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CLISP-ALP

Climate-Resilient Spatial Planning in the Alps

EUSALP, Action Group 8

An analysis of the integration of climate change adaptation and climate resilience in spatial planning systems and practice in the Alpine region

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80 million people, 7 countries, 48 regions, mountains and plains addressing together common challenges and opportunities

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EXECUTIVE SUMMARY

Spatial planning is generally identified as a **key sector in climate change adaptation** that supports a climate resilient development. Therefore, spatial planning receives a specific focus in the recent EUSALP activities. Foremost, the development of a common spatial development perspective is an objective within the INTERREG Alpine Space project AlpGov2. EUSALP Action Group 8 (Risk Governance) decided therefore to actively contribute to this common spatial development perspective with an overall analysis of the status quo of climate resilient spatial planning. Climate change impacts are of course closely connected to natural hazards in the Alpine area and spatial planning represents an essential component of (climate) hazard prevention.

The study covers the whole EUSALP perimeter and can of course not portray national planning systems and diverse planning practice concerning a resilient spatial development, that integrates climate change adaptation measures, in detail. It seeks therefore to **evaluate the overall status quo of connecting climate change adaptation** (as well as disaster risk management) **with spatial planning**. The study starts with a secondary analysis of the **expected and observed climate signals in the Alpine region** and identifies the relevance and role of spatial planning to adapt to climate change impacts. Against this background, the study continues with a **status quo analysis of climate resilient spatial planning in international and national research projects** as well as **national policy documents** – primarily the National Adaptation Strategies and National Actions Plans. To understand implementation activities and day-to-day practice a number of **interviews with planners on national, regional and local levels** as well as **experts responsible for coordinating adaptation measures** were conducted. Additionally, to highlight the local and regional perspective a **workshop in October 2021** focussing on the Walgau valley in the province of Vorarlberg, Austria was organised. There, local politicians and regional stakeholders that have responsibilities in implementing climate change adaptation measures to foster a resilient development presented and discussed with the participants adaptation initiatives and priorities.

Especially the interviews provided an overall evaluation of existing challenges as well as entry points for mainstreaming climate change adaptation in spatial planning policy and practice. Overall, climate resilience is not an established concept and guiding principle yet all over the Alpine space and transnational perspectives are weak, while in general sectoral approaches prevail. Here, planning also hardly addresses emerging land use conflicts that come with necessary adaptation activities. Anyhow, planning legislation is continuously enhanced, new information basis and technical standards have been developed and specific competences are established with administration. Specific funding streams are not well established and there is a need for extensive cooperation of governmental authorities. Here, different adaptation priorities on different levels with a widely weak national planning level lead to a situation, where adaptation goals are well established on national level while implementation is primarily driven forward by the local level – especially cities – causing a certain implementation gap. Planning instruments (e.g. regional programmes, land use plans) are increasingly used to safeguard climate services but monitoring of their effectiveness is still marginal.

Finally, the study led to **three overall recommendations** for all relevant stakeholders in mainstreaming climate change adaptation into spatial planning to foster a climate resilient development:

- Develop **adaptation pathways** that integrate spatial planning and **rely on extensive coordination**;
- Identify **dependencies of nature-based solutions** to better inform planning decisions;
- Establish an **iterative learning process** to foster a resilient development.

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LIST OF ABBREVIATIONS

ACB ..... Alpine Climate Board
AG ..... Action Group(s)
BMLRT..... Ministry for Agriculture, Regions and Tourism (*Bundesministerium für Landwirtschaft, Regionen und Tourismus*)
CCA ..... Climate Change Adaptation
CCM ..... Climate Change Mitigation
COP ..... Conference of Parties
DRM ..... Disaster Risk Management
DRR ..... Disaster Risk Reduction
ERDF ..... European Regional Development Fund
EU ..... European Union
EUSALP..... European Strategy for the Alpine Region
IPCC..... Intergovernmental Panel on Climate Change
NAS ..... National Adaptation Strategy
NAP ..... National Adaptation Plan
NDC..... National Determined Contributions
SDGs..... Sustainable Development Goals
UHI ..... Urban Heat Island
UN..... United Nations
UNFCCC..... United Nations Framework Convention on Climate Change

1 Introduction

Climate change is an inescapable phenomenon that alters environmental conditions globally. Especially in the Alps, average temperatures rise and glaciers melt faster than anywhere else.[1] Society has to undertake great efforts in mitigation, to reduce CO_2 emissions, but also in adaptation to strengthen resilience in all kind of dimensions. It is generally acknowledged that spatial planning plays an important role herein. How climate adaptation under the overall objective of fostering climate resilience in spatial planning actually works in practice is still vague though while especially Alpine cities tackle this challenge already comprehensively.

The **INTERREG Alpine Space project AlpGov 2** supports during 01/2020-06/2022 activities of the EU Strategy for the Alpine Region (EUSALP). Within the identified 'strategic policy areas' so-called 'cross sectoral implementation initiatives' should be put into practice. Specific policy recommendations will be developed to ensure the implementation of the EUSALP-Action Plan. The role of spatial planning is herein determined towards territorial cooperation and fostering cross-sectoral initiatives.[2] Therefore, the question of climate resilience in and through spatial planning is a key concern in the EUSALP. Objectives that were discussed for the cooperation and coordination in spatial planning are:

- To develop and to agree on a **common spatial development perspective** for the Alpine area,
- To **improve the coherence** of the national, regional and cross-border spatial development strategies **with this new common Alpine spatial development perspective**,
- To **identify and implement actions**, which contribute to this **common spatial perspective** for the Alpine area.

Concrete intended outputs are a **spatial development perspective for the Alpine area** agreed upon by the General Assembly of EUSALP, better coherence of spatial development strategies across the Alps and a roadmap for implementation actions. The document with the outline can be retrieved online.[3]

Under the leadership of EUSALP Action Group 8 a study should contribute to both, the evaluation of climate change adaptation within the EUSALP perimeter and with its results to the policy recommendations and common spatial development perspective for the Alpine area. An essential basic condition for the study is the fact, that spatial planning is strongly fragmented in legislation as well as execution in the single member states of the EUSALP. The European Union has formally no competence for spatial planning and supports therefore in the first-place initiatives on territorial cohesion[4] and cooperation by using financing instruments mainly. A voluntary coordination and cooperation within the EUSALP on spatial development, especially on local level, could help foster cooperation on other levels as well and contribute to a flourishing Alpine area.

Climate resilient spatial planning is not explicitly mentioned in the initial AlpGov 2 concept on spatial planning as a joint territorial perspective. Nevertheless, spatial planning contributes substantially to climate resilience and the Action Group 8 co-lead (BMLRT, Austria) pushed for a study to position the aspect of climate resilience within the indented joint territorial perspective. This work should therefore enhance the exchange among the EUSALP members on knowledge and solutions concerning the integration of climate adaptation in spatial planning.

To analyse the status quo of climate change adaptation and climate resilience in spatial planning within the EUSALP member states in a cooperative manner the study incorporates **(i) an analysis of the status quo**

[1] Gobiet et al (2014).
[2] Online: https://www.alpine-space.eu/projects/alpgov/en/about-alpgov/project/obj, 17.05.2022.
[3] Online: https://www.alpine-space.org/projects/alpgov/alpgov2/deliverables/wpt3/spatial-planning.pdf, 17.05.2022.
[4] Information on EC territorial cohesion policy: https://ec.europa.eu/regional_policy/en/policy/what/territorial-cohesion/, 17.05.2022.

(adaptation needs, overall objectives in strategies and action plans), **(ii) an analysis of the possible operationalisation** of **climate resilient spatial planning** by different instruments on different levels and **(iii) a cooperative workshop with local and regional stakeholders** as well as experts from the Alpine region to discuss and evaluate different approaches and needs.

The status quo description and proposed analysis will focus on the EUSALP perimeter which represents the study area including 48 regions of 7 countries. In any case, Monaco is not included in the analysis fully as a comparative perspective is difficult to establish due to the size of the city state.

Figure 1: EUSALP – EU Strategy for the Alpine Region

Source: EC, 2017.

1.1 Climate Adaptation and Climate Resilience in Spatial Planning

Integrating climate adaptation and climate resilience in spatial planning in the Alpine area has been identified as a key priority by many research projects and experts over the years to meet adaptation necessities, reduce climate risks and prevent socio-economic impacts of disasters.[5] Anyhow, the terminology and perspectives differ depending on the specific problem understanding and agenda of policy makers. Especially the professional discourse on resilience is multi-layered and the term extensively used regarding the integration of climate and disaster risk into development. Besides a vast amount of research papers there are many documents that provide guidance on the topic – especially by development banks.[6] Even though climate risk and disaster risk management is originally rooted in two different (scientific) communities, the topics and communities are increasingly converging and both use similar or even the same frameworks and approaches. It is therefore essential to connect the discussion on climate adaptation and climate resilience to the work in Disaster Risk Management (DRM) and Disaster Risk Reduction (DRR). As a basis for any further discussion, it is essential to define the key terms:

- **Resilience** is generally understood as the ability of a system, community, or society exposed to hazards to resist, absorb, accommodate, and recover from the effects of a hazard promptly and efficiently. – Land use planning and ecosystem management are relatively low-cost "no- regrets" approaches to

[5] For an overview of research projects see chapter 4.1.
[6] e.g. World Bank, GFDRR (2013). World Bank, GFDRR (2015). Jha et al. (2013).

managing disaster and climate risks effectively, especially for small- and medium-sized urban centres/settlements that lack resources and capacity.[7] Taking into account future risks and uncertainties, resilience relies on redundancy. [8]

The concept of resilience can be amongst other fields applied in context of managing climate change impacts as well as DRM. Essential components of resilience that are typically distinguished:

- **Structural:** (Infra-)Structural resilience refers to a reduction in the vulnerability of built structures, such as buildings and transportation systems. It also refers to sheltering capacity, health care facilities, the vulnerability of buildings to hazards, critical infrastructure, and the availability of roads for evacuations and post-disaster supply lines. Infrastructural resilience also refers to a community's capacity for response and recovery.
- **Institutional:** Institutional resilience refers to the systems, governmental and non-governmental, that administer a community.
- **Economic:** Economic resilience refers to a community's economic diversity in such areas as employment, number of businesses, and their ability to function after a disaster.
- **Social resilience:** Social resilience refers to the demographic profile of a community by sex, age, ethnicity, disability, socioeconomic status, and other groupings, and the profile of its social capital. Although difficult to quantify, social capital refers to a sense of community, the ability of groups of citizens to adapt, and a sense of attachment to a place.[9]

- **Hazard:** "A process, phenomenon or human activity that may cause loss of life, injury or other health impacts, property damage, social and economic disruption or environmental degradation [...] Hazards may be natural, anthropogenic or socio-natural in origin".[10]
- **Exposure:** "The situation of people, infrastructure, housing, production capacities and other tangible human assets located in hazard-prone areas".[11]
- **Vulnerability:** "The conditions determined by physical, social, economic and environmental factors or processes which increase the susceptibility of an individual, a community, assets or systems to the impacts of hazards".[12]

The terms of hazard, exposure, vulnerability and resilience are common throughout the climate and disaster risk discourse. The essential question for this study is the operationalisation of this concept from a planning perspective. Throughout Europe the 'art term' **spatial planning** is used for addressing land use and urban planning. Concerning the integration of climate change in spatial planning practice the terms climate change mitigation (CCM) and climate change adaptation (CCA) are used over resilience typically. In fact, the resilience concept is the broader one and encompasses adaptation action but is often put simply on a level with adaptation only. For spatial planning itself, there exist various definitions. The land use planning definition by UNISDR though, is framed in connection to DRM and is suitable for the climate resilience discourse as well:

- **Land use planning:** The process undertaken by public authorities to identify, evaluate and decide on different options for the use of land, including consideration of long-term economic, social and environmental objectives and the implications for different communities and interest groups, and the subsequent formulation and promulgation of plans that describe the permitted or acceptable uses.[13]

[7] Jha et al. (2013), p 9.
[8] ebd, p 3.
[9] Cutter et al. (2010).
[10] United Nations General Assembly (2016), p 18.
[11] ebd, p 18.
[12] ebd, p 24.
[13] UNISDR (2009).

While the management of natural hazards was in the beginning perceived as a reaction to static environmental conditions that can be described with simulations and calculations it is generally acknowledged that DRM and DRR have to operate with uncertainties and dynamic parameters. Climate change impacts heavily influence some of these parameters, in the first-place environmental conditions.

ENVIRONEMTNAL DYNAMICS DUE TO CLIMATE CHANGE

Overall, the number of disasters is rising in our changing world. During the period of 1980-2012 the estimated total economic losses due to disasters amount to US$3.8 trillion.[14] World areas are affected by disasters to a differing extent hitting especially the global south and urban poor. This also means that climate change impacts – that do not only relate to disasters, but also to food security, water supply, etc. – affect the vulnerable even more. Figure 2 shows some **key drivers of this change in disaster risk** that is truly a dynamic process. Besides climate change, e.g. poorly planned development, poverty and environmental degradation influence the risk of a climate event becoming a disaster. In order to address loss and damage appropriately, these factors need to be managed collectively.[15]

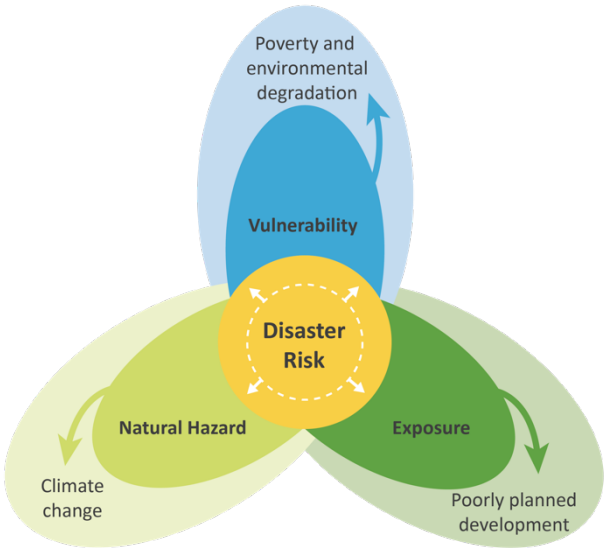


Figure 2: Drivers of disaster risk; adopted from IPCC (2012)

In the coming decades, the major driver of increasing damages and losses from disasters will be on the one hand population growth and assets in harm's way, especially in urban areas.[16] But also the dynamics of natural hazards triggered by climate change will contribute to increasing disaster risk. This observation accounts also for the EUSALP perimeter with its densely populated valley floors and large cities on the brink of the Alps.

TOWARDS CLIMATE AND DISASTER RESILIENT DEVELOPMENT

The reaction to identified dynamics in climate and disaster risk needs to have a comprehensive approach. Spatial planning has an essential role to play, especially when it comes to the control of hazard emergence, the reduction of vulnerabilities, the prevention of environmental degradation and of course in the first place the control of exposed people and assets through development and land use planning. Figure 3 provides a framework with an action-oriented perspective to tackle climate and disaster risk on different levels.

[14] World Bank, GFDRR (2013), p 5.
[15] ebd, p 11.
[16] IPCC (2012).

The general basis of any action is the identification of risk by appropriate assessments and analysis that help to inform decision making. Pillars 2-3 are in fact prevention measures that need to be developed and implemented before disaster strikes and are therefore categorized as prevention measures. Resilient reconstruction has to be prepared up front as well, but is implemented in a post-disaster environment.

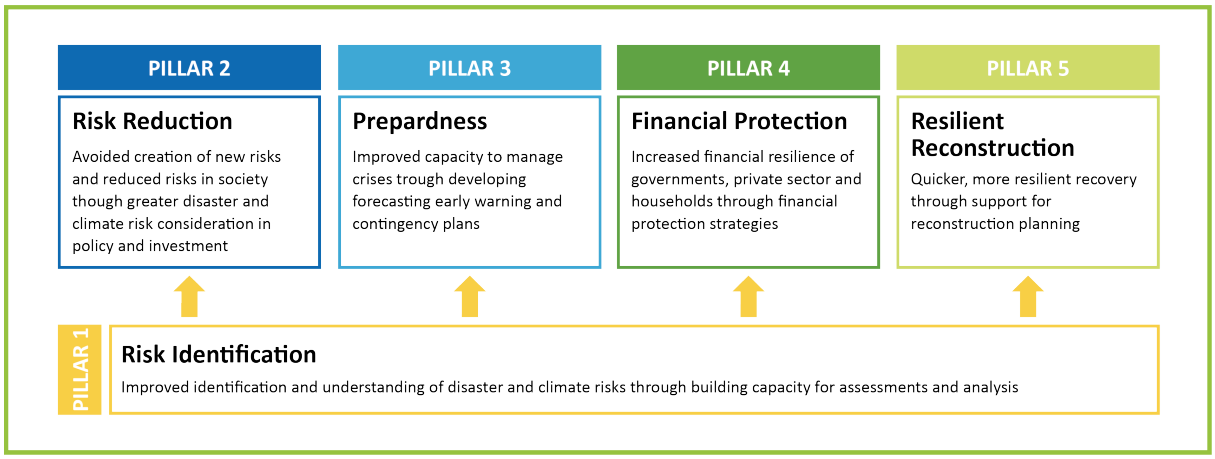


Figure 3: Framework for tackling climate and disaster risk; adapted from the Sendai Report World Bank (2012).

Concerning climate change there exist global efforts to document observed changes of environmental conditions and forecast the further development. The **Intergovernmental Panel on Climate Change** (IPCC)[17] plays with its reports and recommendations a crucial role. Apart from the global perspective there exist all kind of measurements, mappings and databases on national, regional and local levels to have a solid and sound basis for identifying climate related changes in exposure, vulnerabilities and risk.

Especially **UN organizations and development Banks** (World Bank, Asian Development Bank, Inter-American Development Bank, etc.) have predominantly a (long-term) project approach when it comes to addressing the different pillars introduced in Figure 3. Principles they imply are: (a) climate and disaster resilient development requires long-term, flexible programmes based on predictable financing; (b) risk identification needs to be effectively linked to decision making, taking future uncertainties into consideration; (c) risk management requires complementary actions at various levels of responsibility – household, community, national and international; (d) institution building and mainstreaming need to take incentives into account; (e) in their urgency to protect assets, climate and disaster resilient development programmes should not lose sight of the people.[18] This understanding directly aims for a stepwise approach; first identifying risks and second develop cross-sectoral actions and third facilitate implementation.

Spatial planning is typically limited in its possibilities to identify risks, develop projects and ensure quick and sound implementation. **Spatial planning itself** is more a **tool in managing climate and disaster risk** and especially suited to **ensure long term risk reduction** and **resilient reconstruction**. The discussion on potentials and limitations of spatial planning in climate and disaster risk management is influenced by concepts and frameworks developed mainly in the American and European context and further developed to suit also developing countries context. Raymond Burby discussed together with colleagues already more than 20 years ago e.g. how hazard resilient communities could be created through land-use planning. He outlines the process that needs to be established to **utilize land-use planning for hazard mitigation**: (i) **formulating the planning process**, (ii) **undertaking hazard assessments**, (iii) **crafting programmes to manage urban development** so that the

[17] Online: *https://www.ipcc.ch*, 17.05.2022.
[18] World Bank, GFDRR (2013), p 28f.

community is more resilient to natural hazards.[19] He further suggests that planning and implementation have to be aligned and building standards and development regulations adjusted accordingly. Overall, he argues for a comprehensive perspective. The research work done on the topic of integrating DRM in spatial planning is the baseline also for integrating climate risk in planning and concepts and frameworks have been enhanced over the years leading to the use of the term "risk-based land use planning" or "risk-sensitive land use planning" that works for the integration of hazard as well as climate risk in spatial planning. Various guidance documents exist on this topic, that should help governments, administrations but also external advisors to facilitate risk-sensitive decision making in spatial planning. **Risk-sensitive land use planning** identifies the **safest areas to prioritize investments in urban development and infrastructure projects**. Land use and other regulatory plans **influence the location, type, design, quality, and timing of development**. Mainstreaming land use planning in infrastructure projects reduces risk in rapidly growing urban centres in hazard-prone areas. While land use planning informs urban spatial development, comprehensive risk reduction requires social and economic policies and programmes that will increase the capacity of the urban population to adapt to risks.[20]

Key characteristics of risk-sensitive land use planning are:[21] It

- allows and **promotes development without generating new risks**;
- identifies and **mitigates the root causes of disaster risks** embedded in existing land development practices;
- modifies and **reduces vulnerable conditions** of people (physical/social/economic) and places;
- **pre-empts disaster damage** before it happens through mitigation;
- **reduces losses and increases people's ability to recover** by speeding up the process of reconstruction/rehabilitation;

While these key characteristics were formulated in light of DRM, they prove to be well suited for the operationalization of climate risks in spatial planning, adding the essential aspect of dynamic environmental conditions and the necessity to take uncertainties into account.

Anyhow, the scientific community also debates how far the issue of **climate change is too big for spatial planning to grasp?**[22] Especially the requirement to contribute to an effective reduction of CO_2 emissions on different levels (settlement structure, mobility, energy supply) and foster adaptation action at the same time is an enormous and challenging task.

Well known planner and thinker Simin Davoudi also poses the question if resilience is a bridging concept or a dead end. As resilience was a recent addition to planners' discursive repertoire more than a decade ago it was not a new concept at all then. Davoudi argues that especially the essential aspects of **evolutionary resilience** "…with its rejection of equilibrium, emphasis on inherent uncertainty and discontinuities, and insight into the **dynamic interplay of persistence, adaptability and transformability**"[23] provide a useful framework to understand complex socio-ecological interdependencies that can also be integrated in spatial planning.

The broad discourse on (climate) resilience and spatial planning requires a certain degree of pragmatism to establish an understanding that is suitable for an analysis such as conducted for this report.

[19] Burby et al. (2000).
[20] Jha et al. (2013), p 4.
[21] World Bank, EMI (2014). Jha et al. (2013), p 57.
[22] Campbell (2006).
[23] Davoudi (2012).

1.2 International Framework and Guidelines on Climate Change Mitigation and Adaptation

The global community – in the first place led by the United Nations[24] – undertakes a comprehensive collaborative effort to address climate change mitigation and adaptation already on a global level and provide guidance as well as binding goals to meet climate change impacts. It proved to be easier to address climate change mitigation on a macro-level and focus on the reduction of CO_2 emissions to ensure quantifiable and comparative action of single countries. Climate change adaptation though is widely assigned to regional and local action and is only addressed marginal on a trans-national level. This chapter seeks to provide a brief overview of trans-national arrangements/agreements on climate action that also include climate action through spatial planning which set the scene for climate adaptation and resilience in spatial planning within the EUSALP perimeter.

UN – SUTSTAINABLE DEVELOPMENT GOALS

The United Nations Member States adopted in 2015 the **2030 Agenda for Sustainable Development**[25] which provides a shared blueprint for peace and prosperity for all people on the planet. A key role in this agenda is assigned to the 17 Sustainable Development Goals (SDGs) that cover all areas of life and address challenges such as poverty, hunger, inequalities etc. **Goal 13** of the SDGs is simply called **Climate Action** (take urgent action to combat climate change and its impacts).[26] To operationalize the goal, targets and indicators are defined:

- 13.1: **Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters** in all countries (Indicators: number of deaths, missing persons and persons affected by disasters per 100,000 people; number of countries with national and local disaster risk reduction strategies; proportion of local governments that adopt and implement local disaster risk reduction strategies in line with national disaster risk reduction strategies);
- 13.2: **Integrate climate change measures into national policies, strategies and planning** (Indicator: number of countries that have communicated the establishment or operationalization of an integrated policy/strategy/plan which increases their ability to adapt to the adverse impacts of climate change, and foster climate resilience and low greenhouse gas emissions development in a manner that does not threaten food production (including a national adaptation plan, nationally determined contribution, national communication, biennial update report or other);
- 13.3: **Improve education, awareness-raising and human and institutional capacity** on climate change mitigation, adaptation, impact reduction and early warning (Indicators: number of countries that have integrated mitigation, adaptation, impact reduction and early warning into primary, secondary and tertiary curricula; number of countries that have communicated the strengthening of institutional, systemic and individual capacity-building to implement adaptation, mitigation and technology transfer, and development actions);
- 13a: Implement the commitment undertaken by developed-country parties to the United Nations Framework Convention on Climate Change to a goal of **mobilizing jointly $100 billion annually** by 2020 from all sources to address the needs of developing countries in the context of meaningful mitigation actions and transparency on implementation and fully operationalize the Green Climate Fund through its capitalization as soon as possible.

[24] Online: *https://www.un.org/en/*, 17.05.2022.
[25] UN (2015): A/70/L.1 Resolution adopted by the General Assembly on 25 September 2015.
[26] Online: *https://sdgs.un.org/goals/goal13*, 17.05.2022.

- 13b: Promote mechanisms for raising capacity for effective climate change-related planning and management in least developed countries and small island developing States, including focusing on women, youth and local and marginalized communities. Acknowledging that the **United Nations Framework Convention on Climate Change** is the primary international and intergovernmental forum for negotiating the global response to climate change.

The **SDG 13** addresses mitigation and adaptation aspects at the same time and clearly refers to DRM as climate change impacts rapidly change hazard exposure around the globe. National authorities are obliged to **strengthen resilience as well as adaptive capacities**, develop specific policies and strategies and improve also the education and awareness to tackle climate change comprehensively. Nevertheless, the indicators do not necessarily state on the quality of implementing the single targets. But overall, SDG 13 demands action to foster resilience and adaptation throughout all sectoral domains of public administration also encompassing spatial planning.

UNFCC – PARIS AGREEMENT

The UNFCC secretariat (UN Climate Change) is an entity within the United Nations tasked with supporting the global response to threat of climate change. The **United Nations Framework Convention on Climate Change** (UNFCC) has nearly universal membership (197 parties) and is the parent treaty of the 2015 Paris Agreement. The secretariat was established in 1992 and is located in Bonn/Germany. The secretariat overall supports the implementation of the Convention, the Kyoto Protocol and the Paris Agreement. It especially acts as an international hub on the topic and pursues a broad communication strategy to inform all kind of stakeholders.[27]

The essential binding framework for international efforts and collaboration on climate change mitigation and adaptation is the **Paris Agreement**. This legally binding international treaty on climate change was adopted by 196 parties at the 21st Conference of Parties (COP) on 12th December 2015 and entered into force on 4th November 2016. The overall goal is to limit global warming to below 2 °C compared to pre-industrial levels and pursue efforts to limit the temperature increase to 1.5°C (Art 2, 1, a). The Agreement works on a 5-years cycle of increasingly ambitious climate action assigned to the single countries and requiring economic and social transformation. The national determined contributions (NDC) the countries communicate their actions to reduce Greenhouse Gas emissions in order to reach the goals of the Paris Agreement. Besides CO_2 reduction for CCM the Paris Agreement also tackles climate resilience and adaptation. Article 7 states that parties establish hereby the global goal on adaptation of enhancing adaptive capacity, strengthening resilience and reducing vulnerability to climate change. Thereby, the Paris Agreement demands in particular a long-term strategy and approach for climate change adaptation as well.[28]

For the EUSALP region and its member states and regions the Paris Agreement formulates a clear and binding requirement. There is clearly no choice whether to act or not but an unambiguous obligation to develop policies, strategies and implementation action to achieve the by the NDC defined overall goals.

EUROPEAN UNION – EUSALP

The European Union (EU) addresses Climate Change through different programmes and initiatives relying in the first place on policies and financial incentives. There exists nearly an unmanageable number of publications that assesses climate actions on European level; e.g. looking into capacity building programmes[29], accomplishing SDG

[27] Online: *https://unfccc.int/about-us/about-the-secretariat*, 17.05.2022.
[28] Online: *https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement*, 17.05.2022.
[29] Domorenok and Prontera (2021).

13 by European action[30] and many more. The EU integrated climate action into the **European Green Deal**[31] that also tackles environmental degradation. The Green Deal is a growth strategy that aims to "…transform the EU into a fair and prosperous society, with a modern resource-efficient and competitive economy where there are no net emissions of greenhouse gases in 2050 and where economic growth is decoupled from resource use."[32] To achieve this overall goal an action plan seeks to (i) boost the efficient use of resources by moving to a clean, circular economy and (ii) restore biodiversity and cut pollution. The action plan outlines in the first place investments needed and defines financing instruments. First climate action initiatives under the Green Deal include the **European Climate Law** that enshrines the 2050 climate-neutrality objective, the **European Climate Pact** to engage citizens and all parts of society, the **2030 Climate Target Plan** to reduce net greenhouse gas emissions by at least 55% by 2030 and the **EU Strategy on Climate Adaptation** to make Europe a climate-resilient society by 2050, fully adapted to the unavoidable impacts of climate change.

The European Commission adopted the **EU Strategy on Climate Adaptation**[33] rather recently on 24th February 2021. Adaptation has to be informed by robust data and risk assessment tools that are available to all. With **Climate-ADAPT**[34] there exists a European platform for adaptation knowledge and monitoring. The strategy asks for systemic actions and identifies three **cross-cutting priorities**:

- integrating adaptation into macro-fiscal policy,
- nature-based solutions[35] for adaptation,
- local adaptation action.

The **EU Strategy for the Alpine Region** (EUSALP)[36] seeks to improve cooperation in the Alpine States and foster effective transnational collaboration. Its actions are based on 3 thematic policy areas and priorities with a focus on governance on a cross-cutting policy area. Climate change was in particular addressed during the French presidency (2020-2021) in line with the European Green Deal. As there is no Action Group (AG) that solely focuses on climate change mitigation or adaptation, it lies in the responsibility of the single Action Groups to integrate climate change issues into their activities. Due to the connection of climate change with natural hazards it is imperative for "AG 8 – Risk Governance" to tackle climate action.

ALPINE CONVENTION

The Alpine Convention is an impressive example of managing common problems and challenges in the Alps in a comprehensive and collaborative manner. Based on international treaties between the Alpine countries Austria, France, Germany, Italy, Liechtenstein, Monaco, Slovenia and Switzerland as well as the European Union it encompasses besides a framework convention nine specific protocols and two ministerial declarations on sectoral topics. Deriving from discussions that have started in the 1980s, the convention entered into force in 1995 and represents a legally binding **international treaty for the protection of the Alps** and a **well-adjusted sustainable development**.[37] References to the danger that natural hazards pose, can be found throughout the treaties text. Natural hazards appear to be especially linked to spatial planning[38], mountain forest management

[30] Kokotovic et al. (2019).
[31] EC (2019).
[32] ebd.
[33] EC (2021).
[34] Online: *https://climate-adapt.eea.europa.eu*, 17.05.2022.
[35] Raska et al. (2022).
[36] Online: *https://www.alpine-region.eu*, 17.05.2022.
[37] Alpine Convention (2010).
[38] e.g. Protocol: Spatial Planning and Sustainable Development: Art. 8 2 e) "…determining the areas subject to natural hazards, where building of structures and installations should be avoided as much as possible".

and climate change adaptation. The conventions protocols indicate the necessity of an integrative approach to dealing with risks and effects of natural hazards. Governance as a term though is only mentioned once stating that the "…participative method of risk governance in the planning process" should be used to reinforce the adaptation capacity to climate change.[39] The convention itself provides a rather rigid legal framework but already includes the idea of integrative, inter-sectoral efforts in dealing with natural hazards.

The challenge of climate change mitigation and adaptation in the Alps has entered the Alpine Convention agenda more recently but has seen manifold actions through specific assessments, policy documents and declarations. As there is no protocol on climate change the Alpine Conference adopted already in 2006 a **declaration on climate change**.[40] In 2019 the Alpine Conference adopted under the title **Climate-neutral and Climate-resilient Alps 2050** the declaration of Innsbruck.[41] The declaration in particular introduces the **Alpine Climate Target System 2050** and intends to develop the Alpine area as a model region for integrated climate change mitigation and adaptation activities. To oversee and coordinate actions and implementation activities the **Alpine Climate Board** (ACB)[42] was established. The work of the ACB is based on comprehensive work concerning climate change mitigation and adaptation within the Alpine Convention perimeter relying on the **'Alpine Climate Target System 2050'** and the recently developed pathways for implementation.

The overall strategic targets of the system are (i) climate-neutral Alps by 2050 as well as (ii) climate-resilient Alps, followed by sectoral climate targets. Interestingly, the spatial planning targets are the first ones:[43]

- **Priority** for **climate change mitigation and adaptation in spatial planning** processes,
- Planning systems in **risk management** changed from passive to **proactive**.

By now, according pathways for the implementation of these objectives have been formulated to foster climate-neutral and climate-resilient Alps in line with the declaration of Innsbruck.[44] For spatial planning two pathways have been formulated:

- (1) Alpine wide concept "**Spatial Planning for Climate Action**",
- (2) Measures for **reducing** the need of **individual car traffic**.

Both defined pathways address CCM and CCA aspects and have very clear sequences of implementation steps as well as a mapping of stakeholders needed for implementation. Pathway 1 takes good practices for growth and shrinking strategies into account and focuses on land saving targets and challenges. Here a cooperation with/and integration of the newly established **Spatial Planning and Sustainable Development Working Group** can be expected.

Overall, the work of the Alpine Convention towards climate-neutral and climate resilient Alps is closely connected with recent efforts in the EUSALP to establish spatial planning and especially its role in CCM and CCA as a cross-sectoral policy priority to foster trans-national cooperation and enable implementation activities.

[39] Alpine Convention (2010), p 191.
[40] Alpine Convention (2006).
[41] Alpine Convention (2019).
[42] Online: *https://www.alpconv.org/en/home/organisation/thematic-working-bodies/detail/alpine-climate-board/*, 17.05.2022.
[43] Alpine Convention (2019), p 12f.
[44] Online: *https://alpineclimate2050.org*, 17.05.2022.

2 Methodology

The study looks into the widely established idea, that climate change adaptation has to be implemented in particular through spatial planning. This is the case on local, regional, national but also transnational level as shown above. Starting point for the discussion on climate adaptation and climate resilience in spatial planning is the general notion, that there are still extensive implementation gaps although numerous studies and projects highlight the importance of integrating a climate change perspective in planning regulations and processes. The study seeks to summarise the status quo of **(i) climate change in the Alp**s and the **necessities of CCA** through planning, (ii) and looks into the **existing planning objectives and frameworks** for CCA and explores and identifies **pathways to enhance the adaptive capacity** of spatial planning. This reflection should especially contribute to the common spatial development (strategy) and cross-cutting policy sector of the EUSALP agenda.

This overall objective of the study results in a set of research questions that guide the process:

- Which changing **climate signals in the Alps are relevant for spatial planning** and trigger the need for adaptation via planning strategies and instruments?
  Overview of the state of research and establishing a reference system for spatial planning in climate change research.
- How can spatial planning in the single Alpine countries **operationalise overall goals of climate adaptation with existing planning instruments and procedures**? Which criteria are existing for such a climate proofing[45] or would be possible and useful?
  Outlining and analysing the frictions of a normative planning system and the pro-active reaction to dynamically changing environmental conditions as well as their manifestation on local level causing the need to act via spatial planning.
- Which **planning instruments and decision-making criteria are of particular importance** concerning climate resilient spatial planning?
  The plurality of planning instruments (analytical, strategic, binding) and dynamic environmental conditions request a higher flexibility of planning interventions and measures.
- Which **planning instruments can in what manner increase climate resilience** on different level?
  An analysis of the spatial planning instruments on different levels for decision making and how they can be enhanced to be sensitive to climate induced environmental changes.
- Which **best-practice examples from the Alps**, illustrate the integration of CCA and climate resilience in spatial planning, exist?
  This question can be especially conducted in close collaboration with the AG members.

The single questions are assigned to separate work packages in the study to build on already conducted research and existing overall political objectives and principles. Thereby, the study explores the operationalisation of CCA and resilience in spatial planning from a process and instrumental perspective. To connect the discussion to the actual day-to-day practice, a workshop is organised in a mountain municipality in Austria.

[45] Schindelegger et al. (2021). Birkman and Fleischhauer (2009), pp 114-127.

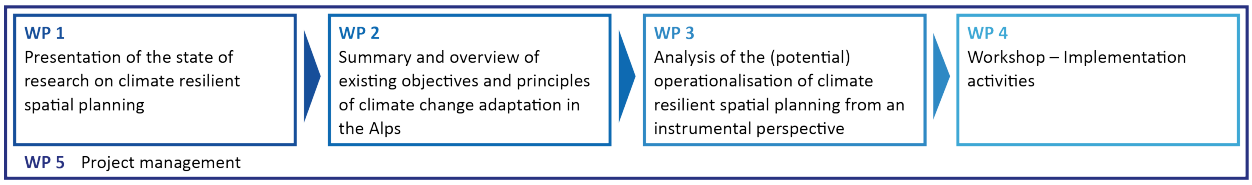


Figure 4: Overview of the single work packages of the study

1. **Presentation of the state of research on climate resilient spatial planning**
   Summary of the results coming from research projects, essential publications on the Alps; graphic and textural presentation of the expected significant climate change impacts in the Alps.
   Method: desk research, bilateral coordination with the AGs

2. **Summary and overview of existing objectives and principles of climate change adaptation in the Alps**
   Systematic overview of the operationalisation of decision-making processes and planning instruments so far; esp. on regional and local level originating from identified adaptation needs (drawing on provisions in NAS, NAP)
   Method: desk research; using the network of the AGs for setting up specific interviews with relevant stakeholders on national/regional level

3. **Analysis of the (potential) operationalisation of climate resilient spatial planning from an instrumental perspective**
   Identification of climate induced dynamics in environmental conditions that need to be integrated in planning decisions to increase climate resilience. That tackles especially dynamics of natural hazard exposure but also dependencies on climate services (e.g. protective forest, protection infrastructure). Evaluation of existing and potential operationalisation of climate resilience through spatial planning instruments and processes.
   Method: explorative development of recommendations based on stakeholder interviews and existing actions and initiatives

4. **Workshop – Implementation activities:**
   In consultation with AG8 co-lead a pilot municipality for the organisation of a stakeholder workshop is identified. The workshop focuses on actual CCA activities, the awareness of local exposure towards climate change impacts and the practical challenges that come with sectoral coordination. The results will be documented and integrated in the study.

5. **Project management:** bilateral cooperation; bi-annual meetings of EUSALP AG8 with input and workshops; publication of project results.

3 Climate Change in the Alps

3.1 Global Climate Change

Anthropogenic triggered climate change is the most substantial present change of environmental conditions – besides development induced degradation – that rapidly transforms our earth. The causes for the increase of greenhouse gases in the atmosphere are manifold but in particular the burning of fossil raw materials and large-scale deforestation and extensive agricultural cultivations relying on monocultures and pesticides contribute the largest share. The main effect of an increased greenhouse gas concentration is a rapid global warming due to the changed thermal retention capacity of the troposphere. The enlarged counter-radiation in the atmosphere also increases the energy input to the surface and the layers of air close to the ground.[46] Although there are natural fluctuations in temperature increase/decrease due to complex interactions between the components of the global climate system, a clear upward trend is evident. The **anthropogenic influence contributes** significantly to this **overall temperature increase**. The global mean temperature is already 1°C above the pre-industrial period (1850-1990).[47] Another critical factor is the rapidity of the observed global warming. The interval from 1983-2012 was the warmest period ever recorded. The warming of the oceans plays a major role as well, dominating the increase in energy stored in the climate system and accounting for the majority (approximately 90%) of the energy accumulated between 1971 and 2010.[48]

The sustained emission of greenhouse gases leads to continuous global warming of the troposphere. Therefore, a further increase in the average temperature is predicted. The **global warming of 1.5°C and 2°C will be exceeded during the 21st century** (relative to 1850-1990). This is a model calculation and relates to a scenario in which no appropriate interventions are made. The following figure shows the potential temperature development until 2100 from the IPCC 2021 report. Accordingly, very likely ranges are shown for the scenarios SSP1-2.6 and SSP3-7.0, which entails a temperature increase of 1.8°C to 4°C degrees.[49]

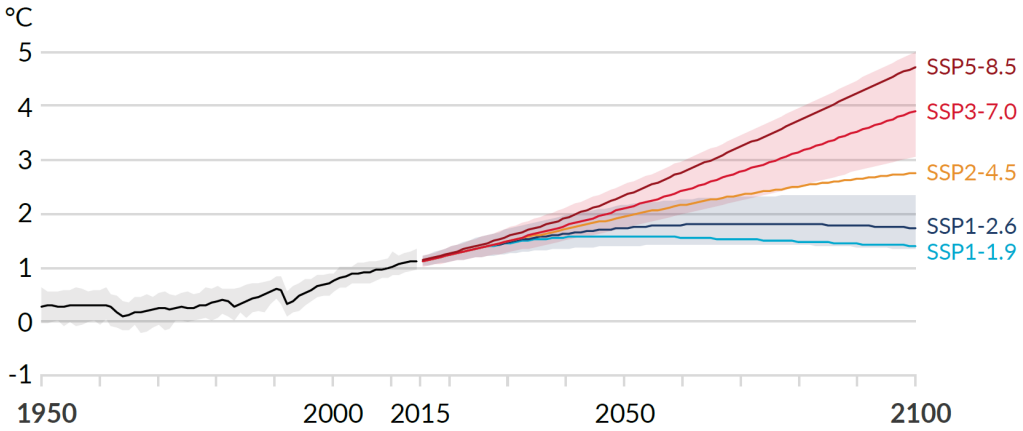


Figure 5: Global surface temperature change relative to 180-1900 and development until 2100 (IPCC (2021), p 29.)

[46] Steffen et al. (2011), p 746.
[47] IPCC (2018), p 4.
[48] IPCC (2014), p 4.
[49] IPCC (2021), p 29f.

Climate signals cause **significant impacts on environmental conditions**, which in turn affect our living conditions. The most important climate signals in general are:[50]

- an **increase of the number, period and intensity of hot days**;
- **seasonal shifts in precipitation**;
- **more frequent and intense extreme events**.

The dynamics of climate impacts differ in their temporality. They range from gradual environmental changes such as the melting of glaciers to sudden natural hazard events like for instance massive debris flows due to heavy rain. The loss of the glaciers is mainly caused by the overall temperature increase. It is a global phenomenon as the duration of snow coverage has decreased significantly. In particular, small glaciers are expected to disappear entirely by 2050. Large glacier will lose 30-70% of their volume until 2050.[51] Glacier retreat is also connected to the decline of permafrost in mountain areas. This, along with the fact that seasonal precipitation shifts, means that hydrological systems are changing in many mountain regions, which in turn affects the quality and quantity of water sources. The human-induced climate change also contributes to a change in extreme weather events. Since 1950 there has been a global decrease in events triggered by cold temperature while those due to warm temperatures are on the rise. This manifests itself e.g. in an increased frequency of heat waves. A significant rise of heavy precipitation events can also be observed, which is linked to pluvial flooding events that cause extensive damages and are difficult to predict.[52]

The above-mentioned climate impacts encounter changes in exposure and vulnerabilities of natural and human systems. This results overall in an increasing disaster risk with new risks on the rise (e.g. casualties due to heat waves in Canada in 2021). However, the climate-related consequences are not evenly distributed. Some have global relevance and others have rather regional effects. In addition, the climate impacts and their significance differ depending on settlement structures. Therefore, urban areas are typically exhibit other climate change related risks than rural regions.

3.2 Climate Change in the Alpine Region

Climate change is taking place. But climate change impacts differ regionally. The Alps are characterised as a particularly varied region with a great diversity natural and cultural landscapes that differ depending on natural parameters such as altitude, temperature, precipitation, exposure or soil types. They Alps stretch across central continental Europe and play apart from other socio-economic and ecological functions an essential role in Europe's water supply. Furthermore, the **Alps are a particularly climate-sensitive** and vulnerable region to climate change impacts. This is also noticeable in the fact that the measured average temperature increase in Europe over the last hundred years was about 0.9°C and is with 1.5°C significantly higher in the Alps. According to the forecasts of the IPCC in 2021, the global surface temperature will increase by 1.2°C to 1.9°C by the year 2040 depending on greenhouse gas emissions, compared to 1850-1900. Rising temperatures are also predicted for the Alps and the Alpine region.[53]

The following figure displays the forecasted change in mean temperature (in C°) and precipitation (in %) on a seasonal basis for 2071-2100 compared to the reference period 1971-2000.

[50] Spehn and Körner (2017), p 407.
[51] ebd, p 410.
[52] IPCC (2014), p 4ff.
[53] IPCC (2021), p 41f. IPCC (2014), p 4ff. Schröter et al. (2005), p 2.

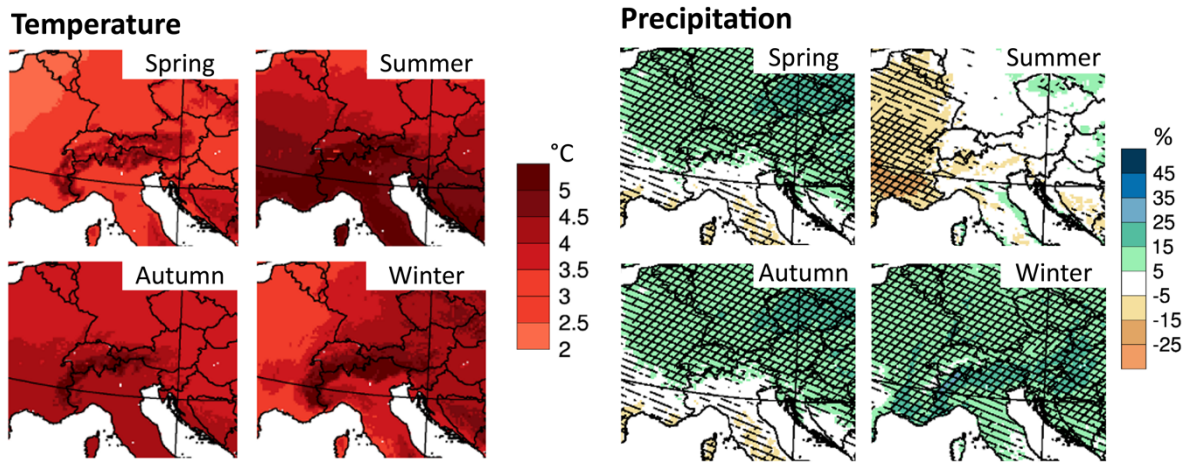


Figure 6: Projections for the change in air temperature and precipitation on a seasonal basis in the Alpine region[54]

The Alpine region has unique and specific climate change exposure with strong regional disparities. Climate change impacts in the Alpine region often differ significantly within only a few kilometres. The discussion here equates the Alpine area with the EUSALP perimeter. In addition to the core area of the Alps, this includes the Alpine foothills and as well as the surrounding flatlands. Most research though, mainly refers to the high mountain areas and the inner-Alpine valleys. The spacious delimitation of the Alpine region means that it encompasses topographically-wise very different areas. The single regions in the Alpine areas have different settlement structures and economic pillars. Therefore, every region has a specific (climate) risk profile as risk is always connected to the anthropogenic uses and consequences of climate change in the Alpine region are diverse.

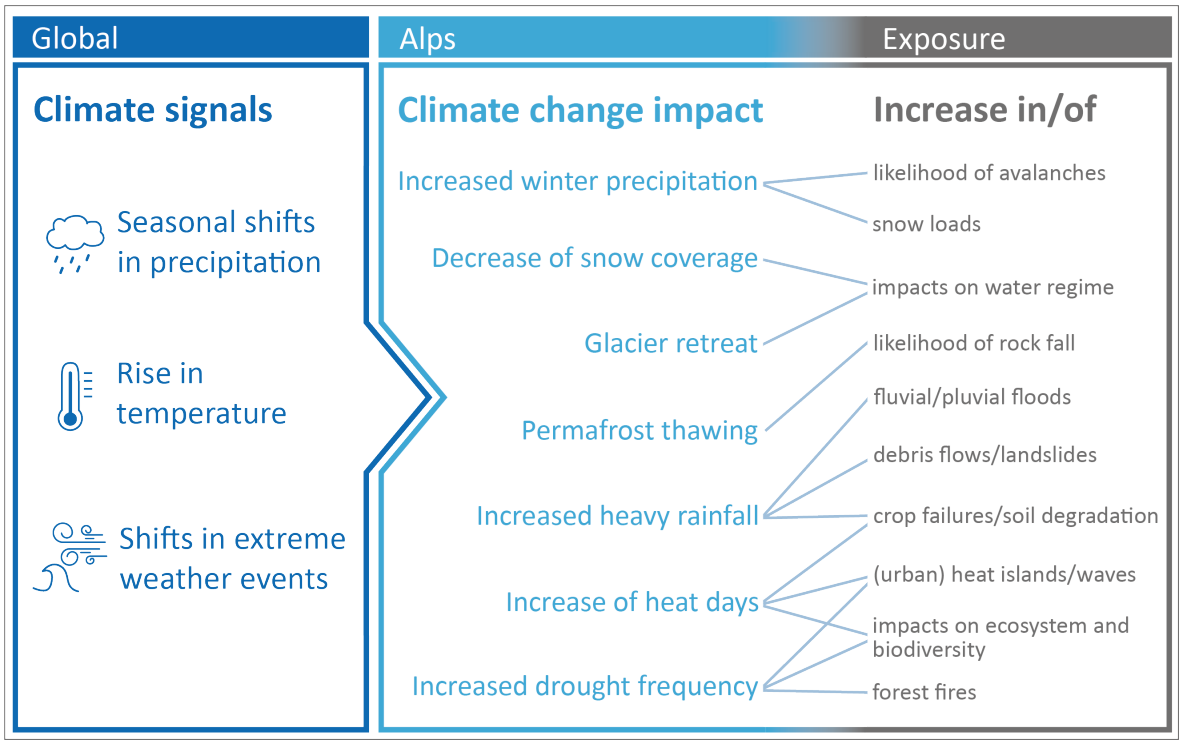


Figure 7: Climate signals and their effects in the Alps

[54] Modified from: Jacob et al. (2014), p 567.

The impacts of the overall temperature increase manifests differently depending on regional characteristics. Therefore, it is e.g. possible that hazard events occur where they have never done before, or that they now take place regularly. However, they can also weaken or no longer occur at all. Consequently, climate change impacts must be differentiated. Overall, an increase in precipitation is expected, while there is already less yearly precipitation than before in certain. Regionally the climate change induced dynamics differ widely. And it is important to highlight, that climate change impacts overlap with effects of environmental degradation caused by human activities. Changes in hazard exposure and vulnerabilities are not solely based on climate change in the Alps. This makes the use of regional (climate) risk profiles even more important to have a sufficient degree of accuracy to inform spatial planning and development in general. The single climate signals entail specific climate change impacts in the Alpine region that are outlined below:

Temperature: A perceptible climate signal under the use of scenarios is the overall rise in temperature. Even slight changes in mean annual temperatures can have dramatic long-term effects. For example, the year 2020 was one of the three warmest ever recorded with a global temperature surplus of +1.2°C compared to pre-industrial values. The **past decade is also considered to be the warmest in the Alps** since recordings began.[55] The increase of high temperature days is even more grave than the rise in mean temperature. Research states, that warming above average is to be expected in the South Tyrol region and the southern foothills of the Alpine arc. Otherwise, the temperature increase is distributed relatively homogeneously in the Alpine region. However, the warming is more pronounced in higher altitudes. With a seasonal perspective, the strongest warming is expected for the annual mean temperature in summer.[56]

For example, in Switzerland both the number of very heat days (over 30°C) and the measured temperature of the hottest summer days and nights are increasing. It is predicted that the number of very **heat days will rise by 3 to 17 days a year** and the temperature of the hottest days will increase around 2°C to 5.5°C by the middle of the century.[57] A similar trend is assumed for the entire Alpine region. Even though the Alpine region can be predominantly described as rural, there are some (major) urban areas. These are typically the most sensitive ones to heat waves and formation of heat islands. Due to the high absorption of solar radiation on paved surfaces, heat storage by sealed surfaces, lack of green infrastructure (parks, alleys etc.), trapping of long-wave radiation in urban canyons, reduced circulation of air and the additional release of anthropogenic heat such urban areas intensify overall heat. The temperature of sealed areas is in general significantly higher than in unsealed ones. Greater incidence of heat waves leads already to an increase in urban heat stress. The intensification of the so-called **Urban Heat Island** (UHI) effect is expected. This effect means an excess of heat in combination with reduced nocturnal cooling and less ventilation. The associated air pollution also increases the health risks for urban populations.[58]

The change in mean temperature leads to an extension of dry periods in summer. That in consideration, the longest dry period in summer could last approximately a week longer by the middle of the century. Combined with a decreasing quantity of precipitation during summer

[55] OcCC (2020), p 4.
[56] Jacob et al. (2014), p 568.
[57] CH2018 (2018), p 117.
[58] Birkmann et al. (2021), p. 2f.

months, the soil becomes drier and besides soil degradation and wind erosion, the likelihood of forest fires increases. Forest fires in return particularly endanger infrastructure and settlements in the Alps also through the loss of the protective function of forests falling victim to forest fires.

Precipitation: Higher temperatures result in higher air humidity and thus the formation of precipitation. According to the IPCC, future winter precipitation in the European middle and high northern latitudes is likely to increase and more intense precipitation events are supposed to appear more frequently.[59] Calculations show that in the 21th century the average **quantity of precipitation** in these latitudes, which also include the Alps, will **increase by 0.5 to 1% every decade**. The effects can also be seen in the increase of 1- to 5-days of extreme precipitation in Central Europe. By the end of the century heavy precipitation events that currently occur every 8 to 20 years are predicted to occur approximately every 5 years.[60]

There are once more significant regional and seasonal differences. The north-western Alps record a higher increase in precipitation, especially in winter and spring. The summer is characterized by a sharp decrease in precipitation in the western Alpine region.[61] However, precipitation depends of course on the altitude. At low and medium altitudes, there will be more rain and less snow, which is why the frequency of winter floods will rise.[62] The increase in precipitation intensity brings the potential for frequent floods and debris flows. Frequent storms also increase the likelihood of extreme precipitation. Changes in precipitation also have an impact on the water balance system. Because of the reduction in regional precipitation and the increase in evaporation, the annual runoff volume is likely to decrease, especially in the southern Alpine region and in the Alpine foothills. In addition, the formation of new groundwater can decrease in summer and autumn in all non-glaciated areas.[63]

Snow coverage and glaciers: The snow cover in the Alpine region shows considerable yearly fluctuations. In the last few decades, however, he duration of snow coverage has decreased significantly. It is assumed that duration of **snow coverage will decrease** (below elevations of 1.500-2.000 m throughout the 21st century) significantly, a shortening of the snow season and an increase in ground temperature to the end of the century are the consequences.[64] It is not completely clear how the change in snow coverage will for example affect the overall likelihood of avalanches as they depend on other factors mainly (heavy snow fall combined with strong winds). Yet the likelihood could increase due to changes in extreme weather conditions. The change to receive more precipitation in form of rain in the winter months hardly moderates the risk, instead this could lead to more wet snow avalanches.[65]

The **glaciers of the Eastern Alps** have **lost over half of their area and more than two thirds of their mass in the last 150 years**. The hot summer of 2003 alone led to a loss of 10% of the remaining glacier area. As Zemp et al. (2015) and the 'Glacier Report 2021' from the Austrian Mountaineering Association[66] state, the glacier retreat has accelerated in recent years. The

[59] IPCC (2014), p 40.
[60] Frei et al. (2006), p 3.
[61] Brunetti et al. (2006), p 4f.
[62] OcCC (2003), p 71.
[63] OcCC/ProClim (2007), p 22.
[64] Bender et al. (2020), p 1. IPCC (2021), p 150.
[65] OcCC (2014), p 6. OcCC (2003), p 80.
[66] OeAV (2021).

glaciers in the entire Alpine region are currently losing around 40 km^2 of their present area and around 2 km^3 of their volume annually.[67]

Zemp et al. (2006) evaluated the glacier cover in the entire Alpine region using an integrated approach. The past, present and the potential future course of the Alpine glaciers were examined and shown by means of a numerical model. The model is based on a 3°C warming event of summer air and shows that the Alpine glacier cover could be reduced by more than 80% in comparison to the reference period 1971-1990. In the event of a 5°C temperature increase, the glacier cover would be reduced by more than 90%. This would mean that the **Alps would become almost completely ice-free**. The impact of changes in precipitation on the total snowpack is a minor one and will not have any effect on the total decrease as a result of rising temperatures.[68]

In addition, the rise in temperature in the Alps also influences the freezing processes. This has profound consequences for permafrost. This exists in the Alps from an altitude between 2.000 m and 3.000 m upwards. Due to the rise of the freezing point in winter to higher altitudes, the permafrost thaws increasingly.[69] Between 1960 and 1990, an increase of the zero-degree limit from approx. 600 m to 900 m could be measured in the Swiss Alps which corresponds to an increase of 300 m in only 30 years. Permafrost thawing bears the risk of erosion and slope instability.[70]

Natural Hazards: Changes in the mean annual temperature and precipitation patterns have various consequences in a mountain environment. These include natural hazards that can be exacerbated by climate change. The natural hazard processes can change to different degrees depending on the topography. The project ClimChAlp[71] identified a number of possible effects of climate change on natural hazards in the Alpine region. An increase in the frequency and intensity of flood events can be already observed. On the one hand this is triggered by the increase of winter precipitation in certain areas in conjunction with the simultaneous rise of the snow line and on the other hand by the increase of extreme precipitation in summer. Also, there is an increase of the frequent and extended slope instabilities, an increase in rock fall events, tending towards higher altitudes, as well as the risk of landslides. The increased risk results from glacier retreat, the decline in permafrost, the change in vegetation cover and the distribution of heavy precipitation. The increasing occurrence of glacier and permafrost hazards is one of the clearest indications for the effects of climate change on natural hazards in the Alpine regions. Due to possible heavy precipitation in winter, likelihood of avalanches changes as well. The anticipated heavier snowfalls can make avalanches occur more frequently. The reduced summer precipitation and drought exposure lead to desiccation of soil and thus to a higher risk of forest fires. Which in return favours the risk for other natural hazards threatening the settlement area.[72] The findings from the ClimChAlp project address the overall expected and

[67] Björnsen Gurung and Stähli (2014), p 36.
[68] Zemp et al. (2006), p 3.
[69] IPCC (2012), p 187.
[70] OcCC/ProClim (2007), p 19.
[71] ClimChAlp (2008).
[72] ebd.

recorded changes very generally making it necessary to develop individual risk profiles for local to regional contexts.

Forest: Higher temperatures in combination with longer drought periods are likely to lead to more frequent and more intense forest fires. At the same time, changes in forest management in the sense of extensive management as well as changes in tree species have an impact on the vulnerability of forests. In addition to the increasing drought likelihood, heat stress, weak rejuvenation and game browsing also increase the vulnerability of mountain forest towards storm damage and bark beetle infestation. The accumulation of dead wood as a result may rise fire residence time and fire severity.[73] Forest fires caused by lightning are also expected to increase in the future[74]. Extreme forest fires are often associated with foehn events in combination with drought. The change in the general weather conditions caused by climate change can also change the local and large-scale wind systems, which leads to a change in the propagation direction and speed. Forest areas have an important protective function concerning natural hazards. The elimination of this natural protection structures changes the long-term hazard exposures of settlement areas and infrastructure.[75] In particular, conifer-dominated forests on southern slopes and inner Alpine dry valleys are generally at great risk for forest fires. There has been a significant increase in the annual average fire danger in the Western Alps and particularly in the Southern Alps. In the Northern and Central Alps, the increase was so far marginal. In addition, topography also has an influence on the likelihood of forest fires. Canyons, steep terrain in mountainous regions and south-facing slopes with dry vegetation have a higher risk potential.[76]

In addition to the extensive forest coverage, the Alps are also characterized by their unique biodiversity. However, the rise in temperature causes mountain plants to migrate to higher areas. The progressive course could lead to an enormous loss of botanical habitat especially in the Alpine zones.[77]

Agriculture: Weather, climate and the soil conditions have a major influence on agricultural productivity. Climate change can increasingly lead to fluctuating yields and temperature extremes to the deterioration of soil fertility through erosion.[78] With conventional tillage and moderate fertilizer use, the climate change impacts are expected to cause a decrease in the yield rate by -1.13 to -9%, with low fertilizer usage even to a reduction in the yield rate by -17.50 to -26%.[79] Due to an increase in extreme weather conditions such as heavy rain, hail or late frost, significant crop failures can be expected. Changes in the water regime and the increase in the likelihood of dry periods will pose a particular challenge in regions that are already under water stress (in particular the southern Alps and some inner-Alpine valleys). Another negative side effect are invasive species. The mentioned challenges apply in the first place to extensive agricultural areas in the Alpine foothills, but also mountain pastures will see changes.[80] Besides

[73] Müller (2020), p 16.
[74] Conedera et al. (2006), p 1.
[75] Müller (2020), p 11ff. Wastl et al. (2012), p 1.
[76] Wastl et al. (2012), p 1.
[77] BMU (2008), p 33.
[78] Beniston and Stoffel (2013), p 1135.
[79] Mitter et al. (2013), p 46f.
[80] Beniston and Stoffel (2013), p 1135.

> climate change soil sealing is a major issue for agriculture in the Alpine area. Climate change is therefore not the only challenge for agricultural production.[81]

3.3 Relevance of Spatial Planning

Spatial planning is of great importance for adaptation to climate change because climate change impacts have typically direct spatial effects and influence actual and future land uses. Numerous studies are available on climate change impacts[82] and a variety of studies addresses specifically the Alpine region[83]. Due to the limited permanent settlement area and the changing environmental conditions, it is necessary to manage the associated risks and to use technical and organisational measures as well as planning measures in order to achieve a long-term control and reduction of climate associated risks. Considering its preventive character and the influence it has on the spatial distribution and intensity of uses, **spatial planning is gaining an increasingly important role in climate change adaptation**. A fundamental measure widely debated at the moment is the reduction of land take in order to preserve as much soil as possible to deliver climate services and to prevent further environmental degradation. In addition, it is important to promote resource-saving spatial structures and to keep areas free of development for example for flood retention and multi-functional green spaces.[84] Flood management for itself is already a difficult coordinative task.[85] Securing retention areas brings up the question of compensation and justification for development restrictions through spatial planning.[86] And a grave yet very effective adaptation strategy spatial planning has an important role in are planned relocations.[87] Adaptation activities reach down to the plot level and include building design as well as planning open spaces.

Climate change impacts on permanent settlement areas and the living conditions vary regionally but have already changed significantly in the Alpine region. Depending on spatial characteristics specific challenges for urban development, agriculture, forestry, etc. arise. The Alpine region has a great territorial heterogeneity. The settlement structure of the Alpine region within the perimeter of the Alpine Convention currently has only six larger urban regions with more than 200.000 inhabitants (Klagenfurt-Villach, Innsbruck, Trient and Bozen, Grenoble, Annecy-Chambér). All larger urban centres are located on the edge of the Alpine arc but still within the EUSAP perimeter (Vienna, Munich, Milan, Zurich, Turin, Brescia, Maribor, Graz, Turin etc.). However, ribbon-shaped settlement and commercial structures with urban densification are forming in the main Alpine valleys such as the Tyrolean Inntal, Rhine Valley, or Rhone Valley.[88]

Based on existing studies and analyses[89], five spatial types were defined as the basis for the Strategy Development of the Alpine area as part of the 2013 Alpine Space Programme. The perimeter of this programme relates to the INTERREG area, but it also includes all relevant spatial structures for the Alpine region, from the mountainous core area to the surrounding foothills. The spatial types are based on functional interaction patterns such as demography and economy, as well as selected patterns such as tourism hotspots and are classified as space metropolises, Alpine cities, stable growing rural areas, declining rural areas, and tourism areas have been defined[90]. These spatial types are used in an adapted form regarding the topographical situation for

[81] BMNT (2017a), p 43f. Schweizerische Eidgenossenschaft (2020), p 38f. Government Liechtenstein (2018), p18.
[82] IPCC (2021), p 41f.
[83] Kruse and Pütz (2013), p 2621. Schmidt-Thomé and Greiving (2013), p 303ff.
[84] Bartol et al. (2022).
[85] Rauter et al. (2019).
[86] Löschner et al. (2019b).
[87] Schindelegger (2019). Weingraber and Schindelegger (2018). Schindelegger (2018). Schindelegger et al. (2021). Thaler et al. (2020).
[88] Tischler (2016), p 168.
[89] 3rd Report on the State of the Alps, REGALP-Project under the 5th EU Framework Programme, MARS-Project from Alpine Space Programme, and Alpine Space Prospective Study 2005.
[90] Alpine Space Programme (2013), p 53ff.

this study. The first two types can be categorized as urban areas and are therefore grouped into one category. The other three categories comprise rural types that differ in their socio-demographic and economic development. Instead of their population development and economic importance, the rural types are differentiated according to their location in the Alpine foothills or in inner-Alpine valleys:

- **Urban areas:** Such areas have at least 50.000 inhabitants in the functional urban area and a connection to high-speed transport networks. It is characterized by an extensive suburban area. Numerous such urban areas are either on the edge of the plains around the Alpine core area or in the Alpine valleys. They typically have all urban features and often valuable cultural heritage that make them attractive for city tourism. Examples of this type are the bigger cities in and near the Alps such as Lyon, Munich, Zurich, Ljubljana, or Turin. This type also comprises medium-sized cities like Bolzano, Innsbruck, St. Gallen, Constance, or Grenoble.
- **Rural Alpine foothills:** This type describes the rural areas around the core area of the Alps. These are mostly flat with large agricultural areas. The quality of the transport connections depends on the proximity to the cities. Examples of this spatial type are parts of the Allgäu, parts of Piemont or Auvergne-Rhône-Alpes.
- **Rural inner-Alpine valleys:** This type comprises rural areas located in the inner valleys of the Alps. Here narrow valley floors and steep slopes pose a significant hazard risk to the residential and economic development. This type includes well-developed valleys in terms of traffic infrastructure as well as economically less developed settlement areas. They are in general beyond commuting distance of main Alpine cities and depend on extensive yet vulnerable traffic infrastructure. This spatial type makes up the majority of the Alpine core area in all Alpine countries.
- **Tourism areas:** Tourism has a particularly strong impact on the local and regional economy in the Alps. It is often the main source of income and generates strong dependencies. Especially winter tourism is investment intensive and has severe environmental impacts. There are various destinations (winter sports and summer sports destinations, cultural destinations, etc.) in the Alps that compete on the international market for visitors. Typically, there are strong seasonal peaks and an inevitable dependency on revenue from tourism to sustain the local/regional economy and societies. Examples for this type would be well know tourism hot-spots such as: St. Moritz, Crans-Montana, Verbier or Ischgl.

For an overall analysis of the relevance of spatial planning for climate resilience, a differentiation is made by sectors and the above introduced spatial types. This should help displaying the heterogeneous perspectives on CCA and climate resilience according to the respective spatial type. This means that priorities and adaptation measures differ depending on the specific exposure. Climate impacts are likely to have a number of secondary effects on the different sectors. These vary depending on the topography, settlement density, etc. Depending on the spatial and functional characteristics of an area, different climate induced risks are likely to occur, which require specific adaptation activities in planning.

3.3.1 Agriculture

The overall rise in temperature and likelihood of drought both have negative impacts on agriculture, as they lead to a decline in production and, in the worst case, to crop failure. Increased drought stress might play a role here as well. On the one hand, this is a major threat to intensive farming in the lowlands, but also to mountain farming in the Alps. This will primarily be a challenge for semi-arid regions like the inner-Alpine valleys and the southern

Alpine parts. Changes in weather conditions can lead to a further impairment of agricultural yields.[91] From the climate change impacts mentioned, the greatest planning-relevant risks emerge as securing local and regional food supplies and the economic damage caused by the decline in production. In order to protect and maintain agricultural land, a significant reduction in soil sealing is required to preserve as much soil as possible with all its functions. Soil is an important carbon pool and therefore preserving it is crucial, because only healthy soils can store carbon. A low level of soil sealing is essential for climate protection, but it also fosters climate resilience by increasing coping capacities.

Adaptive capacities of spatial planning for different types are the following:

- **Urban areas:** In order to preserve the agricultural production areas in the surrounding area of the major cities, the undeveloped and agriculturally productive areas must be protected. Clear restrictions for urban sprawl through spatial planning while fostering urban densification and brown field development are important here.
- **Rural Alpine foothills:** These areas see extensive agricultural usage while having typically a substantial population growth. Urban development conflicts with agricultural usage leading to loss of agricultural land and soil sealing. As spatial planning cannot hardly influence the form of cultivation, the focus lies primarily on qualitative and quantitative soil protection and integrate climate services in decision making processes (cold air emergence, fresh air corridors, biodiversity, flood retention).
- **Rural inner-Alpine valleys:** Qualitative and quantitative soil protection on a smaller scale is the focus in such areas as well. But typically, with the need to take the qualities of u cultural landscapes into account.
- **Tourism areas:** Tourism areas depend economically hardly on agriculture but strongly on the quality of cultural landscapes. Here preservation of open agricultural land and a cultivation and management sensitive to climate change is important. For spatial planning this means in the first-place quantitative soil protection.

3.3.2 Forestry

For spatial planning, forests primarily represent a protection infrastructure – a so-called nature-based solution. Climate change leads to wide ranging changes in natural processes within the forest and to an increased threat of fungal and beetle infestation. This weakens the resistance, which can lead to failure or complete loss of forest functions in the event of disruptions such as storms, forest fires or heavy snow loads. A major planning-relevant risk is the **loss of the protective function** for entire locations and individual objects. Forests act as natural protection structures against rockfalls and slop instability. Forests help also with local water infiltration. In addition to its protection function, forests play an important role in cold air emergence. In future, the effects of forest fires will particularly affect urban areas that border directly on forest and open land (so-called Wildland-Urban-Interface). Due to the increased desire for more proximity to nature and the settlement pressure, urban development is particularly expanding towards forest areas. Critical infrastructure and technical facilities built near or in the forest may also experience a higher risk of destruction.[92]

Adaptive capacities of spatial planning for different types are the following:

- **Urban areas:** The protection of forest areas and thus the maintenance of its climate services is relevant for all spatial types. For urban areas, forests are primarily important for cold air production. In order to enforce climate resilience planning has to ensure that areas for cold air emergence, as well as fresh air

[91] Gobiet et al. (2014), p. 1146. Beniston and Stoffel (2013), p 1135.
[92] Müller (2020), p 13, 16, 43. Beniston and Stoffel (2013), p 1134.

corridors are protected and sustained. Numerous urban climate analyses provide relevant information for this.

- **Rural Alpine foothills:** For this spatial type, forest also provides central climate services as cold air production areas for densely build up areas. The forest areas should be preserved through planning measures and kept free from infrastructure and urban development.
- **Rural inner-Alpine valleys:** In particular, forest areas are to be preserved where they serve as protection against natural hazards. A diversification of the forests is also sought to increase resilience, but this can hardly be influenced by planning.
- **Tourism areas:** The main adjustment service in spatial planning is the preservation and securing of the forests as a protective infrastructure. Exposed winter tourism areas are already exposed to possible avalanches and are in need the protective function of forests.

3.3.3 Water Management

The flood situation in the Alps and in the foothills of the Alps has exacerbated over the past decades due to the complex interplay of human activities and climate change impacts. This results in increasing flood risk in both rural and urban areas.[93] Changes in precipitation regimes result in the loss of soil moisture and a reduction in groundwater levels, which can increase vulnerability to severe hydrological droughts. This represents a risk for the security of the water supply in terms of quality and quantity for the Alpine region in general. Probably the higher mountain domains will be less affected (e.g. the upper part of the Rhone catchment) than lower elevations downstream (e.g. Po Valley).[94] Besides agriculture, hydropower will be affected by changes in the water regime leading to seasonal shifts in electricity production and an overall decrease of effectivity of large run-of-river power stations.[95] It is generally expected that the generation of electricity from hydropower plants will decline. In Germany, a decrease of 1-4% in electricity generation by hydropower plants is assumed by 2050, in the further future of up to 15%.[96] In Austria, national annual production from hydropower is expected to decrease by 6-15% by the end of the century.[97]

The above-mentioned risks related to drought, drinking water supply and electricity production should be considered in all planning decisions. Primarily, spatial planning can help to keep areas free of development for flood protecting, flood retention and drainage zones, as well as ecological services. This serves to protect build-up areas from floods by securing and recovering natural flood plains and water retention areas.

Adaptive capacities of spatial planning for different types are the following:

- **Urban areas:** Large-scale retention is hardly possible in urban areas. Therefore, micro-scale measures such as green spaces for infiltration, water storage and on-site retention are essential. Green spaces also serve for drainage and provide short-term retention in order to avoid pluvial floods. The drainage routes for surface water must be taken into account in urban planning. As well as local retention areas and the adaptation of the wastewater infrastructure.
- **Rural Alpine foothills:** In the flat parts of the Alpine foothills, retention and drainage areas need to be identified and kept free of development and natural floodplains can be restored. This has to be coordinated of course regionally. On the local level pluvial flooding is a growing challenge. Here, drainage routes need to be taken into account in urban development. The overall changes in the water

[93] Gobiet et al. (2014), p 1149.
[94] Beniston and Stoffel (2013), p 1134. Gobiet et al. (2014), p. 1146.
[95] Gaudard et al. (2013), p 1211. Gobiet et al. (2014), p. 1146f.
[96] Umweltbundesamt (2012), p 41.
[97] APCC (2014), p 815.

regime can be hardly influenced through planning but drinking water supply and safeguarding groundwater resources are especially important in the rural Alpine foothills that also see extensive agriculture.

- **Rural inner-Alpine valleys:** For valleys with limited permanent settlement space, pluvial as well as fluvial floods pose a relevant threat. The adaptation service of spatial planning is primarily to keep retention and flood runoff areas free of development. In addition, spatial planning has especially on the local level the possibilities to control the damage potential in flood prone areas. With the shifts in precipitation pluvial flooding is gaining momentum in the discussion and has to be mainstreamed in planning legislation and practice still.
- **Tourism areas:** The adaptation services for this spatial type are similar to those above.

3.3.4 Construction and Housing

For settlement structures climate change impacts bring numerous challenges. In densely built-up areas heat stress is an essential issue while pluvial flooding has to be considered increasingly. This not only due to more frequent heavy rain events but also due to soil sealing and the lack of infiltration.[98] The change of the likelihood of extreme weather events contributes to an overall risk increase in built-up areas. Even very rare precipitation events that occur statistically only once every 100 years so far, are expected to accumulate.[99] Shifts in precipitation will contribute to the short-term increase the snow loads in winter.

Adaptive capacities of spatial planning for different types are the following:

- **Urban areas:** Spatial planning, amongst other sectoral domains, plays an important role in identifying UHI, developing adaptation measures, and implementing them via urban planning instruments. To improve the micro and meso climate, extensive green and blue infrastructure is essential, especially in densely built-up areas. Continuous unsealing of public and private areas will be necessary for this. Green spaces in settlement areas with effective shading are also to be applied. Improving the quality of open spaces to foster climate resilience should be a fundamental principle in urban planning. As a strategic objective, this should also be taken into account in spatial development strategies. At the building level, greening, increasing the reflection of roofs and the use of cool building materials can reduce the urban heat stress and improve the microclimate. Some of these measures are already being implemented in public buildings and open spaces. Concrete framework conditions such as determinations of bio-climatically effective measures in development plans are also to be cited as an adaptation service for private buildings. Financial funding for adaptation services for new buildings and renovations can also contribute. At the supra-local level, the connection of green spaces, the definition of cold air generation areas and fresh air corridors are relevant. Pluvial flooding is an increasing challenge all over the Alpine region. A well-designed rainwater management in combination with adapting the existing building stock and a hazard sensitive design of new development is crucial here.
- **Rural Alpine foothills:** The aforementioned aspects also apply to this spatial type. Of course, UHI are less common here, but any densely built-up areas can suffer from heat stress. Adaptation of the existing building stock and hazard sensitive designs are relevant here as well.
- **Rural inner-Alpine valleys:** The aspects relating to the climatological improvement of densely built-up areas (open spaces planning and structural measures on buildings) must also be taken into account here as well. To protect against natural hazards and to reduce damage to buildings, stronger individual

[98] Gobiet et al. (2014), p 1149.
[99] ebd, p 1147.

measures to protect property, either permanently or temporarily, can be encouraged and demanded. If there are already developed areas in endangered areas, these should be defined as redevelopment areas. Areas at high risk can also be relocated. However, the levee effect should be avoided. This means that after technical protective measures have been implemented, further settlement activities will take place in the protected area. That would again drastically increase the damage potential and therefore the risk. This also means that settlement areas should be designated depending on the protective infrastructure.

- **Tourism areas:** The aforementioned measures in the other spatial types are relevant here as well.

3.3.5 Other Sectors

It would be possible to continue a detailed for other sectors as well. Such an approach is widely used in NAS also addressing the following sectors: ecosystem and biodiversity, tourism, transport infrastructure, energy, health, and business/industry/trade. Because these sectors can hardly be addressed by spatial planning measures, they are not described in more detail. Nevertheless, climate change impacts desire adaptation actions in these sectors as well. For example, climate change must be considered in regional and national tourism strategies to promote a climate sensitive and sustainable tourism and changes in the environmental conditions urge us to rethink nature conservation approaches and pro-actively designate areas for the climate services they deliver. This list could be continued of course but spatial planning has with its strategies and binding instruments only a minor role to play.

3.3.6 Conclusion

In the Alpine region municipalities and regions have to coordinate land uses already on limited available land areas. Besides vast urban development, climate change contributes to increasing hazard exposure. This does not only encompass natural hazards but also changes in the water regime that can pose manifold challenges e.g. for agricultural production, drinking water supply or electricity production. Research clearly shows that the Alpine region is affected by climate change more severely than other European regions. This entails the necessity to act, also through spatial planning. Action on all levels is necessary to meet adapt to the observed and expected environmental changes. The national level ideally provides a clear direction with consistent objectives and goals (e.g. quantitative goal for soil protection). The regional and local planning levels are all over the Alps the executing planning levels with various planning instruments at hand to foster adaptation action. The main adaptation services and considerations that spatial planning can safeguard:

- **Adaptation goals and objectives on all levels:** Spatial planning typically operates within a setting that has to justify decisions on basis of overall goal and objectives. Therefore, it is essential that specific and measurable climate adaptation and resilience goals and objectives are defined on all planning levels.[100]
- **Integrate dependencies:** An essential dimension of CCA action through planning is the establishment of a common understanding of (sectoral) dependencies that enable development. Planning decisions have to integrate climate services delivered through all kind of natural areas and cultivated land. Most importantly the protection that is provided by forests in the Alpine region.
- **Keeping areas free of development:** While spatial planning controls urban development it has consequently the ability to keep areas free of development. The reasons for restricting development can be manifold (food security, soil protection, flood retention, cold air emergence, etc.) but have to

[100] see e.g. Kruse and Pütz (2013). Gruber et al. (2018).

follow a clear purpose. Connectivity of habitats and biodiversity play a crucial role here as well.[101] Such measures are likely to be embedded in regional planning instruments.

- **Control urban development and building design:** Spatial planning is the essential sector to guide urban development and control the design of districts and even buildings. This means planning on the local level can foster densification, establishment of green and blue infrastructure, establish green networks, etc. All these measures are well-known as good planning practice, but contribute in the light of climate change also to CCA.

Given the same climate signals, not all areas in the Alpine region are affected to the same extent by climate change. Most climate change impacts apply to all areas to a certain extent, but some are more affected than others. A certain prioritisation of the adaptation actions required is not only possible but rather necessary. The adaptive capacity of spatial planning is limited in some sectors, although the effects of climate change in the Alps have major impacts on this. Spatial planning plays an important role in adapting to climate change because of its strategic and long-term approach and ability to coordinate policy fields.[102]

For the introduced spatial types, the following tendencies should be taken into account for a climate-sensitive and sustainable development that contributes to an overall resilient development:

- **Urban areas** are in particular prone to climate change impacts. Heat stress is not only a topic in urban areas on south of the Alpine arc but instead for many inner-Alpine cities as well already. The high degree of soil sealing in urban areas contributes to heat stress and aggravates pluvial flood risk. Urban areas are therefore key target areas for adaptation through spatial planning strategies and measures. This entails the establishment of sufficient green and blue infrastructure, a sustainable land management to access land for measures and overall, the re-design of public spaces.
- **Rural areas** receive a lot of urban sprawl and are at the same time the agricultural backbone in the Alpine region. Soil and nature protection in coordination with required climate services is imperative to ensure regional food supply, habitat connectivity and sustained biodiversity. While people living in this spatial type are not severely suffering from climate change impacts, these areas provide many climate services needed for effective adaptation.
- **Rural inner-Alpine valleys** are the predominant spatial type in Alpine core areas. They hold important traffic infrastructure and businesses while they experience a wide-ranging hazard exposure (e.g. floods, mudflow, avalanches and rock falls). Inner-Alpine valleys are key areas for hazard and climate risk management and need to protect forests effectively and alleviate hazard intensities (e.g. flood retention measures). Urban development needs not to be only sensitive to the existing hazard exposure but has to integrate expected climate change induced changes as well.
- **Tourism areas** in the Alps are versatile but all have a strong dependency on a single economic pillar. Especially winter tourism areas are already seeing many changes and seek at the moment to adapt through technical innovation (snow cannons, snowing ponds). In the long run an economic transformation and diversification is necessary in which spatial planning plays a certain role.[103]

[101] Ramel et al. (2020). Soboll and Dingeldey (2011).
[102] Kruse and Pütz (2013), p 2621.
[103] Bonzanigo et al. (2016). Pröbstl-Haider et al. (2015).

- **All spatial types:**
  - **Quantitative and qualitative soil protection** through planning is an essential low-regret measure (meaning it serves several purposes). In particular the preservation of forests and agricultural land is crucial for establishing climate resilient development. Keeping areas undeveloped for various reasons is imperative for effective CCA.
  - **Building design:** Addressing building and urban design on the plot level is a promising pathway in all spatial types to adapt to climate change impacts. This comprises especially the greening of buildings (roofs, facades), keeping areas unsealed for water infiltration or the positioning of buildings in a manner that allows air circulation. Building design also tackles the regionally important aspect of snow loads that needs a revision of technical standards.

4 Status Quo – Climate Resilience and Planning

While the previous chapter identified the necessary mobilisation of adaptive capacities through spatial planning, this chapter looks into the status quo operationalisation of climate resilience in spatial planning. So far climate impacts and overall adaptation needs were identified. This raises the question how these adaptation needs can be addressed through planning instruments and what the adequate actions are.[104] Of course, **every country has a unique planning system,** and it **is only possible to abstract the discussion** in such an overview. Table 1 provides an idealized synopsis of instruments and climate change adaptation actions on different administrative (and legislative) levels in spatial planning. It is neither complete nor fully applicable for every EUSALP member state (e.g. Slovenia has no regional planning level) but outlines the overall direction the concrete effects of planning instruments for adaptation can have.

LEVEL	INSTRUMENT	ACTION and IMPACT
National	Development concepts	- adaptation **priorities, objectives, and principles** for subordinate planning levels
Regional	Development concepts/programmes	- strategic development of **green and blue infrastructure** (e.g. green corridors) - **limit land take** and **soil sealing** through e.g. settlement boundaries
	Sectoral concepts/programmes	- consolidation of overall **development orientation from a sectoral perspective** with a specific (climate) focus (e.g. flood sensitive development)
Local (scale < 1:10,000)	Development concept(s)	- **specific adaptation action** on the local level and definition of development priorities - strategic development of **green and blue infrastructure** - **identify and assign climate services** to certain areas (protective function, flood retention, etc.)
	Land use plan	- **risk sensitive zoning** to avoid development in hazard exposed areas (e.g. flood areas) - **zoning for specific purposes**: flood retention, cold air emergence, heat management, etc. and keep it free of development
	Detailed development plan	- building arrangement for **cold air circulation, cooling** etc. - adapted **building design** (esp. green roofs and facades) - defining **green spaces** on plot level - on-site **water retention and infiltration**

Table 1: Adaptation action through planning instruments[105]

As outlined above planning documents that cover the whole national territories can hardly demarcate specific adaptation actions in plans. Nevertheless, the **national level** is often essential for any further action as it can **set the priorities, objectives and principles for subordinate planning levels** and the overall coordination within administration. In addition to existing national adaptation strategies and plans, it is possible to further specify the contribution to climate change adaptation.

The **regional planning level** typically provides **adaptation actions that need an inter-municipal** (or trans-**national) perspective**.[106] As actual land use and development planning is typically assigned to the local level,

[104] For a similar evaluation of the status quo see: Kruse and Pütz (2013).
[105] Gruber et al. (2018).
[106] Rannow et al. (2010).

regional plans coordinate the overall spatial development and provide stipulations for municipalities. Therefore, regional concepts/programmes can limit land take and soil sealing through clear limits for urban development and strategically develop green and blue infrastructure to receive adaptation services. This could be especially green corridors for ecological connectivity, biodiversity, cold air emergence, and fresh air corridors as well as blue infrastructure for pluvial flood management and water infiltration.

The **broadest set of adaptation measures** through planning instruments is possible **on the local level**. Typically, municipalities can steer urban development, land usage and building development through a set of instruments and are at the same time in charge of public space design. This makes municipalities clearly the main actors. Besides defining priorities for climate change adaptation, fostering green and blue infrastructure, they are the ones who can keep areas free of any development or allow only a risk sensitive development that is in line with the identified needs and purposes. On the plot level, municipalities can steer the building design (in line with the legal authorization) and building arrangement.

Overall, spatial planning instruments are meant to coordinate spatial development on the whole and can especially keep areas free of any development to safeguard specific climate services and manage hazard risks. Additionally, it is possible on the local level to steer the building development in a manner that takes natural hazards and observed dynamics in general into account to adapt via a resilient design.

4.1 Research

Climate change adaptation and mitigation have been in the focus of many Alpine based research projects – transnational, national or even regional – over the years. Some explicitly target the spatial dimension of efforts to reduce CO_2 emissions and adapt to changing environmental conditions. The following overview presents essential projects that cover all/several Alpine countries and highlights some national projects that tackle in particular the integration of climate adaptation in spatial planning as well as the resilience approach.

In course of the project an **analytical framework on the integration of climate change adaptation in spatial planning** was drafted. It is generally based on a framework developed for assessing 'climate proofing' of planning instruments[107] that was simplified for this application. The framework displayed in Figure 8 is divided into three main components. The first one **[1] represents the overarching strategies and legal norms**; the second one **[2] differentiates the capacities and competencies** required for effective adaptation in spatial planning; the third and last one **[3] outlines an idealized planning process with regard to adaptation** and presents the levels with the respective planning instruments. Changing environmental conditions, adaptation measures and monitoring/evaluation are integrated in this component as well. This framework is used for many processing steps throughout the CLISP-ALP project. It is the basis for the expert interviews and their analysis, as well as the selection and presentation of relevant projects in the field.

[107] Schindelegger et al. (2021).

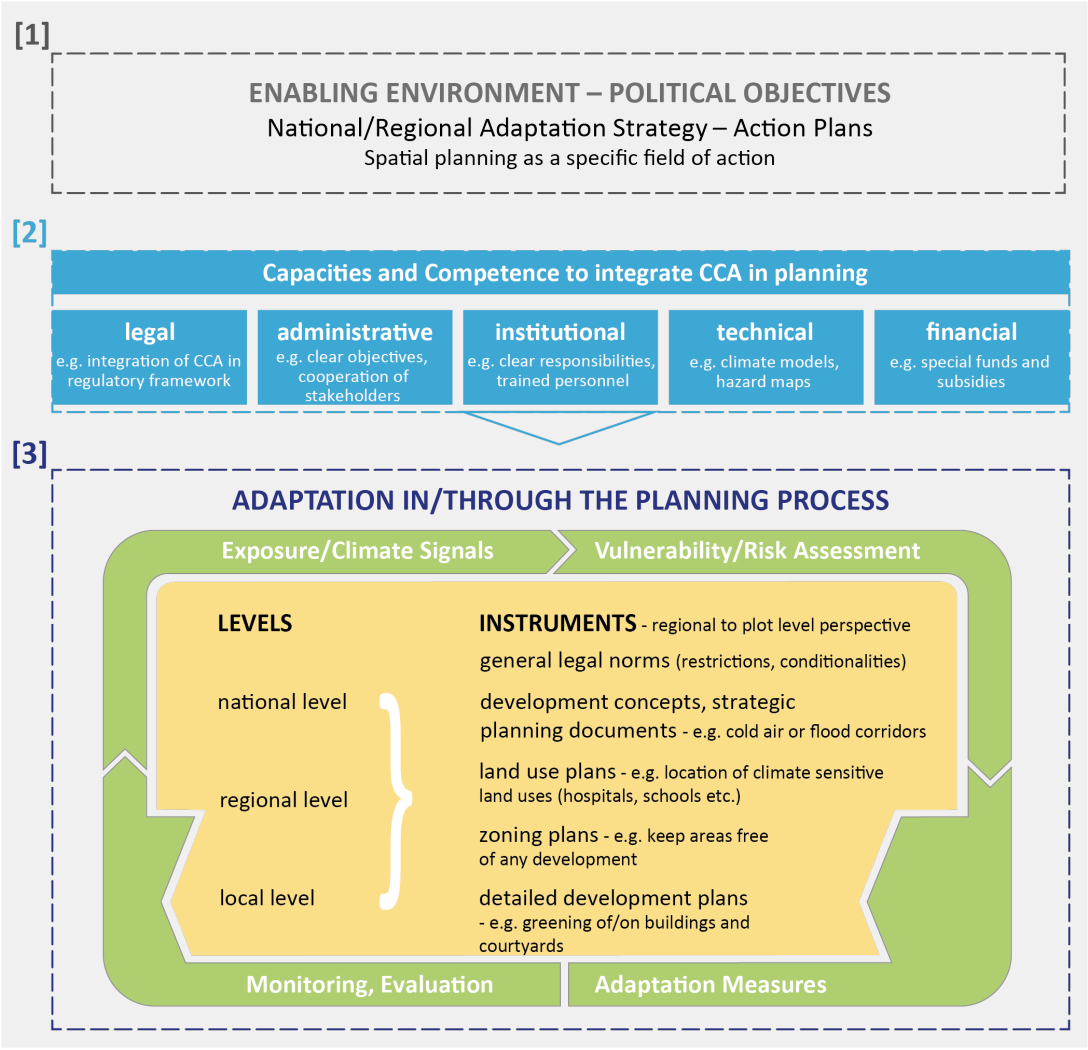


Figure 8: Analysis framework for integration of climate change adaptation in spatial planning

The following criteria were used for the selection of the international projects, which get presented and assessed in detail in chapter 4.1.1:

- Projects conducted after the year 2000 as before the new millennium, hardly any relevant projects on climate change adaptation in spatial planning were carried out with reference to the Alpine region.
- Projects carried out within the framework of the **European research programmes** INTERREG (Alpine Space and Central Europe), Horizon 2020 and ESPON and with **clear reference to the Alpine region**.
- Projects that focus on spatial planning and relate to one or more components in the framework presented above. Two **criteria** are particularly relevant:
    - projects that address capacities and competencies that allow informed decision making;
    - projects that tackle planning processes and planning fundamentals (climate signals, adaptation measures to tackle climate change in planning, etc.).

The chosen projects are briefly described, and the general specifications (project duration, funding, consortium) are presented through a project profile. The overall objective/research question is highlighted including the scientific added value and applied methodology. The single profiles conclude with references to outcomes and publications. Following this general description, the projects are assessed with regard to their relevance for climate adaptation and resilience in spatial planning based on the introduced framework. A systematic approach is applied in which the relevant outcomes for the three main components **[1] contribution to the provision of**

adaptation strategies for planning at a strategic level, [2] capacities and competences as well as **[3] planning process** are listed. The assessment criteria in more detail:

(1) First the assessment looks into the projects' approach to support overall political objectives and the enhancement of the enabling environment for further adaptation action in planning. In detail, if the project evaluates such objectives or contributes to their formulation.

(2) Any implementation of adaptation action through planning instruments relies on sufficient capacities and competences within administration (or non-governmental bodies). Therefore, the assessment takes a look into five essential dimensions of capacities and competencies (legal, administrative institutional, technical and financial) and whether they are addressed through the project.

(3) As a third component the assessment identifies, if the integration of climate change adaptation in planning processes gets addressed: in detail, if changing exposure or vulnerability/risk due to climate change impacts is a research subject, if climate change adaptation measures in actual planning instruments are relevant or if monitoring and evaluation schemes to keep track of effectiveness of actual measures is a focus. Here, governance questions are integrated in the overview.

4.1.1 International Research Projects

Around 20 years ago, the first major European projects started assessing climate signals and climate change impacts in the Alpine region and their connection to spatial planning and urban development. Such projects were mainly conducted within well-known research programmes such as INTERREG – here of course the Alpine Space programme –, Horizon2020 and ESPON. These European research programmes aim to build a knowledge- and innovation-based society and a competitive economy while contributing to sustainable development. They also contribute to the implementation of the political guidelines of the European Commission.

INTERREG is the largest project funding programme for European investment and structural policy. The research programme significantly promotes interstate cooperation on spatial development – also in the Alps, one of six cooperation areas. Other transnational INTERREG programmes also overlap with the Alpine region and deliver relevant results for sub-areas such as urban areas. Particular relevance for the Alpine area is the INTERREG programme **Alpine Space**[108]. It was established in 2000 and co-finances and supports cooperation projects across the borders of seven Alpine countries. The cooperation area was expanded in the 2021-2027 funding period compared to the previous period and now includes all of Bavaria and Baden-Württemberg in Germany. Through the cooperation of key actors from science and administration, from business and innovation sectors as well as political decision-makers, joint solutions for the challenges in the Alpine region should be developed. Another INTERREG programme that at least partially covers the Alpine region is **Central Europe**[109]. The project perimeter covers Austria, Slovenia and partly Germany and Italy. The overarching object is to improve the capacities for regional development, including the areas of carbon dioxide reduction and the protection of natural resources.

Horizon 2020[110] was a funding programme running from 2014-2020 and is the follow-up programme to the 7th EU Research Framework Programme. The basic elements of HORIZON 2020 are excellent science, industrial leadership, and societal

[108] Online: https://www.alpine-space.eu, 17.05.2022.
[109] Online: https://www.interreg-central.eu, 17.05.2022.
[110] Online: https://ec.europa.eu/programmes/horizon2020/en/h2020-sections-projects, 17.05.2022.

challenges. The latter also includes climate change mitigation, the environment and resource efficiency.

ESPON[111] (European Spatial Observation Network) is a network programme co-financed by the European Regional Development Fund (ERDF). It aims to strengthen the perspective of the "European Territorial Dimension" by providing spatial information, knowledge transfer and mutual exchange. It exists since 2002 and deals with the ongoing spatial observation of the European area by "Transnational Project Groups (TPG)".

The following overview and brief assessment of the selected research projects should provide an insight into the status quo of relevant research in the field of.

[111] Online: *https://www.espon.eu*, 17.05.2022.

ClimChAlp – Climate Change, Impacts and Adaptation Strategies in the Alpine Space[112]

General specifications:

- Duration: 03/2006 – 04/2008
- Funding: ClimChAlp was a transnational project within the EU programme Interreg IIIB Alpine Space 2000-2006. It was allocated in Programme Priority 3, Measure 3 – "Cooperation in the field of natural hazards."
- Consortium: The project partners were 22 administration authorities and research institutes from all countries in the Alpine region. Lead partner of the project was the Bavarian State Ministry of the Environment, Public Health and Consumer Protection.

Objective/research focus: climate signals and climate change impacts in the Alpine region; the main project goal is to develop transnational adaptation strategies and measures in the areas of natural hazards, risk prevention, spatial development, and economics; results were meant to support decision makers concerning the protection from natural disasters linked to climate change impacts.

Scientific field/methodology: The project is primarily rooted in natural sciences with climate data analysis, projections, and simulations. Quantitative results were complemented by expert interviews and stakeholder workshops.

Results/products: As a result of the project, a common strategic paper with recommendations for adaptation to climate change elaborated in the different work packages was published[113]. Specific recommendations and the overall results of the project have been summarised in an Extended Scientific Final Report.[114]

Relevance for the integration of climate change adaptation in spatial planning

[1] Contribution to the provision of adaptation strategies for planning at a strategic level: Based on an evaluation of the effectiveness of current strategies and instruments of spatial planning and the economic sectors, various proposals for adaptation services through spatial planning, tourism, forestry and agriculture within the model regions as well as the entire Alpine region are developed. The project thus provides reliable information for the formulation of adaptation strategies and the setting of priorities.

[2] Capacities and competences: In the ClimChAlp project, essential information on climate change, future hazard potential and hazard monitoring is compiled. This primarily contributes to increasing the technical capacities. The development of the 'Flexible Response Network' contributes to the administrative capacity by comparing and adapting strategies across countries. In this way, the available knowledge and experience in the Alpine region should be used efficiently.

[3] Planning process: The project primarily examines the question of exposure as a prerequisite for planning decisions. Subsequently, recommendations for dealing with the consequences of climate change are formulated with regards to spatial planning.

[112] Online: https://www.alpine-space.org/2000-2006/temp-results1153a6e.html?&L=yobycrvtmtp, 17.05.2022.
[113] ClimChAlp Partnership (2008a)
[114] ClimChAlp Partnership (2008b)

CLISP – Climate Change Adaptation by Spatial Planning in the Alpine Space[115]

General specifications:

- Duration: 09/2008 – 09/2011
- Funding: Funding authority was the Alpine Space Programme under the European Territorial Cooperation 2007-2013
- Consortium: The partners were 14 planning authorities such as federal ministries, departments for state, regional and municipality development from Austria, Germany, Italy, Slovenia, Switzerland, and Liechtenstein. The lead partner in this transnational project was the Environment Agency Austria.

Objective/research focus: The aim of the project CLISP was to outline "climate-safe" spatial planning, and thus to contribute to sustainable territorial development in the Alpine region. At the same time the project aimed to strengthen the awareness of political decision-makers, planning and other public authorities as well as the general public in the Alpine region for the challenges triggered or intensified by climate change.

Scientific field/methodology: The theoretical basis of the project is an overview of the general architecture of the spatial planning systems of the Alpine countries. In the empirical part, vulnerability analyses and the assessment of the "climate change fitness" of the current spatial planning systems in model regions with a standardized survey were carried out.

Results/products: The project delivered comprehensive publications such as a guide and checklist for planners to assess the adaptive capacity of spatial planning instruments, a "vulnerability analysis" and an assessment of the "climate change fitness" of current spatial planning systems in 10 model regions. For each model region a vulnerability map was created. Based on the results from risk dialogues with local stakeholders, guidelines for risk governance in spatial planning were developed.

CLISP is in fact the most comprehensive international research project that tackles the intersection of CCA and spatial planning in the Alpine region. The project is still a milestone and has unfortunately not seen a continuation or update yet.

Relevance for the integration of climate change adaptation in spatial planning

[1] Contribution to the provision of adaptation strategies for planning at a strategic level: The project explicitly addresses planning processes on a comprehensive strategic level as one of the few international research projects during the last decades. The main focus though, is on the other two aspects.

[2] Capacities and competences: This part is one of the essential contributions of the CLISP project. All capacity dimensions, except the financial side, are assessed and diverse recommendations developed to strengthen them.

[3] Planning process: Climate vulnerabilities and risks are examined in the project and processed as a basis for planning decisions. The connection of adaptation measures to planning instruments is worked out in detail. Monitoring/evaluation of measures is not addressed as it is rather an exploratory project.

[115] Online: *https://www.alpine-space.org/2007-2013/2007-2013/projects/projects/detail/CLISP/show/index.html* 17.05.2022

ADAPTALP – Adaptation to Climate Change in the Alpine Space[116]

General specifications:

- Duration: 12/2008 – 08/2011
- Funding: Alpine Space Programme under the European Territorial Cooperation 2007-2013
- Consortium: The 16 partners were ministries, federal states and research centres from Germany, Austria, Italy, Slovenia, France, and Switzerland. The lead partner was the Bavarian State Ministry of the Environment and Consumer Protection.

Objective/research focus: The overall aim is to generate know-how, products and recommendations for natural hazard and disaster management in order to increase coordinated management in the Alpine Space.

Scientific field/methodology: The project is primarily rooted in natural sciences with climate data analysis, projections and simulations as well as hazard mapping. Quantitative results were complemented by expert interviews, network initiatives and stakeholder workshops in pilot regions.

Results/products: The results of the project are a common strategy paper that provides information on the strategies and examples of good practice for managing natural hazards taking climate change into account. The added value is also the harmonization of approaches and the development of tools to improve the mapping of vulnerable areas.

Relevance for the integration of climate change adaptation in spatial planning

[1] Contribution to the provision of adaptation strategies for planning at a strategic level: AdaptAlp aims to harmonise the different national approaches in dealing with climate change in the Alpine region from a transnational level down to the local level. The results should help countries to better understand natural hazards and their climate change induced dynamics and to integrate them into their NAS in a standardised manner.

[2] Capacities and competences: The project looks in particular into technical competences with regard to data provision and administrative competences through networking initiatives.

[3] Planning process: The project provides the basis for integrating climate chane exposure, vulnerability, and risk into planning decisions. Above all, methods of risk assessment, hazard mapping and risk management are examined. Planning instruments are only dealt with to a minor extent with regard to risk dialogue. The monitoring of measures is not addressed.

[116] Online: https://www.alpine-space.org/2007-2013/2007-2013/projects/projects/detail/AdaptAlp/show/index.html, 17.05.2022.

C3-ALPS – Capitalising climate change knowledge for adaptation in the Alpine space[117]

General specifications:

- Duration: 01/2012 – 12/2014
- Funding: Alpine Space Programme under the European Territorial Cooperation 2007-2013
- Consortium: A transnational consortium of 17 partners from all Alpine countries conducts the initiative. The lead partner of the project was the Environment Agency Austria. The partnership combines authorities responsible for climate adaptation policies on national and regional levels and expert institutions that support national and European adaptation strategies.

Objective/research focus: C3-Alps seeks to harmonise the available theoretical knowledge from previous projects and initiatives on climate adaptation and its application in practice. In addition, integrated knowledge is generated by considering the topic across sectors and developing cross-sectoral adaptation strategies. The main objective of C3-Alps is the transfer of knowledge gained within relevant projects on climate change to the stakeholders and decision makers on regional and municipal level.

Scientific field/methodology: The project analyses ex post the strengths and weaknesses of existing projects and their impact on the political process of climate change adaptation in the Alpine countries. An empirical implementation in pilot regions follows the analysis of the results of previous Alpine Space projects.

Results/products: The key products are harmonised knowledge on climate change adaptation in the Alps and a web platform with a master plan for continued operation. Guidelines on communication strategies, manuals on passing knowledge as well as communication of adaptation issues are drawn up as well. For municipalities adaptation packages are developed. The project found that legally binding adaptation measures in spatial planning are a clear limiting factor in the projects examined.

Relevance for integration of climate change adaptation in spatial planning

[1] Contribution to the provision of adaptation strategies for planning at a strategic level: C3-Alps supports bottom-up adaptation measures in Alpine regions and municipalities, contributes to the implementation of national adaptation strategies and disseminates Alpine adaptation capital.

[2] Capacities/competences: By combining available theoretical knowledge on the subject of climate adaptation and implementation in practice, the project primarily contributes to building institutional capacities.

[3] Planning process: The knowledge about exposure, vulnerability and risk in previous projects and initiatives is collected as well as Alpine adaptation capacities. Planning instruments are addressed in connection with implementation competences and extended knowledge at regional and local level. There is no focus on the monitoring/evaluation of measures.

[117] Online: https://www.alpine-space.org/2007-2013/2007-2013/projects/projects/detail/C3-Alps/show/index.html, 17.05.2022.

ALPBIONET2030 – Integrative Alpine wildlife and habitat management for the next generation[118]

General specifications:

- Duration: 11/2016 – 12/2019
- Funding: Alpine Space Programme under the European Territorial Cooperation 2014-2020
- Consortium: The project consortium combines participants from six Alpine countries (Austria, France, Germany, Italy, Slovenia, and Switzerland) and from different levels: protected areas, research institutions, administrative level, private sector business and NGOs. Lead Partner was ALPARC – Alpine Network of Protected Areas, France.

Objective/research focus: The main objective is to enhance transnational cooperation in the field of nature conservation while providing a unified concept for preservation of natural habitats and mutual planning tools to achieve a high level of ecological connectivity for the conservation of biological diversity.

Scientific field/methodology: The project combines scientific analysis with GIS–based spatial analysis. In pilot working regions, human-nature conflicts are examined and strategies for conflict resolution tested.

Results/products: The main result of the project is the method developed for the Alpine-wide analysis of open spaces. Besides standard project publications, the ALPBIONET2030 Atlas[119] with a spatial analysis and perspectives of ecological connectivity in the wider Alpine areas was developed. To raise awareness among the general public a comic book for kids and adults on human-nature conflicts during holidays in the Alps (in English, French, Italian, German) and a game about ecological connectivity were published.

Relevance for the integration of climate change adaptation in spatial planning

(1) Contribution to the provision of adaptation strategies for planning at a strategic level: The project does not address the overall strategic level for CCA in spatial planning. The project results though are an important basis to inform especially trans-national CCA objectives and cooperation.

(2) Capacities and competences: The project contributes to strengthening the technical and institutional capacities in particular by producing maps as a basis for decision-making and supporting transnational cooperation in planning.

(3) Planning process: Exposure, vulnerability and risk were only partially assessed in relation to climate change impacts on the topics of ecological connectivity and green infrastructure. The focus of the project is less on planning instruments, but provides essential foundations, especially for transnational cooperation in planning. Monitoring/evaluation of measures and adaptation strategy is not a focus of the project.

[118] Online: *https://www.alpine-space.org/projects/alpbionet2030/en/home*, 17.05.2022.
[119] Joint Ecological Continuum Analysing and Mapping Initiative online via: *https://www.jecami.eu/*, 17.05.2022.

LOS_DAMA! Landscape and Open Space Development in Alpine Metropolitan Areas[120]

General specifications:

- Duration: 11/2016 – 12/2019
- Funding: Alpine Space Programme under the European Territorial Cooperation 2014-2020
- Consortium: The ten partners were administrative units of cities, research institutes and universities from Austria, France, Germany, Italy, and Slovenia. Lead partner was the city of Munich.

Objective/research focus: The project deals with urban green and landscape areas concerning conflicts between settlement development, local recreation, traffic, nature conservation, agriculture and forestry and other uses. The research focus is on the questions of how to protect and develop such areas and meet at the same time social requirements and to actively involve the population.

Scientific field/methodology: An evaluation framework is developed as a basis for the scientific analysis for the upgrading of peri-urban green infrastructure. Using an exploratory approach, transferrable methods and tools were tested.

Results/products: The project outcome provides planning support in the form of reports, policy recommendations and a toolbox aimed at inspiring and supporting cities and city-regions. Another project result is the establishment of the Alpine City Network and practitioner network.

Relevance for the integration of climate change adaptation in spatial planning

[1] Contribution to the provision of adaptation strategies for planning at a strategic level: The project has not focus on NAS and the role of spatial planning. However, strategies for the connectivity of the green spaces are designed at local, regional and European level in the project.

[2] Capacities and competences: Above all, the project makes a contribution to strengthening administrative competence, as cooperation between cities and regions is particularly encouraged. The informal planning tools could be improved through the exchange of experiences and the pilot tests.

[3] Planning process: The project is less concerned with climate change impacts. The focus is on planning instruments and how open space protection and management plans can be implemented. Various approaches are developed in the project to include green infrastructure in planning processes. Monitoring/evaluation of the measures is not addressed explicitly.

[120] Online: https://www.alpine-space.org/projects/los_dama/en/home, 17.05.2022.

GoApply – Multidimensional Governance of Climate Change Adaptation in Policy Making and Practice[121]

General specifications:

- Duration: 11/2016 - 04/2019
- Funding: Alpine Space Programme under the European Territorial Cooperation 2014-2020.
- Consortium: The five partners were the Environment Agency Austria, Austrian Federal Ministry of Sustainability and Tourism, German Federal Environment Agency, Swiss Federal Office for the Environment and Lombardy Foundation for the Environment. First one was the lead partner.

Objective/research focus: The project aims to create a transition from adaptation strategies to putting climate change adaptation measures into practice. The focus here is on vertical implementation across the territorial level, horizontal mainstreaming in sector policies and more active involvement of local, regional and non-governmental actors.

Scientific field/methodology: The project is based on the circumstance that NAS already exist in Alpine countries, but multiple obstacles to steering adaptation policies across sectors, levels and actors inhibit implementation. National adaptation governance systems are compared, and further developed, and transferrable regional/local stakeholder interaction formats are tested.

Results/products: The main outputs are a portfolio of multilevel governance approaches, good practices, and innovations, as well as pathways and options for mainstreaming adaptation, transferable stakeholder interaction formats and strengthened transnational cooperation networks.

Relevance for the integration of climate change adaptation in spatial planning

[1] Contribution to the provision of adaptation strategies for planning at a strategic level: The project makes less of a contribution to the formulation and enhancement of NAS/NAP but makes a significant contribution to building capacities for multi-stage and cross-sector control of adaptation processes in the single NAS.

[2] Capacities/competences: The project contributes to building administrative and institutional competence by the reappraisal of adaptation governance at all administrative levels. This also includes strengthening climate change adaptation in the local agenda.

[3] Planning process: Working up the basics about risk and vulnerability are not an essential part of the project. It sets a focus on the processing planning instruments and improved control of climate adaptation on several levels. The existing NAS are reviewed from a governance perspective and supplemented with appropriate governance designs, models, and formats, as well as effective ways of cooperation pathways. Monitoring/evaluation is not explicitly dealt with in the project.

[121] Online: https://www.alpine-space.org/projects/goapply/en/home, 17.05.2022.

OpenSpacesAlps- – Sustainable development of Alpine open spaces by enhancing spatial planning governance[122]

General specifications:

- Duration: 10/2019 – 06/2022
- Funding: Alpine Space Programme under the European Territorial Cooperation 2014-2020.
- Consortium: The project consortium combines six research institutions from five Alpine countries (Austria, France, Germany, Italy, and Slovenia). Lead partner was the Salzburg Institute for Regional Planning and Housing. The other project partners were the Urban Planning Institute of the Republic of Slovenia, University of Würzburg, Eurac Research - Institute for Regional Development, the Italian Federation of Parks and Nature Reserves – Europarc Italy and ALPARC - the Alpine network of protected areas.

Objective/research focus: The project brings together information on the effectiveness of spatial and sectoral planning instruments from all Alpine countries to see how open spaces can be preserved. The main goal is to promote sustainable development of the Alpine region and adapt to climate change by preserving open spaces as part of the green infrastructure. The aim is to initiate and moderate a process for the adaptation of new spatial planning approaches in the Alpine countries.

Scientific field/methodology: With an analytical attempt, the existing planning approaches for safeguarding open spaces in all Alpine states are examined with regard to their effectiveness. A comparative transnational analysis of the different legal framework conditions of spatial and technical planning (nature conservation, forestry, agriculture, etc.) and the corresponding planning instruments is then carried out. Quantitative results are complemented by expert interviews and stakeholder workshops.

Results/products: In addition to the usual project results (report and handbook), a demarcation system for Alpine open spaces is developed and the available planning tools and instruments are examined, including their adaptive capacities.

Relevance for the integration of climate change adaptation in spatial planning

[1] Contribution to the provision of adaptation strategies for planning at a strategic level: The project contributes to the discussion on Alpine-wide cross-border harmonisation of instruments that help to safeguard open spaces. Regional, national and transnational spatial planning processes are to be strengthened and better coordinated through participatory approaches.

[2] Capacities/competences: The project aims to strengthen existing intersections between the EU and other governmental levels to improve administrative capacity. The legal competences are to be strengthened through concrete measures and approaches for safeguarding open space and to tackle climate change impacts through spatial and sectoral planning instruments as well as cross-border harmonisation of safeguarding instruments.

[3] Planning process: The project is less concerned with climate change impacts, risk and vulnerability. The focus is on planning instruments and their context-specific capacities. The project contributes to the improved integration of ecosystem services and thus to the integration of CCA into the national planning systems. This is to be achieved by initiating a process to introduce new spatial planning approaches. Monitoring/evaluation of the measures is not addressed explicitly.

[122] Online: https://www.alpine-space.org/projects/openspacealps/en/home, 17.05.2022.

PROLINE-CE – Efficient Practices of Land Use Management Integrating Water Resources Protection and Non-structural Flood Mitigation Experiences[123]

General specifications:

- Duration: 07/2016 – 09/2019
- Funding: Central Europe Programme 2014-2020.
- Consortium: The project has on board 13 partners from seven countries in the CENTRAL EUROPE region. The Alpine countries involved were Austria, Slovenia, Italy and Germany. Lead partner was the Austrian Federal Ministry of Sustainability and Tourism.

Objective/research focus: The project focuses on key challenges regarding land use and drinking water resources management that are common for all EU countries. Therefore, the main project's objective is the improved protection of drinking water resources in an integrated land use management approach that takes into account climate change issues.

Scientific field/methodology: A major focus is put on the necessary close cooperation between countries. A set of 38 measures is selected and classified according to their importance and overall impact in the Central European region in terms of their most pronounced problems in different land use categories.

Results/products: The testing of selected best management practices in the nine pilot areas has shown that their implementation is currently limited by economic, administrative or governance issues or even by social acceptance. At the end of the project, well-known decision-makers from all seven participating countries jointly signed a „Declaration Charter". Not only contributions for already existing EU guidelines, such as the water framework or flood directive, but also forward-looking recommendations for regions outside the Central European Programme area (Danube and Alpine Space Programme, Adriatic/Ionian and Baltic Programme area) were developed.

Relevance for integration of climate change adaptation in spatial planning

[1] Contribution to the provision of adaptation strategies for planning at a strategic level: The project provides a methodology and implementation support at the operational level, by fostering implementation-roadmaps and transferability of results, operationalisation of best management practices, identifying funding systems and encouraging intensive cooperation with relevant stakeholders.

[2] Capacities/competences: The project contributes to increasing administrative competence by recognising gaps in practice and developing recommendations and implementation guidelines tailored to them.

[3] Planning process: The project is less concerned with climate risks and vulnerability. It rather tackles existing land use and flood/drought management practices in relation to drinking water protection as well as adapting political guidelines in the respective project countries, sectors and spatial types. Monitoring/evaluation of the measures is not addressed explicitly.

[123] Online: https://www.interreg-central.eu/Content.Node/PROLINE-CE.html, 17.05.2022.

ESPON Alps2050 – Common Spatial Perspectives for the Alpine Area. Towards a common vision[124]

General specifications:

- Duration: 11/2017 – 11/2018
- Funding: The project was funded by the ESPON 2020 Programme (European Territorial Observatory Network).
- Consortium: The project partners consisted of six research institutes from Austria, Germany, Italy, France, Slovenia, and Switzerland. The project was led by Friedrich-Alexander University Erlangen-Nürnberg.

Objective/research focus: The main objective of the project is to develop a common spatial vision and spatial perspectives for the entire Alpine area. The aim is to support territorial cooperation and sustainable development in the Alpine region and to develop a territorial planning model that integrates the various actors at all levels (multi-actor system).

Scientific field/methodology: The project builds on the activities of the Alpine Convention, the EU programme Alpine Space and the EUSALP process and draws on these for the analysis.

Results/products: Output of the projects are manifold: a final document, an "atlas" displaying the main results of the project, as well as guidelines for the development of spatial perspectives and a spatial vision.

Relevance for the integration of climate change adaptation in spatial planning

[1] Contribution to the provision of adaptation strategies for planning at a strategic level: A common vision for an area as far-reaching and diverse as the Alpine region can only comprise general guidelines and recommendations for action. The vision of ESPON Alps2050 represents a basis for further place-based cross-border and transnational cooperation. It has a supporting effect in identifying further options for the development of the Alpine area. The vision and the spatial perspectives also contribute to other strategic cooperation in the Alpine area.

[2] Capacities/competences: The project contributes to the improvement of administrative capacities by providing guidelines for the development of spatial perspectives and a spatial vision in decision making processes. The strategic recommendations are on a macro level and can also be transferred to other European transnational cooperation areas. Maps are provided as a basis for decision-making fostering technical capacities. These also contain information on climate signals, climate change impacts (temperature rise, drinking water supply, etc.) and ecosystem services (protected area).

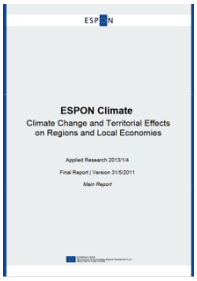
[3] Planning process: Vulnerability and risk were examined more closely in the project and prepared in the form of maps as a basis for planning decisions. In addition, proposals for more effective solutions for balanced sustainable development within the framework of territorial cooperation and for the sustainable strengthening of informal and formal cooperation between the actors are being drawn up to contribute to climate change mitigation. Monitoring/evaluation of the measures is not addressed explicitly.

[124] Online: https://www.espon.eu/Alps2050, 17.05.2022.

ESPON CLIMATE – Climate Change and Territorial Effects on Regions and Local Economies in Europe[125]

General specifications:

- Duration: 03/2009 – 04/2011
- Funding: ESPON CLIMATE is an applied research project within the EU network ESPON 2013.
- Consortium: The partnership behind the ESPON programme consists of the EU Commission and the EU27 Member States plus Iceland, Liechtenstein, Norway, and Switzerland. The project leader was the Technical University of Dortmund, Institute for Spatial Planning (IRPUD).



Objective/research focus: In this project, the extent of climate change impacts on the competitiveness of European regions and Europe as a whole is assessed. The focus lies on a vulnerability analysis as a basis for determining regional typologies in terms of exposure, sensitivity, vulnerability and impacts of climate change. On this basis, appropriate adaptation options could be derived and implemented in order to cope with regionally specific patterns of climate change.

Scientific field/methodology: In order to develop and compare measures, the first step was to analyse the climate model, emission scenario and socio-economic development trends. In the second step, risk and vulnerability analyses were created. From this, the urgency and prioritization of the need for adjustment was determined. The project worked with seven case studies in the Alpine Space.

Results/products: The main product is a comprehensive report including European maps on the degree of vulnerability of different types of European regions to climate change and their adaptation and mitigation capacities.

Relevance for the integration of climate change adaptation in spatial planning

[1] Contribution to the provision of adaptation strategies for planning at a strategic level: The project examines how unavoidable effects can be managed through adaptation measures and how synergies between adaptation and climate protection strategies can be exploited. Existing strategies are reviewed and new adaptation options for the regional/spatial types are developed.

[2] Capacities/competences: The project provides a series of maps on exposure and the possible negative impacts of climate change on various sectors such as agriculture, tourism, and energy, thereby strengthening especially technical capacity.

[3] Planning process: Risk and vulnerability analysis of various European regions (the Alpine area is particularly relevant here) as well as the investigation of the adaptability of the areas and their further improvement possibilities are prepared as a basis for decision-making. Within the Alpine region, new development opportunities are mostly related to tourism and water management as the sector is important to the regions development. Monitoring/evaluation of the measures is not addressed explicitly.

[125] Online: *https://www.espon.eu/climate*, 17.05.2022.

CLARITY – Integrated Climate Adaptation Service Tools for Improving Resilience Measure Efficiency [126]

General specifications:

- Duration: 06/2017 – 08/2020
- Funding: The project was funded under H2020-EU.3.5.1. (Fighting and adapting to climate change)
- Consortium: The 18 partners involved were not only from the Alpine countries Germany, Austria, and Italy, but also from other EU countries. The coordinator of the project was the AIT Austrian Institute of Technology GmbH.

Objective/research focus: The CLARITY project aims to support urban planners and politicians in their efforts to identify and mitigate the risks of climate change more easily. Digital tools are intended to facilitate the development of strategies to mitigate the risks of climate change. The project is not explicitly aimed at the Alpine region, but at all of Europe. The results for urban areas are also relevant for the metropolitan regions in the Alpine Space.

Scientific field/methodology: The project is based on the scientific finding that climate change poses a threat to the economies of EU countries and cities. The project relies primarily on digital and online tools. The project team developed a generic methodology that is appropriate for both expert and screening studies and aligned with the IPCC-AR5 approach.

Results/products: A digital tool and several online platforms are developed to provide up-to-date scientific data in a tailored way to end-users in cities and regions. The digital tool aims to support the necessary informed decision-making to make urban and transport infrastructure more climate-resilient. The established marketplace for various interest groups enables an exchange between all those involved at all levels.

Relevance for the integration of climate change adaptation in spatial planning

[1] Contribution to the provision of adaptation strategies for planning at a strategic level: The project provides what-if decision support functions to study the impact of adaptation measures and mitigation options and to allow comparison of alternative strategies. This refers to the specific project context. However, the strategic approach that those responsible for planning in order to reduce the risk of flooding and heat should use screening tools is abandoned.

[2] Capacities/competences: The project provides technical capacity assistance through maps and data on climate risks and vulnerability in urban areas. It also helps to improve decision-making in the planning process by supporting the identification of adaptation options on local level. The established network 'Marketplace' enables an exchange and the cooperation of actors at different levels thus increases administrative competence.

[3] Planning process: CLARITY provides the practical means to include the effects of climate change impacts in risk management strategies and spatial planning. The web-based early warning services improve planning performance by providing early detection of climate risks and the impact of concrete measures to reduce the urban heat island effect. Monitoring/evaluation of the measures is not addressed explicitly.

[126] Online: https://clarity-h2020.eu/, 17.05.2022.

During the project analysis, various projects were found which, although not specifically related to planning, do provide helpful information and analysis on climate risks.

- **MANFRED – Management strategies to adapt Alpine Space forest to climate change risks**[127] (Alpine Space Programme; Duration: 08/2009-07/2012): The objective was to improve understanding of the impact of climate change on forestry in the Alpine region. The study dealt with forest management, climate change, future distribution of tree species, pest pressure and protection against natural hazards.
- **PARAmount: Reliability and security of Alpine transport infrastructure related to mountainous hazards in a changing climate**[128] (Alpine Space Programme; Duration: 09/2009-11/2012): The objective was to analyse risks of natural hazards in connection with transport infrastructure and to develop a formula that identifies high risk areas. The main focus was on rockfall, debris flows and avalanches.
- **PermaNET – Permafrost long-term monitoring network**[129] (Alpine Space Programme; Duration: 07/2008-07/2011): The overall objective was to make a significant contribution towards the mitigation of natural hazards related to permafrost and manage their consequences (e.g. alters discharge patterns and water quality of Alpine headwaters), with specific regard to climate change impacts.
- **RockTheAlps- Alpine Forests are Rock Stars!**[130] (Alpine Space Programme; Duration: 11/2016 – 12/2019):-The main goal of the project was the improvement of forest ecosystems to provide protection against rockfall. For the first time a harmonised rockfall risk and protective forest map was drafted, which also contains an evaluation of the efficacy of the ecosystem service.
- **GreenRisk4ALPs**[131] (Alpine Space Programme; Duration: 04/2018-08/2021): The main objective of the project was the development of strategies and innovative decision support tools to include protective forests in integration natural hazard management.
- **CESBA Alps - Sustainable Territories**[132] (Alpine Space Programme; Duration: 12/2015-06/2019): The project aims to improve the sustainability of the Alpine built environment through the development of the first assessment tool at territorial scale, which will be contextualised for regional specificities.
- **Links4Soils - Caring for Soils - Where Our Roots Grow**[133] (Alpine Space Programme; Duration: 11/2016-04/2020): The objective of the project was to raise awareness on soil as a non-renewable resource and to promote sustainable soil management. Measures for sustainable soil management for agriculture, forestry, water management, natural hazard management, nature conservation and spatial planning were developed and implemented in pilot projects in the Alpine region.
- **ADO - Alpine Drought Observatory**[134](Alpine Space Programme; Duration: 10/2019–06/2022): The overall objective of the project was to provide a platform for the monitoring and forecasting of drought with specialised products for the Alpine region, which will contribute to an improved drought preparedness.

[127] Online: https://www.alpine-space.org/2007-2013/2007-2013/projects/projects/detail/MANFRED/show/index.html, 17.05.2022.
[128] Online: https://www.alpine-space.org/2007-2013/2007-2013/projects/projects/detail/PARAmount/show/index-2.html, 17.05.2022.
[129] Online: http://www.permanet-alpinespace.eu/home.html, 17.05.2022.
[130] Online: https://www.alpine-space.org/projects/rockthealps/en/home, 17.05.2022.
[131] Online: https://www.alpine-space.org/projects/greenrisk4alps/en/home, 17.05.2022.
[132] Online: https://www.alpine-space.org/projects/cesba-alps/en/home, 17.05.2022.
[133] Online: https://www.alpine-space.org/projects/links4soils/en/home, 17.05.2022.
[134] Online: https://www.alpine-space.org/projects/ado/en/home, 17.05.2022.

4.1.2 National Research and Pilot Projects

Numerous research projects on climate change adaptation with close reference to spatial planning have been conducted in the EUSALP member states in recent years. Projects typically address different aspects of the introduced framework (see Figure 8) and seek either to provide data and information, evaluate and enhance planning instruments as well as framework conditions or also simply guide implementation activities. The following exemplary overview of some relevant projects classifies them accordingly: (1) provide an **understanding of exposure, vulnerability and risk concerning climate change with reference to spatial planning**; (2) examine the **effectiveness of spatial planning and its instruments**; (3) **practical implementation tools**.

(1) Projects contributing to the understanding of exposure, vulnerability and risk concerning to climate change

AT: Austrian Assessment Report 2014 (AAR14)[135]

- The AAR14 is based on the status reports of the IPCC and was created in a three-year process in which numerous institutes and research facilities were involved. It consists of three volumes, each of which is chaired by 3-4 co-chairs. It is a scientific synthesis of how climate change has and will impact Austria. However, it also shows far-reaching measures for CCM and CCA and thus represents a guide for decision-makers and wider the public.
- In a first step, the research findings on climate change are aggregated. The effects on the environment and society are then discussed in more detail. The changes and the increasing risk caused by climate change are described in detail for different areas. Measures by sector (including agriculture and forestry, water, energy, tourism, buildings) are shown in the chapter on CCM and CCA action. The AAR14 is just one example for a comprehensive report on climate signals and climate change impacts that exists in other EUSALP member states in a similar manner.

CH: Climate Change and Switzerland 2050 – Expected Impacts on Environment, Society and Economy[136]

- More than 100 specialists from a wide range of disciplines were involved in this project. The wide range of knowledge about possible consequences and changing vulnerabilities of the environment, economy and society in Switzerland up to the year 2050 was brought together in workshops and meetings. The report analyses the effects of climate change and their importance for the sectors of ecosystem, agriculture, water management, health, energy, tourism, infrastructure, urban space and insurance in Switzerland.
- Adaptation strategies for the sectors mentioned are discussed based on the scientifically based assessment of probable climate-related developments and risks. With the recommended measures, a distinction is made between gradual changes and extreme events. The adaptation measures in spatial planning are aimed at the strategic level (such as decentralization or protection of traffic routes and infrastructure), protection zones for agriculture and forestry, sustainable land use (such as avoiding urban sprawl), and right down to the building level (good insulation of the building shell).

IT: Climate report South Tyrol[137]

- In order to get an overview of the climate change in South Tyrol, EURAC Research was commissioned to write the South Tyrol climate report which was published it in 2018. It describes regional climate signals

[135] Online: *https://ccca.ac.at/wissenstransfer/apcc/aar14*, 17.05.2022.
[136] OcCC (2007).
[137] Zebisch et al. (2018).

and climate change impacts on nature and society in detail. The description of the impacts on the settlement areas and transport infrastructure is an essential part of the analysis.

- In addition to the essential basics of climate change and its impacts, the report also deals with concrete measures. Policies and legislation are studied and analysed in key cross-sectoral areas (e.g. water management). Spatial planning is also specifically addressed and recommendations for climate adaptation are formulated. Practical examples present good implementation from other regions and nations.

SL: Expert basis for risk and vulnerability assessment in Slovenia[138]

- The report on climate change impacts and vulnerability assessment was published in 2014 by the Ministry of Agriculture, Forestry and Food. It contains fundamentals on climate change and a national adaptation/vulnerability analysis.
- The report gives an overview of climate change impacts by sector, as well as a description of the existing instruments and measures. An essential part of the report is the analysis of the assessment of exposure and adaptability of Slovenian regions. This is also done based on selected sectors. The results provide a basis for decision-makers.

(2) Projects that examine the effectiveness of planning and its instruments

CH: Risk-based spatial planning[139]

- The synthesis report on risk-based spatial planning in Switzerland was published in 2014. The report presents a test planning of risk-based spatial planning, summarizes the main findings, lists the open questions and gives an outlook on the next steps.
- The research builds on the circumstance that disaster damage caused by natural hazard events has increased steadily in recent decades, despite considerable effort to provide protection. A test planning was carried out in the project in order to specify the approach of a risk-based spatial planning. The results and findings are aimed at planners, natural hazard experts and other stakeholders who are involved in spatial planning.

FR: Gestion Intégrée des Risques Naturels sur le massif alpin (GIRN-Alpes)[140]

- This initially experimental project was developed with the aim of expanding and improving the integrated management of natural hazards in the Alps by supporting the local decision-makers of the POIA for the period 2014-2020.
- The project aims to develop integrated management approaches for natural hazards in the mountains on an interregional level. The proposed approach aims to complete the classic and sovereign approach to natural hazards at technical, organizational and territorial levels, allowing the emergence of new local dynamics on natural hazards, developed jointly with mountain stakeholders.

[138] Kajfež-Bogataj et al. (2014).
[139] Camenzind and Loat (2014).
[140] Online: *http://risknat.org/girn-alpes-2/actions-des-TAGIRN/GAM/index.html*, 17.05.2022.

(3) Practice implementation tools

CH: Climate change and spatial development. A working aid for planners[141]

- In 2013, the Federal Office for Spatial Development published a guidance for planners to promote understanding of the direct and indirect consequences of climate change and to show concrete options for action with the help of practical examples (this guidance was updated in 2022). The document aims to deal with the spatial consequences of climate change at an early stage and should help to plan ahead.
- The document is divided into three sections. The first one describes the relevant consequences of climate change for spatial development. The topic of heat stress, snow uncertainty for ski areas and extreme events are addressed. In the second section, the possible CCA action in spatial planning is outlined. Finally, the third section provides good planning examples that demonstrate implementation can look like in practice.

FL: The protection forest in Liechtenstein[142]

- This report was published in 2009 by the Office for Forest, Nature and Landscape of the Principality of Liechtenstein and describes the functions of the protection forest and the connection of protection services by forests to manage and mitigate natural hazards.
- In addition to the framework conditions (natural hazards, legal requirements, etc.) and basic knowledge about the protection functions of the (mountain) forest, the report offers support in assessing the condition of the protection forest. The documentation bases and forms for recording and success control also make an important contribution.

GER: Climate pilot ("Klimalotse")[143]

- The climate pilot has been provided by the Federal Environment Agency since 2010 and has since been extensively revised. This is an online guide for supporting local authorities in adapting to the consequences of climate change in Germany.
- The tool offers comprehensive support from the identification of risk/vulnerability, through measures, legal framework conditions, to the evaluation of the medium-term effectiveness of the measures. The guidelines are primarily aimed at decision-makers in cities and municipalities, like environmental agencies or urban planning.

4.1.3 Research Focus and Outcomes

In the last two decades, numerous research projects on climate change adaptation related to spatial planning have been carried out. The projects were conducted on the one hand at international level and financed by Europe-wide funding programmes, on the other hand within the EUSALP member states on national or regional level. The project results are very wide-ranging and overall make a fundamental contribution to the development or strengthening of capacities and competences that help to mainstream CCA into spatial planning.

The **research focus** of the described projects is primarily set on CCA measures and the connection to natural hazard management. A significant share of the research projects is primarily dedicated to natural hazards and the risks associated with them integrating additionally climate change perspectives. Flood and water management in particular are frequently the area of focus. More recently, however, there have been an

[141] ARE (2013).
[142] AWNL (2009).
[143] Online: *https://www.umweltbundesamt.de/themen/klima-energie/klimafolgen-anpassung/werkzeuge-der-anpassung/klimalotse#Einf%C3%BChrung*, 17.05.2022.

increasing number of projects on forest management and protection forest (e.g. GreenRisk4ALPs, RockTheAlps). Due to the persistent drought and the increasing incidence of forest fires, this focus is apparent. However, fewer projects were found on heat stress in the Alpine region. There are also larger urban agglomerations here and heat stress due to climate change is increasing. Research projects were also carried out in which the focus was specifically or only partly on topics on which spatial planning has little influence but whose climate-related changes have a significant impact on settlement areas, such as tourism, forest management or agriculture. These are not included in the above list.

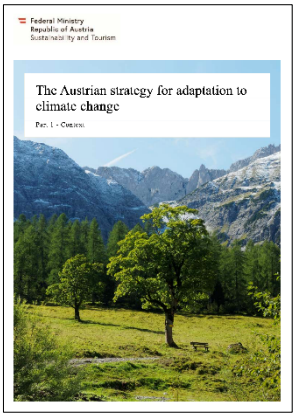
In general, most of the projects have the **overall objective** to improve the **basic knowledge of the impacts, risk and vulnerability** connected to climate change. The project results make a significant contribution to increasing technical competence and help to enhance established natural hazard maps. This created a broad knowledge base. Only a few international projects tackle legal and institutional competences to mainstream CCA in planning law and practice. Interestingly funding needs and models for CCA action in planning has not been addressed by any projects. GoApply is in fact outstanding as it focuses on governance aspects and thus contributes to strengthening them. It can be stated that CLISP is the only project conducted that has a clear focus on the Alpine region and its specific necessities and encompasses a comprehensive perspective on planning. Monitoring and evaluation approaches for CCA measures was not a focus in any of the assessed projects. They were also predominantly exploratory projects. In order to review implemented CCA measures this will be an important field of research in the future.

With regards to **results and recommendations**, most projects come to the conclusion that better international cooperation in all respects (fundamentals, planning, risk analysis, etc.) is necessary in order to tackle the consequences of climate change. Another frequently formulated recommendation is the integration of sustainable cross-border adaptation and mitigation concepts. From this it can be concluded that there is a gap in the current planning approaches. What is also striking is that the recommendations are aimed at a strategic level for development concepts, such as limited land take, and less on the actual implementation at the local level. However, the **addressees** are **predominantly local decision-makers or planning authorities**.

4.2 Overall Objectives for Climate Adaptation in Planning (Policy)

All EUSALP member states have national adaptation strategies (NAS) complemented by state led programmes and implementation activities to foster climate adaptation on all levels. Especially in federally organised states there also exist typically regional adaptation strategies. Over the past 20 years, comprehensive frameworks and action plans have been drafted and adopted by governments. Overall, climate adaptation is a joint effort of public and private stakeholders touching upon different sectoral domains. Spatial development in general, and more specific spatial planning as a state responsibility distributed over different levels, is addressed in these documents as well. Against the background of the international research and recommendations the following brief overview seeks to outline (1) if the **Alpine area is addressed separately/explicitly** in strategic documents and (2) what **role and responsibilities are assigned to spatial planning** concerning climate adaptation.

4.2.1 Austria



Austria passed his first national adaptation strategy in 2013, followed by an evaluation report in 2015. In 2017 the updated **national adaptation strategy**[144] and **national action plan**[145] were politically adopted. Every five years an evaluation report should help monitoring the implementation progress. The federal provinces of Austria have partly adopted their own adaptation strategies, combined climate adaptation and mitigation strategies, integrated adaptation aspects in the existing mitigation strategies or integrated adaptation directly within sectoral domains.[146] This leads to a rather confusing co-existence of various climate adaptation policy documents.

(1) Identifying the Alpine area with its specific exposure and needs:
The national adaptation strategy gives a comprehensive overview of climate signals and expected impacts in Austria. Here, the specific exposure of the Alpine area of Austria is recognised when it comes to temperature increase and changes in precipitation.[147] Goals and measures anyhow are not generally differentiated in light of the topographical conditions of different regions, but the importance of measures for certain areas is generally highlighted in the national action plan. Austria is fully located within the EUSALP perimeter and the country predominately characterised by the Alps. So, adaptation measures are in general taking the specific exposure and needs of the Alpine areas into account.

(2) Role and responsibilities of spatial planning:
In the national adaptation strategy and action plan spatial planning is clearly assigned a pivotal role. Spatial planning is one of 14 adaptation fields for which 13 specific adaptation goals are defined:[148]

- Development and provision of practice relevant **data and information**,
- Establishment and protection of **flood retention** and drainage zones and clear regulation of **zoning prohibitions**,
- Reinforced legal links between **zoning and hazard-zone planning**,
- Regulations for handling **existing zoning and building in hazardous areas**,
- Promotion of **inter-municipal cooperation**,
- Protection of **fresh/cold air production areas**, ventilation paths and “green” and “blue” infrastructure within residential areas,
- Review and (if necessary) adjustment of **bio-climatically active measures** in **development plans**,
- Increased **protection of water resources** and improved integration of spatial planning, water management planning, and usage with water demand,
- Increased **protection** of ecologically important **open spaces** (undeveloped semi-natural areas, habitat corridors, biotope networking) and minimization of further habitat fragmentation
- Increased **cooperation** between **spatial planning and tourism** to promote a climate change-adapted, sustainable tourist infrastructure,
- Promotion of **energy-optimized spatial structures**,
- **“Climate proofing”** of spatial plans, development concepts, procedures, and projects with spatial impacts,
- Promotion of **quantitative soil protection** and consideration of soil quality in land use decisions.

[144] BMNT (2017a).
[145] BMNT (2017b).
[146] Online: *https://www.klimawandelanpassung.at/kwa-politik/kwa-bundeslaender*, 17.05.2022.
[147] BMNT (2017a), p 41.
[148] ebd, p 130-132.

The list of goals appears to be somehow arbitrary as it has no clear structure. A majority of the goals relate to natural hazard management and therein to keeping areas undeveloped or dealing with building and zoning stock at risk. Spatial planning has in Austria extensive responsibility for urban development. But the section **"Cities – Urban Green and Open Spaces"** is listed independently addressing the management of water, heat and cold air in urban development.[149] In fact, it is completely in the local spatial planning agenda. The action plan elaborates on all the details of every goal and also assigns the implementation to public stakeholders.

In 2021 the second evaluation report on climate change adaptation in Austria was published.[150] It also contains an evaluation for the 'activity area' spatial planning but it does not follow the thematic structure introduced by the strategy which makes it somehow difficult to directly trace the status quo of implementation of specific measures. The evaluation report highlights besides good practice examples, efforts that need to be undertaken to foster implementation.

The adaptation strategies of the federal provinces take the overall goals from the national level as a basis for more specific commitments, also in the field of spatial planning. Overall, none of these adaptation strategies are binding but serve as a guideline for public funding and actual implementation initiatives. There are no mechanisms in place in case the overall goals are not achieved.

4.2.2 France

France is in comparison to Austria of course a very different case when it comes to addressing the Alpine areas in the national adaptation strategy as the Alps measure only up to 7 % of the national territory. The Alps are also not the only mountainous region (Pyrenees, Massif Central) in France. Anyhow, the Alps reach from the Mediterranean Sea up to Mont Blanc, the highest peak of the Alps. This brings manifold challenges for human development in the Alpine area and makes it overall strongly exposed to climate impacts.

The French **National Adaptation Strategy**, adopted in 2006, marked the beginning of the government's focus on adaptation. The Strategy identifies four overarching goals to be considered in national planning processes: (i) to protect people and property from the effects of climate change by enhancing safety and public health; (ii) to take social considerations into account and to avoid inequality in the exposure to climate risks; (iii) to limit the costs linked to the effects of climate change and to exploit possible opportunities; and (iv) to preserve French natural heritage.[151] The NAS was followed by a **National Adaptation Plan** that its now available in the 2nd edition.[152]

(1) Identifying the Alpine area with its specific exposure and needs:
France holds a share of approximately 21 % of the Alps which are important for fresh water and tourism. The NAS outlines in the first-place overall objectives and principles for adaptation. It does not distinct actions for different regional entities, but it actually mentions the importance of the Alps for fresh water.[153] The French NAP also misses a specific reference to the Alps but many outlined actions are especially relevant in mountainous areas. Of course, on the regional level a further differentiation and prioritization of adaptation measures is undertaken.

[149] BMNT (2017a), p 133.
[150] BMK (2021).
[151] ONERC (2007).
[152] Ministère de la Transition Écologique et Solidaire (2018).
[153] ONERC (2007), p 53.

(2) Role and responsibilities of spatial planning:

The French NAS highlights the role of spatial planning throughout the document but does not identify planning at this level as an essential field of action.[154] This task is fulfilled by the NAP in a certain extent. An overall objective is the protection of people against risks and disasters in connection with climate change. For example, forest fires should be taken into account in spatial planning as they pose a considerable risk for settlements and infrastructure.[155] The NAP also tackles the long-term perspective of transforming territories through spatial planning including the reduction of land take, de-sealing of land and ecological standards in urban restoration. It specifically highlights the need to assess the dynamics of natural hazards and changes in biodiversity in mountain areas to be integrated in decision making.[156] So overall, spatial planning is targeted as a field of action for implementing the principles and objectives defined in the NAP. France has seen a territorial reorganization in 2016. Now the two regions Auvergne-Rhône-Alpes and Provence-Alpes-Côte d'Azur are the two regions that cover the Alpine area. The essential strategic planning document on the regional level is the so-called SRADDET (Schéma régional d'aménagement, de développement durable et d'égalité des territoires). The instrument was introduced through the 2015 act on the New Territorial Organisation of the Republic (loi NOTRe) and is the main planning document to specify the abstract adaptation objectives further.

4.2.3 Germany

Germany is a federally organized country with the two states Baden-Württemberg and Bavaria located within the EUSALP perimeter and has been very active in participating in international research projects as well as conducting national/regional projects on the connection of climate change adaptation and spatial planning. On the federal level the key document is the **German Adaptation Strategy to Climate Change**[157] adopted in 2008 and which was already evaluated twice.[158] The single states have widely adopted individual adaptation strategies in line with the national one. The state of Baden-Württemberg has a **Strategy for the Adaptation to Climate Change** from 2015 in place and Bavaria was amongst the first to adopt a Climate Adaptation Strategy already in 2009 and revised it in 2017. Overall, this means that there are several governmental levels and strategic policy documents relevant for assessing the relevance of spatial planning concerning Alpine areas in adaptation strategies.

(1) Identifying the Alpine area with its specific exposure and needs:

The German Adaptation Strategy to Climate Change addresses the specific exposure the Alpine area experiences. Especially impacts on mountain forests and possible changes in hazard probabilities.[159] It also refers to what climate change means for tourism industry – in the first-place winter tourism. The strategy is therefore clearly aware of the fact, that measures need to be adjusted to specific exposures, vulnerabilities and risk of areas. The Adaptation Strategy of Baden-Württemberg contains the outcomes of regional assessments on climate change exposure and vulnerabilities showing also the particularities of Alpine areas.[160] The first Bavarian climate Adaptation Strategy has a main chapter that is dedicated to specific challenges of the Alpine area. It tackles

[154] e.g. ONERC (2007), p 53
[155] Ministère de la Transition Écologique et Solidaire (2018), p 7.
[156] ebd., p 9f.
[157] Deutsche Bundesregierung (2008).
[158] Progress reports from 2015 and 2020 accessible via: *https://www.umweltbundesamt.de/themen/klima-energie/klimafolgen-anpassung/anpassung-an-den-klimawandel/anpassung-auf-bundesebene#weiterentwicklung-der-das*, 17.05.2022.
[159] Deutsche Bundesregierung (2008), p 31, 47.
[160] Ministerium für Umwelt, Klima und Energiewirtschaft Baden-Württemberg (2015).

expected changes in hazard exposure, climate impacts on mountain forests, the loss of glaciers and changes in the water regime, changes in habitats and the decrease of snow cover.[161] The revised strategy also has a – comprehensive – chapter on climate change in the Alps.[162]

(2) Role and responsibilities of spatial planning:
Spatial planning occurs throughout the German Adaptation Strategy to Climate Change as a field of action. Spatial planning is supposed to **foster risk prevention in light of the expected increase and intensification of extreme weather events**. This should succeed through enforcing restrictions (e.g. for flood zones) and enhancing urban development by integrating bioclimatic exposure (esp. heat). Spatial planning should also **manage specific risks of mountain areas** through prevention measures.[163] The document refers to existing and planned studies on spatial planning and climate change adaptation, many of which have been conducted since.

The **state of Baden-Württemberg** identifies urban and spatial planning as one of nine fields of action in climate change adaptation. It defines objects of protection (e.g. urban green infrastructure) and overall objectives for planning followed by a set of measures:[164]

- Securing areas for thermal relief (green areas, green corridors);
- Ensuring sufficient fresh air supply and reduction of land take;
- Enforcing unsealing and greening of the built environment;
- Measures for the climate adjusted design of buildings and infrastructure;
- Improving the quality of public spaces;
- Enhancing the planning instruments in context of climate change;
- Improving the data situation.

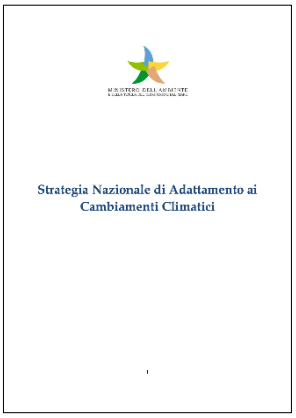
This regional adaptation strategy thereby clearly shows how the level of detail increases and actual measures for urban and spatial planning are identified. This is similar in the first **Bavarian Climate Adaptation Strategy**. Spatial planning is as well identified as a specific field of action but with a low level of detail. Overall, planning should coordinate land uses and integrate hazard and risk information on regional and state level.[165] The revised strategy provides already far more details on the topic. It especially introduces a set of measures for state and regional planning; some of them are:[166]

- Evaluate goals and principles in the state development programme;
- Designate priority and reserved areas for climate change adaptation in regional plans;
- Develop green corridors and green infrastructure further.

This shows the development that took place in terms of strategies over the past decade that have nowadays a much greater level of detail and accuracy.

[161] Bayerisches Staatsministerium für Umwelt und Gesundheit (2009), p 53.
[162] Bayerisches Staatsministerium für Umwelt und Gesundheit (2017), pp 178-185.
[163] Deutsche Bundesregierung (2008), p 43.
[164] Ministerium für Umwelt, Klima und Energiewirtschaft Baden-Württemberg (2015), pp 125-128.
[165] Bayerisches Staatsministerium für Umwelt und Gesundheit (2009), p 36f.
[166] Bayerisches Staatsministerium für Umwelt und Gesundheit (2017), p 124f.

4.2.4 Italy



The administrative situation in Italy for this analysis is rather complex. Italy has several regions that are located within the EUSALP perimeter. Piedmont, Liguria, Lombardy and Veneto have a regular status as regions while Trentino-South Tyrol, Aosta Valley and Friuli Venezia Giulia are autonomous regions that grant them wide ranging independence in legislative matters. For Italy on the whole, the Ministry of Ecological Transition approved the **National Adaptation Strategy for Climate Change** in 2015.[167] The strategy analyses the state of scientific knowledge on impacts and vulnerability to climate change for the major socio-economic and environmental sectors. Objectives and outcomes of the Strategy can be summarized in: developing a national vision on how to address the adaptation for different sectors; providing actions and guidelines to build adaptive capacity; minimizing risks of climate change; maintaining or improving the resilience of natural, social and economic systems; taking advantage of any opportunity arising from new climate conditions.[168] So far there does not exist a NAP and the practice of the single regions concerning the development of a strategic document varies as well. For example, the autonomous provinces of South Tyrol and Trentino have no regional adaptation strategy adopted yet but are working on it.

(1) Identifying the Alpine area with its specific exposure and needs:
The NAS states impacts and vulnerability to climate change in general and outlines the specific case of the Alps and the Apennine.[169] It is aware of the specific adaptation needs for mountainous areas.

(2) Role and responsibilities of spatial planning:
Due to the fragmented administrative structure, it is difficult to have general statements on the role and responsibilities of spatial planning in climate change adaptation as the autonomous regions have widely established independent legislation. The NAS anyhow refers throughout the document to the role of spatial planning from a sectoral perspective but does not identify it as a key field of action.

4.2.5 Liechtenstein

Liechtenstein is a principality in the upper Rhine valley that has due to its size (160 km^2) a simplified administrative and political structure with 11 municipalities and no regional level. This allows overall a close cooperation between national administration and municipalities but entails of course also limitations when it comes to resources.

Liechtenstein has published a series of documents that deal with climate change. A central guiding document is the **Climate Vision 2050**[170] that deals in the first place with carbon neutrality. Another guiding document is the 2015 published general **Climate Strategy**[171] complemented by the **National Adaptation Strategy**[172] published in 2018. Liechtenstein has therefore an up-to-date set of policy documents that guide climate change mitigation and adaptation.

[167] Ministry of Ecological Transition (2015).
[168] Online: *https://climate-adapt.eea.europa.eu/countries-regions/countries/italy*, 17.05.2022.
[169] Ministry of Ecological Transition (2015), p 54f.
[170] Regierung des Fürstentums Liechtenstein (2020a).
[171] Regierung des Fürstentums Liechtenstein (2015).
[172] Regierung des Fürstentums Liechtenstein (2018).

(1) Identifying the Alpine area with its specific exposure and needs:

For the case of Liechtenstein, this is anyhow the case due to its inner-Alpine location.

(2) Role and responsibilities of spatial planning:

The role and responsibilities of spatial planning in climate change adaptation and achieving climate resilience in Liechtenstein is addressed through a two-sided approach. First and foremost, through the National Adaptation Strategy and secondly, through climate sensitive provisions in the overall **Spatial Development Concept**[173] of the principality. There also exists a spatial development concept by a Liechtensteiner foundation[174] which is no official document but contains of course climate sensitive provision.

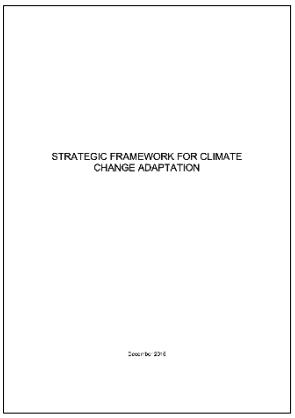
The National Adaptation Strategy structures very clearly necessary adaptation efforts and actions in different sectors. Spatial planning appears in several sectoral fields but also has its own section *4.9 Spatial Development*. Here, three priority actions for planning are identified:[175]

- **Planning instruments:** Integrate climate induced changes in planning instruments on municipal and national level. This entails e.g. heat waves and urban heat islands as well as hazard prevention through planning (e.g. retention areas).
- **Safeguard areas:** Keep areas undeveloped based on climate scenarios.
- **Guidelines for spatial development:** To enforce the integration of climate change adaptation needs in planning processes.

The Spatial Development Concept draws a normative scenario for the spatial structure of Liechtenstein in 2050 and mentions climate change as a framework condition but does not tackle climate change adaptation in detail. Overall, the framework allows and asks for the integration of climate change in planning on national and municipal level but does not already set normative and quantifiable goals.

4.2.6 Slovenia

Slovenia has a very specific location at the intersection of the Alps, the Mediterranean, the Pannonian Basin and the Dinaric Alps. This entails challenges for overall spatial development and especially, for climate adaptation due to the diverse exposure to climate change impacts.[176] Besides the recently adopted **Slovenia's Long-term Strategy until 2050**[177] that deals primarily with climate mitigation there exists a **Strategic Framework for Climate Change Adaptation**.[178] The framework is a rather slim document focusing on essential aspects in climate change adaptation and represents an overall guiding document. Adaptation activities have to follow primarily via sectoral policies.



(1) Identifying the Alpine area with its specific exposure and needs:

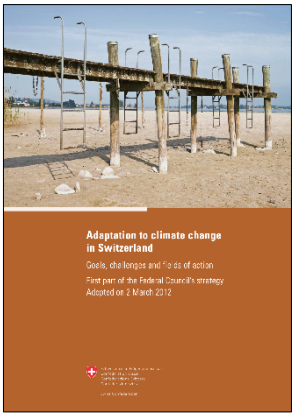
The Strategic Framework for Climate Change Adaptation does, due to its nature as a guiding document, not differentiate between specific exposures and adaptation needs of different areas of the country. Anyhow, Slovenia is fully located within the EUSALP perimeter.

[173] Regierung des Fürstentums Liechtenstein (2020b).
[174] Stiftung Zukunft.li (2019).
[175] Regierung des Fürstentums Liechtenstein (2019), pp 40-42.
[176] Climate-ADAPT (2022).
[177] Republic of Slovenia (2021).
[178] Republic of Slovenia (2016).

(2) Role and responsibilities of spatial planning:

The Strategic Framework highlights right in the beginning the importance of taking "[…]climate change impacts into account when undertaking development and spatial planning."[179] The document further states, that climate change impacts have to be mainstreamed in regional and local planning processes. Here, the use of environmental impact assessment instruments should be strengthened.[180] The document does not contain any further details on the role and responsibilities of spatial planning in climate adaptation, leaving the implementation to the municipalities and the Ministry of the Environment and Spatial Planning.

4.2.7 Switzerland



Switzerland has been like Germany very active on the climate change adaptation agenda and conducted many national research and pilot projects as well as participated in international research projects. Switzerland has successfully established a NAS and a NAP accompanied of many activities. The **National Adaptation Strategy**[181] was adopted in 2012 and identifies the general objectives, challenges and fields of action. The actual guideline for implementation is the **National Action Plan**[182] which is valid for a five-year period.

(1) Identifying the Alpine area with its specific exposure and needs:

Switzerland is fully located within the EUSALP perimeter while the northern part of Switzerland is by definition not part of the Alps and therefore also not situated within the Alpine Convention perimeter. Anyhow, the Alpine part of Switzerland experiences different changes in exposure due to climate change in comparison to the northern half of the country. The NAS acknowledges this fact and especially identifies challenges to certain regions of the country.[183] It also highlights the challenges natural hazards in general and the expected dynamic entail for the Alpine area. The NAP subsequently puts this into an implementation orientated scheme for climate change adaptation.

(2) Role and responsibilities of spatial planning:

Spatial planning is in Switzerland a shared responsibility of the federal state, the cantons and the municipalities and it also has coordinative responsibilities among sectoral domains. The NAS explicitly addresses spatial planning as a key field of action. It distinguishes four main focus areas:[184]

- Quality of life in cities and metropolitan areas (R1);
- Tourism (R2);
- Natural hazards (R3);
- Energy and water (R4).

For these areas specific goals are defined. For example, R1 – green infrastructure for managing heat islands, R2 – enhancement of summer tourism, R3 – risk-based planning, R4 – integrative water management, etc. The NAS provides already a comprehensive framework for climate change adaptation explicitly addressing and highlighting the role of spatial planning. The NAP specifies the actual contribution of spatial planning to adaptation action.

[179] Republic of Slovenia (2016), p 5.
[180] ebd, p 8.
[181] BAFU (2012).
[182] BAFU (2020).
[183] BAFU (2012), p 8-19.
[184] ebd, p 42ff.

4.2.8 Similarities and Differences

The brief look in the national – and some regional – climate change adaptation policy documents of countries in the Alpine area reveals similarities but also differences concerning the way they address spatial planning. First of all, the single **NAS have very different approaches**. Some are very general and **provide a basic framework and essential objectives** (e.g. Slovenia), while other are already **extremely detailed with identifying sectoral domains for adaptation action** (e.g. Switzerland, Austria). Interestingly, the specific challenges Alpine areas face, are not explicitly addressed in general. Some NAS highlight the specific vulnerabilities of Alpine areas (e.g. Switzerland) while other documents do not introduce such a distinction on this level (e.g. Slovenia, France). Liechtenstein for example is due to its size a special case that simply has no need to distinct between Alpine and non-Alpine areas.

When looking at the **role and responsibilities assigned to spatial planning**, the approach in the NAS and NAP documents varies significantly as well. In general, all documents refer to spatial planning as a field of action but many documents provide no further details (e.g. France, Slovenia, Italy). Austria for example has an extremely detailed list of adaptation actions that need to be taken through spatial planning. This is also the case for Switzerland which has a very comprehensive NAS. Liechtenstein has a very recent NAS and also identifies three target fields for spatial planning. Germany on the other hand also relies due to its federal structure strongly on the single states and outlines in its NAS especially what research activities are needed for adaptation action in the field of spatial planning. Many of them have been meanwhile completed.

Looking at the **NAS and NAP** it becomes obvious that **there has been an overall progress in the formulation of such documents** over the past decade with **the latter being more detailed and specific**. Interestingly, resilience does not occur as a guiding principle in NAS and NAP and sectoral perspectives are dominant. This makes it of course easier to address certain public institutions and administration.

5 Foster Implementation and Adaptation Pathways

The overview of national adaptation strategies and their context with spatial planning as well as the analysis of research projects in the field, reveal clearly that there exists comprehensive knowledge on climate change adaptation and possible actions through spatial planning instruments on different levels. Yet, the implementation of CCA measures is neither consistently documented nor well researched. Kruse and Pütz have published in 2014 their research on **adaptative capacities of spatial planning** in the context of climate change in the European Alps.[185] To make efficient use of adaptative capacities the authors conclude that (i) relevant climate information and professional support needs to be provided to authorities and (ii) adaptation needs to be mainstreamed within the institutional framework of spatial planning. This is in fact a finding already shared in the synthesis report of the CLISP project in 2011.[186] In the past decade another concept in line with CCA has gained momentum. The discussion on adaptation pathways is extensively led by scholars around the globe. **Adaptation pathways** in general can be framed as **sequences of actions – implemented progressively – depending on how the future unfolds and the development logic**. Desired outcome of such a pathway development would be (i) meeting short and long-term adaptation needs, (ii) promoting collaborative learning, adaptive planning and adaptative capacity and (iii) accounting for complexity and long-term change.[187] The development of adaptation pathways in planning is problem driven and needs a collaborative and time-sensitive approach. There is actually hardly any research that looks into the use of adaptation pathways for CCA implementation in planning so far.

This leads to a situation where recommendations and outcomes of research projects tend to become generic and repetitive. Main target areas for mainstreaming CCA into spatial planning are well-known but progress on the implementation side is rather slow. Therefore, this chapter looks into the actual practice by conducting expert interviews.

5.1 Expert Interviews on Implementation Activities

The study relies in its evaluation of existing efforts and pathways towards integrating climate resilience in spatial planning as outlined on expert interviews conducted between December 2021 and February 2022 (the interviews 12-14 were already conducted in 06/2021, transcribed, coded, and integrated in the analysis). The interviewees were chosen in the first place based on the recommendation of EUSALP AG8 members. Table 2 gives an anonymised overview of the interviewed persons/institutions.

All guided interviews were recorded and fully transcribed afterwards. For the coding, a scheme was developed on basis of the introduced CCA framework (see Figure 8). The statements of interviewees were assigned according to the coding scheme and generalised to highlight their normative meaning.

[185] Kruse and Pütz (2014).
[186] Pütz et al. (2011), p 18ff.
[187] Werners et al. (2021).

INTERVIEW NUMBER	COUNTRY	ORGANISATION	Group of Experts (i) CCA-EXPERTS (ii) PLANNERS	
1	AT	Regional administration	i	CCA Coordinator
2	CH	Federal administration	ii	Disaster risk management & planning
3	DE	Regional administration	ii	Planer – regional
4	FL	Federal administration	i	CCA coordinator
5	FR	Regional administration	ii	Planer – regional
6	IT	Regional administration	ii	Planer – regional
7	DE	Planning office	ii	Planer – consultant (local/regional)
8	FL	Federal administration	ii	Planer – regional
9	FR	Regional administration	ii	Planer – regional
10	IT	City administration	ii	Planer – local
11	SL	Federal administration	ii	Planer – local
12	CH	Planning office	ii	Planer – consultant
13	CH	Federal administration	ii	Planer – national
14	CH	City administration	ii	Planer – local

Table 2: Expert interviews 12/2021-02/2022 and integration of 3 interviews conducted in 06/2021 (12-13)

5.1.1 Enabling Environment

Any efforts to implement CCA measures and achieve climate resilience in general is embedded in a policy framework typically with a spanning national strategy and a subsequent regional and/or local differentiation. This is of course also the case for CCA measures and climate resilience in spatial planning. Therefore, the conducted interviews asked for the role and significance of overall strategies and policies for the development of implementation pathways and the day-to-day planning practice on different levels.

As already portrayed national **adaptation strategies** typically address spatial planning and urban development as a key sector for adaptation action. An aspect that was mentioned several times in the interviews, are the **difficulties in operationalising national strategies**. Interviewees reported friction losses in the discussion of responsibilities for actual action and difficulties that emerge through the absence of an according transfer to the regional level that is essential for local measures. Usually, there is no clear implementation pathway from the national to the local level assigning adaptation measures to according levels. While the planning relevant content of the NAS/NAP was not widely debated, the operationalisation is seen as a key challenge (Interviews 4, 6, 7, 13). The discussion with the interviewees on CCA and CCM strategies resulted in several other shared statements. In the first place, that **NAS/NAP need an according translation and specification to the regional level**, which is a time-consuming process (Interviews 1, 6) and is partly also seen as an additional burden that requires sufficient resources (Interview 4).

Besides the role of strategies, the actual **assignment of implementation responsibilities** was discussed profoundly. CCA measures that are connected to spatial development are not always assigned to planning departments, as they often also fit in environmental, disaster risk management and health agendas (Interview 14) and spatial planning authorities have typically no leadership function in CCA but rather get assigned certain responsibilities through strategies (Interview 13). While there exists nowadays a common understanding what spatial planning can contribute to CCA in coordination with other sectors (Interview 12) a clear assignment of CCA action through planning documents/instruments is still missing so far (Interviews 3, 7). An immanent challenge here is the temporal dimension. Climate change demands planning decisions to be taken with foresight addressing an uncertain future. This long-term and dynamic perspective is rather new for spatial planning that typically builds on recent societal, economic, and ecological assessments and needs (Interviews 2, 12). At the

same time spatial planning has typically no advocate that helps coordinating CCA responsibilities within a national planning system (Interview 7). Assigning CCA measures is seen difficult in general due to wide ranging regional differences in climate exposure in the Alpine area. One-fits-all solutions concerning responsibilities would not be sufficient (Interview 14). Anyhow, **cities are** often the **forerunners** in adaptation activities due to the climate change impacts they already face even though they are not clearly assigned any responsibility for example to manage urban heat, cold air, etc. (Interview 14). And **besides public stakeholders on local level, the real estate developers are key stakeholders** for implementing actual CCA measures (Interview 12). The superior inter-municipal/regional level was identified as an essential level for planning to develop and coordinate measures and if this level is not well established – like in the case of Slovenia – this poses a substantial challenge (Interviews 7, 11). Assigning responsibilities is anyhow is only one side of the coin, as confidence in the CCA implementation performance through spatial planning is a matter of doubt (Interview 12).

Another aspect discussed with the interviewees in connection with the enabling environment was the role of and necessity for **sectoral coordination**. Spatial planning, amongst other sectors, has typically a hierarchical structure with national, regional and a local level. To effectively implement CCA measures there is an overall need for guidance on predominantly horizontal sectoral coordination and vertical coordination within planning systems beyond formal requirements (Interview 5, 8). The sectoral approach in CCA action otherwise fosters isolated perspectives resulting sometimes in self-defeating actions (Interview 12). An effective sectoral coordination presumes clear institutional responsibilities (Interview 2) and if possible, the integration of inter-sectoral institutions such as 'Le comité de massif des Alpes' in France.

The actual implementation of CCA measures relies strongly on the development of so-called **implementation pathways**. In this study pathways are rather simply framed as development trajectories that can be seen as an iterative, continually evolving process for managing climate change adaptation needs with substantial contribution of spatial planning instruments. The interviewees were asked to identify gaps, highlight and outline existing integrative and iterative processes, that help implementing CCA measures and state what essential success factors are based on their experience. In general, guidelines and established approaches for CCA in spatial planning – especially on national level – tend to be very persistent (Interview 12). Therefore, it makes sense to connect them already at an early stage to existing initiatives and discussions connected to CCA. For example, **CCA measures in planning** are **closely connected to natural hazard management and risk-based planning** and finding achievements and established structures in this field can be helpful for CCA as well (Interview 2). Overall, cities were highlighted once again as forerunners in adaptation action but with the need to integrate learnings in an iterative manner in the general CCA framework (Interview 10). Cities as best practice examples for CCA do not help to improve the adaptation framework, if there are no such mechanisms for enhancement (Interview 7). The regional level was identified as highly suitable for a coordinative role as CCA is typically one aspect in strategic comprehensive planning activities (Interviews 3, 9). The national level was seen critical as NAS/NAP try in Alpine countries to some extent to develop implementation pathways, but the actual implementation is sparse and evaluation processes hardly foreseen (Interview 12). Interviewees highlighted different criteria that need to be taken into consideration for developing implementation pathways: being well aware of the temporal dimension of developing pathways (Interviews 2,12), the need for sufficient resources (Interview 14), platforms for coordination (Interview 4), innovation that is based on evaluating adaptation action (Interview 12) and differentiated measures for different spatial areas.

The discussion with the experts on the enabling environment clearly shows, that a consistent operationalisation of adaptation actions through spatial planning – based in NAS/NAP – has not yet taken place. Especially NAS/NAP assign spatial planning certain responsibilities but the clarification which level is actually in charge is still missing widely. Cooperation of public stakeholders – sectoral as well as vertical – was highlighted as essential criteria for

effective implementation of CCA measures while the development of so-called implementation pathways has not been established consistently.

5.1.2 Capacities and Competences

The discussion of capacities and competences is in general underrepresented in studies and discussions on development gaps and possible entry points for enhancing climate resilient spatial planning. In some cases, the focus is set on only one aspect, e.g. the regulatory and legal dimension, or in other cases completely excludes the discussion of necessary resources for successfully implementing CCA measures. In the interviews the experts were asked on their perception of legal, administrative, institutional, technical, and financial capacities and competences for CCA measures in the respective national planning system.

Legal capacities are without any doubt essential to regulate planning activities and procedures of public authorities on different levels. Interviewees stated, that CCA as an overall objective should be integrated in planning legislation on all relevant levels. At the moment, this is often the case only implicitly (Interviews 1, 3, 6). Especially the regional planning level would need clear legal objectives and responsibilities on how to integrate CCA actions in its instruments (Interview 3). Besides the defining objectives in planning legislation the existing planning **instruments need to be developed further** to **better consider adaptation needs**. This is often a new perspective for the framing of the services that spatial planning has to ensure (Interviews 7, 13). At the same time many Alpine cities already tackle climate induced challenges and absent legislative foundations get simply substituted by local guidelines and strategy documents (Interview 10). This actually reveals the necessity for integrating not only clear mechanisms for adaptation action in planning legislation but also the need to prioritise measures, evaluate the implementation and take cumulative effects into account (Interviews 4, 7). Anyhow, interviewees reported, that CCA measures become increasingly binding in planning instruments (Interview 11) and enhancements are especially accomplished where problems are already pressing, e.g. to integrate green infrastructure on the local level to deal with urban heat (Interview 14). Overall, the development of legal capacities is a continuous process that is already underway (Interview 3).

Another important aspect are **administrative capacities** that relate to the potential and actual performance of administrative staff in public authorities. The interviewees highlighted several times the complexity of integrating CCA measures in planning decisions at the right level. The requirements concerning personal abilities and knowledge of administrative staff are constantly increasing. Therefore, **administrative staff needs educational possibilities and according resources**. Especially for small and rural municipalities this is an increasingly difficult task as they have to satisfy numerous administrative tasks (Interviews 4, 7, 9). At the same it is easier for small administrations to cooperate on a personal and direct basis (Interview 8). Especially regional cooperation was mentioned to exist already across borders (Interview 1). Interviewees highlighted at the same time, that the awareness for adaptation action especially through local spatial planning is not yet generally established (Interview 2). This is also because measures in NAS/NAP are not consistently thought through concerning the administrative capacities needed on regional and local level to foster actual implementation (Interviews 7, 11, 13).

The third aspect discussed in the interviews are **institutional capacities** that address in the first place a clear understanding of responsibilities and abilities of institutions. Concerning CCA the sectoral authorities (land use planning, nature conservation, water management, forest management, etc.) are typically the ones that should plan and implement adaptation measures leaving the **CCA coordinating institutions often in a position with no power to request actual implementation action** (Interview 1). Additionally, CCA is in institutions often the 'little brother' of CCM which is with its quantitative approach clearly regulated (Interview 6). Another highlighted aspect is the internal logic and prioritisation within public institutions that often result in poorly coordinated

adaptation actions (Interviews 6, 11). This is also why supervisory authorities have an essential role here to make sure that adaptation needs are integrated in planning decisions (Interview 3). An aspect that was also mentioned is the unequal distribution of possibilities to enforce CCA measures through regional institutions that have often only an advisory role (Interview 5). Besides the question of responsibilities of institutions, the actual abilities to act within institutions were mentioned by interviewees as well. For example, communicative expertise is nowadays essential (Interview 3) and overall sufficient recourses for the assigned duties need to be established (Interview 13).

The fourth aspect the interviews touched upon were **technical capacities** that are necessary to inform planning decisions. Climate data is in the first place processed through national meteorological services that have established international cooperation. National administrations – often in cooperation with regional ones – have set standards for climate scenarios and production of maps. Therefore, good and detailed scenario-based maps on climate signals are available (Interviews 1, 13). Especially **cities have overall the best and most detailed analysis and assessments at hand** (Interview 13) and compensated over the past years partly the lack of general assessments and analysis through their proactive role – also in research projects (Interview 14). An aspect that was highlighted as essential, is the cooperation between funding bodies and administrations that helped to define consistent data formats (Interview 1). Research projects that cooperate with regional and local authorities and administrations especially can take into account specific climate change exposures and adaptation perspectives (Interview 11). Interviewees also highlighted the start-up support especially INTERREG projects provide to develop research and practice further (Interview 4). At the same time, often the scientific perspective dominates the discourse leaving practical requirements aside (Interview 12). Overall, projects help to tackle the difficult question of dynamics and insecurities that come with climate scenarios and provide a solid basis for decision making (Interview 2).

A last aspect discussed in this interview section were **financial capacities**. A consensus in the interviews was, that funding for CCA activities comes mainly from the national/federal level in Alpine countries while implementation takes place mainly on the local level. Therefore, there is a **need for a thought-through system of distributing funds** (Interview 2) and such a system has to address CCA specifically. An integration in existing subsidy schemes would be the obvious choice (Interviews 1, 7). The regional level plays in many Alpine countries a major role in allocating European funds that are becoming more climate sensitive as well (Interview 10). Pilot projects were seen critical as they help to identify funding needs but do not automatically trigger a mainstreaming into existing financial funding schemes (Interviews 12, 13). A clear and transparent basis for such schemes is essential to plan ahead (Interview 13) while public budgets at the moment often clearly miss to address funding needs for implementation activities (Interview 4). Given the overall need for long-term strategic action to CCA, financing a solely project-based approach is seen to be not sufficient (Interview 2) even though especially European research programmes help initiatives to evolve (Interview 11).

The discussion on capacities and competences in the enabling environment for achieving and contributing to climate resilient development revealed interesting perspectives from the interviewed experts. Overall, there is no country in the Alpine region that has established a comprehensive framework addressing the five capacity categories for planning and implementing CCA measures. There is in general a need to clarify CCA objectives in planning legislation, to invest in training and expertise in administration and to improve the institutional coordination while defining responsibilities for CCA. The technical side was not seen as critical as often portrayed. Informed decision making on basis of existing climate scenarios, hazard maps or local/regional climate analysis is in fact possible – of course further enhancement is possible. Interestingly, financial capacities were seen as rudimentary developed with neither a clear budget for CCA action nor an appropriate distribution system in

place. A long-term funding perspective for CCA action is widely missing and a pilot-project based approach widely prevails.

5.1.3 Climate Adaptation and Resilience in Planning Practice

A key section in the interviews was the discussion on actual changes and innovation in planning practice to mainstream CCA and achieve a resilient development guided by informed planning decisions.

Climate signals mean for spatial planning – of course on different scales – a **change of hazard exposure**. Having certainty on observed and expected changes is key for any informed planning decisions. This is actually not easy to achieve as it is for certain hazard processes (e.g. fluvial flooding, landslides) statistically not possible to verify already a clear trend (Interview 2). This entails challenges for augmenting proactive adaptation measures. These uncertainties are difficult to communicate to (political) stakeholders. Especially, as hazard maps were produced for a different purpose[188] (mainly designing protection measures) and the integration of uncertainties needs guidance for inclusion in spatial planning (Interview 2). The necessary **adaptation is yet not displayed in connection with exposure maps to locate actual adaptation measures** (Interview 4), but this is in fact seen as a field of recent improvements (Interview 3). Often maps and assessments are drafted for rather small territories (Interview 4) with a specific need for a spatially coordinated implementation approach (Interview 13).

The knowledge on changing exposures is only one side of the medal. To guarantee effective use of funds, it is necessary to have solid knowledge on (changing) **vulnerabilities and climate risk**. Climate risk analyses are an essential component of NAS and exist mainly as large-scale assessments (Interview 13). Existing maps and assessment tools deriving from Disaster Risk Management are widely suitable to be further developed and included in the future climate change content as well. The need for a periodic update is of course a challenge (Interview 2). Any risk analysis depends on their purpose and has to choose the right scale (Interview 7). On the very local level insurance companies typically require detailed risk analysis and already integrate climate change in appraisals (Interview 2). Risk-based planning has been a priority in Switzerland, but the uncertainties and dynamics of climate change impacts make it extremely difficult to mainstream it into spatial planning consistently (Interview 12).

While the knowledge based on climate change impacts and deriving adaptation needs through spatial planning are fragmented all over the Alpine region, measures are implemented on different levels guided by either NAS and NAP or the immediate need to react and adapt. On **national (and trans-national) level** there is in the first place the need to clarify what CCA measures are assigned to spatial planning in particular, while it is typically rather unimportant for actual implementation (Interview 13). Monaco and Liechtenstein are due to their size of course an exception. In Slovenia, with its missing regional administrative level, the national level has more CCA responsibilities on national level than usual. The national level can especially provide guidelines and recommendations (Interview 13) and seek for trans-national coordination (Interview 4). CCA **measures on regional level** were seen essential in the interviews as spatial planning has a strong leverage here (Interviews 7, 13). The regional level has typically a strong coordinative role (Interviews 11, 13) and CCA measures on this level should be a main focus (Interview 3). The advantage of CCA measures on regional level is, that they are typically binding for any local planning and generate a direct impact (Interviews 3, 6, 9). Especially green infrastructure is dependent on connectivity and a regional perspective to deliver according climate services (Interviews 3, 7, 11). Historically, spatial planning is strongly anchored on the local level in nearly all Alpine countries and with land use planning on local level as a key to adaptation action (Interviews 6, 11). The **local planning level** is of course

[188] Schindelegger and Kanonier (2019).

a matter of political process. This might undermine adaptation needs, as measures should not be dependent on political priorities (Interview 7). Anyhow, CCA measures are at the moment only determined implicitly and would need a concise regulatory basis (Interviews 8, 10). Interviewees highlighted, that the reduction of soil sealing and preservation of agricultural areas is increasingly a planning principle on local level, even if not framed as a CCA measure (Interviews 7, 8, 10). This principle is of course connected closely with densification and brownfield development (Interview 10). Another aspect taken up on the local level is urban heat that receives own strategic plans and priority actions especially in cities (Interviews 9, 11). Cities are also the forerunners in addressing building design to deal with changing environmental conditions (Interviews 8, 10, 14) giving them a leading role while smaller (rural) municipalities struggle with the plurality of interests and responsibilities making CCA only one of many aspects to consider (Interviews 7, 11). Therefore, CCA measures on local level are typically problem driven and have to be built on established networks and approaches to be successful (Interview 14). Sometimes trade-offs with private landowners (on a contractual basis) are an approach that can be used for CCA activities as well (Interview 8).

The **implementation of CCA measures** is in the end a shared responsibility of many different public and private stakeholders. CCA measures are typically assigned to sectoral authorities leaving it up to them to decide what actions should be taken. Restrictive regulations can help to achieve coordination across levels and sectors and foster transparency (Interview 7). This also entails the need for defining priorities on CCA funding (Interview 13). Here CCA measures should be especially checked for multi-purposes and the combination of services (e.g. nature conservation) they deliver (Interview 2, 6). Existing procedures such as the Strategic Environmental Assessment hold a large potential to deliver such assessments (Interview 3). Especially in the Alpine region settlement and infrastructure depend on the services green infrastructures provide (protection forests, alluvial forests, etc.) but this is not represented in CCA implementation accordingly as it is an Alpine characteristic (Interview 8). In general, the iterative design of the practice was seen critical as experiences in the field, monitoring and evaluation should be used to develop the adaptation system further (Interview 13) and this process is rather slow at the moment (Interview 3). Once more, cities implement CCA measures problem driven and can serve as role models for the further development of the CCA system in spatial planning (Interview 13).

Even though the need for **monitoring in CCA** might be a general consensus, interviewees stated that consistent monitoring processes are not yet established (Interviews 3, 13). Cities are here among the first to design indicator-based systems (Interview 14). In fact, a prove of effectiveness of measures should be the prerequisite for funding and therefore monitoring always planned as an integrative component (Interview 13).

Two further key components discussed, were **sectoral cooperation and participation of citizens**. Sectoral cooperation was widely framed as essential with spatial planning as a coordinative and integrative platform (Interview 13) but in practice there is not a general common effort towards this role (Interview 11). For example, on keeping areas undeveloped, various perspectives are relevant and need to be incorporated in management (Interview 4). Cooperation needs in the first-place specific knowledge and capacities. The increasing necessity for accurate communication of public authorities needs often professional support (Interview 12) and should be close to scientific research (Interview 6). Functional rather than administrative entities should be the norm here (Interview 13) and especially municipalities should build on cooperation structures that already exist (Interview 1) as municipalities anyhow typically integrate different sectoral perspectives in public management activities (Interview 10). Participatory approaches are nothing new to spatial planning but especially CCA measures could be contested and need appropriate communication and participation of affected stakeholders (Interview 12). Here, competitions within municipalities could help to foster collaboration between experts and citizens to find innovative and accepted solutions (Interview12). Of course, it is essential to ensure transparent communication e.g. via WebGIS applications (Interview 11).

Some additional aspects were raised in the interviews not covered by the coding scheme. For example, that CCM is now well-established through civil engagement e.g. “Friday’s for Future” with CCA dragging behind in the public perception (Interview 1). In fact, the public awareness has changed during the past few years, but spatial planning has not understood fully to make use of this general awareness (Interview 3). Communication and wording are sensitive nowadays and need according expertise (Interview 12) as CCA can also be used as an argument for blocking development (e.g. densification projects) as well (Interview 1). And in general, the rather slow integration process of a comprehensive CCA perspective in spatial planning was mentioned, leading to a situation in which transformation processes are not fast enough to meet adaptation needs (Interview 2).

The discussion on CCA and resilience in spatial planning with the interviewees highlighted many essential aspects that need to be considered for further improvements. First of all, planning struggles to integrate uncertainties and dynamics in hazard exposure into its decision-making processes and the public communication. At the same time climate sensitive vulnerability and risk analysis are drafted for different purposes from local to national level but yet seek a consistent implementation through strategic and normative planning instruments. The national level provides guidance for CCA activities in all Alpine countries. The regional level is step-by-step strengthened to execute coordination on the one hand and actual CCA implementation through binding planning instruments on the other. In the end, the local level is still the main level for implementing CCA measures. Here, guidance by the regional level and an enhancement of planning instruments is needed to meet according requirements. Implementation action presents itself to be scattered and problem driven with cities typically as forerunners and hardly any monitoring schemes in place to actually learn through implementation activities. Sectoral cooperation is an immanent need as CCA implementation is typically not centrally coordinated. And overall, CCA measures need public participation to ensure understanding and acceptance.

5.2 Adaptation Pathways towards Climate Resilience in Spatial Planning

The interviews reflect the status quo of CCA implementation in and through national spatial planning systems. In the first place, the revealed shortcomings but also highlighted existing initiatives where adaptation is successfully taking place. The question of resilience and development of adaptation pathways was discussed widely implicitly with the interviewees revealing across the Alpine region a rather consistent picture.

Climate resilience is **not established as a guiding principle and concept** within spatial planning so far. But also NAS/NAP are widely not conceptualising climate resilience. The predominant approach is a sectoral one; identifying climate impacts and assigning adaptation services to different sectors. The responsibilities explicitly assigned to spatial planning differ widely among Alpine countries while the interviews show, that planning especially on local level is independently addressing adaptation needs even without guidance from the regional or national level. This leads to a situation, where climate resilient spatial planning has neither a common established understanding nor common indicators to evaluate the contribution of different CCA measures to the overall coping capacity towards climate change induced disruptions.

This starting position explains why the assessment for adaptation pathways, understood as development trajectories, delivers rather similar results. **Adaptation pathways** are **not an established concept** within CCA in general and spatial planning in particular in the Alpine region. There is in fact a rather problem driven and cause-and-effect based approach predominant. This means that planning perceives itself rather as a sectoral domain than a coordinative platform for adaptation action and with independent adaptation actions and logics on different planning levels. The shortcomings of the existing approaches are obvious and there are hardly any

approaches in place that base their considerations and CCA actions around a long-term adaptive approach to manage measured and likely climate change impacts.

Nevertheless, many actions and initiatives in Alpine countries already contribute to the development of integrative adaptation trajectories or have the potential to do so. The following examples give an exemplarily overview.

- **CCA guidance for regional planning – Switzerland:** No doubt, besides the strategic work for the integration of CCA in planning practice the capacity building among planning practitioners is crucial. The Federal Office for Spatial Development in Switzerland published recently a guidance on the integration of climate change into strategic regional plans.[189] The document is brief and clear in its objective to show what is already possible within the existing legal framework and also refers to good practice examples for orientation. Such easily accessible documents help to inform and educate planners and decision makers from a practical perspective.
- **KLAR! Regions – Austria:** Austria has launched in 2016 the KLAR! programme[190] to support regional bottom-up initiatives for climate change adaptation. Regions can apply to participate in the programme and receive funding to draft an adaptation concept (1 year) and implement actual measures in the following 2 years. In the 3 years continuation the regions will receive support through the KLAR! monitoring to consolidate collaborations and climate action. The programme aims to strengthen the regional perspective and help with initial funding to establish a continuous climate change adaptation process.
- **Klimacheck – Germany/Bavaria:** Bavaria developed within the C3-Alps project a "climate check"[191] tool for small and medium sized municipalities to provide guidance for adaptation action. In the first place the tool should help municipalities to evaluate the status quo of their climate change knowledge and awareness. The questions strongly relate to the exposure and vulnerability towards natural hazards. As the check represents only a snapshot it can be used to monitor the progress within a municipality. Furthermore, it is easily accessible and manageable. Spatial planning aspects can easily be included in the evaluation.
- **Klimalotse – Germany:** Climate change requires a comprehensive perspective and a systematic evaluation of climate impacts. "Klimalotse"[192] is a guidance tool, available since 2010, that addresses stakeholders especially on municipal level to better integrate climate impacts into their work a decision making processes. It relies on 4 modules: (1) Understanding climate change, (2) Identifying vulnerabilities, (3) Developing measures and compare them, (4) Developing a strategy and its integration, (5) Monitoring and evaluation. The tool can be used directly online and is therefore easily accessible.

[189] ARE (2022).
[190] Online: *https://klar-anpassungsregionen.at*, 17.05.2022.
[191] Online: *https://www.stmuv.bayern.de/themen/klimaschutz/kommunal/klimacheck.htm*, 17.05.2022.
[192] Online: *https://www.umweltbundesamt.de/themen/klima-energie/klimafolgen-anpassung/werkzeuge-der-anpassung/klimalotse#Einführung*, 17.05.2022.

6 Show-Case – Walgau/Vorarlberg

Applied climate change adaptation studies typically make use of case studies to analyse and illustrate the day-to-day practice especially on local level. Good practice examples should typically help as points of reference to mainstream topics in the general awareness. This is a common and valid approach at the same time debated as it typically falls short of integrating the actual complexities of e.g. achieving a climate-resilient development that is by nature always cross-sectoral and spanning different administrative levels. Nevertheless, the study acknowledges the need for referring to actual real-life situations and especially integrate the voices of those who in the end have to make political decisions and those who work on the very local level on the implementation of an effective climate change adaptation. Therefore, in the course of the project a stakeholder workshop was organized.

This **workshop** – originally planned as an on-site event – was conducted due to the overall pandemic situation via Zoom on 15th October 2021. It focused on the **State of Vorarlberg**, the **Walgau region** and the municipality of **Nenzing**. Besides the introduction of the study there were presentations by the mayor of Nenzing Florian Kasseroler on the status of climate change adaptation in the municipality, Andreas Marlin from the State Administration on keeping areas free of development, Wolfgang Lexer from the Austrian Environmental Agency on the KLAR! programme and Wolfgang Schilcher on protection forest management in times of climate change. The participants were invited to discuss with the speakers and reflect on implementation pathways based on their individual experience. The presentations were disseminated to the participants.

Figure 9: Workshop flyer – 15th Oct 2021

The workshop contributed to leading the discussion not only in a science orientated environment, but instead together with stakeholders from administration as well as political decision makers. The following sections should give an overview.

6.1 Climate Change Adaptation in Vorarlberg

The State of Vorarlberg is located in the very west of Austria bordering Germany, Switzerland and Liechtenstein. It has a total population of approx. 400,000 inhabitants and an area of 2,600 km^2. The urban development is concentrated on the eastern shore of Lake Constance, the Upper Rhine Valley. Vorarlberg is overall a very mountainous state with the lowest point at 395 m at Lake Constance and mountains reaching more than 3,000 m. Many municipalities are located in the valley floors with the settlement area reaching up the slopes. This brings overall a high exposure towards climate change impacts like changes in the water regime and rising temperatures.

Over the past years there were a number of research projects conducted in Austria – especially under the umbrella of the Austrian Climate Research Programme[193] –on regional to local climate projections and aiming on providing sufficient data. Therefore, Vorarlberg has a recent climate risk profile, decisions can be made on. The

[193] Online: https://www.klimafonds.gv.at, 17.05.2022.

data is available online open access[194] which is an essential step to reach out to stakeholders and decision makers on all levels. While there are no sever changes expected for precipitation, the number of heat days will significantly increase in Vorarlberg in any case (see Figure 10 for TCP 8.5). This is a drastic change that will affect sectors such as agriculture and forestry but also vulnerable people and especially economic sectors such as tourism that depend on a long-lasting snow cover in wintertime.

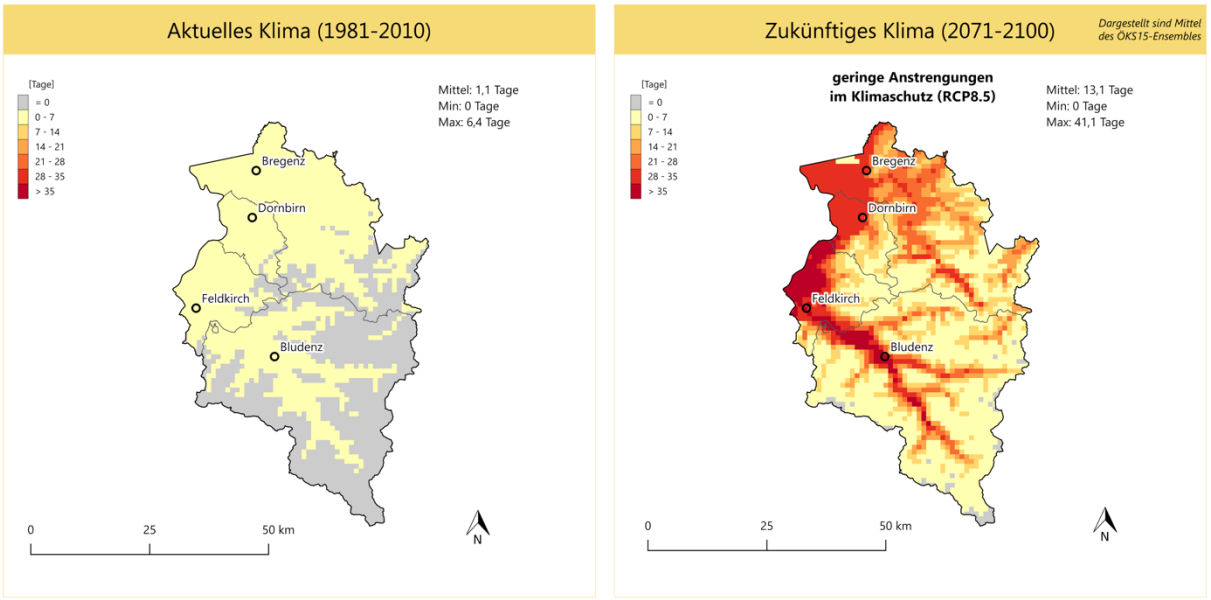


Figure 10: Number of heat days (CLIMAMAP)

Analyses show that the mean temperature might increase up to 4°c until 2100 in the business-as-usual scenario (RCP 8.5) which illustrates once more the disproportionate climate change impacts in the Alps. At the same time winter precipitation will increase but not necessarily falling as snow.[195]

Besides climate change mitigation efforts, the **State of Vorarlberg** adopted a **Climate Change Adaptation Strategy** itself.[196] It actually focuses on giving guidance to municipalities for adaptation activities and identifies nine sectoral domains for specific action (protection against natural hazards; spatial planning and building regulations; civil protection; water management; human wellbeing; ecosystem, biodiversity and environmental protection; traffic infrastructure; agriculture and forestry; tourism).

The implementation of the overall aspired objectives should be conducted by municipalities and state – as we as other – administration in collaboration. This means there are no pre-defined implementation pathways that get carried out through a climate change adaptation unit. In fact, there is only one person employed in the state administration of coordinative work.

A national programme regional associations can apply for, is the KLAR! programme.[197] It focuses on developing climate adaption actions on small-scale regional level to coordinate actions between municipalities and tackle existing adaptation needs together. In total 601 municipalities, approximately a quarter of all Austrian

[194] Online: https://data.ccca.ac.at/group/oks15, 17.05. 2022.
[195] Maraun et al. (2016).
[196] State of Vorarlberg (2016).
[197] Online: https://klar-anpassungsregionen.at, 17.05.2022.

municipalities, in 74 KLAR! regions are part of the programme that provides expertise, guidance and funding. In Vorarlberg five such KLAR! regions exist at the moment.

The adaptation actions in the State of Vorarlberg are therefore multi-layered, including local, regional, state and sectoral actions which all need in the end coordination and funding.

6.2 Climate Change Adaptation and Resilience in Spatial Planning

The **Climate Change Adaptation Strategy** of the **State of Vorarlberg** does not operationalise the resilience concept in any way, in fact it is very brief on the overall need for and challenges in adaptation action. This shows a very **pragmatic approach** that is in fact critical as the main document for climate change adaptation does not tackle important aspects such as inter-sectoral cooperation, governance, adaptive capacities, etc. that have been analysed and discussed in numerous publications.[198] Concerning the integration of climate change adaptation and resilience in spatial planning, several action fields are relevant: First, protection against natural hazards.[199] Municipalities should implement hazard maps and risk information via their planning instruments (development concept, land use plan, detailed development plans). This tackles especially keeping areas for flood retention and for flood run-off free of any development. Second, spatial planning and building regulations.[200] Municipalities should tackle water management on the local scale (retention, infiltration), foster object protection against natural hazards and manage heat through their planning instruments. The given approach of the Climate Adaptation Strategy shows, that spatial planning is seen as a key sector for adaptation action on municipal level but at the same time the document fails to formulate need for action and measures at the state level and state spatial planning which is rather surprising and, in any case, unfavourable.

To specify adaptation action, the state government adopted an **Action Plan 2021/2022**[201] in line with the Climate Change Adaptation Strategy and emphasizes especially the coordinative aspect needed for any effective action. It also reports on adaptation activities within state administration. For spatial planning the activities are (i) taking climate change into account in municipal development concepts, (ii) an Interreg project,[202] (iii) a survey on green roofs, (iv) and a guideline for green roofs. Besides, a consultation service on several topics exists. The essential action will be a regional climate analysis for the Rhine valley and Walgau region that will assess heat islands, fresh air corridors and cold air formation areas.

The state of Vorarlberg is in charge of spatial planning legislation and planning action on state level. The planning law does in fact only mention climate in course of the content of municipal development concepts. These concepts should take needs due to climate change into account.[203] A very vague reference indeed. **Andreas Marlin**, spatial planner and employee of the State Government, presented during the workshop on 15th October 2021 traces of climate change adaptation in the state's spatial planning. For the whole state territory there exists a non-binding development concept "Raumbild Vorarlberg 2030".[204] The concept refers to climate change and the need for action several times. It highlights e.g. the added value and climate service of green roofs. It also brings up the connection of climate change with natural hazard exposure. But overall, the document neither

[198] e.g. Kruse and Pütz (2014). Pütz et al. (2011).
[199] State of Vorarlberg (2016), p 2.
[200] ebd., p 3.
[201] State of Vorarlberg (2021).
[202] Online: http://klima.dachplus.org, 17.05.2022.
[203] § 11 Abs. 1 lit. f Vlbg Spatial Planning Law, https://www.ris.bka.gv.at/GeltendeFassung.wxe?Abfrage=LrVbg&Gesetzesnummer=20000653, 17.05.2022.
[204] State of Vorarlberg (2019).

operationalizes climate resilience nor gives clear guidance for adaptation action through planning. Andreas Marlin explained that adaptation action can be found implicitly in other planning documents. These are:

Ordinance on **green zones in the Rhine and Walgau region**: These green zones derive already from the 1970s and were initially meant to keep agricultural areas free of development and structure urban development. Over time the gained additional functions like recreational purposes and in recent years the value of these green zones for providing climate services (fresh air, cold air corridors, water storage etc.) is increasingly acknowledged but not yet codified.[205]

Ordinance on the **blue zone in the Rhine valley**: This ordinance was adopted in 2014 to keep areas free of development in the Rhine valley for flood retention and flood run-off. It overlays widely with the green zone but enforces an even stricter regime to avoid any development that would be adverse in case of flood events that exceed the design standards of flood protection infrastructure.[206]

The **white zone inventory**: This is a rather new accomplishment of the state administration and has only an informational purpose. A new methodology was developed to assess and express the degree of development for small scale landscape entities. Little developed areas are typically crucial for biodiversity and therefore important for climate change adaptation as well. The inventory is a basis for spatial planning general but without any binding effect to whomever.[207]

This overview impressively shows, that even if spatial planning is formally not assigned specific adaptation actions on state level there is a set of plans that implicitly contribute to climate change adaptation.

The **mayor of Nenzing** municipality **Florian Kasseroler** presented in the course of framework conditions of the municipality an overview of the manifold activities the municipality is involved in besides the mandatory administrative tasks. Most importantly Nenzing is a member within the regional association formed by 14 municipalities in the Walgau region. Via this association the municipalities cooperate on many topics (identity, cultural heritage, common infrastructure etc.).[208] The regional association is also the entity that applied for the participation in the already mentioned KLAR! programme. The municipalities developed together a **climate change adaptation concept for the Walgau region** and work now together towards the implementation.[209] The concept outlines 10 activity fields with specific measures. The overall measures address communication and awareness in the population. For the spatial planning sphere several measures are relevant: (i) reduction of soil loss (erosion in the forest, humus and retention) and (ii) managing heat (consulting service, green roofs, design of public spaces, building with clay). This clearly shows that for many relevant natural hazards (esp. floods, debris flows, avalanches) comprehensive information for decision making is already existing (e.g. hazard maps, expert advice in building procedures) and is integrated in local planning decisions. Like in all other Alpine countries there exist legal regulations on restrictions and conditionalities that harmonize natural hazard management in spatial planning. Pluvial flooding and heat as well as dependencies on natural features (open areas for water retention, protection forest to prevent erosion, etc.) are here integrated into planning via the adaptation concept of the regional association.

One last talk was given by **Wolfgang Schilcher**[210] on the management of protection forest in times of climate change. In general, mountain forests are essential for hazard protection but also for keeping steep slopes stable

[205] State of Vorarlberg (2017a).
[206] Löschner et al (2019b).
[207] State of Vorarlberg (2017b).
[208] Online: *https://www.imwalgau.at*, 17.05.2022.
[209] Fischer et al. (2020).
[210] Head of Regional Headquarters Bludenz, Austrian Service for Torrent and Avalanche Control.

and preventing erosion. Climate change brings new challenges and aggravates existing ones in forest management. Increasing aridity worsens the bark beetle situation, especially for spruce trees. Snow loads encounter weakened trees leading to wide ranging devastation, gliding snow poses as an additional threat to forests as well as buildings and infrastructure. Climate change also brings new illnesses to the forest such as the black snow mold. Windthrow affecting predominantly weak trees poses another problem. One of the biggest challenges though is the high number of game that browses in the forest and impedes natural rejuvenation. This leads overall to a situation in the area where the mountain forest is in bad shape and needs constant attention and investments. Spatial planning is in fact not explicitly showing the dependency of settlement development on the protection service mountain forests provide. In fact, settlement activity would be strongly limited without the mountain forest if not impossible.

Concluding, spatial planning is tackling climate change adaptation already on different levels in the State of Vorarlberg even though it is not always titled as such. Regional cooperation turned out to contribute a new momentum and promoting adaptation action through planning in coordination with other sectoral domains.

6.3 Transferability of Results

The workshop discussion contributed additional perspectives on climate change adaption in and through spatial planning from other Alpine regions. There was a certain consensus that the model of Walgau/Vorarlberg serves well as a role model for reflecting the topic as **similar challenges** occur:

- **Unclear responsibilities:** Adaptation action is depending on local initiatives as there is no coordinated CCA approach among different sectoral domains. This coordination on regional level is an essential field for improvements.
- **Weak transnational context:** Spatial planning is in general hardly trans-nationally orientated and that is just the same for climate change adaptation. Measures apply mainly to the regional and local level. Especially in natural hazard management cooperation exists (e.g. flood protection at the Upper River Rhine) and CCA aspects can be increasingly mainstreamed in existing international cooperation. The generation of trans-national assessments and maps on regionally relevant climate impacts is already slowly being implemented and could be improved further.
- **From conceptualisation to implementation:** The case of Walgau/Vorarlberg shows, that overarching CCA objectives and strategies are in place, but a consistent implementation is still absent. This is due to the nature of such a process which does not fit a project logic but is a continuous process.
- **Dependencies are not displayed:** Spatial planning does not clearly display dependencies for development on areas that provide protection and climate services. This would be especially necessary for protection forest and areas that provide flood retention services or are important for cold air emergence and fresh air circulation.

Knowing the gaps and shortcomings in the case study region on the one hand and the CCA initiatives on the other hand, the question of transferability comes up. Which approaches and solutions could inform and help other Alpine regions and stakeholders?

- **Regional cooperation based on existing structures:** The workshop and especially the statements of mayor Kasseroler clearly highlighted the importance to establish CCA action based on existing regional

cooperation structures. As there are limited resources on local level and the most co-benefits emerge if local stakeholders combine different perspectives and responsibilities in one cooperation network.

- **CCA needs to be denominated:** Spatial planning in the case study region already addresses climate impacts on different levels but does not explicitly highlight actions as adaptation activities. This approach makes it difficult to establish monitoring and evaluation schemes. CCA activities need to be denominated therefore explicitly.
- **KLAR! region:** The main reason why CCA is increasingly implemented in the case study region is the KLAR! region programme which pursues a bottom-up approach and fosters local and regional initiatives by providing initial funding and slowly handing over funding responsibility for CCA action to local and regional authorities.

Within the project a short **video clip on CCA in Walgau and Vorarlberg** (Austria) was produced. It is available via the EUSALP Action Group 8 Homepage and via *Youtube*.[211]

[211]Online: *https://www.alpine-region.eu/results/regional-actions-climate-change-adaptation*, 17.05.2022.

7 Conclusion – Recommendations

The study proves to be a timely contribution to the overall discussion within the EUSALP perimeter on a better integration of CCA action in spatial planning. The meta-analysis of relevant climate signals and climate change impacts in the Alpine region clearly outlines fields of action for spatial planning on different governmental levels and shows that a differentiation in adaptation approaches based on spatial, societal, and economic characteristics would be more suitable as one-fits-all solutions (see chapter 3). The secondary analysis of research projects reveals further that only the INTERREG project CLISP did take a comprehensive look into CCA and its connection to spatial planning in the Alpine area. Findings and recommendations of this project are widely valid to this day.[212] Of course, other international research projects touch upon planning as well and contributed over the last years to the enhancement of the common knowledge basis (see chapter 4.1). The review of adaptation strategies on different levels further gave a clear insight in the different rationales. The specific climate change exposure of mountainous regions is not generally acknowledged and assigned responsibilities to spatial planning in CCA action are sometimes generic and in other cases extremely detailed (see chapter 4.2). Finally, the interviews with planning and CCA experts from all over the Alpine area and the review of recent initiatives helped to identify both, gaps in the recent implementation practice and entry points for enhancements.

The following discussion summarises first results of the study and formulates recommendations for action. The results are clustered for a better overview according to the introduced framework for CCA in spatial planning (Figure 8).

- **ENABLING ENVIRONMENT**
  - **Climate resilience is not yet a guiding principle in spatial planning**
    Especially the interviews showed that climate resilience as a concept is rather used in science and not established as a guiding principle in day-to-day planning practice. CCA action in planning is therefore rather problem-oriented and does not seek for a comprehensive evaluation and enhancement of coping capacities to overcome climate change triggered disruptions.
  - **Trans-national perspectives are only exemplarily integrated in CCA action**
    The interviews also revealed that spatial planning overall has not a strong trans-national perspective in the Alpine region even though many common challenges exist. Therefore, CCA action is also hardly undertaken in a cross-border collaborative effort. One explanation is the fact that borders of EUSALP member states are often formed by high mountain ranges that prevent close cooperation in spatial planning to a certain extent. Of course, exemptions exist as well. For example, in the upper river Rhine valley Switzerland, Liechtenstein and Austria cooperate already for some time. Urban development and climate change perspectives are step-by-step integrated here as well.
  - **CCA action in spatial planning is guided by manifold goals and objectives but is not consistently operationalised – a sectoral perspective prevails**
    The single NAS/NAP provide throughout the Alpine area comprehensive guidance for CCA action and assign responsibilities to authorities in charge of spatial planning. Generally, a sectoral approach prevails but consistent pathways as adaptation trajectories hardly exist. This makes adaptation action a matter of political priorities and/or perceived urgency.

[212] Pütz et al (2011), pp 13-18.

- **CCA and spatial planning are hardly addressing emerging land use conflicts**
  The provision of climate services by natural features (mountain forests, alluvial forests, etc.) and public/private spaces causes in fact emerging land use conflicts with other overall societal objectives (e.g. agricultural production, provision of affordable dwellings). NAS/NAP are not addressing the fact, that CCA action is competing with other societal needs and experiences opposition as well.

- **CAPACITIES AND COMPETENCES**

  Overall, no EUSALP member state has established a comprehensive planning and budgeting for CCA action that would include responsibilities that lie with spatial planning. Capacities and competences are developed in a complex interplay of international and national research projects as well as rather problem-driven initiatives on national, regional and local levels.

  - **Legal:** Planning law was reported to be enhanced continuously but with a widely differing pace and dependent on political processes. Here, perspectives of experts differ strongly: some argued that CCA measures are widely possible within the existing legal planning frameworks and with the established planning instruments while others urged that legislation needs to be developed further to not just enable but rather request effective CCA. NAS/NAP are not consistently implemented through planning legislation.
  - **Institutional:** CCA is in the Alpine area widely assigned to sectoral authorities leading on the one hand to the need for extensive coordination concerning single CCA measures and on the other hand to a situation where nobody is in charge. Especially in spatial planning, the different planning levels have typically no clear idea of CCA measures they would be responsible for and predominantly have a problem-driven approach.
  - **Administrative:** Projects and interviews clearly showed that CCA is on the agenda in single public administrations and that specific expertise gets established according to the actual needs, while there is no comprehensive planning for personal resources and competences in place.
  - **Technical:** Technical capacities and competences have seen the biggest improvements over the past few years on all governmental levels and across the Alpine area. Many CCA relevant analysis and maps (pluvial flooding, drought exposure, urban heat islands, cold air emergence. etc.) are now available that did not exist a few years back. New technical standards have been developed and spatial planning has actually a sound basis now for strategic planning and decision making. Interviewees generally claimed, that the quality and availability of information on climate change is not an obstacle anymore for effective adaptation action.
  - **Financial:** In fact, the study could not look into greater detail into the financial dimension of CCA in spatial planning, yet the interviewees outlined, that there is hardly any specific funding for adaptation action in planning. It has to be mainstreamed in existing planning processes in the first place. Especially cities are forerunners in CCA on local level and increasingly establish sufficient funding in their budgets.

- **CCA MEASURES IN PLANNING PROCESSES AND INSTRUMENTS**

  Actual implementation of CCA measures by and through spatial planning instruments is mainly carried out on regional and local level. The interviews addressed implementation practice and shortcomings from an expert perspective.

  - **Different priorities on different levels with a weak national planning level concerning CCA**
    There is hardly any CCA planning on national level while local and regional levels pursue typically

different goals in adaptation leading to a situation where actions on different levels are not well coordinated.

- **There is a sound information basis for some climate change impacts while for others the determination of proportional adaptation measures is difficult**
  Small-scale climate impacts are increasingly mapped especially on local level. In particular, urban heat islands as well as cold/fresh air and general climate risk assessments on municipal levels complement the well-established hazard maps (e.g. fluvial flooding, debris flows, avalanches, rock fall). While heat effects can be comparatively well predicted the likely changes of e.g. fluvial flooding events are difficult to assess. This leads to a situation where decision makers would need to take uncertainties and dynamics into account. This is typically opposing the planning principle of an objective basis for decision making.

- **Resilience as an overall objective is not mainstreamed in day-to-day planning practice**
  Spatial planning has to satisfy diverse societal, economic and ecological needs and balances interests guided by planning goals. The integration of a CCA perspective is rather a slow development than a paradigm shift or transformation to resilient spatial planning in general.

- **Existing planning instruments are increasingly used to safeguard climate services and adapt urban development to encounter climate change impacts**
  Planning instruments on regional and local level integrate climate services in their justification which means in the first place keeping areas free of development and manged in certain ways. On the local level urban development tackles increasingly urban heat, cold air flows, and small-scale water retention in planning procedures and through planning instruments.

- **There are hardly any evaluation and monitoring systems in place to help improve adaptation strategies and prioritise measures**
  The interviewees highlighted adaptation measures that are increasingly integrated in spatial planning procedures and instruments but also acknowledged the fact that there are no standardised evaluation and monitoring approaches to actually prove the effectiveness of measures and enhance the adaptation framework in general.

Overall, the analysis and interviews show, that adaptation pathways are not yet comprehensively discussed and implemented for spatial planning. Climate resilience is rather a haphazard product of numerous efforts and individual decisions of stakeholders in planning processes and procedures. Cities in the Alpine region are with no doubt the forerunners in integrating CCA in spatial planning as they experience climate change impacts directly.

7.1 Recommendations

The results of the study support the development of three major fields of action concerning climate resilient spatial planning in the Alpine region. These fields are rather action than science orientated to help develop concrete adaptation action and not only elaborate on the understanding of climate resilience and adaptation pathways.

A general and important statement concerning the effectivity of integrating adaptation action in planning by many interviewed experts was the necessity to **acknowledge climate change adaptation as imperative**. It should not be a question of political priorities, if it is acknowledged as an essential aspect within spatial planning. The Alpine states have already widely adopted CCA as a guiding principle in their planning laws but improvements to highlight the urgency are possible.

The following recommendations can be formulated on basis of the conducted study and analysis:

(1) Develop adaptation pathways that integrate spatial planning and rely on extensive coordination

Adaptation pathways are typically problem-driven and should rely on a flexible framework that allows to adapt over time to changing conditions.[213] The need for a certain flexibility to adapt priorities over time is essential for spatial planning that has to satisfy manifold development needs. Now, it has to additionally integrate CCA in planning and decision-making processes. Environmental conditions change rapidly due to climate change and adaptation has to rely on efficient sectoral coordination and polycentric governance to develop and support effective adaptation action. There is an **urgent need to understand CCA as an integrative part** of a **management assignment** in spatial planning that reaches from the **trans-national to the local level** according institutions in defining well-adjusted adaptation measures. It is **not sufficient to assign responsibilities to single sectors** and expect effective adaptation action without establishing sufficient capacities and competences at the same. **Extensive cooperation** has to integrate politicians and decision makers on the respective levels and ideally builds on existing cooperative structures. Especially local and regional decision makers would need the possibility to better integrate sectoral perspectives (water management, disaster risk management, nature conservation, etc.) in their decision-making processes. The legal authorisation and **assignment of responsibilities** alone **does not deliver sufficient climate change adaptation** by itself. It is therefore indispensable to understand CCA as a long-term management process that needs to be flexible concerning its spatial scale and combination of sectoral perspectives. This is in fact an alternative draft to the common approaches. Finally, this would mean, that climate impacts should be managed on the respective relevant level with the specifically needed stakeholders based on a continuous iterative learning process. This propagates a problem-driven approach that is boundary spanning.

(2) Identify dependencies of nature-based solutions to better inform planning decisions

Planning documents – especially strategic ones – hardly display what areas are needed for specific climate or hazard management services. Open land fulfils typically manifold functions (agricultural production, cold air emergence, recreation, hazard protection, control of hazard emergence, flood retention etc.) that are a prerequisite for any urban development in the Alpine region. Especially the **Alpine core area depends extensively on protective forests** that preserve soil, provide hazard protection, hold biodiversity, are economic assets and areas for recreation. As spatial planning can especially contribute in the preservation of open land to safeguard certain functions – foremost on regional level – it would be essential to **better integrate dependencies on areas that provide climate services, hazard protection or control hazard emergence** in planning processes and finally **in planning documents**. This requires a close collaboration with other sectoral domains, especially forest and water management as well as nature conservation. Interdependencies need to be communicated better to the general public to generate awareness and acceptance. This can be seen as an entry point for participation as local knowledge and personal experiences would be required to identify dependencies. It is therefore not solely a technical and systematic question.

(3) Establish an iterative learning process to foster a resilient development

Spatial planning systems in the Alpine region have hardly operationalised climate resilience. To support a resilient development, it would be of outmost importance to establish a **monitoring and evaluation practise** that displays the **effectiveness and efficiency of CCA measures implemented through spatial planning**. Typically, an indicator-based approach would allow a comparative and context independent monitoring and could be used to enhance

[213] Werners et al. (2021).

the enabling environment, build capacities and improve overall climate governance. No doubt**, Alpine cities are the forerunners in integrating CCA action in spatial planning** as they also experience immediate climate impacts. The networks Alpine cities build are showcases that mutual learning and extensive cooperation is necessary to foster a resilient development. A learning process also means that established approaches need to be questioned. Integrating "climate proofing" in planning processes and procedures could be a possible approach.[214] The enhancement of EIA and SEA to better integrate climate signals and impacts should be considered as well. Also, Disaster Risk Management needs to allow development by integrating climate change in its existing schemes and approaches.

The results of the desk research and interviews clearly put forth the shortcomings of CCA in spatial planning in the Alpine region that has not yet mainstreamed climate resilience as an overall societal objective and has not established a comprehensive approach to ensure effective and efficient CCA action. Therefore, a stronger focus on cross-sectoral coordination, identifying areas and the climate services they provide and an ongoing learning process is necessary.

[214] Birkmann and Fleischhauer (2009). Schindelegger et al. (2021).

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