- The action plan must be based on and include the results of a comprehensive Baseline Emission Inventory (BEI) and Climate Risk & Vulnerability Assessment (RVA).
- The "My Covenant" platform must be completed correctly and the data reported must be coherent and complete.
- The BEI must cover the key sectors of activity (at least three out of four key sectors).
    - For mitigation, the action plan must cover the key sectors of activity (Municipal buildings, Tertiary buildings, Residential buildings and Transport) (at least two out of three selected key sectors), including at least 3 key actions.
- The RVA must identify the most relevant climate hazards and vulnerable sectors
    - For adaptation, the action plan must include a set of actions, including at least 3 key actions.

The public administration must identify at least one adaptation goal and characterize this goal in qualitative/descriptive terms and/or in quantitative terms. One goal is mandatory, whereas additional adaptation goals are optional. For each goal, public authorities must specify the unit, target and baseline years and progress achieved to date. To comply with the minimum requirements, at least three key adaptation actions must be reported within four years after joining the initiative. It is strongly recommended that adaptation actions address the most relevant climate hazards and vulnerable sectors identified in the RVA.

The identified actions should indicate the climate hazards addressed, the sectors related to the action, the expected outcome, the vulnerable population targeted, the avoided damage costs or the accrued benefits, the number of years over which the action helps to avoid costs, the return of the investment and the jobs created.

Before 2015, municipalities had the opportunity to commit on adaptation (Mayors Adapt) or on mitigation separately, whereas, in the Covenant of Mayors for Climate and Energy the mitigation and adaptation commitments are intertwined. The signing of the Covenant is bounded to the development of a SECAP with commitments on both adaptation and mitigation. The commitments on mitigation are quite ambitious, requiring having an assessment of the baseline emissions, a monitoring scheme and an expected reduction of at least -55% by 2030. This twofold commitment is mandatory for entering in the Covenant and, in some cases, it may hamper the signing of municipalities interested in adaptation or mitigation only.

Figure 4: Overview of signatories with a submitted action plan covering only mitigation until 2020 (a) or both mitigation until 2030 or 2050 and adaptation (b) (Source: European Commission, 2024)



(a) (b)

Currently, according to the European Commission (2024) the Global Covenant of Mayors for Climate and Energy counts more than 11,300 cities and local governments from Europe and its neighbouring countries. A very high number of the GCoM signatories comes from the EU-27 or from other regions where the EU has been supporting the Covenant of Mayors since 2011 (notably Eastern Partnerships countries). Most cities and local authorities remain committed only to 2020 mitigation targets and have not yet integrated a commitment to adaptation or renewed their pledges to 2030 or 2050. As a result, most of the submitted action plans has a focus on climate mitigation only and a time horizon limited to 2020. However, while committed signatories and adaptation action plans are less numerous than mitigation ones, figures are constantly growing. In terms of adaptation, European Commission observes that Covenant signatories are developing a thorough understanding of their climate risks and vulnerabilities. However, they are facing challenges in setting measurable goals prioritizing the hazards and impacted sectors to address. Consequently, the large number of planned actions are not directly linked to defined goals, making it challenging for signatories to measure their progress on adaptation. Most of the Covenant signatories (55%,

covering 35.5% of the CoM population) remains committed only to the 2020 mitigation targets, while 44% (representing about 61% of the CoM population) committed to a 2030 or 2050 mitigation target combined with adaptation. The remaining 1% has a commitment to adaptation only or to adaptation combined with a 2020 mitigation target. There are 1,941 reported information on risks and vulnerabilities while the reported adaptation actions are 1,764. Because the CoM Europe reporting requirements allowed extra time to provide adaptation actions, about 9% of adaptation plans report a RVA but do not have corresponding reported adaptation actions. Overall, 17% of signatories have reported information on the adaptation pillar. This is linked to the fact that the initiative started with a commitment only dedicated to mitigation, and only later expanded to include the adaptation pillar. Looking at the pillars addressed, 74.9% of the submitted action plans cover only mitigation and just 24.7% address both mitigation and adaptation, even though the number of action plans with a commitment to a 2030 or 2050 mitigation target and to adaptation is constantly growing. While there is still a gap between identified risks & vulnerabilities and action taken, 57% of signatories reporting at least one high-risk hazard are also already reporting at least one matching action to address it.

2.2.3. Methodology

This analysis aims to assess whether specific local socio-economic and institutional conditions are statistically linked to the development of adaptation commitments and plans. The goal is to investigate the impact of the presence of some adaptation enablers on the development of adaptation policies. The focus is on adaptation commitments inside the Covenant of Mayors framework, focusing on the design of adaptation policies, but not considering the implementation of the measures. We consider the signing of the CoM and the planning of policies as a proxy of the public administration willingness to overcome the local bureaucratic, political and socio-economic barriers, to define a process to increase the resilience of the local community. However, we are aware of the complexities in implementing planned adaptation policies. In a first preliminary analysis of these adaptation measures, the pace of the implementation of adaptation is still quite slow, confirming the difficulties in turning adaptation measures in concrete actions, effective in increasing the local resilience. A more detailed analysis on the implementation of adaptation actions inside the CoM framework may be developed in a second version of this work.

In order to assess the enablers inside the CoM framework, we have firstly collected data on the municipalities with valid adaptation commitments to the Covenant of Mayors for Climate and Energy. JRC collects information on the Covenant of Mayors signatories, regularly publishing a dataset with details on both the mitigation and adaptation commitments (https://data.jrc.ec.europa.eu/collection/id-00354). We used the fifth release of this dataset, published in May 2024 and updated to CoM signings at January 2024. We focused on the Italian municipalities with a valid adaptation pillar in their SECAP. The Covenant of Mayors specifies in the dataset if a municipality is compliant with the prerequisites for the development of adaptation commitments (e.g. the risks and vulnerabilities are assessed, the goals and related measures are defined, etc…). In order to have a homogeneous group of municipalities in terms of commitments inside the Covenant of Mayors framework, we restricted the selection to the Covenant of Mayors for Climate and Energy, the network established in October 2015, where the municipality must pursue both adaptation and mitigation commitments in their Sustainable Energy and Climate Action Plan.

Before quantitatively analysing the effectiveness of socio-economic and institutional adaptation enablers, we preliminary investigate the effect of some major policy relevant driver aimed at fostering the development and implementation of adaptation policies, such as the presence of a regional funding scheme or an overarching normative framework (e.g. regional adaptation strategies and plans). Secondly, drawing from key

insights in the literature, we examined the factors influencing the adoption of climate change adaptation strategies using an econometric approach. Specifically, we employed a cross-section probit model. In line with the literature, we tested multiple models incorporating various socio-economic dimensions and proxies for potential enablers of climate adaptation strategies. These included several aspects related to local government adaptive capacity as explained in the reviews of Rogers et al. (2023), Fila et al. (2024) and Brullo et al. (2024). The indicators are identified to represent proxies of the enablers categories presented in literature. Some dimensions can be barely characterised with socio-economic or institutional data, whereas interviews can be more effective in discussing these factors. However, the quantitative approach can be effective in identifying and discussing enablers without the influence of personal judgments and subjective evaluations by interviewed officials. The indicators we applied in our methodology are referred both to the public administration directly and to the whole local community. Table 6 presents the indicators, organised by adaptation enablers literature categories and referred to the public sector or to the local community. The selection of indicators was guided by the following criteria: i) consistency with the indications from literature and, in particular, with the categories presented by the literature review by Brullo et al (2024); ii) suitability of the indicator to characterise the enablers category in the European and Italian context; iii) availability of data in the Italian context at the municipal level.

Table 5: Description of the indicators used in the econometric model

Indicator	Short description	Unit of measure	Source
MAQI (municipal administration quality index)	Combined indicator of administrative quality at municipal level	Unitless	MAQI (2025)
Municipal surface	Surface of the municipality	Km^2	ISTAT (2021)
Green preferences	Number of votes to the Green party (vote to "Alleanza Verdi e Sinistra" in the national elections 2022)	Number of votes	ELIGENDO (2022)
Hydrological risk	Combined indicator between 0 and 1 considering hydrological risks for population, buildings, enterprises, cultural heritage	Unitless	ISPRA
Geological risk	Combined indicator between 0 and 1 considering geological risks for population, buildings, enterprises, cultural heritage	Unitless	ISPRA
Hydrogeological risk	Combined indicator between 0 and 1 considering hydrogeological risks for population, buildings, enterprises, cultural heritage	Unitless	ISPRA
Population density	Average population density (years 2018-2022)	N per Km^2	ISTAT (2022)
Green investments	Number of photovoltaic installations in the municipality per Km^2	N per Km^2	GSE (2022)
Third sector	Per-capita number of Third Sector Organisations (NGOs) registered in the municipality	N per capita	(Registro Unico Nazionale del Terzo Settore)
Average income	Average income in the municipality (years from 2018-2022)	€	MEF (2022)
Human capital	Percentage of population with a university degree	% of the population	ISTAT (2022)
Waste sorting rate	Percentage of volumes of sorted waste on total waste produced in the municipality	%	ISPRA (2020)
Density of entrepreneurship	Factor variable representing the per capita presence of commercial enterprises at municipal level	Unitless	ISTAT (2019)
Real estate value	Average maximum house selling price	€/m^2	OMI (2022)

Employment rate	Employment rate	%	ISTAT (2022)
Housing renting price	Average maximum house renting price	€/m^2	OMI (2022)
Dependency index	Dependency ratio (15-65)	% of population	ISTAT (2022)

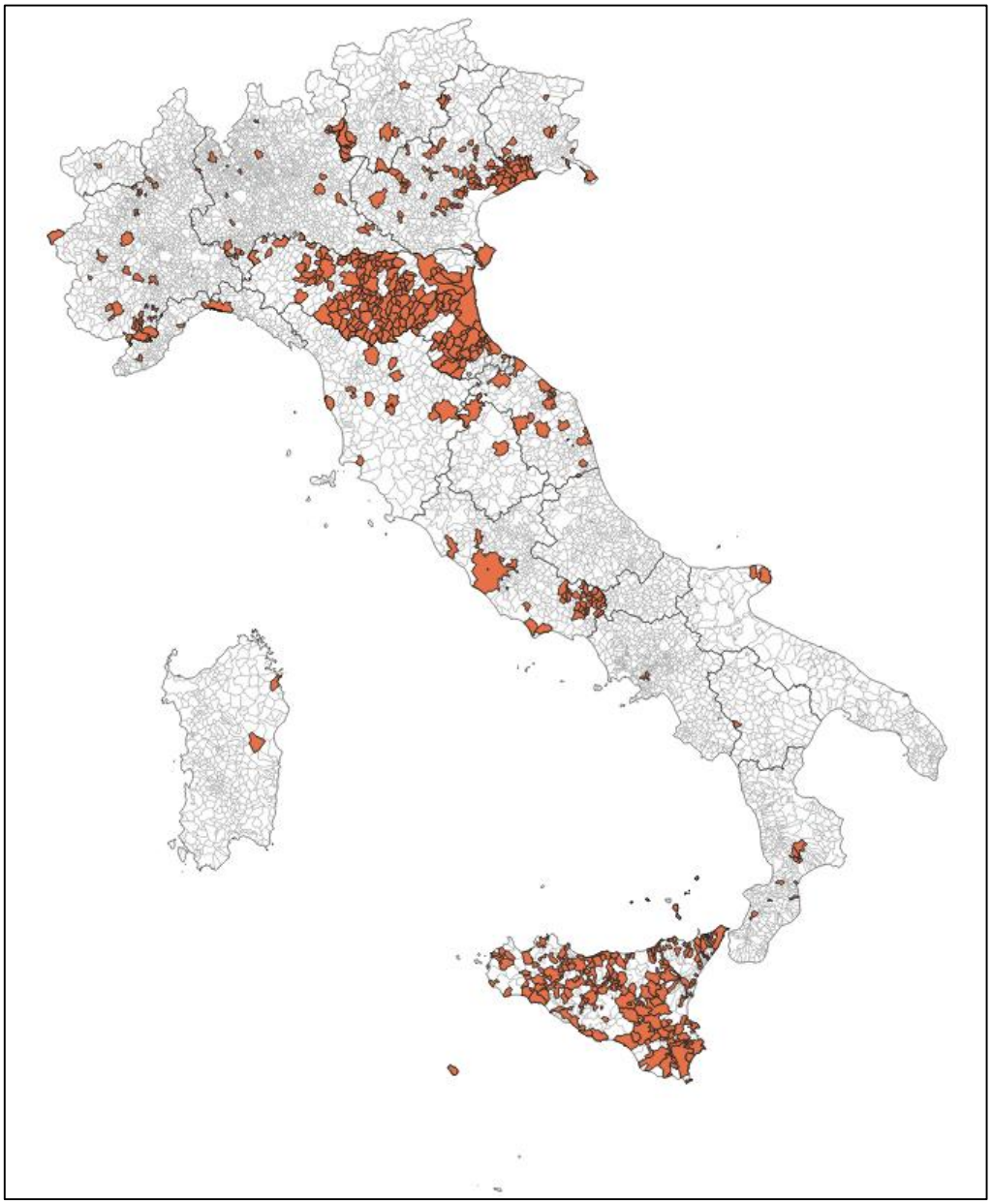
Table 6: The indicators and their related enabler category (according to the categories presented by Brullo et al, 2024)

Public Admin. (PA) / Local Community (C)	**Indicator**	**Enabler category (Brullo et al, 2024)**
Public Administration	MAQI (municipal administration quality index)	Sufficient resourcing
	Municipal surface	Sufficient resourcing
Public Administration / Community	Green preferences	Others (environmental values); Proactive leaders
	Hydrological risk	Environmental factors
	Geological risk	Environmental factors
	Hydrogeological risk	Environmental factors
	Population density	Sufficient resourcing
Community	Green investments	Others (environmental values); Proactive leaders
	Third sector	Social capital
	Average income	Sufficient resourcing (Human capital)
	Human capital	Adaptation awareness, Risk perception
	Waste sorting rate	Social capital; Others (environmental values);
	Density of entrepreneurship	Sufficient resourcing
	Real estate value	Sufficient resourcing
	Employment rate	Sufficient resourcing (Human capital)
	Housing renting price	Sufficient resourcing; proactive leaders
	Dependency index	Sufficient resourcing

2.2.4. Results

5,215 local administrations have signed the Covenant of Mayors in Italy, 1,342 as a part of groups of signatories, and the other 3,873 as individual signatories. 629 cities have signed the Covenant of Mayors since November 2015 and approved a SECAP with valid adaptation commitments. Figure 5 presents the geographical distribution of these municipalities.

Figure 5: The distribution of municipalities with valid adaptation commitments in their SECAP (source: author elaboration on JRC data)



According to Figure 5 and data in Table 7, the valid commitments on climate change adaptation are concentrated in few regions, mainly in Emilia-Romagna and Sicily.

Table 7: Italian municipalities with valid adaptation commitments

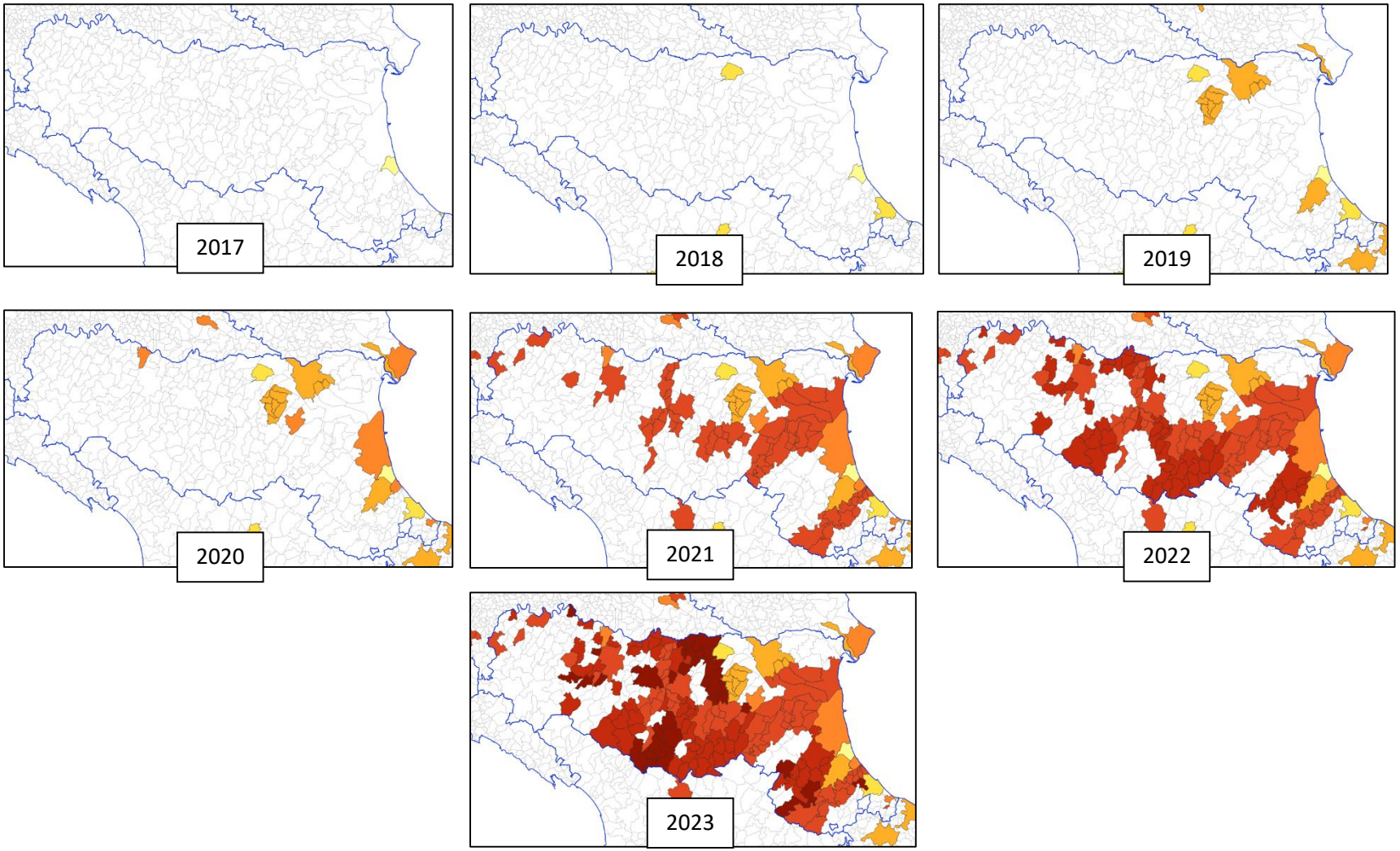
Region	municipalities	signings	percentage
Abruzzo	305	0	0.0%
Aosta Valley	74	1	1.4%
Apulia	257	2	0.8%
Basilicata	131	1	0.8%
Calabria	404	10	2.5%

Campania	550	3	0.5%
Emilia-Romagna	330	192	58.2%
Fiuli-Venezia Giulia	215	12	5.6%
Latium	378	40	10.6%
Liguria	234	3	1.3%
Lombardy	1506	23	1.5%
Marche	225	16	7.1%
Molise	136	0	0.0%
Piedmont	1181	39	3.3%
Sardinia	377	2	0.5%
Sicily	391	184	47.1%
Trentino-Alto Adige	282	11	3.9%
Tuscany	273	12	4.4%
Umbria	92	2	2.2%
Veneto	563	76	13.5%

The engagement of municipalities in the adaptation pillar of the Covenant of Mayors framework is quite uneven in Italy. Emilia-Romagna and Sicily have the highest share of municipalities committed on adaptation by far. Veneto (13.5%) and Latium (10.6%) are the third and the fourth regions considering the share of municipalities committed on adaptation inside the Covenant of Mayors since 2016. However, there is a significant difference in numbers between these two regions and the number of signings in Emilia-Romagna and Sicily.

Focusing on the evolution of Emilia Romagna since 2017 to 2023, it seems to be a sort of contamination between nearby municipalities to motivate the progression of these adaptation commitments. In this preliminary assessment, we did not quantitatively assess this pattern. However, this spillover effect emerges as particularly evident looking at the Figure 6, where signings to the Covenant of Mayors start from the municipalities along the coast and progressively reach the more inner parts of the region. The elements and motivations leading to this progressive contamination are not quantitatively explored in this work. This analysis can be conducted in a second, refined, research work, focusing on political elements and beliefs, social relations between the municipalities and environmental characteristics, i.e. catalysing conditions, such as extreme events or concerns connected to ongoing or expected impacts of climate change.

Figure 6: Municipalities with valid adaptation commitments in Emilia Romagna: progression since 2017 (source: authors elaboration on JRC data)



The motivations behind these uneven performances around Italy can be related to various enablers or catalysing conditions. We firstly focus on the "sufficient resourcing" dimension, especially analysing data on economic resources and public funding schemes. According to a preliminary desk review on regional funding schemes, four regions have published calls to assist local administrations in signing the Covenant of Mayors and defining a SECAP (Table 8).

Table 8: Regional calls delivering financial grants aimed at municipalities to sign the Covenant of Mayors and to develop a Sustainable Energy and Climate Action Plan (source: author analysis on data published on regional administrations websites)

Region	Regional Calls - grants	Number of calls	First year	Grant
Abruzzo	no	-	-	
Aosta Valley	no	-	-	
Apulia	no	-	-	
Basilicata	no	-	-	
Calabria	no	-	-	
Campania	no	-	-	
Emilia-Romagna	yes	3	2019	Single municipality: < 15,000 = 6,000 €; 15,000 < inhabitants < 30,000 = 10,000 €; 30,000 < inhabitants < 50,000 = 12,000 €; 50,000 < inhabitants < 70,000 = 15,000 €; 70,000 < inhabitants = 20,000 €
				Group of municipalities: < 15,000 = 10,000 €; 15,000 < inhabitants < 30,000 = 15,000 €; 30,000 < inhabitants < 50,000 = 20,000 €; 50,000 < inhabitants < 70,000 = 25,000 €; 70,000 < inhabitants = 30,000 €
Fiuli-Venezia Giulia	yes	1+	2020	< 5,000 inhabitants = 6,000 €; 5,000 < inhabitants < 15,000 = 7,000 €; 15,000 < inhabitants < 75,000 = 8,000 €; 75,000 < inhabitants = 10,000 €
Latium	no	-	-	
Liguria	no	-	-	
Lombardy	no	-	-	
Marche	no	-	-	
Molise	no	-	-	
Piedmont	yes	1	2025	21,693 € to be divided among the municipalities according to the ranking determined by call criteria
Sardinia	no	-	-	
Sicily	yes	3	2018	< 5,000 inhabitants = 10,000 €; 5,000 < inhabitants < 10,000 = 12,500 €; 10,000 < inhabitants < 100,000 = 15,000 €; 100,000 < inhabitants < 200,000 = 15,000 €; 200,000 < inhabitants = 15,000 €

				+ a variable amount based on the exact number of residents
Trentino-Alto Adige	no	-	-	
Tuscany	no	-	-	
Umbria	no	-	-	
Veneto	no	-	-	

Emilia Romagna published three calls so far[3]: i) D.G.R. n.379 of 11 March 2019 containing "*Call for Local Authorities to support membership of the Covenant of Mayors for Climate and Energy and the process of drafting the Action Plan for Climate and Sustainable Energy (SECAP)"*[4]; ii) resolution no. 218 of 15/2/2021 containing "*Call for local authorities to support membership of the Covenant of Mayors for Climate and Energy and the process of drafting the "Action Plan for Climate and Sustainable Energy (Paesc)"*[5]; iii) Regional Council resolution no. 479 of 28 March 2022 where the Emilia-Romagna Region promote the European initiative Covenant of Mayors for Climate and Energy within the local authorities system. Apart from the financial contributions, Emilia Romagna region has supported municipalities through various tools and opportunities. Following the final approval of the Regional Adaptation and Mitigation Strategy of December 2018, Emilia Romagna established a Permanent Forum for Climate Change (DAL 187/2018), involving the main regional public and private stakeholders, together with the regional environmental associations. Webinars were organized, together with ANCI E-R to provide training to local authorities, to address some issues related to adaptation and on providing tools and methods for the definition of Sustainable Energy and Climate Action Plans (SECAP). In collaboration with ARPAE and ART-ER, climate projections (2021-2050) were produced for eighteen regional homogeneous areas, and they were available and downloadable by all local authorities from the region's website in the Climate Change section. In 2020, within the framework of the European project AdriaClim (Interreg Italy-Croatia Strategic), a new Integrated Management Strategy for the Defense and Adaptation of the Regional Coast to Climate Change (GIDAC) was launched. CLIMAX PO - CLIMate Adaptation for the PO river basin district, an integrated project co-financed by the LIFE 2021-2017 Programme, was launched, which aims to promote adaptation to climate change through intelligent management of water resources in the PO river basin district

Secondly, we focused on the normative framework as a possible driver of adaptation commitments in the Covenant of Mayors framework. We firstly considered the presence of regional adaptation strategies and plans as a possible factor contributing to an enabling environment for the local administrations. The survey has been conducted looking at the information published on the regional official websites. For a refined version of this work, a direct survey may provide more reliable and detailed information on the status of the regional adaptation policies. Table 9 summarises the status of adaptation strategies and plans by regions in Italy. The definition of adaptation policies at the regional level is quite uneven in Italy. There are different approaches, where some administrations presented an adaptation strategy or plan specifically dedicated to adaptation, other regions included adaptation policies inside their Sustainable Development Strategy, whereas some other regions defined an overarching document dedicated both to mitigation and adaptation, or, lastly, other regions prepared adaptation strategies specifically dedicated to a particular sector (such as the agriculture sector). In our survey, we focused on the presence of official strategies or plans on adaptation,

[3] https://energia.regione.emilia-romagna.it/piani-programmi-progetti/patto-dei-sindaci#strumenti-per-i-comuni

irrespective of the structure and the elements contained in the document. Moreover, some regions are currently developing their adaptation strategies, but the document has not been yet approved.

Table 9: Italian regions with an adaptation strategy or plan

Region	Adaptation strategy or plan	year
Abruzzo	no	-
Aosta Valley	yes	2021
Apulia	no	-
Basilicata	no	-
Calabria	no	-
Campania	no	-
Emilia-Romagna	yes	2018
Fiuli-Venezia Giulia	no	-
Lazio	yes	2022
Liguria	yes	2023
Lombardy	yes	2014
Marche	yes	2023
Molise	yes	2022
Piedmont	yes	2022
Sardinia	yes	2019
Sicily	no	-
Trentino-Alto Adige	no	-
Tuscany	no	-
Umbria	no	-
Veneto	no	-

In the Covenant of Mayors framework, the development of a regional normative framework seems to be quite ineffective on the development of adaptation policies by itself. Emilia-Romagna has a long-standing experience on adaptation policies at the regional level, whereas Sicily has not yet developed an adaptation strategy or plan. Emilia Romagna published its own mitigation and adaptation strategy in 2018, recognising that municipalities have a pillar role in fostering policies to face the impacts produced by climate change. The other regions with a significant share of municipalities engaged in the Covenant of Mayors framework are Lazio (10.6%) and Veneto (13.5%). Lazio developed an adaptation strategy in 2022, whereas Veneto does not have a strategy or plan on adaptation yet. Lombardy and Sardinia are instead regions with a long-lasting commitment on climate change adaptation. Lombardy Region produced an adaptation strategy in 2014 and an adaptation plan in 2015, whereas Sardinia developed the adaptation strategy in 2019. Moreover, Lombardy and Sardinia regions teamed up in a European LIFE project, focused on approaches to design adaptation strategies at different administrative levels (Master Adapt). However, according to the data collected by JRC and to the analyses made in this work, the share of municipalities with valid adaptation commitments in the Covenant of Mayors for Climate and Energy is still quite low (1.5% of municipalities in Lombardy and 0.5% in Sardinia). Municipalities in Lombardy were significantly committed on climate change policies in the first stage of the Covenant of Mayors, the one instituted in 2008 and exclusively dedicated to the mitigation topic. Moreover, according to a preliminary web-based analysis, various municipalities in

Lombardy committed on adaptation through a different policymaking approach or solutions (such as Milano, where adaptation goals were integrated in a plan mainly dedicated to air quality and mitigation policies, i.e. Piano Aria e Clima). However, the pace of adaptation commitments by the municipalities in these regions is still quite slow in the Covenant of Mayors for Climate and Energy framework.

The presence of adaptation enablers has been further investigated through a quantitative modelling approach. This analysis has been conducted in collaboration with Prof. Roberto Zoboli and Prof. Andrea Pronti of the Department of International Economics, Institutions and Development of the Catholic University of Milan.

The aim of the analysis is to quantitatively assess the presence of socio-economic, institutional and environmental conditions as enabler of the definition of adaptation policies at the municipal level. As we mentioned above, we have identified indicators to represent the categories of enablers emerging from the literature review (Table 5). The dependent variable is the presence of a SECAP with valid adaptation commitments. We do not investigate the ambition, or the effectiveness of the adaptation policies identified in the SECAP, but we just focus on the presence of adaptation commitments, formally valid for the technical evaluator of the Covenant of Mayors (i.e. the JRC). Moreover, we consider the definition of policies, not the implementation and the governance of the measures.

The results of the analysis are presented in Table 10. The factors have been tested in a series of models, assessing different combinations of these factors to identify the most significant and robust factors. In Table 10, we present the outcome of the analysis, summarising the results of the different models applied in the econometric analysis. A plus sign represents a potential enabler, thus statistically significant in relation with the definition of adaptation policies, whereas the minus sign means that the factors emerge as a barrier to adaptation policies. The asterisk represents the robustness of the results (*** p<0.01, ** p<0.05, * p<0.1).

Table 10: Output of the statistical regression testing the significance of factors for the definition of adaptation policies inside the Covenant of Mayors framework

Indicator	statistical significance
green investments	+*
green preferences	+*
MAQI (municipal administration quality index)	+***
municipal surface	+***
third sector	no
average income	?
human capital	no
hydrological risk	+***
geological risk	no
hydrogeological risk	+**
waste sorting rate	no
density of entrepreneurship	+*
real estate value	+**

employment rate	no
housing renting price	-***
dependency index	no
population density	no

According to our analysis and using the categories by Brullo et al (2024), three main enabler dimensions emerge to have an influence on the climate change adaptation policy-making process: the presence of hydrological risks, environmental values, sufficient resourcing. The sufficient resourcing issue is distinguished between the public authority sphere (i.e. quality of institutions) and the local community environment (i.e. the human capital and the local economic resources).

Hydrological risk emerges as a significant driver for adaptation planning, whereas geologic risk is not statistically significant. When these two enablers are considered together, the composite indicator is again positively associated with the definition of adaptation actions. This suggests that hydrological risk is one of the primary drivers influencing adaptation strategies, while geological risk plays a negligible role. This result is in line with the literature. The presence of risk could be a motivation for the public administration to design coping or adaptive strategies, to prevent losses and to increase the resilience of the community. However, according to enablers literature, the presence of risk is not considered an enabler by itself, but it is effective when connected to the presence of knowledge on the effects of disasters and on the benefits of coping strategies and anticipatory measures. According to Reckien et al (2014), even though the environmental characteristics of a territory (e.g. living in a low elevation coastal area) can influence the propensity to design and implement adaptation measures, these dimensions seem to have an impact as adaptation enablers only when they influence the risk perception of the local community. The presence of so-called catalysing conditions (IPCC, 2022), such as extreme events, can be a significant factor triggering the relation between the presence of risk and the risk perception of the local community and public administration. Extreme events or political windows of opportunities (e.g. the approval of an important policy or treaty on climate change, such the Paris Agreement) can be significant triggers even for the rise of community led movements, improving their awareness on local risks and their motivation to ask for more concrete and effective adaptation policies. Literature presents various case studies where the awareness on climate issues and the presence of extreme events can be a trigger for motivating climate change action (Dilling et al, 2017; Simonet and Leseur, 2019), also pushing professionals to launch new technological trajectories (Mo Madsen et al; 2019). We have also explored environmental and morphological characteristics using the average elevation indicator. The average elevation seems to be not significantly correlated with the adoption of adaptation policies. This finding is in line with other papers. In the research work by Reckien et al (2014) being in the low elevation coastal zone or very close to the sea decreases the chance of having an adaptation plan and the presence of relatively warm summer temperatures seems to be ineffective on the development of adaptation policies. These cities, despite being at risk from higher temperatures and heat waves in the future, have fewer adaptation plans. Thus, similarly to other enabling factors, the combined presence of drivers (e.g. morphological conditions, risk perception, extreme events) could be necessary to create effective enabling conditions for adaptation policies.

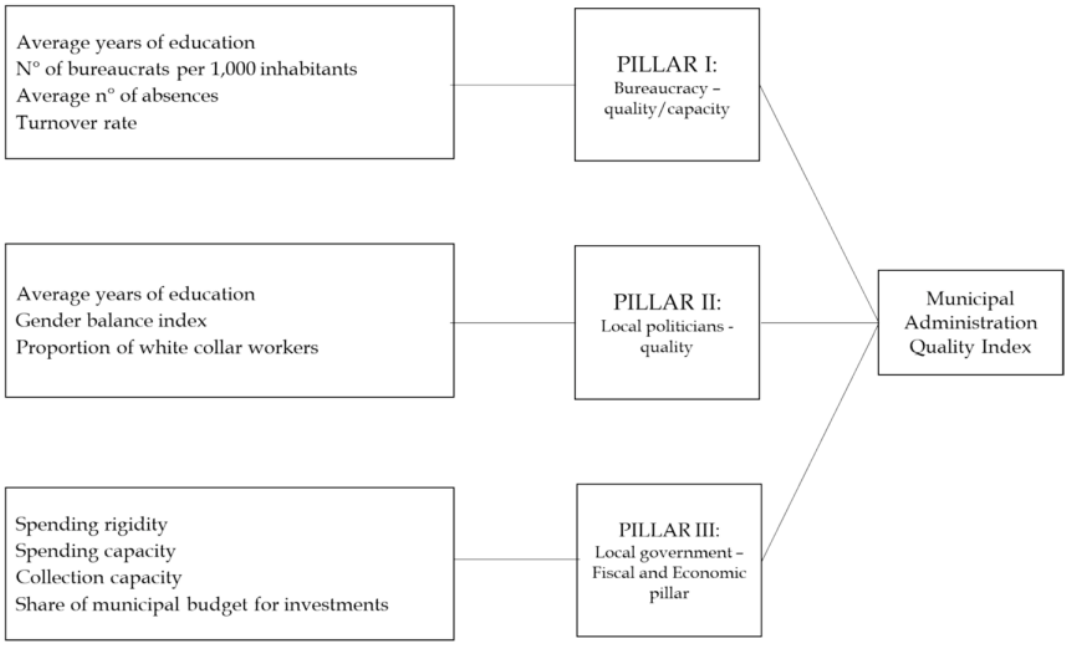
The diffusion of photovoltaic systems and the share of votes to green parties emerge as potential significant enablers of adaptation policies. These dimensions can be connected to the presence of environmental values and of political polarization on environmental topics. According to literature, climate change policies are

frequently considered commitments to protect and improve the quality of the environment. Moreover, these policies are frequently assigned to the duties of the environment policies departments, meaning that the defence of the environment is one of the expected outcomes of these interventions. The presence of environmental values and environmentally friendly behaviours can be seen as a forerunner of a public administration commitment on mitigation and adaptation topics. According to Patterson (2021), public administrations may act early on adaptation if already strongly committed on environmental policies. Patterson (2021) affirms that institutional adaptation seems to be motivated by political issues rather than more rational explanations (such as the response to climate risks or to extreme weather events). According to Moser and Ekstrom (2010) values and beliefs can be a barrier to adaptation because they can influence how people perceive, interpret and think about risks and their management. However, as discussed in the first chapter, the relevance of political beliefs and values is debated in literature. In the case study by Giordono et al (2020) even though there is evidence of political polarization on the climate change topic, policy response to extreme events is not influenced by the political preferences of the local community, especially when dealing with high impact events. According to literature, the relevance of political beliefs and values is again connected to the presence of other drivers. Political pressure is effective when combined with agency, possibly also in the presence of knowledge on adaptation benefits or on the effects of climate change impacts, triggered by some catalysing conditions (such as extreme events) (Giordono et al, 2020). The importance of change agents confirms extensive literature highlighting the role of agency and leadership in urban climate governance. The role of change agents and proactive leaders is widely explored in the adaptation enablers literature, describing the importance of this dimension, especially at the local level. However, this enabler is usually assessed through surveys or interviews, which are more effective in understanding and explaining the role of officials or political leaders in fostering the adaptation agenda inside the public administration. The political stability of the municipality is considered another possible enabler triggering the effectiveness of political values and beliefs in fostering adaptation policymaking processes (Pasquini et al, 2015). Political stability is intended as the frequency with which the political alignment of the municipality shifted, even during the same administrative cycle. Frequent changes in the political alignment can redirect economic resources to other priorities, replacement of senior staff and deferment of decisions (Pasquini, et al, 2015). According to literature, political values and beliefs are relevant even in the Covenant of Mayors framework. However, the political beliefs and political will seems to be significant exclusively on the moment of adherence (signing the Covenant) because it produces political visibility and legitimacy, whereas the implementation and monitoring of adaptation measures is often considered a bureaucratic burden (Basso and Tonin, 2022).

The sufficient resource category is here assessed by two distinct perspectives: one focused on the resources of the public administration and another one dedicated to the local community, considering the human and economic development of the territory. The size of the local authority is positively correlated with the presence of adaptation policies. This is consistent with the findings by Reckien et al (2015) and Araos et al (2016). The size can be a proxy of the structure and overall administrative capacity of the municipality. Bigger municipalities generally have more officials, sometimes with departments specifically dedicated to climate change or resilience policies. According to the monitoring reports of the CoM, small municipalities need technical support and the effective commitment of local decision makers to enhance the effectiveness of the entire process of CoM implementation at a local level (Santopietro and Scorza, 2021). However, the number of officials can be also positively correlated to the reporting capacity of the administrations. Thus, in bigger cities, the adaptation commitments and achievements can be disseminated and reported more easily. Furthermore, the relevance of this dimension changes when assessed through interviews. According to the interviews made in the Simonet and Leseur paper (2019), the influence of the size of the local authority is among the five least expressed drivers. The resources of the public administrations can be also described by

the quality of institutions indicator (MAQI index), which is one of the enablers with a significant and robust correlation to adaptation policies. The MAQI index is composed by three main pillars, capturing a recognised driving factor of municipal administration quality: (i) the quality and capacity of the local bureaucratic apparatus, the quality of local politicians, and the fiscal efficiency and economic performance of local governments. Figure 7 presents the structure of the index and the indicators used to characterise each pillar.

Figure 7: The Municipal Administration Quality Index



Municipalities with higher-quality institutions are likely to have greater administrative capacity, more effective governance structures, and stronger policy coordination, all of which facilitate the design and implementation of complex climate adaptation strategies. Strong institutions can also provide better access to funding opportunities, technical expertise, and inter-municipal networks, which are crucial for the planning and implementation of adaptation plans. Finally, well-functioning institutions are more capable of integrating scientific evidence and risk assessments into local policymaking, ensuring that adaptation strategies are both efficient and targeted to local vulnerabilities. The size of the municipality and the presence of technical and economic resources in the public administration are both recognised to be important drivers even for the implementation of commitments inside the CoM framework, which is considered the most complex step in the CoM policymaking cycle (Basso e Tonin, 2022).

The sufficient resources dimension has a different behaviour when considering the whole community. The share of the population with a university degree and the distribution of economic resources in a community (entrepreneurship and house price) are usually considered proxies of local adaptive capacity (i.e. *a system's ability to adjust its characteristics and behaviours to cope with changing conditions, reduce harm, and enhance resilience, often in response to stresses like climate change*). Adaptive capacity is commonly considered a significant driver of adaptation policies (Dilling et al, 2017; Reckien et al, 2015; Araos et al, 2016; Berrang Ford et al, 2014). Communities with higher human and economic resources can be more easily equipped to designing and implementing adaptation policies. Human resources can be connected to risk perception and to the capacity to understand the complex climate change knowledge. Furthermore, high economic and human resources can be connected to a wealthier status, with a higher availability to dedicate

resources and efforts to future needs or long-term benefits, whereas poor communities may be worried by more urgent economic and social needs (even though in some cases, climate impacts are already a significant threat to the wellness of the local communities). High economic resources can be also connected to high value of exposed elements on the territory, thus leading entrepreneurs or communities to stress an intervention by the local administration to protect their assets, enhancing the resilience of the territory. In our analysis, human capital is statistically significant in relation to the adoption of an adaptation plan, and it can be referred to the enhancement of local expertise, decision-making capacity and to the increase of risk perception. On the contrary, the economic factors have an uneven performance in our analysis. Here, the correlation between these factors and the definition of adaptation policies is uneven. Entrepreneurship and house price are positively correlated with adaptation, whereas the employment rate and the average price of rents are not a significant factor, and the robustness of the correlation between adaptation and average income is quite low. Furthermore, the municipal financial autonomy (% of taxes managed by the municipality on the total) has not emerged as a significant enabler for adaptation. The density of firms is instead statistically significant as an enabler, likely reflecting the availability of local economic resources and organizational capacity, which can facilitate the planning and implementation of climate adaptation policies. Moreover, the density of firms can also be a motivation for the public administration to adopt risk mitigation and climate adaptation measures, reducing the exposed elements and enhancing the adaptive and coping capacity of the community, to limit climate related risks and losses.

Lastly, the proxies used in our paper for the social capital do not emerge as statistically significant in relation to the adoption of adaptation policies, even though, according to enablers literature (Brullo et al 2024), social bonds are considered relevant for adaptation at the local community and local administrations levels.

The presence of economic resources, the quality of institutions, the diffusion of environmental values, the presence of hydrological risk and the level of education of citizens (diploma rate) have emerged as enablers of adaptation policies. This quantitative analysis helped us in identifying and characterising possible adaptation enablers at the local level in Italy. The quantitative analysis is an innovative approach applied to this field, which is usually investigated through surveys and interviews. The econometric approach gives us the opportunity to discuss the role of enablers without dealing with personal and subjective judgments, but instead focusing on data on the local socio-economic, institutional and environmental characteristics. However, a quantitative approach on enablers struggles in assessing the role of more subjective factors, such as personal motivations, human relations or risk perception, usually assessed by interviews.

Furthermore, according to literature, enablers appear to be dynamic in relation to the transitory needs of the local community or of the public administration. Here, the analysis considers a single time period, without assessing a possible evolution of enablers during the life of the CoM. The Covenant of Mayors for Climate and Energy was defined in the end of 2015, and we probably have not the proper time extension to assess possible changings in the needs for adaptation policymaking and related enablers. This refined analysis would be potentially possible with next versions of the JRC dataset on signatories monitoring reports. According to Rogers et al (2022), it would be also relevant to assess enablers in relation to the different policy making stages. We assessed enablers referred to the planning of adaptation commitments. In an updated version of this work, we can assess the evolution of enablers through time and the enablers of the implementation and monitoring of the identified commitments. Lastly, the Covenant of Mayors is just one of the possible solutions for municipalities to plan and implement adaptation policies. A local administration can design its own adaptation strategy, without committing to an international network, or it can take part in other networks, such as Resilient cities, C40 or ICLEI. In next research we can enrich the group of local administrations and

adaptation frameworks considered, with the aim to take into account a wider spectrum of adaptation policymaking processes.

2.2.5. Summary

Local administrations are essential to improve the resilience of the community to the ongoing and expected impacts of climate change. In this case study we have focused on municipal commitments inside the Covenant of Mayors for Climate and Energy framework. We have identified the municipalities with valid adaptation commitments in Italy, and we have applied an econometric approach to identify and characterise possible enablers to adaptation planning. Adaptation policymaking emerges as statistically linked with the presence of hydrological risk, the diffusion of environmental values, the quality of local institutions, the presence of human capital and the average price of properties in the real estate market. The relevance of local risk profile for the planning of adaptation measures confirms findings in literature even though risk perception and some trigger events are also necessary to improve the pace of adaptation policies. The political beliefs and local values seem to be another important enabler to adaptation. However, according to literature the effectiveness of this enabler is usually enhanced by the presence of proactive officials, political stability or again by the presence of catalysing conditions or political and natural events. The quality of resources is particularly relevant for the definition of adaptation policies, even though the number of officials and the quality of institutions are also connected to an effective monitoring and reporting capacity. The relevance of human capital and economic dimensions related to the local community is more uneven. A refined version of this research may tackle some of the limit of this work: (i) a static analysis, not considering the possible evolution of enablers through years; (ii) a focus limited on the planning step; (iii) an assessment limited to the CoM framework.

3. Conclusions

According to the first Global Stocktake by the UNFCCC, the efforts on mitigation are still insufficient to reach the goals identified in the Paris Agreement. Thus, the pace of adaptation policies should be accelerated, to enhance the resilience of the local communities, preparing them for the ongoing and expected impacts generated or exacerbated by anthropogenic climatic changes. In this report we have presented adaptation enablers: socio-economic, institutional and environmental factors driving the dissemination and implementation of the urgent adaptation strategies and measures. Enablers are defined as: "*Factors that make it easier to plan and implement adaptation actions, that expand adaptation options, or that provide ancillary co-benefits".* In this research we have firstly discussed the intricate conceptualisation of adaptation enablers in literature, focusing on the plurality of definitions, terms and categories presented by international research organisations or scientific literature. Enablers emerge as a context dependent dimension, deeply connected to the temporary needs of the local communities and to the different steps of the various policy-making stages.

In the second part of this research work, we have applied the categories of enablers from literature to case studies at different administrative levels. In the first case study we have analysed the National Communications to the UNFCCC, focusing on self-assessed enablers and barriers by the national governments. Institutional factors, economic resources, the presence of knowledge on the impacts on climate change and the coordination among different sectors and administrative levels emerge as the most recurring enablers, even though the relative importance of these elements change in relation with the area of the world (e.g. Annex I and non-Annex I countries) The second case study is focused on Italian municipalities inside the

Covenant of Mayors framework. We have applied an econometric approach to identify the socio-economic, institutional and environmental enabling conditions behind the signing of the CoM and the planning of adaptation policies. Quality of institutions, hydrological risk and environmental values emerge as the most significant enablers for local administrations. However, further developments are needed to refine the outcomes of the analyses. In an improved version of this research, we should focus on three main aspects: (i) the assessment of enablers over different time periods; (ii) the focus on different policy stages, not limiting the analysis to the planning phase; (iii) a wider look at different approaches to design adaptation policies, not limiting the research to the CoM initiative.

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