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Macro-Regional Strategies, Climate Policies and Regional Climatic Governance in the Alps

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Abstract: This paper describes the macro-regional governance framework behind the climate adaptation policies that are currently in place in the Alpine area. Through this discussion, it specifically considers the implications of the regional governance of South Tyrol and Lombardy as case studies. Despite rising concern at the European level, there are still no specific guidelines in place for climate change governance at the macro-regional level. Macro-regions encompass multiple regions that have certain shared morphological characteristics. To address climate changes that occur here, they adopt optional larger-scale strategies without adequately considering territorial and governmental specificities at the regional level. Each individual region adopts specific climate adaptation strategies to deal with the challenges of the territories they govern, without considering the effects on their neighbours, decentralises climate policies to the lowest tiers of government, and encourages participation from individuals and non-governmental organisations. The Alpine macro-region is governed by three separate international/transnational institutions at the macro-regional level and is subject to different regulations from each of the 48 regions/autonomous provinces. One of these regions is Lombardy, which is particularly exposed to the effects of climate change due to having the highest values for land consumption and pollution in Italy. From the administrative point of view, it is an ordinary region, which means that it has the same legislative competences of the other Italian regions. South Tyrol is entirely mountainous. Being an autonomous province, it benefits from greater legislative autonomy than ordinary regions. Based on documental analysis of climate adaptation strategies, findings demonstrate that the preferred governance structure involves the presence of a coordinating institution (such as the province in South Tyrol or the region in Lombardy) that decides climate action, along with several other local institutions and stakeholders that have less decision-making power. Its preferred mechanism for addressing specific climate challenges is the definition of specific regulations and the draft of regional and mono-sectoral plans. These regulations do not relate strongly to wider-scale strategies at the macro-regional level, but are inspired by their principles and priorities. At both definition and implementation levels, the participation of local organisations is limited and not incentivised. Administratively, South Tyrol enjoys greater autonomy, whereas Lombardy must comply more closely with state regulations that limit its decision-making freedom.

Keywords: climate governance; climate change; Alps; South Tyrol; Lombardy

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1. Introduction

Even if worldwide efforts to reduce emissions are successful, climate change is still occurring [1]. 2022 ranks among the 10 hottest years ever recorded [2]. The yearly average worldwide surface temperature throughout the period 2009–2018 is over 1 degree higher than the preindustrial average [3]. The world's temperature is predicted to rise by 0.3 to 1.7 degrees in the lowest emissions scenario and by 2.6 to 4.8 degrees in the highest [4]. Extreme weather and climate-related phenomena (such as floods and

droughts) are likely to become more frequent, with agribusiness and tourism two of the most affected economic sectors. Consequences for biodiversity and natural ecosystems appear to be negative. Negative effects are also hypothesised for human health and well-being [5–8].

Adaptation policies related to these changes appear to be urgent and require some form of global collective action [9]. Climate change is described as a problem that must be resolved at the international level [10] as its causes and implications depend on unstructured, international, and multiterritorial interdependencies.

The European Union has recently unveiled the EU climate actions [11], in close collaboration with international partners and local policies. These include the European Climate Law, which incorporates the 2050 climate-neutrality goal into EU law, and the European Climate Pact, which unites citizens and all aspects of society in climate action. A list of initiatives to cut net greenhouse gas emissions by at least a further 55% by 2030 is also included in the 2030 Climate Target Plan.

At the next rung of administrative level, national governments primarily negotiate multilateral agreements to govern climate change [12,13] and then coordinate climate policies through transnational networks, such as C40 or ICLEI, to make commitments to specific climate targets.

Recently, other organisations—including financial institutions, non-governmental organisations (NGOs), businesses, associations, and civic groups—have been participating in their decisions. Their participation involves a new approach to international multilateralism and international cooperation. It suggests moving away from top-down institutionally driven climate governance, instead favouring bottom-up polycentric approaches [14]. Finally, it promotes the implementation of policies that are more geared toward certain regions, as well as the inclusion of climate governance into a multi-focused approach to sustainable development at both the local and the national level [15,16].

Between these actors, there is an additional administrative layer in Europe—this is the macro-regions.

Macro-regions span several states and regions. Local conditions and climate change can be comparable between the regions covered, but their consequences can vary greatly at ground level and go beyond traditional administrative boundaries (see, e.g., [17]). To manage their territories, macro-regions use larger-scale strategies, which are optional or do not devote adequate attention to the unique characteristics of any regions included. Within them, each region is managed differently, according to national and regional laws. As such, each of them implements unique climate adaptation strategies and policies to solve the specific problems of the territories they control, without considering how such decisions might affect their neighbours, sometimes with the collaboration of nongovernmental organisations and subnational authorities. This form of governance is expected to implement effective and timely solutions and adapt to the needs of specific communities. However, several factors reduce its usefulness—these include multi-actor interest, information scarcity, lack of coordination, geographic specificities, etc. (e.g., [18,19]).

Despite growing attention on the subject, there are currently no specific guidelines for how to manage climate change at this level.

In the Alps sits the Alpine macro-region. This area is a fragile ecosystem [20,21]. Climate change turns it into a location with high-risk environments (e.g., glacial lake outburst, avalanches, etc.; e.g., [22,23]) and low level of natural diversity, and opportunities to exploit them for economic reasons (touristic and agricultural activities) [24–26]. Administratively, it covers eight countries (Italy, Germany, Austria, Switzerland, France, Slovenia, Monaco, and Liechtenstein), 48 regions/autonomous provinces, and 5700 municipalities. Each institution has specific competences in policies related to climate change and adopts various governance structures and procedures to manage the administered territories. In addition to the national, regional, and local governments, there are other organisations that exert some influence and work to advance the interests of this macro-region: one

international institution (the Alpine Convention), one transnational strategy (EUSALP Strategy), and the beneficiary area of European funds (the Alpine area for Alpine Space Program-Interreg). Despite the large number of institutions involved, the decision about which administrative level would be the most appropriate to adopt relevant adaptive policies has not yet been taken. Rare attention is also paid to governance structures or stakeholder participation methods, at macro-regional and regional level, or to the consistency of regional decisions when it comes to strategies to address climate vulnerabilities at macro-regional level [27]. Closing this gap is relevant because it enables the better coordination of the efforts of all stakeholders and the adoption of more effective policies to safeguard the climate of this important region, which in turn affects that of many other European regions.

The present article describes climate change adaptation strategies and their relative governance at the macro-regional and regional level, and their connections. In other words, it tries to answer these research questions:

(i) What governance mechanisms have been adopted at the Alpine macro-regional level to govern climate change and adopt relative adaptation policies? And at the regional level?
(ii) Which stakeholders are involved in the elaboration and implementation of climate strategies and policies at those levels?
(iii) How do the strategies relate to EU, transnational and/or national climate change adaptation strategies and what interactions exist between Alpine, national, and regional policy domains?

As case studies, the article considers Lombardy and South Tyrol, in the Italian area of the Alpine macro-region.

In recent years, the Lombardy region has made considerable efforts with its climate change adaptation policies. Following the pioneering studies of the Kyoto-Lombardy project (2004–2008) and the 2010 strategic document on the sustainable development, it has adopted specific sectoral policy instruments in the fields of energy, risk management, rural development, and air quality, which include a series of interventions aimed at reducing climate-altering emissions and increasing the capacity of soils and agro-forestry ecosystems to absorb and store carbon. However, the effects of these policies are limited because the region is exposed to high climate vulnerability and drift, as well as to extreme weather events that occur, on average, much more frequently than in other European countries.

South Tyrol is an autonomous province that has more legislative autonomy than other Alpine provinces and Italian regions. Due to this increased autonomy, this province implements more specialised policies and plans in response to the demands of its territory, working in collaboration with associations, universities, and local research centres. One of the most relevant of these plans is the PAESC (Action Plan for Sustainable Energy and Climate), which was approved by the Municipality of Bozen within the framework of the Covenant of Mayors of the European Commission in 2020.

This paper's methodology is based on a document analysis of the strategies for coping with climate change that have been adopted over the past five years—at the European macro-region level by the Alpine Convention, EUSALP action groups and the Alpine area for the Alpine Space Program-Interreg, and by local institutions—to address climate change in Lombardy and South Tyrol.

The paper is set up as follows. The second section briefly examines the present literature on the governance of climate change, and the third one discusses the peculiarity of the Alpine area. The fourth section provides a brief explanation of the method behind the present investigation, while the following ones detail measures put in place over the past five years to cope with climate change by the Alpine Convention, EUSALP action groups, the Alpine Space Program-Interreg at the European level, and by the Italian government at national level. The following sections illustrate the test areas, past and future-estimated climate changes and their hypothetical impacts on economic activities, as

well as their governance structures, the institutions' engagement, and the relationship with other strategies at various geographical levels. The discussion and conclusion are included in the final paragraphs.

2. Background

Climate change governance is a term used to describe a specific decision-making procedure used to address climate change at various levels of government and society (for example, [28–31]). This governance includes decisions regarding the adaptation of territories and people to present and predicted climate changes and their repercussions (see, e.g., [32,33]). At the national level, it reflects negotiations and multilateral agreements that have happened at the international level. The global community decides on shared goals and a minimal set of practices and regulations, while each state defines its commitment to its own territory and assesses how to achieve global objectives. The European Union introduces targets and guidelines to orient national decisions. It also promotes central states' authority, as well as encouraging the close cooperation of governmental organisations, non-governmental ones, and individuals. Immediately below the European Union, at a level immediately above the state level and with predominantly advisory rather than regulatory powers, there is an additional governmental layer—the macro-regional level, which includes climate change alongside many other policies. A macro-regional strategy is "a policy framework which allows countries located in the same region to jointly tackle and find solutions to problems or to better use the potential they have in common" (European Union, 2017). Currently, there are four macro-regions in Europe (Baltic Sea, Danube region, Adriatic-Ionic region, and Alpine region/EUSALP), which address some common problems related to certain transnational issues, such as navigability, pollution, global trade, and competition, etc. Eventually, other organisations also contribute to the creation and application of more specific strategies—these include national and local institutions, agencies, and individuals.

The contribution of each institution to the definition of the governance of climate change depends on the extent of the shift in the balance of power and authority along three dimensions: (i) the transfer of power from the federal/central government to local governments; (ii) the expansion of the power-sharing relationship between the state and civil society; and (iii) the reduction of state sovereignty as a result of the adoption of international coordination mechanisms [34].

The literature improves the conversation about the most appropriate governance structures, stakeholder engagement, and compatibility of the adopted policies with current and larger-scale plans. Some academics predict that the ongoing fragmentation of climate governance will reduce the decision-making power of international institutions and is likely to result in contradictory expectations regarding the function and impact of various authorities [35]. On the contrary, Zelli and van Asselt [36] and Keohane and Victor [37] reject the idea of a single regime for climate change and promote the participation of newly emerging institutions in the governance space.

With an emphasis on climate change, Sapiains et al. (2021) [13] consider these three dimensions and specifically analyse the governance structures, stakeholder participation methods, and connections to larger-scale strategies. Based on this, they provide a list of 30 distinct types of climates and/or environmental governance and divide them into six categories.

One of these is associated with the concept of multilevel governance, which combines several elements (organisations, scales, and interactions) into a more comprehensive plan (see, e.g., [38,39]). Decentralisation, defined as "decision-making taking place at a range of geographical levels or scales" ([40], p. 251), is its essential feature. Along with the governmental players, emergent actors also play a critical role. However, they may not always cooperate on an equal footing.

The second cluster of approaches comprises those that operate under the assumption that the problem of climate change must be addressed by global governance. Although

most of these approaches are of some importance to the national states that continue to play a central role, some of them reveal a great emphasis on developing comprehensive adaptation strategies in which the role of the scientific community becomes increasingly important (see, e.g., [41–43]).

The third category consists of transnational, polycentric, and adaptive governance strategies that emphasise the importance of national states, which continue to play a crucial role in transnational governance, and of the role of private actors and the ways in which they participate in climate governance (such as through public-private partnerships or informal law-making) (e.g., [44,45]). However, despite an enthusiastic narrative on international activities, concerns regarding the authority and legitimacy of these actors are frequently overlooked.

Contrary to these strategies, those found in cluster 4 focus on the importance of local networks and communities. As a result, they propose a kind of 'polycentric order' that includes 'orchestration' [13], new tools to take into account international law [39], non-state and substate agencies and/or actors, and network governance [46]). This governance emphasises local experiences and uses "urban or local governance" as a case study. Other geographical scales, such as the macro-regional level, are ignored. Adaptive governance initiatives, grouped as Cluster 5, focus on local experiences, using case studies on "local" or "urban" governance or focus on the management of natural resources. Key concept such as panarchy, resilience, scale, tipping points, the Anthropocene, social-ecological systems and interdisciplinarity are central to this approach.

The final cluster provides an illustration of experimental and transformative methods that use "learning by doing" mechanisms at smaller scales (e.g., [47]). The disparity between jurisdictional scales and the challenge of climate change is what leads to the variety of these governance models. It is challenging to adopt general or transdisciplinary plans or long-term strategies at a higher level due to differences in spatial, temporal, and sectoral scales. Less frequently occurring climate change is being addressed by the federal government. Overcoming legislative discrepancies, conflicts over the distribution of competencies across institutional levels within the network, the integration of policies, and the existence of regional implementation hurdles could all be issues.

3. The Alps in a Changing Climate

The Alps spread across the borders of eight European countries that share geographical and environmental characteristics and challenges. These challenges are related to the presence of a mountainous environment and diverse culture, accessibility, as well as rich and sensitive biodiversity and environment, economic disparities.

The Alps cover an extremely exposed area that is sensitive to climate change. The area has a variety of climates, with colder regions at higher elevations and warmer regions, particularly in the lowlands. The past years have also seen an increase in temperatures. Between the end of the nineteenth century and the beginning of the twentieth century, the temperature increased by 2 °C [48], with a significant acceleration of warming since the 1990s [49]. High-alpine ecosystems have changed significantly and are extremely vulnerable to climatic changes. According to future projections, summers will be drier and winters will be more likely to have more precipitation. More days and nights with extreme temperatures, as well as extreme weather events like droughts and heavy rain, are also possible. From 2021 through to 2050, the temperature will rise dramatically (Figure 1).

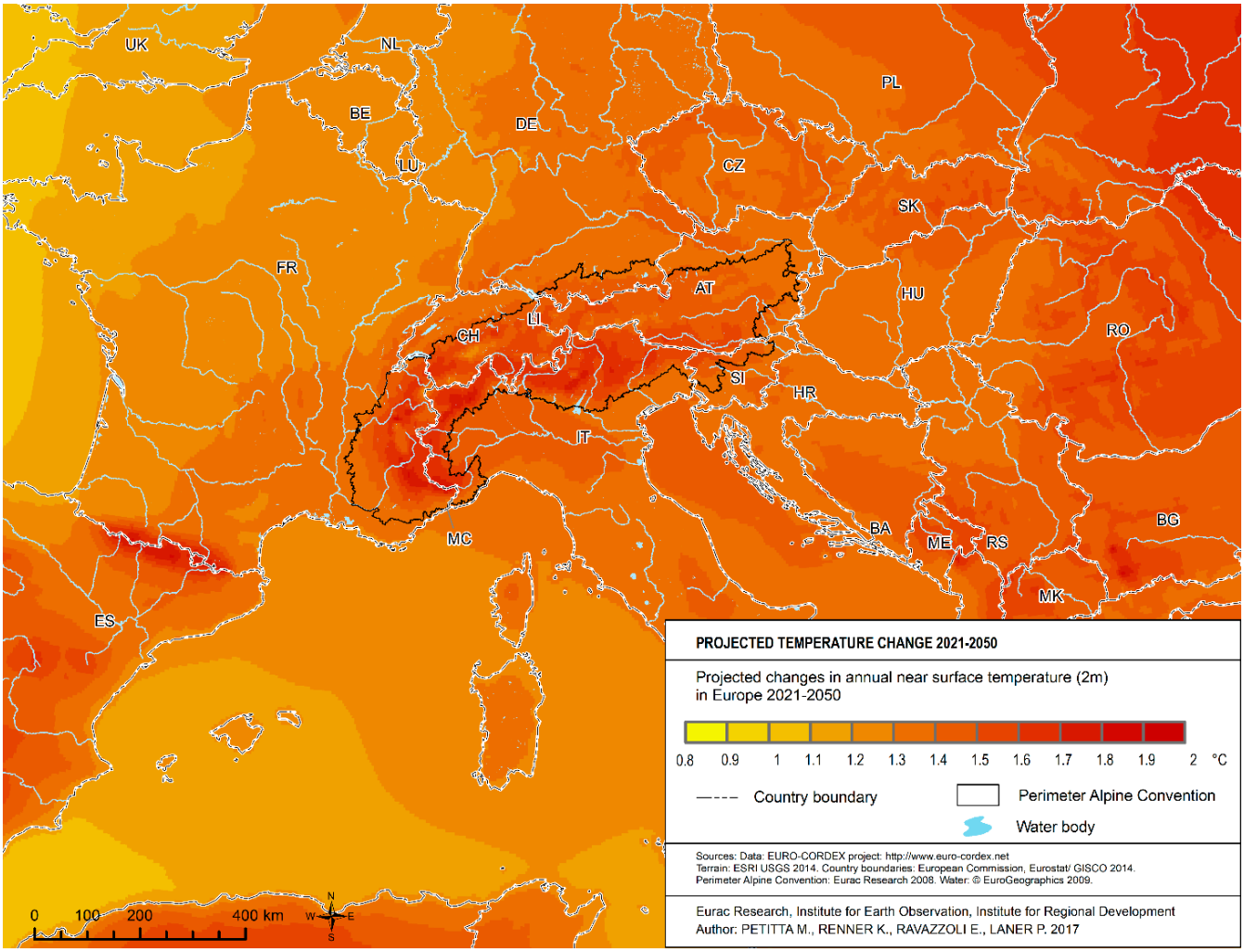

Figure 1. Projected temperature change 2021–2050. Source: Permanent Secretariat of the Alpine Convention, 2017, Eurac Research, and Permanent Secretariat of the Alpine Convention, 2017 [50]. Reprinted with the permission of the author.

The total surface area of glaciers was halved between 1900 and 2012 [51,52], while the frequency and volume of rockfall on rock faces increased [53]. Since 1971, the eastern half of the Alps has seen an increase in precipitation, whereas the western part has seen a decrease in precipitation. The south-west regions of the Alpine arc experience less precipitation, while the Northern Alps, Ticino (Switzerland) and northern Italy experience most of it (Figure 2).

Sustainable and effective protection from climate change appears as an essential predisposition for settling and the promotion of socio-economic development in the Alps. Excessive exploitation of natural resources for economic reasons, together with the exposure to climate change, increases the risk of damage to the local landscape and natural biodiversity. The interests of economic development, and especially of mobility and tourism need to balance risk reduction and safety management. This requires new risk governance instruments and processes with a view to find the optimal governance approach.

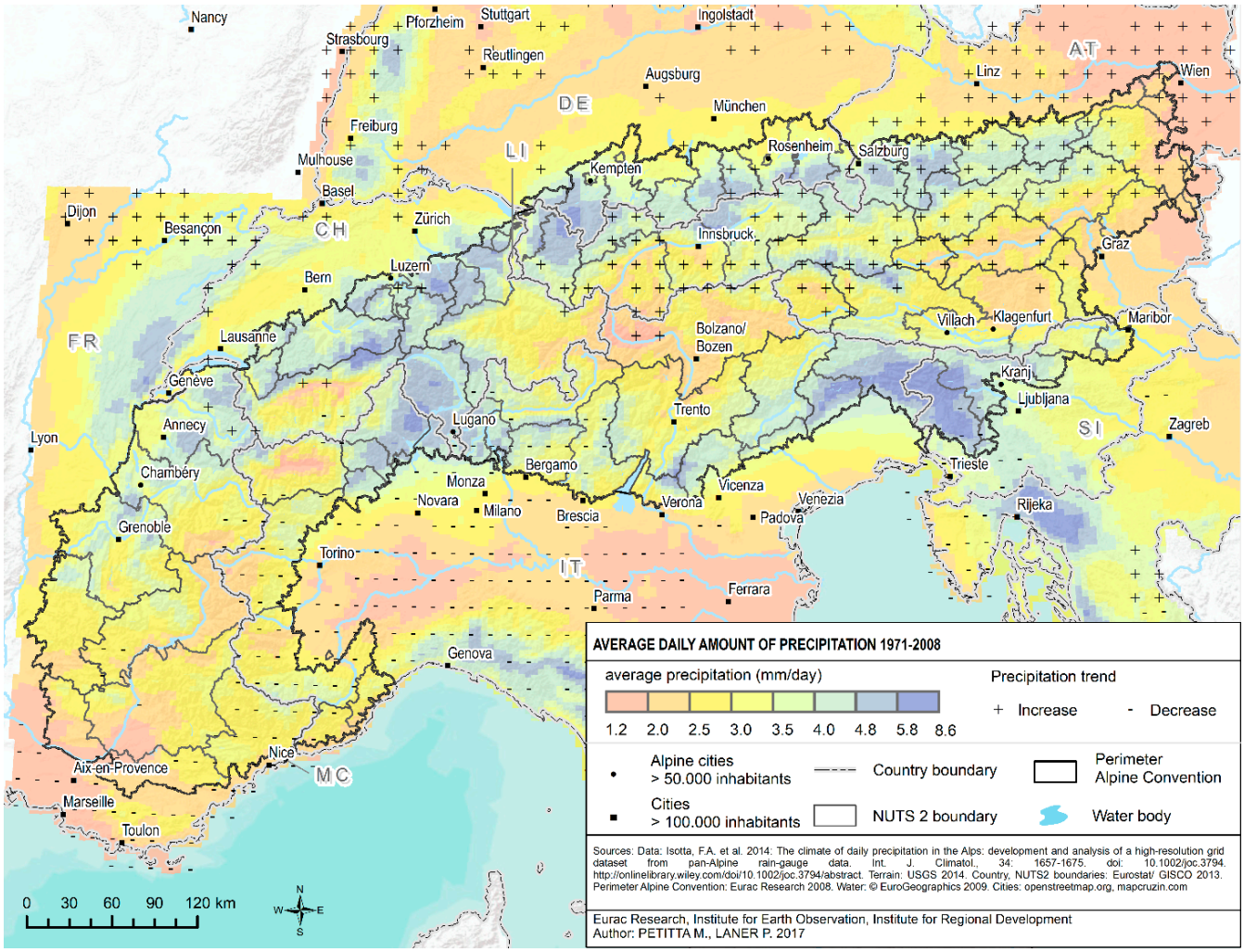

Figure 2. The average of cumulated daily precipitation 1971–2008. Source: Eurac Research, Permanent Secretariat of the Alpine Convention, 2017 [50]. Reprinted with the permission of the author.

4. Methods

The current paper investigates: (i) the governance structures and mechanisms adopted to govern climate change at macro-regional and regional level, (ii) stakeholders' involvement in these structures and (iii) the existing links with macro-regional and regional strategies. Regarding point (i), the study considers information related to the institutions involved in climate change adaptation policies and the instruments they have adopted to formulate and implement them (laws, plans, etc.). Concerning point (ii), it selects the most relevant information about the participation of stakeholders, in particular associations, citizens and non-profit organisations. Finally, with respect to point (iii), the analysis considers the plans, projects, and actions promoted by Alpine Convention, EUSALP, and Alpine Space-Interreg, and assesses how the included regulations have been transposed into documents adopted at the national or regional level. When discussing these topics, the article specifically considers Lombardy and South Tyrol as case studies. Methodologically, it investigates these three topics through a document analysis of the most important climate adaptation strategies, plans and databases formulated at the European level for the entire Alpine region, as well as at the regional/provincial level. Lists of these documents are reported in Table 1 (for those adopted at macro-regional level) and Table 2 (for those adopted at the regional level by the institutions operating in the two case studies).

Table 1. List of documents formulated at the European level for the entire Alpine regions considered in the present study.

Institutions	Types of Documents Analysed	Analysed Documents
Alpine Convention	Declaration	Declaration on Climate Change (2006) [54]
	Action Plan	Action Plan on Climate Change in the Alps (2009) [55] Climate Action Plan 2.0 of the Alpine Convention (2020) [56] Closing the gap on climate action-Building new rope teams to support climate-neutral & resilient living in the Alps (2022) [57]
	Report	Sixth Report on the State of the Alps entitled 'Green Economy in the Alpine Region' (2016) [58]
	Multiannual work plan	14th Alpine Conference—Multiannual Work Plan (MAP) (2017) [59]
EUSALP	Documents	Actions Groups 8 working documents [60]
	Database	CAPA (the Climate Change adaption platform for the Alps) [61]
The Alpine area for the Alpine Space Program-Interreg	Database	Financed Projects in the last 5 years [62]

Table 2. The list of documents elaborated at the regional level for case studies.

Institutions	Types of Documents Analysed	Analysed Documents
Lombardy	Guidelines	Guidelines for a Climate Change Adaptation Plan (2012) [63]
	Strategy	Strategy for Adaptation to Climate Change (2014) [64] Strategy for Sustainable Development (2021) [65]
	Document	Regional Action Document on Adaptation to Climate Change (2015) [66]
South Tyrol	Plan	Climate Plan Energy South Tyrol 2050 (2011) [67] PAESC (Piano di Azione per l'Energia Sostenibile e il Clima), 2020 [68] Urban Mobility Plan 2020 (2009) [69]

5. The Climate Adaptation Strategies and the Associated Governance Structure for the Alpine Area at the Macro-Regional Level

A transnational strategy (EUSALP Strategy), an international institution (the Alpine Convention), and a European funds beneficiary area (the Alpine area for Alpine Space Program-Interreg) are the three organisations that operate in the Alpine area and are in administrative charge of its promotion and regulation (Figure 3).

The Alpine Convention is an international treaty signed by Austria, France, Germany, Italy, Switzerland, Liechtenstein, Slovenia, Monaco, and the European Union in 1995. Its goals are the sustainable development and protection of the Alps, as well as the preservation of this territory for future generations, through transnational cooperation between national, regional, and local authorities. As a legally binding treaty, its decisions are included in specific protocols, which are mandatory for the signatory states. Its boundaries do not correspond to those of the included regions.

Alpine Convention decisions are inspired by principles and targets fixed at the international level within global strategies (i.e., SGDs Agenda 2030). Its aims are to lead the transition towards a climate-neutral & climate-resilient Alps area and are legitimated in protocols and decisions. Within this international institution, several thematic working groups are currently operating, carrying out research and consulting activities. One of these groups specialises in climate-relevant activities, and the elaboration of the Alpine guidelines for the management of water resources, natural disasters, and local adaptation is one of its most important roles. Decisions deliberated at this governmental level are

mandatory for the acceding states, which must therefore transpose them and inspire the actions of lower levels of government.

Figure 3. The Alpine Convention, the Alpine Space, and the EUSALP in the Alpine area. Source: EUSALP, direct contact, 2020.

The Alpine Convention adopted a Declaration on Climate Change in 2006 [54] and an Action Plan on Climate Change in the Alps in 2009 [55]. Some years ago, it elaborated the Sixth report on the state of the Alps entitled 'Greening the Economy in the Alpine Region' (2016) [58]. In 2016, it set the objective "Finding action on climate change" as one of the six priorities of the Multiannual Work Plan (MAP) [59] for the period 2017 to 2022 and decided "to establish an Alpine Climate Board to bundle together existing climate change initiatives and contributions in the Alpine area and to develop proposals for a concrete Target System of the Alpine Convention target system" in regard to the perspective of a "climate neutral Alpine space in accordance with the European and international objectives".

Since then, the Alpine Climate Board has been operationalising the Alpine Climate Target System 2050. To achieve this, it is developing a set of implementation paths (i.e., sequences of short- and medium-term measures in ten different sectors of activity, identified in close cooperation with the other Thematic Working Bodies of the Alpine Convention and further experts) and planning matchmaking workshops for representatives of all Alps-related industries. The paths are detailed in the 'Climate Action Plan 2.0 of the Alpine Convention', a text published in 2020 [56]. The board is also supporting the establishment of a strong Alpine community to take on the implementation pathways through a range of exchange, promotion, and monitoring activities. Within its 2023–2024 mandate, it is also focusing on promoting networks and cooperation between specific sectors to create and strengthen synergies and propose solutions to potential conflicts. Now, it is also collaborating with external observers and the contracting parties of the Convention on cross-sectoral aspects of climate adaptation in the production of guidelines, workshops, and experimentation projects. Among these scientific outputs, the document "Closing the gap on climate action—Building new rope teams to support climate-neutral & resilient living in the Alps" (2022) [57] booklet is one of the most important and updated publications. With this document, the Alpine Convention invites mayors and local policymakers, citizens,

and NGOs, to help the board to deliver its Alpine-wide vision for climate-neutral and climate-resilient Alps. In Figure 4, the Alpine-specific opportunities and threats listed in the booklet on which these stakeholders should reflect.

Figure 4. Alpine-specific opportunities ant threats to develop climate-neutral & resilient lifestyles. Source: Closing the gap on climate action, Alpine Convention, 2022 [57].

The European Council has supported the formulation of EUSALP (EU Strategy for the Alpine area), a macro-regional strategy and integrated framework, to address the common challenges the Alpine region faces. Alpine states are encouraged to cooperate across borders, identify shared goals, and carry them out more successfully. Action groups—groups of stakeholders and change agents—operate alongside political bodies to better coordinate national policies and choices. The Action group specialising in environmental issues, Action group 8, explores how to improve risk management, better manage climate change, and minimise serious natural threats. It also improves risk and adaptation governance mechanisms in the region in question by valorising the existing forms of cooperation. This results in studies, best practices, and choices for improving risk and adaptation policies. One of the most recent documents is entitled 'Climate change? Adaptation as a collaborative action climate resilient spatial planning', analysing the importance of the spatial development perspective to revise the status quo of climate-resilient spatial planning, as delineated in international and national research projects and national policy documents. Improved cooperation is another relevant result; this is achieved though the promotion and implementation of local, regional, and international pilot projects and programmes based on strategic priorities and funding opportunities. An example of these projects is CAPA (The Climate Adaptation Platform for the Alps), a platform that makes it easier to explore knowledge by condensing important information about Alpine regions on all scales, from local to global.

The Alpine Space Program-Interreg is a European transnational cooperation programme for the Alpine region, rather than a consolidated organisation. It offers a framework where stakeholders can collaborate and provide funding for climate-related projects. Past examples of these projects include GreenRisk4ALPs and OpenSpaceAlps (for promoting green and open areas), GoApply (for developing national strategies and action plans for climate change adaptation) and ALPTREES (for assisting European forests and urban areas mitigate against climate change). Its territorial targets include all regions and

cities in Europe, and its priorities are the support of digitalisation, resilience, and improved cooperation to achieve climate neutrality by 2050 (Figure 5).

Figure 5. List of priorities of the Alpine Space Programme-Interreg. Source: https://www.alpine-space.eu/, 2022 (accessed on 22 December 2022).

The Alpine Space Program-Interreg and EUSALP decisions are not binding on the regions. At a lower level, pertinent policies ought to be enacted and put into practise. Because they attempt to translate and implement European and national recommendations within uniform supraregional (transnational) sectors, initiatives, working groups, and platforms are closely watched. These macro-regional or European programmes do not define what governing bodies should decide or tools should be used to achieve the goals they suggest.

For the moment, writing a plan remains the preferred mechanism to govern climate change. A plan is typically a lengthy, monosectoral document that solely considers the long-term effects on the climate of one specific area of activities. Its adoption process is rather easy because all that is needed is agreement from the programme participants; however, these monosectoral policies scarcely take into account the cross-sectoral effects of climate change.

There is still no system in place to monitor the efficacy of these decisions, nor are there incentives or penalties for institutions that assume or implement them. The participation of stakeholders in this decision-making system is limited. Working groups and conferences are generally the only public settings where lower levels of government, associations or citizen organisations are consulted.

Links with existing and larger-scale strategies are constantly recommended in reports, studies, and international climate change adaptation targets. However, no instruments currently test their effectiveness. Table 3 summarizes the strengths and weaknesses of each organisation.

Table 3. The list of the strengths and weaknesses of each organisation.

Organisation	Strengths	Weakness
The Alpine Convention	It is formalised by an international treaty, so it is a fully fledged institution with full powers	It mostly produced studies, research, guidelines
EUSALP	It strengthens international cooperation for the development and the promotion of projects of common interest	Its borders are built on those of the regions and therefore include territories that are not mountainous. It formulates strategies and gives guidelines that are not mandatory
Alpine area for Alpine Space Program-Interreg	It was created to better divert and manage funds allocated to the Alpine area	Its purpose is strictly financial and project-related and does not include the formulation of strategies, or guidelines or prescriptions

Source: own elaboration, 2022.

6. Climate Adaptation Strategies and the Associated Governance Structure for the Alpine Area at Italian National Level

The National Strategy for Adaptation to Climate Change, established in 2015 [70], and the National Plan for Adaptation to Climate Change, in its 2022 version [71], are the most appropriate references in this debate.

These documents include citations of the most significant strategies and plans adopted at the European level, representing guidance to local institutions on climate adaptation and providing standards for the analysis of vulnerability and risk assessment. At the macro-regional level, the Alpine Convention Guidelines for climate change adaptation offer a broad overview of procedures and decisions, as well as the key implications at the local level.

These documents emphasise the fragility of the entire Alpine region and encourage the creation of more accurate climate change scenarios. They offer an investigation into climatic impacts on the mountain hydrographic basins and water reserves, considering the increased sensitivity to a wide range of natural threats as well as a growth of demographic and environmental pressures (such as effects on glaciers and snow). However, none of their analysis is particularly targeted at South Tyrol or Lombardy. These documents promote the participation of decision makers and stakeholders, along with a preference for the adaptation of current policies rather than the introduction of new ones.

Recently, these documents have been integrated with the Plan for the Ecological Transition (PTE), which is in turn integrated with the PNRR—Recovery plan. This latter document is an instrument for coordinating and updating a series of environmental policies, including those related to climate change mitigation and adaptation.

Legislatively, climate issues are attributed to the competences of the regions, which adopt acts specifically dedicated to climatic issues (such as strategies, plans and documents of regional actions), or include specific prescriptions in other documents such as territorial planning plans or sectoral plans, or those related to the sustainable development. Regions are also involved in technical-scientific coordination and incentive-setting operations related to climate change-related challenges, conducting applied research activities and providing climate change training, information, and education.

7. The Case Studies

7.1. The South Tyrol: An Autonomous Province in the Alps

The province of South Tyrol is totally mountainous. Its climate is the result of the interaction of three climatic types: warm with wet winters and dry summers; dry with cold winters and scorching summers (continental East); and humid-moderate. Normally, it is drier than other Alpine regions because the mountains prevent air masses such as Foehn (warm, dry autumn wind) from entering directly. The irradiation conditions are significantly impacted by the slope orientation. As the height increases, temperatures drop as precipitation gets heavier. Rivers and streams, especially the Adige River, have left their mark on valley systems. Most of the locals live in the valleys. The urge to convert

land for housing and productive purposes has reduced the amount of forest cover, which has an impact on climate, especially changes in albedo (the ability of the surface to reflect incoming radiation), evaporation rates, and soil roughness. The effect is more noticeable in the area's largest cities.

Administratively, South Tyrol is an autonomous province with greater legislative authority in many areas, notably climate protection, compared to other Italian provinces and regions. This is due to its history, multilingualism, and the presence of people of various cultural and national backgrounds (German, Austrian, Ladin and Italian). In recent years, it has signed the Alpine Convention and is a member of EUSALP and the Interreg Alpine Space.

7.2. The Governance of Climate Issues in South Tyrol

Analysis of the provincial documents suggests that climate governance is essentially controlled by the Province of Bozen (which has initiatives, regulatory and planning power, and competences). The province coordinates both strategies and the resultant actions. However, coordination with local municipalities is challenging. Some municipalities adopt their own climate plans, and their choices do not merge at the provincial level into a single document. This implies that some sectoral plans or legislative proposals at provincial level are not in line with what has been decided at the lowest level. Furthermore, although some initiatives or adaptation measures are decided collaboratively, their effects are often deemed inadequate.

In a very few cases, other institutions collaborate with the province. These include the agency for civil protection, Kasaclima, Koinstitut, Federazione protezionisti Sudtirolesi, and Eurac Research (the latter for scientific and thematic consultations). The Koinstitut, which addresses climate protection, is the most active private organisation, working with the province and towns to develop policies for more energy-efficient or environmentally friendly transportation and providing support for these efforts. It also works with private businesses to reduce their energy usage and improve resource management. Additionally, it aids both private and public organisations in organising events with low environmental impact, which are occasions that are organised, planned, and carried out in accordance with sustainability standards, such as the use of environmentally friendly goods, energy efficiency, the creation of local economic opportunities, and waste management. Eurac Research carries out studies and investigations supporting the provincial decisions.

The province does not encourage the systematisation of sectoral policies and has not adopted a long-term coordinated strategy for climate adaptation efforts.

The Climate Plan Energy South Tyrol 2050 [67], which implements the energy plan at the provincial level, is the most significant strategy document for tackling climate change. By improving the ability of local authorities and private operators to shape integrated energy and climate strategies, the document suggests some measures to reduce CO_2 emissions and promote the use of renewable energy. These measures are in line with the National Energy Strategy's prescriptions, which incentivise the decarbonisation process with climate-changing emissions reduction targets of 39% by 2030 and 63% by 2050 [72].

However, this plan cannot be seen as a broad framework for policy. It emphasises the past and future effects of climate change as direct results of energy policy, despite its goal of empowering municipal, public, and private operators to implement sustainable energy and climate solutions. Only tangentially does it analyse the impact caused by economic activities on climate conditions and suggest what measures can be adopted to mitigate them. Positive implications include the promotion of the collaboration between the public and private entities that have elaborated the plan (Province of Bozen, BOKU University, and the CasaClima Agency). They also include the innovativeness of their prescriptions, as well as the determination of a set of indicators intended for periodical monitoring to evidence technological advancements or altered framework conditions.

Climate issues are also considered in certain other sectoral plans, but only marginally.

The local RDP (rural development programme) financially supports farmers who employ extensive agronomic methods compatible with biodiversity and with reduced levels of carbon dioxide, methane, and nitric oxide emissions. This support is part of a strategy that is monosectoral and based on a dual governance structure. It only pertains to one economic sector (agriculture) and does not evaluate any indirect or associated impacts on other economic sectors. Additionally, it strengthens the ties between the recipient businesses and a single entity (the province that allocates the financial contribution).

Among its objectives, the Urban Mobility Plan [69] includes the reduction of CO_2 emissions and the use of non-environmentally friendly transportation. Its adoption is part of the provincial Green Mobility package designed to promote sustainable mobility in the province of Bozen and the Alps. It is supported by provincial funding and serves as an excellent illustration of inter-municipal collaboration. Its prescriptions are based on previously agreed goals that are in line with sectoral and provincial plans and future demographic forecasting. Climate variations are only considered as an indirect consequence of their implementation rather than a driving factor.

Although tourism is an important economic sector for the South Tyrol, the relevant strategy does not contribute to the design of a framework for climate protection or an adaptation strategy [73]. This document emphasises the importance of natural snowfall, its reduction due to higher temperatures, and the substantial environmental impact of artificial snow. It outlines the rising summer temperatures in urban areas at lower altitudes, which pushes tourists towards higher-altitude locations. Traditional tourist destinations are being forced to reconsider their offerings because of this change, while the locations that tourists are now gravitating towards need to build new facilities, which have an adverse effect on the environment. High temperatures or concentrated snowfall during specific seasons cause overtourism. Despite outlining all potential climate impacts, the strategy does not offer advice on how to protect the environment for the tourism industry, nor does it suggest specific laws or consider how accessibility to tourist destinations may be impacted by transport connectivity.

This gap was filled by the province, which introduced in 2017 the obligation to evaluate provincial plans and programmes environmentally, as well as to assess the potential economic, social, climate and natural effects of the proposed actions. However, few institutions currently evaluate plans and programmes during their implementation. On the contrary, they generally evaluate them ex ante.

The strategies adopted at macro-regional level, or the decisions of the Alpine Convention, concern all member regions and provinces, and do not contain specific requirements for this province. However, all entities operating in this province and mentioned above are inspired by the values, objectives and priorities set at the European and macro-regional levels and respect the mandatory prescriptions of the Alpine convention. The provinces and the other entities are involved in several climate-related Interreg projects.

7.3. The Lombardy, an Ordinary Region with a Diversified Landscape and Climate

Warming has intensified considerably over the last 30 years. During this time, there has been a positive anomaly in the average temperature of approximately (+)0.2–0.3 °C, compared to the average for the 1968–1996 period. As in all Alpine areas, the warming has been more intense than the European and global averages. Due to the higher temperature, the same period has also seen an increase in the frequency of extreme events relating to high temperatures. As far as the long-term trend in cumulative precipitation is concerned, from 1850 to the present day, a slight downward trend can be seen in the total annual quantity (of the order of −5% every 100 years). This has been most intense during the last few decades, with a decrease of approximately (−)2.0 ± 2.4% compared to the average over the entire period considered. [74]

Lombardy's urban structure contains a network of densely inhabited medium-small cities and a large metropolitan centre (Milan). This structure has grown internally because of the centrifugal effect, while externally the centripetal force encourages communities near

major metropolitan centres to join the urban periphery. This implies the decline of rurality in the periphery, and the transformation of the relative fringes into peri-urban districts. In considering these transformations, Bonomi's hypothesised model of the 'four platforms' across regional territory [75] is no longer appropriate to describe the structure regionally. Based on his considerations, the first platform is that of the Lombardy piedmont, which extends between Varese and Brescia and forms a sort of 'infinite city'. The second platform extends around the axes between Pavia and Mantua, while the third was the Milanese platform, which is clearly distinguished from the Alpine arc (the fourth platform). The invalidity of his hypothesis is determined by the fact that recent increases of urbanisation and suburbanisation have favoured the merging of three platforms. In coming closer together, these platforms have generated a sort of continuum where levels of fragmentation in the urban geometry have been progressively lowered by filling in the empty spaces. What still distinguishes the four platforms is their different levels of land consumption. Some northern provinces curb peri-urbanisation through further urbanisation of the vacant spaces among residential and productive nuclei. Southern provinces, which have the largest expansion of agricultural areas, record double-digit growth in land consumption due to the extensive conversion of these areas for residential and productive uses. The intensity of these transformations implies that Lombardy is the region with the highest value of soil consumption in Italy [76]—more than 10% of the regional surface area is sealed with concrete and asphalt.

Administratively, Lombardy is an ordinary region, which means that it has the same competences of other Italian regions. Climate is not a specific topic mentioned in the Italian Constitution, or specifically among the exclusive competences of the State. Some related topics, like environmental preservation, are decided exclusively by the Italian state, and regions must adapt their legislations to fit with national prescriptions. For other topics, such as territorial governance, national states fix a general framework while regions autonomously define the rules to apply in their territories. Based on article 117 of the Italian Constitution, other matters not expressly mentioned are left to the exclusive competence of the regions. By inference, it would therefore appear that the subject matters not mentioned are within the competence of the regions. Therefore, the regulatory framework is unclear and the Lombardy region has different levels of autonomy depending on the subject matter.

7.4. The Governance of Climate Issues in Lombardy

In the perspective of multilevel governance, the Lombardy region acts as a guide for local authorities, recognising the centrality of a place-based approach to adaptation. Therefore, the definition of local adaptation plans occurs in conjunction with the topics addressed by the National Climate Change Adaptation Plan, the Regional Strategy for Adaptation to Climate Change (SRACC) and the Regional Action Document, with particular attention to the specificities of urban and mountain areas. It is also in line with the strategies adopted at macro-regional level, or the decisions of the Alpine Convention, although the relative documents do not contain specific requirements for this region. On the other hand, all entities operating in this province and mentioned here are inspired by the values, objectives and priorities set at the European and macro-regional level and respect the mandatory prescriptions of the Alpine convention. Participation in Interreg-Alpine Space projects related to climate issues are discrete.

With the support of Fondazione Lombardia per l'Ambiente, in 2012 the Lombardy region presented the Guidelines for a Climate Change Adaptation Plan (PACC) [63]. This plan carefully considered what has been produced and proposed by institutional and environmental agencies at the European level, analysed adaptation plans formulated by EU Member States and European regions, and coordinated closely with the national strategy that is currently being developed. Its presentation was followed a year later by the development of the Regional Strategy for Adaptation to Climate Change (SRACC) [64]. This strategy has defined the role of regional institutional stakeholders and their participation through specific internal consultation mechanisms within the same region. It has also

deepened and updated basic climate data and information (past and ongoing climate change, climate variability, and future climate change) at the regional level. Within the theme of adaptation to climate change, measures are categorised into three categories. The first of these includes non-infrastructural measures, which concern activities related to the diffusion of knowledge and information, monitoring promotion, and modifications in the existing legislation. The second covers infrastructural activities that consist of tangible interventions in the adaptation or design of infrastructure necessary for adaptation. The last group includes green or ecosystem-based measures that have a direct impact on the environment to exploit natural ecosystem services in order to contain current and future climate change pressures. Adopting an intersectoral approach, this strategy also presented an opportunity to conduct quantitative assessments on sectoral impacts (meta-analysis of the scientific bibliography) and analysis of vulnerabilities to climate change in the eight key sectors, and for each of them the functional relationships between impacts, general adaptation objectives, and specific measures. This exercise was particularly useful for considering the overall framework of sectoral and intersectoral policies and interventions already in place or planned by the regional administration. However, its integration with existing strategies at European level has not been fully implemented because it only partially fulfils some of their requirements.

Based on this strategy, this region is developing the Regional Programme for Energy, Environment, and Climate to identify the priority areas in which to intervene. This document represents an important governance tool that recognises and defines priority areas with respect to the effects produced by climate territorially, as well as identifying interventions to minimise risks and impacts, and increases natural and environmental resilience. As such, this document—which includes targets for 2030 and a vision to 2050—updates and integrates the current Regional Environmental Energy Programme (PEAR), and represents the roadmap for the energy-climate transition, built in a participatory way and assessing the feasibility conditions of the assumed targets and the redistributive effects of the chosen actions. Based on this document, policies to combat climate change are inseparable from energy policies.

All the documents described here cover knowledge gaps on climate change with technical information and a relative spatio-temporal resolution scale consistent with the regional territory, as well as addressing regional vulnerabilities through the identification of the most significant impacts on climate change, the analysis of the sensitivity of key systems and their resilience capacity. With a large degree of success, the documents assess sectors and territories on a priority scale according to vulnerability resilience, costs, and benefits of the different adaptation actions. Another key topic covered in the documents is the adoption of multilevel governance to be defined through sectoral and cross-sectoral action plans. The conviction is that effective and coherent adaptation policies require a high degree of consensus and connection between different levels of governance operating in the same region. As such, there is the indication that the design and implementation of Lombardy's future regional adaptation strategy will have to face the challenges of vertical coordination of the plan (ensuring its complementarity with interregional and national adaptation strategies) and horizontal coordination between the region's sectoral interests. To promote this coordination, adaptation to risks of climate change should be an essential part of all sectoral regional policies and integrated into existing strategies and programmes at both national and local level. Additionally, mechanisms should be included for periodic reviews of the strategy and its subsequent update, as well as specific initiatives to communicate and increase awareness of climate-related issues to all stakeholders, including municipalities, professional organisations, associations, and all citizens in general.

From an organisational point of view, the region has adopted a specific working structure. This structure involves the region's various General Directorates and a group of researchers and scientists promoted by the Fondazione Lombardia per l'Ambiente (Lombardy Foundation for the Environment). Its first task was to map all stakeholders operating within and in collaboration with the Lombardy region, with the aim of identifying

a broad framework of key referents for drawing up the strategy, both from the regional administration (DG Agriculture, DG Trade, Tourism and Services, DG Health, DG Sport and Youth Policies, DG Territory, Urban Planning and Soil Defence, DG Security, Civil Protection and Immigration, DG Infrastructure and Mobility), and from the technical-scientific reference agencies (ARPA, the Lombardy agency for the environment and ERSAF, the Lombardy agency for agricultural and forest issues). Once these interest groups had been identified, the structure created a questionnaire and sent it to all of them to identify the priorities of the strategy, and express their perceptions regarding adaptation policies and climate risk. Subsequently, it organised and ran specific thematic workshops, within which three substantial objectives were sought:

1. To share the most important and up-to-date scientific knowledge on climate change with regional stakeholders and present future trends and projections of the main impacts, based on existing regional models and through a comprehensive review of international literature on the subject.
2. To assess and discuss sectoral targets for adaptation, in order to maximise the resilience and preparedness of Lombardy's society, economy, and environment.
3. To share a set of possible options or measures for adaptation to climate change, broken down by sectors and impacts.

These workshops are not open to private citizens, but other actors operating in the social and environmental sectors should be directly invited by the Lombardy region. Participants share proposals and ideas during these workshops; however, they do not directly contribute to the definition of regional policies in this field.

In the Sustainable Development Strategy [65], the Lombardy Region outlines the importance of the Sustainable Goal n.13: "Promote actions, at all levels, to fight the climate change (adaptation), as well as for the promotion of sustainable models of consumption and production, the creation of resilience territories and communities, to preserve landscapes and cultural goods." To concretise this objective, it identifies as key actions the support of existing networks and partnerships and the creation of new territorial alliances. Other suggested actions include the identification and dissemination of good practices, as well as the implementation of a monitoring system. Their success is possible and actionable through the adoption of a territorial and horizontal governance model that promotes stakeholders' participation and inclusion. As such, one of its aims is to promote more integrated development projects at the local level. At this territorial level, the orientation of policies towards more efficient use of resources, social inclusion, and mitigation to climate changes is definitely possible and will enable the integration of ecological-environmental networks and overcome administrative fragmentation.

8. Discussion

Climate change governance in the Alpine area includes macro-regional/European actors (EUSALP, Alpine Convention, the Alpine area for Alpine Space Program-Interreg), national actors (the national states) and regional/provincial actors (the regions and the autonomous provinces), each of which operate, formulate, and implement climate adaptation strategies in their own way.

Referring to Sapiains et al. [13] and their clustering of climate adaptation governance, the existing governance structures can be included into one or more considered groups. The governance structure adopted at Alpine level by the three international institutions refers to the first cluster; it can be compared to a multi-governance system where several parties are integrated into a larger framework. Most European nations might be categorised in the second group at the level of the individual state, since they place a high value on the state's role in policy formulation and execution. The third and fourth clusters—where the importance of subnational efforts is greater—appear to be undergoing a continuous shift, according to certain aspects. At the provincial level, in South Tyrol, new narratives involving local communities and city networks (which characterise the fourth cluster) and some characteristics of the first cluster (i.e., the essential role of the government, in this case

the provincial government, as well as the plurality of players) merge with the innovation characteristics of the last cluster. In Lombardy, the absence of a consolidated network of actors at the regional level reduces the diversity of the governance model, while decisions remain exclusively under the responsibility of regional government.

Devolution of power from central to local governments leads to greater autonomy for the province, compared to the national state. Therefore, South Tyrol is free to implement more territorially specific policies that are tailored to the area's needs and local particularities. However, adopting such measures can result in territorial imbalances with territories in other nearby Italian regions that do not benefit from the same level of autonomy. Additionally, this can make it challenging for the creation of common policies that will coordinate across the same Italian regions and autonomous provinces located in the Alps. Being an ordinary region, Lombardy should respect the prescriptions from the national state with less freedom in its decisions.

Currently, writing a strategy for a plan or a project remains the preferred method to manage climate change adaptation. All Alpine nations adopt a broad framework for climate policies at the national level, sometimes in conjunction with a specific statute and other times with decisions regarding energy policies. SEI ARRIVATA QUI.

At a lower administrative level, provincial documents outline actions that will be taken to achieve the objectives that are in line with these defined at the national and macro-regional levels, as well as some specific proposals that will be directly supported by more general policies. The Climate Plan Energy South Tyrol 2050 is based on national and international CO2 and energy strategies, standards, and guidelines. It is not a general and cross-cutting climate policy, but merely explains measures to reduce pressures and overexploitation of natural energy resources and promotes the use of innovative technologies and methods for renewable energy. It does not contain integrated local actions, planning, or sectorial policies for sustainable development, and reserve limited attention to the relevance of green infrastructures in reduces climate change impacts (and this represents a substantial difference with respect to other regions, as evidenced by Sturiale and Scuderi (2019) [77] and Scuderi et al., (2021) [78]. Only the RDP encourages the adoption of multi-sectoral approach in defining adaptation policies. Other industries, such as tourism and transportation, promote single projects/actions and do not coordinate efforts. This implies a lack of understanding of the mutual impact of each economic sector on climate challenges, as well as few opportunities to put coordinated initiatives into action.

The absence of a general and multi-sector strategy is probably due to the difficulty of coordinating the high number of stakeholders involved as well as the scarce collaboration among provincial departments. These factors inhibit a general, multi-annual policy framework that could inspire annual policies and better monitor climate change in the long term.

Regionally, Lombardy has started to think about the importance of adopting a strategy at the regional level. At the beginning of 2010s, the Region has elaborated several documents, including the Strategy for Adaptation to Climate Change. With these efforts, the region tries to coordinate its own need and ideal policies with the plans produced and proposed by institutional and environmental agencies at the European level. Another positive element that emerges from this strategy is the interest for different kinds of action that include tangible and intangible action, but that at the same time are across several economic sectors. Adopting an intersectoral approach, the strategy was also the occasion to conduct quantitative assessments on sectoral impacts (meta-analysis of the scientific bibliography), analyzes vulnerabilities to climate change in the eight key sectors, and for each of them also the functional relations among impacts, general adaptation objectives, and specific measures. This exercise was particularly useful in considering the overall framework of sectoral and intersectoral policies and interventions already in place or planned by the regional administration. It is also useful to assess sectors and territories on a priority scale according to vulnerability resilience, as well as the costs, and benefits of the

different adaptation actions. Finally, it was interesting as evidenced the relevance of green infrastructure, therefore confirming Sturiale and Scuderi assumptions.

With reference to stakeholders involved in the elaboration and implementation of the detailed strategies and policies, the situation is articulated. At the macro-regional level, the national states and regions participate in working groups, while other types of stakeholders do not access to their activities. At lower administrative levels, sharing power and responsibilities among bodies interested in climate issues is not evident in South Tyrol, as the participation of local associations or private individuals in decisions vis à vis this field is limited. This hinders the gathering of various and bottom-up suggestions. Although the strategy encourages the role of the regional institutional stakeholders and their participation through specific internal consultation mechanisms, operatively, the Lombardy region only activates regional offices and therefore excludes any form of significant participation of other stakeholders, like private associations and singular citizens. Positively, it recognises the importance of dissemination and communication of data and other knowledge to support regional offices involved in workshops and decision-making processes and inform citizens.

However, its integration with the existing strategies at European level has not been fully implemented because it only partially fulfils some of their requirements. The other mentioned documents include a long-term strategy until 2030 and 2050. While also in these documents emerge the conviction that an effective and coherent adaptation policies require a high degree of consensus and linkage between different levels of governance operating in the same region, operatively there is not any form of coordination with lower level of governments. The promotion of vertical coordination of the plans and strategies, also with macro-regional levels, and horizontal coordination between sectoral interests at regional level is listed as one of the most difficult challenges. At this moment, there is not a larger governance which includes regional departments, local municipalities and institutions and private citizens. There exists a simple structure where regional departments try to collaborate with the support of some scientific organisations. The Strategy for Sustainable Development include some measures to mitigate the negative effects of climate change and outlines another time the importance to adopt a territorial and horizontal governance model which promotes stakeholders' participation and inclusion.

With reference to possible interactions among strategies at different administrative levels, the present situation is quite similar in both case studies.

Policies and strategies at the national and macro-regional levels specify objectives and directives for the entire Alpine region, neglecting South Tyrol, and Lombardy in detail. This orientation provides a comprehensive view of all territories but fails to adequately consider the various climatic conditions or the Alpine regions' needs for adaptation to climate change. The Alpine Convention provides information on the entire region, as well as future projections and guiding principles. However, only lately has invited many organisations that work on climate concerns to participate in the discussion within a multi-participant committee. Similarly, to the EUSALP, it does not specify the ways to pursue the goals they suggest. Implementation of relative actions is left to lower levels of decision-making.

However, as the actions taken at this international level are merely recommendations or project ideas (except for most decisions by Alpine Convention), South Tyrol and Lombardy are still allowed to make extensive decisions about its climate policies without facing repercussions.

9. Conclusions

The Alps are exposed and sensitive to climate change. Due to the articulated topography, climate conditions may alter over extremely short distances. The effects of height variations on climate are significant. The existence of glaciers and permafrost, which may cause slope instability with increasing hazards of rock fall, mud, and debris flows, etc., impacts locally. Variable large-scale precipitation depends on changes in atmospheric wind flow patterns.

This article describes the climate governance system existing in the Alpine regions and specifically in South Tyrol and Lombardy behind the adaptation strategies to address climate challenges at macro-regional level. There is in fact a belief that the difficulties in managing these changes are also determined by the fact that the extension of the mountains exceeds administrative boundaries and spreads across different regions and nations.

The results of the current investigation are pertinent because no recent comparison studies have been done at this administrative level.

One of this is the difference in the level of regional autonomy. Due to the largest autonomy, South Tyrol decides singularly its own climate governance and planning, while Lombardy must comply more closely with state regulations that limit its decision-making freedom. This generates differences in the regulation, as well as in the promotion of coordinated policies. Improvements to this system are several and include the definition of a policy framework, which extends beyond administrative boundaries in the Alpine area. This enables to define better the responsibility, coordinate the efforts of policy-makers and implement more homogeneous policies. Currently, this system cannot coincide with the macro-regional system or one of the three international organizations, because they are not international institutions and do not have full legislative powers, like the European Union. Although the Alpine Convention is an institution, it is not effective because it operates on a territory that does not cover the entire Alpine arc. An effective system should promote more cooperation among territories, invite them to reflect on the consequences of their decisions in their neighbouring territories, and prevent decisions that conflict with the common interest of the entire area.

In the present governance structures, the presence of a coordinating institution at a lower administrative level (the province in South Tyrol or the region in Lombardy) is essential to ensure its functioning. These institutions decide climate actions and several other local institutions and stakeholders collaborate partially and have less decision power. They transpose the recommendations of the three macro-regional institutions, translate them into policy decisions, and then guide the decisions of the lower-level bodies. However, they should be more incisive in this activity. In the absence of a monitoring system, the macro-regional institutions do not verify the effective reception of their decisions at the lower level. At the same time, the province and region do not verify the reception of their decisions in the planning instruments of the lower-level entities. Since these decisions are often contained in plans and strategies and, therefore, not in acts with regulatory value, it is not possible to sanction authorities that do not respect them.

These decisions are included in regional and mono-sectoral plans, but not in specific climate strategies. Formulating a specific long-term and intersectoral strategy to counteract climate change is challenging at this administrative level. However, this effort is urgent to understand the consequences of climate change and mitigate their negative impacts. To facilitate it, the dissemination of information through a suitable system is equally important. Adopted plans are inspired by the same principles and objectives of the macro-regional strategies, but they refer only to the regional administrated territories. This implies the single provinces and regions are responsible only for the territories they administer and consequently their policies do not take into consideration the effects generated in other neighboring territories. Although it is not currently viewed as a critical policy option, incentives to coordinate policies and their activities at the regional level (across various regions, including those belonging to different states but with similar climatic circumstances and with macro-regional strategies) should be promoted.

Another crucial aspect of fundamental importance is the delineation of local institutions' roles and their participation. Local stakeholders are involved in policy development (more in South Tyrol, rarely in Lombardy). Their participation should be incentivized. Efforts should be dedicated also to the delineation of their respective roles and in their coordination.

Using social network analysis techniques, the following research would map all stakeholders and institutions operating in the Alps and examine the existence and strength

of connections between them. Additionally, they could investigate new approaches to encourage the integration of the decisions related to the implication of climate change generated by specific supply chain sectors into the larger strategic decisions. Further investigations could also concentrate their efforts in the definition of a specific system to monitor the impact of macro-regional plans and projects on decisions at the regional and local levels, as well as in the implementation of a penalty system for those institutions that do not consider macro-regional or regional decisions into their plans and strategies. As final suggestion, further analysis could insist on other Alpine regions, including also non-Italian regions.

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