D1.2. Regional Diagnosis for Climate Change Adaptation

Baselines for Demonstrator Regions and Factsheets for Replicator Regions

MOUNT RESILIENCE

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Authors	Alina Bärnthaler, Barbara Demeterova, Katharina Gramiller & Johannes Suitner (TU Wien, Institute of Spatial Planning, Research Unit Urban and Regional Research)
Contributing Partners	Constanze Fetting, Tess Landon, Emma Neuner (ZSI – Centre for Social Innovation)
Reviewers	Università degli Studi di Milano (UMIL) & ZSI – Centre for Social Innovation
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List of Acronyms

CC	Climate change
CCA	Climate change adaptation
DA	Demo activity
EU	European Union
FVG	Friuli-Venezia-Giulia
GDP	Gross domestic product
IC	Impact chain
IPCC	Intergovernmental Panel on Climate Change
NGO	Non-governmental organization
PGK	Primorje-Gorksi Kotar
PPS	Purchasing power standard
SCR	Systemic climate risks
SETS	Social-ecological-technological systems
SRA	Systemic risk assessment
TC	Transformative capacities
VDWS	Regional validation workshops

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Keywords list

- Transformative climate adaptation
- Climate governance
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- Transformative capacities

Note on authorship

The regional profiles of the Demonstrator Regions (chapters 1.1, 2.1, 3.1, 4.1, 5.1, and 6.1) were co-authored by TU Wien and ZSI. The systemic risk assessments for the Demonstrator Regions (chapters 1.2, 2.2, 3.2, 4.2, 5.2, and 6.2) were authored by ZSI. All other chapters were authored by TU Wien.

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Executive summary

The state of CCA in European mountain regions

Great awareness, but lack of strategy and directionality for transformation: Climate change adaptation is a pressing issue in all mountain regions, as awareness of current and looming climate change impacts is generally high. However, compared to climate change mitigation, adaptation is a relatively novel governance issue, as reflected in the limited availability of concrete strategies and transformative visions in most regions. While adaptation is specifically addressed at the national level in all MountResilience regions, only the Canton of Valais and Catalonia have a regional strategy that is solely dedicated to CCA. Hence, most regions lack a clear transformative vision that gives directionality for transformative adaptation in the short, medium, and long run.

Change is incremental, and regional identity is both an adaptation driver and barrier: To date, climate change adaptation in the regions is mainly incremental and reactive, lacking pro-active and forward-looking adaptation action. One reason is that regional adaptation priorities are not perfectly in line with regional systemic risks but often rather prioritise the maintenance of established economic pillars that are synonymous with a regional identity. With that, future-proofing sectors that are essential to that identity becomes a driving force for adaptation – though at best incrementally – while simultaneously complicating transformative adaptation that would call for thinking beyond existing self-images and envisioning alternative economic pathways and climate resilient regional futures. This partly explains the lack of transformative approaches to adaptation as apparent in all demonstrator regions.

Governance innovation and behavioural change are dominant: In all regions, emphasis is placed on innovations in governance (such as new modes of collaboration, policy coherence, improved institutional frameworks, or knowledge management) to effectively address climate change adaptation. However, much of the hopes and responsibilities is put on behavioral change of private households (via awareness raising and educational programs), whereas state regulations are rare. Also, while “intact” nature is a key resource and identity forming factor in most mountainous regions, nature-based solutions only play a subordinate role in climate change adaptation.

Collaboration, knowledge, financing, and acceptance are key: Four issues are recurrently stressed as impeding accelerated adaptation action: (1) Gaps in stakeholder inclusion and cooperation in CCA governance, (2) a lack of CCA-related data and, relatedly, detailed vulnerability assessments and intensified knowledge and data exchange, (3) the financing of adaptation actions lagging behind the will to adapt (particularly in less affluent regions), and (4) acceptance and awareness for the need to adapt among a wider population.

General advice for CCA governance

Establish context-sensitive climate change adaptation governance: There are no one-size-fits-all solutions for regional climate change adaptation governance. Mountain regions vary greatly in their ecosystem and environmental conditions, their structural and functional geographies, as well as their socio-economic structure. These create significantly different patterns of exposure to climate risks and, in combination with established region-specific governance frameworks, local cultures, and well-proven technologies and practices, call for the development of place-based adaptation pathways. The MountResilience regions are trying their hand at it, but at the same time reveal how place-based adaptation governance is a balancing act between evidence and interests, path-dependence and path-shaping. This requires inclusive governance and experimentation for place-based adaptation to be accurate, legitimate and transformative. The Demonstration Activities can be valuable steppingstones towards that, if they are interpreted as resources of learning, capacity building and governance innovation.

Develop clear, positive visions of climate resilient regional futures: Regional climate change adaptation still often gives the impression of a haphazard approach. Numerous valuable ideas are being developed and individual adaptation actions are being implemented, but hardly in concerted fashion. One reason is that regions lack a transformative vision of what a climate-resilient regional economy and society would look like, how the main socio-economic sectors will need to change accordingly and by what means. Such visions are important, as they give directionality for decision-making about adaptation actions and, relatedly, security for investment in transformative projects. They draw up a clear pathway for change for private households and other stakeholders and hold decision-makers accountable. The co-creation of such transformative regional visions should thus be high on the agenda of Europe's mountain regions.

Increase systemic risk awareness: The concrete elaboration of climate change-related vulnerabilities and their interdependencies and cascading effects is an inevitable step to drive effective region-specific adaptation. In line with the IPCC (2022), this vulnerability assessment serves as a starting point and convincing argument for transformative measures, as it demonstrates the increase in risks and costs of inaction, coping or incremental adaptation measures. This requires a regionally well-structured CCA data governance and effective knowledge management between relevant stakeholder groups and decision-making levels. All MountResilience regions are pointing to the relevance of changes in regional governance to succeed in their CCA ambitions. However, there is still room for improvement when it comes to systemic risk awareness in general and among specific stakeholder groups, and as concerns its operationalization in tailored adaptation actions.

Enhance transformative capacity: The development of transformative capacities is indispensable for the success of transformative adaptation. Concluding from the regional diagnosis, the following regional capacities should be particularly emphasized: (1) Inclusive and multiform governance, that is, wide and diverse stakeholder participation and cross-sectoral diversity (specifically in Gabrovo, Lapland, Râu Sadului and Valais), (2) shared understanding, memory and system awareness of adaptation including its system components, implying socio-economic and climate system and ensuing region-specific climate risks (Gabrovo, Lapland, Râu Sadului and Tyrol), (3) foresight, shared CCA vision and understanding of alternative regional scenarios (Gabrovo, Tyrol and Valais), (4) polycentric and socially embedded leadership, allowing for the articulation and commitment of new visions (Piedmont and Valais), (5) empowered and autonomous communities that have access to resources and coalitions (Lapland and Râu Sadului), and (6) transformative projects and practices that allow practical experimentation (Piedmont and Tyrol).

In all the above aspects, regional biophysical, socio-economic, technological and cultural specifics play significantly into the potential pathways for transformative adaptation, which leads to the following specific conclusions for the MountResilience Demonstrator Regions:

The province of **Gabrovo**, with its namesake administrative centre, the municipality of Gabrovo, is located at the foot of the Balkan Mountains. It is particularly affected by climate change through flooding, forest fires, droughts and heat waves. In the municipality of Gabrovo, these extreme weather events are threatening urban green and blue infrastructure, and especially vulnerable population groups. Although the municipality of Gabrovo benefits from a well-connected stakeholder network and good leadership, current CCA approaches remain at focusing on raising awareness in the local community and sustainability initiatives. The municipality and the province both lack a comprehensive CCA strategy that provides concrete transformative vision and guidance for CCA actions. The diagnosis hence concludes that a comprehensive regional CCA governance framework should be established that focuses on (1) increased coordination and cooperation between the public sector and R&D, and (2) empowering and educating local farmers, business owners and residents in CCA practices.

(Northern) **Lapland**, a region with unique arctic conditions and home to the indigenous Sámi communities, is particularly affected by climate change. The main livelihoods in Northern Lapland, (winter) tourism and the traditional Sámi livelihoods of reindeer herding and fishing are especially vulnerable to rising temperatures and extreme weather events, as their economic viability and ultimately their existence is dependent on foreseeable seasonal and climatic

conditions. Even though Finland is a pioneer in CCA strategies in the EU, Lapland lacks a comprehensive CCA governance strategy, although adaptation actions are currently undertaken on an individual level and various projects regarding CCA in the Arctic have been conducted already. However, the intensification of land use conflicts and gaps in action and knowledge of adaptation possibilities intensify the (political) need of approaching CCA with a strengthened governance framework, an improved representation of independent communities, and financing instruments for adaptation action. The diagnosis suggests that in order to properly address its climate challenges, Lapland should utilize experiences from the breadth of prior climate- and sustainability related research and innovation projects and ecosystem-oriented local interventions for developing innovative adaptation actions and incorporate traditional knowledge and perspective of the Sámi in envisioning climate resilient human-nature relations and developing suitable nature-based solutions.

Piedmont faces an increased risk of droughts, hydrogeological instability, floods, forest fires, and coastal erosion. Substantial shifts in land use and farming practices in the region's vital agricultural and industrial sectors will only exacerbate climate change impacts. Key adaptation challenges include inefficient water governance, insufficient agricultural adaptation practices, loss of biodiversity and cultural landscapes, and cooperation, knowledge and action gaps. Addressing these challenges requires more coordinated governance efforts, active community involvement, and innovative water and land management approaches to enhance resilience and enable transformative change. Therefore, the adoption of stronger bottom-up, partnership-oriented approaches, improved data and knowledge exchange and the reduction of reluctance towards agricultural innovations is essential to embrace transformative ideas. With prevailing governance and complex ecosystem challenges related especially to the regional water infrastructure, the region should consider investing in and building strong regional CCA networks. As addressed in the systemic risk assessment, with changing climatic conditions and the increased risk of drought in Piedmont, also water-intensive agricultural products need to be replaced soon, together with finding new ways of governing more efficient water usage in private and agricultural practices and actively protect ground- and surface water availability. Advice is especially directed at the multifaceted challenges in agricultural water management. We identify the need for more flexible water governance, enhanced stakeholder coordination, generational shifts in farming practices, field training, and infrastructure enhancements to foster local resilience. Crucial elements to adaptation are also local community engagement in planning, supporting strategies like digitalising villages, together with building robust knowledge transfer networks among farmers and researchers.

Râu Sadului's key adaptation challenges include threatened (water and transport) infrastructures, endangered local livelihoods, and a lack of stakeholder collaboration and problem awareness among the population. The region is well aware that inclusive governance structures, local problem awareness, the provision of basic CCA funding instruments, active outreach and collaboration are essential. Given these challenges, support for building new stakeholder networks and collaboration is indispensable. As the systemic risk analysis for the agricultural sector has shown, climate change will lower agricultural yields, lead to a loss of biodiversity, depopulation and the abandonment of agricultural land. Hence, knowledge and financial support for local innovation-oriented activities are necessary for developing new solutions in one of the region's most fundamental economic sectors. For the successful implementation of the Demonstration Activity, we hence suggest increasing local stakeholder involvement, the provision of financial support for small farmers, a more thorough integration of research findings into policies, paying attention to balancing agricultural transformation and nature conservation, and fostering collaboration between local councils, educational institutions, and private actors.

Tyrol is a well-known (winter) tourism destination. Its rural, mountainous parts are experiencing increased ecosystem and infrastructure damage and reduced snow reliability for winter tourism, whereas the urbanised Inn Valley is increasingly affected by heat. Key challenges thus include the economic damage and vulnerability of tourism as one of the region's economic pillars, as well as a lack of awareness, ambition and (political) commitment to pro-active and transformative adaptation. Although Tyrol has been engaging in adaptation for more than ten years, the current strategic framework for CCA is considered insufficient. Addressing Tyrol's climate risks therefore requires political

leadership, including a concrete regional CCA vision, and increased implementation and upscaling of adaptation measures by providing more financial and human resources. CCA should be coordinated across administrative levels but implemented in close cooperation with regional managers and local associations and institutions, who are key intermediaries. It is thus advised to (1) initiate a holistic and inclusive discussion on alternative development paths that go beyond the preservation of the status-quo, (2) increase awareness of adaptation requirements, especially of buildings and pursue more profound changes in building culture, (3) strengthen the regional strategy framework and (4) prioritise key adaptation measures, rather than concert a multitude of approaches.

The Canton **Valais** is rich in water resources, but rising temperatures, decreasing precipitation in summer, change in snowmelt and precipitation patterns as well as increasing water needs result in increased periods of water shortage, especially in summer. This has far-reaching secondary consequences for private households, but also industry, tourism and agriculture. A key challenge in this regard is fragmented water governance, which lacks coordinated, proactive and foresighted management and prioritisation of water usage on a cantonal level. Additionally, awareness of CCA requirements and resources for adaptation appear to be lacking among the local administration. Addressing Valais' climate challenges hence requires novel approaches to governance that explore new forms of inter-communal cooperation beyond the strong autonomy of the communes but also consider the crucial role of civil society within Switzerland's direct democratic governance system. In this context, changing people's attitude and behaviour through awareness-raising and nudging is seen as a major lever for driving adaptation action in Valais. Additionally, although Valais is embedded in an extensive strategy framework for adaptation, there is a discrepancy between strategically formulated goals and the actions undertaken. It is therefore advised to (1) utilize the drive stemming from a renewed interest in improving water governance in Valais, (2) engage a critical mass of citizens in water governance, (3) address existing knowledge and power imbalances given that key data on water consumption are gathered by economic actors, and (4) reduce water-demand in general.

First analytical peaks into the MountResilience Replicator Regions draw the following picture:

In **Catalonia**, CCA is comparably high on the political agenda. The region has a dedicated adaptation strategy in place to tackle floods, droughts, heatwaves and wildfires and address adaptation needs in specific socioeconomic (sub)areas and environmental ecosystem dimensions. Implementing tailored governance innovations and nature-based solutions is recommended though to accelerate adaptation in practice.

Primorje-Gorski Kotar at the northern Adriatic coast is particularly challenged by prolonged dry periods followed by sudden and intense precipitation and flash floods, as well as sea level rise, which particularly endangers urban settlement areas. However, to date, CCA is only marginally addressed and the development of an adaptation plan for the coastal area is thus recommended to guide regional adaptation action.

The **Subcarpathian Region** is impacted by more irregular, heavier rainfall and frequent intense heat waves eventually leading to more severe droughts, forest fire and water scarcity. There is no regional adaptation strategy yet. However, resulting from a flagship project in 2015, the city of Rzeszów, which is the capital of the Subcarpathian Region, has published its own adaptation plan. This plan should serve as a starting point for the development of an evidence-based regional adaptation strategy that can tackle the risks for the wider socio-economic and ecosystem.

Friuli-Venezia Giulia, an autonomous Italian region in the country's Northeast, is experiencing an increase in climate hazards and altered precipitation patterns, which adversely affect local livelihoods and biodiversity. A working group composed of regional universities and administrations is already leading the way in CCA research, which is a hopeful for the development of a tailored, evidence-based regional strategy that guides the way for transformative adaptation.

1. Baseline – Gabrovo

1.1. Regional profile

Regional structures, political competencies and development objectives profoundly influence the potential pathways for regional CCA. This chapter introduces the topographic, functional, environmental, and socio-economic characteristics that shape the region structurally, briefly introduces the territorial governance framework to illustrate the region's formal competencies for implementing CCA autonomously and outlines the dominant self-image to sketch the normative starting point for regional CCA.

Bulgaria is particularly vulnerable to climate change (CC), primarily through an increase in CC-related extreme weather events due to rising temperature and extreme precipitation (Republic of Bulgaria 2019). Overall temperatures are estimated to increase from 1.6°C to 3.1°C by 2050 and 2.9°C to 4.1°C by 2080, with more pronounced increases during summer. Precipitation is expected to decrease overall, leading to reduced water storage, with projections indicating a reduction of 15% by 2050, and 30% to 40% by 2080. Winter precipitation may increase by century's end, but this is expected to be offset by significant summer decreases (Municipality of Gabrovo 2021, p. 75).

The annual temperature increase might lead to an extended tourism season (Municipality of Gabrovo 2021, p. 78ff). However, Bulgaria is facing serious climate risks in various sectors, including agriculture, biodiversity, energy, human health, forestry, tourism, transportation, and urban green and blue infrastructure. Socio-economic CC impacts are expected to be amplified by Bulgaria's relatively high level of poverty in affected areas, population concentration in few urban and industrial areas and ongoing consequences of the country's economic transition to market economy.

The municipality of Gabrovo is located in the North Central region of Bulgaria and falls within the climatic conditions of the Pre-Balkan Highland. Gabrovo is no exception of the affected areas and in need for climate change adaptation regarding periods of drought and extreme precipitation, forest fire and floods (Municipality of Gabrovo 2021).

The MountResilience project region Gabrovo is referring to the province Gabrovo. However, as the MountResilience Demonstration Activity will be partly located in the municipality of Gabrovo, the Regional Baseline explores both Gabrovo province and its administrative center municipality of Gabrovo.

1.1.1. Structural characteristics

Overview of topographic and functional characteristics

The province Gabrovo, with its namesake administrative centre municipality of Gabrovo, is located in the North Central region of Bulgaria, below of the Stara Planina, the central Balkan Mountains and in the valley of the Yantra River (cf. Figure 1). There are 134 settlements covering an area of 1871.7 hectares, of which the town of Sevlievo is the largest (Municipality of Gabrovo 2021, p. 27). The province is characterized by rurality, many settlements are abandoned and exist without inhabitants (GI4).

The municipality of Gabrovo is a well-developed economic center within Bulgaria, profiting from a rich industrial tradition (Gabrovo Municipality n.d.) with key industries in the fields of manufacturing (particularly significant are weaving, textiles, and leather) and engineering (most prominently, machine building and engineering production). The Technical University of Gabrovo is one of the largest in Bulgaria and acts as a main cooperation partner with the business sector (European Commission n.d.). The central location of Gabrovo functions as a transport junction - one of the most important road passes through Gabrovo and crosses Bulgaria from north to south. It is a part of the trans-

European transport corridor 9 (Helsinki - St. Petersburg - Kiev - Bucharest - Ruse - Veliko Tarnovo - Gabrovo - Stara Zagora - Dimitrovgrad with diversions to Greece and Turkey) (Gabrovo Municipality, n.d.).

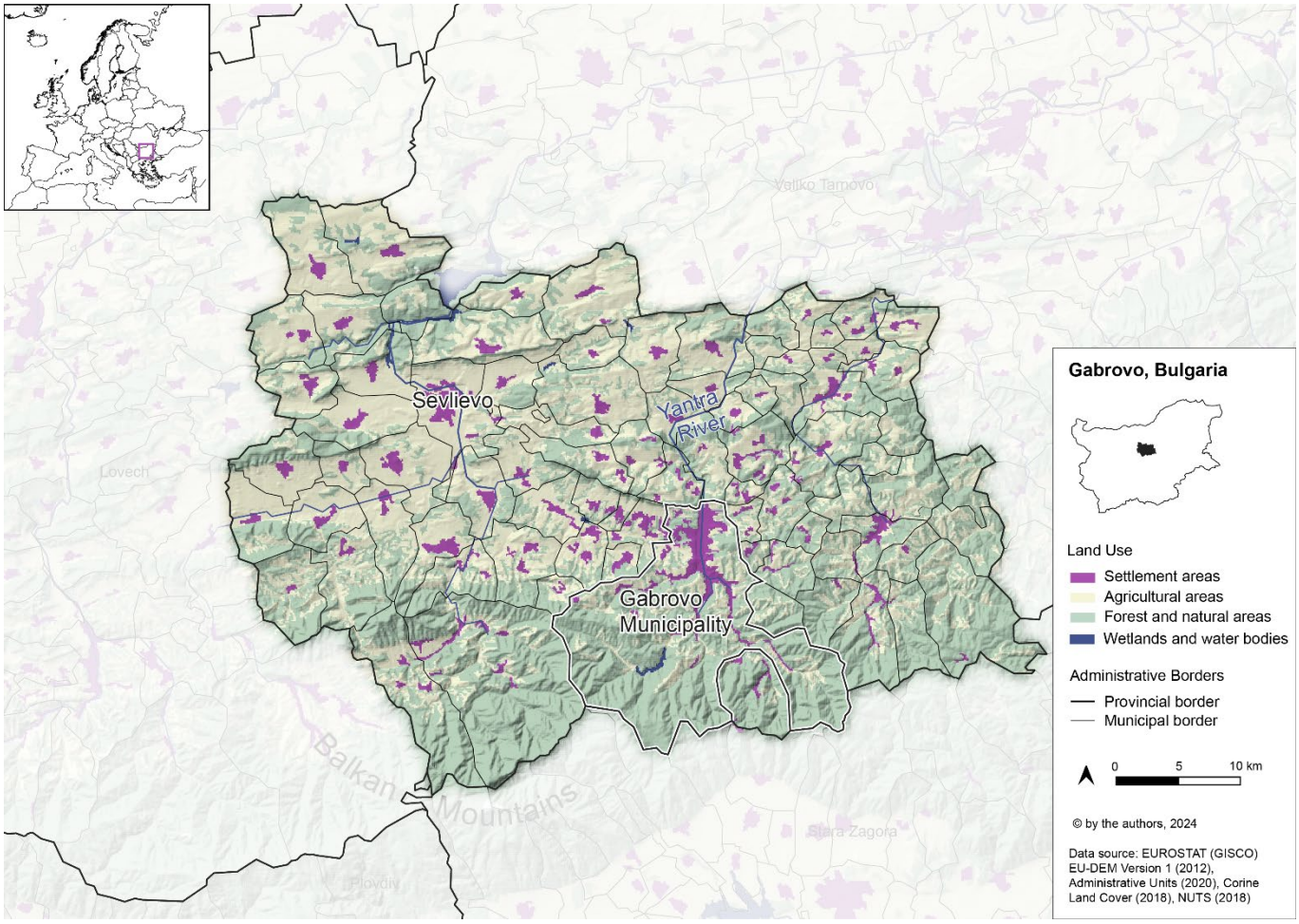

Figure 1. Map of Gabrovo region (TU Wien, 2024)

Overview of ecosystem and environmental characteristics

The landscape in Gabrovo province is characterized by the presence of five rivers and significant forest coverage, with over 50% of its territory covered by forests, one-third of which are part of the Nature 2000 protected areas. The forests are part of one of the 11 national parks in Bulgaria, the central Balkan national park, and contain around half of the biodiversity in Bulgaria with local and protected species (GI4). The municipality's location at the foot of the Balkan Mountain exposes it to influences from both cold northern invasions and Atlantic air masses. The Balkan Mountains also heavily influence precipitation, temperature, and wind patterns in the region and function as a climate barrier, separating the country into a north and a south part. The terrain of Gabrovo province is hilly and mountainous, with a mix of longitudinal heights, narrow ridges, steep slopes, and deep valleys. Erosion and human activity have shaped the landforms with slopes, embankments, deposits, and terraces (Municipality of Gabrovo, 2021, p. 27).

During the winter season, Gabrovo experiences relative humidity levels above 80%, which can exacerbate air pollution. Precipitation patterns are strongly influenced by the Balkan Mountains, with winter precipitation averaging around 165mm and increasing to 297mm in the summer. The Hristo Smirnenski Dam, located 8km southeast of the town, serves as the primary water source for Gabrovo (Republic of Bulgaria 2019).

Socio-economic profile

The municipality of Gabrovo spans an area of 556km² and is home to approximately 65,813 people as of January 2022, with 90% residing in urban areas. In Gabrovo province, the total population amounts to 103,404 inhabitants in 2022 (Eurostat, 2022) following a very strong decline of inhabitants with a population change of -74.7 per 1,000 inhabitants in the year 2022 (crude rate of total population change per 1,000 inhabitants). Gabrovo is no exception in this regard as strong population drain is a common phenomenon throughout Bulgaria (Eurostat, 2022). The population density figures 49.4 persons per km² and is therefore the second lowest within the MountResilience regions (Eurostat, 2022). On NUTS 2 level, Gabrovo province is located in the Northern Central region. Here, the median population age is 47.5 years (Eurostat, 2022). This number is significantly above EU average and, in combination with high out-migration rates, creates a major concern regarding an (over)ageing population in the region. Average employment rates are at 68% within the age group of 15-64 years, with little deviation between male (69.3%) and female (66.7%) rates (Eurostat, 2022). In 2021, the GDP of Gabrovo amounts to € 885.09 million, which is 1.25% of the national GDP (Eurostat, 2022). The Purchasing Power Standard (PPS) of Gabrovo in 2022 numbers € 14,800 PPS per inhabitant (Eurostat, 2022) and is therefore the lowest in comparison with the other regions. Compared with other MountResilience regions, the risk of poverty and/or social exclusion is the highest (37.5%) (Eurostat, 2022). In Gabrovo province, the cities of Gabrovo and Sevlievo generate more than 90% of the district's economy. In Gabrovo municipality, the manufacturing sector amounts to more than 60% of the overall production value with the largest industrials enterprises in metal production (Innova Gab, 2020).

Table 1. Socio-economic data for Gabrovo, compared to EU average (Source: Eurostat 2022)

	Population density *(per km²)*	**Median age** *(in years)*	**Population change** *(in % from 2021 to 2022)*	**PPS per capita** *(in €)*	**Employment rate** *(in %)*	**Risk of poverty** *(in %)*
Gabrovo Province (2022)	49.4	47.5*	-74.1	14,800*	68.0*	37.5*
EU-average (2022)	109.1	44.5	+4.0	35,400	74.4	21.6

**ref. to Northern Centralen*

1.1.2. Governance framework

According to its Constitution of 1991, the Republic of Bulgaria governs as a unitary state with a structured framework for local self-government, which guarantees the municipalities as fundamental administrative-territorial entities (Veleva 2023). The legislative framework for the local self-government in Bulgaria is a progressive and iterative process, incorporating elements of citizen participation, transparency, accountability, and decentralization of power, promoting open governance and local authority accountability. The concept of subsidiarity is emphasized, transferring powers from central to local governments to suit local circumstances (Veleva 2023).

National CCA work lies in the responsibility of the Ministry of the Environment and Water (MoEW). Other ministries are responsible for mainstreaming climate politics and developing adaptation measures in their respective sectors coordinated with the MoEW (Republic of Bulgaria 2019). Local CCA work is strongly shaped by the respective local governance which is composed of the Municipal Council – a local parliament consisting of a chairman and councilors – and the mayor who heads the municipal administration and represents the executive power. Local self-governance is expressed in the right to pass resolutions in the fields of property, enterprises, finance and administration of the

municipality, the structure and development of the municipal territory, as well as social services like education, health care, culture, town-development, tourism, sports and the protection of the environment also with regards to climate change adaptation measures (Gabrovo Municipality n.d.). The budgetary relationships between the central and municipal budgets involve complex financial interactions to allocate resources equitably and transparently, determined by formulas based on factors like population and socio-economic indicators. Municipalities seek greater financial autonomy, yet still rely heavily on central government transfers. Interactions between local and central authorities, regional governments, and civil organizations face complications, impeding effective governance, also in the case of CCA (Veleva 2023).

1.1.3. Identity and self-image

Gabrovo province is perceived as a very diverse region with a heterogenous landscape and a close connection to nature (GI4). Its location in a mountainous area is influencing the climate and therefore influencing people's everyday lives (GI4). The region is characterized by extensive forest cover, abundant open space, and many small settlements scattered and close to the "wild nature and animals" and the forests (GI3). The craft in different fields are a distinctive feature of the region as well and unite the population (GI5). Gabrovo is also known as "Home of humor and satire" – the international biennial of humor and satire in the arts" is carried out for the so-called "May Cultural Holidays§ (Visit Central Balkan 2017).

In the municipality of Gabrovo, sustainability and innovation in relation to CC play a major role regarding its self-image, which is reflected in the following quote from an expert interview: "*Sustainability is no challenge as Gabrovo is one of the cleanest cities in Bulgaria*" (GI1). Numerous awards, projects and initiatives underline Gabrovo's engagement towards this progress, which is unique in Bulgaria (e.g. the Green Leaf Award, part of 100 Carbon Neutral Cities in the EU initiative) (GI1, GI2; GI5) and reinforce the perception, that Gabrovo "*has a lot of potential and has done a lot of work*" already (GI2).

Figure 2. European Green Leaf Award (Source: ric-gabrovo.com/our-work/circular-economy/)

1.2. Systemic climate risks

The most important factors determining the directionality and design of CCA are concrete regional climate hazards and consequent systemic risks. This chapter overviews the main climate risks and relevant climate impact chains, pointing to the challenges for regional adaptation.

1.2.1. Main climate hazards and intermediate impacts

Climate change is expected to increase the intensity and frequency of adverse climatic events, including intense rainfall, heatwaves, cold waves, storms, floods, droughts, forest fires, and landslides with predictions indicating further escalation. Temperatures in Bulgaria are expected to increase between 2°C and 5°C by the end of the century. Projections suggest significant changes in precipitation patterns. All the RCP scenarios for 2016–2035 for annual average precipitation show about 10 percent increase in precipitation for the whole country (The World Bank Group, 2021).

1.2.2. Climate Impact Chain

The regional demonstrator focuses their activities on adapting to and warning about extreme weather events in the region, particularly in the city of Gabrovo. Therefore, a climate impact chain focusing on extreme weather events involving urban heat was developed.

Rising temperatures are expected to alter seasonal patterns, resulting in the absence of permanent snow cover. This change affects soil regimes and plant growth, favoring the spread of invasive species (GI4). Increased temperatures, coupled with decreased precipitation, elevate evapotranspiration rates, leading to drought. This scenario places additional stress on trees and plants, potentially contributing to crop failures and overall yield declines, increasing the risk of forest fires, and exacerbating water scarcity, which is already a persistent issue in Bulgaria.

Higher temperatures, combined with waterlogging from heavy rainfall, can increase insect outbreaks or diseases including the bark beetle and the pine processionary moth, further stressing forests and leading to greater damage from fires and storms (The World Bank Group, 2021; GI4).

Changes in precipitation patterns, particularly their intensity, lead to extreme weather events such as floods and landslides. Intensive and prolonged precipitation events heighten risks for the urban environment, stressing infrastructure and increasing flood risk (Municipality of Gabrovo 2021). When combined with hazardous industrial waste, these events further threaten water resources (GI2). The variability in precipitation, with increased rainfall in winter and decreased rainfall in summer, presents significant challenges (Municipality of Gabrovo 2021; Republic of Bulgaria 2019; The World Bank Group 2021).

Increased winter rainfall, coupled with cold temperatures and sometimes weekly cold waves, threaten food supply and mobility. This situation affects access to social and health infrastructure and education. Declining snowfall and snow cover reduce tourism potential, particularly for cities in mountainous regions. These changes impact water resources, agriculture, forestry, and urban environments. Bulgaria's water sector is particularly vulnerable, with heightened risks from floods and droughts exacerbated by infrastructure vulnerabilities and a lack of preparedness. Surface water supplies and regions with intensive tourism activities are especially at risk (Municipality of Gabrovo, 2021; Republic of Bulgaria, 2019; GI4).

Decreased summer rainfall leads to prolonged droughts and heatwaves. Droughts have multiple impacts on the ecosystem of forests, water and agricultural land leading to heat stress, erosion and soil degradation potentially triggering desertification, marginalization and abandonment of agricultural land (Republic of Bulgaria, 2019). The anticipated increase in mortality from cardiovascular diseases and strokes, especially in densely populated cities,

due to heatwaves and extreme weather events, presents substantial public health risks. Vulnerable populations, such as the poor, the elderly, and those with chronic illnesses, face higher risks. Urban areas including the city of Gabrovo, face unique challenges due to the urban heat island effect. This effect leads to increased health risks due to heat stress and indirect threats, such as higher allergen concentrations. Climate change exacerbates these effects, while at the same time necessitating higher energy consumption for cooling (Gabrovo Municipality 2020). Additionally, the combination of extreme temperatures and increased humidity can worsen air pollution. In 2014, Gabrovo experienced two exceedances of the alert threshold for sulfur dioxide, highlighting the severity of the issue (Republic of Bulgaria 2017).

Extreme weather events pose significant health hazards, especially for vulnerable populations such as the elderly, the poor, and those living in substandard housing or experiencing homelessness. Outdoor workers, particularly in construction and public utilities maintenance, are also at heightened risk. These risks are most visible in the city, which is at higher risk due to soil sealing, and overloaded and old infrastructure (The World Bank Group, 2021; GI3).

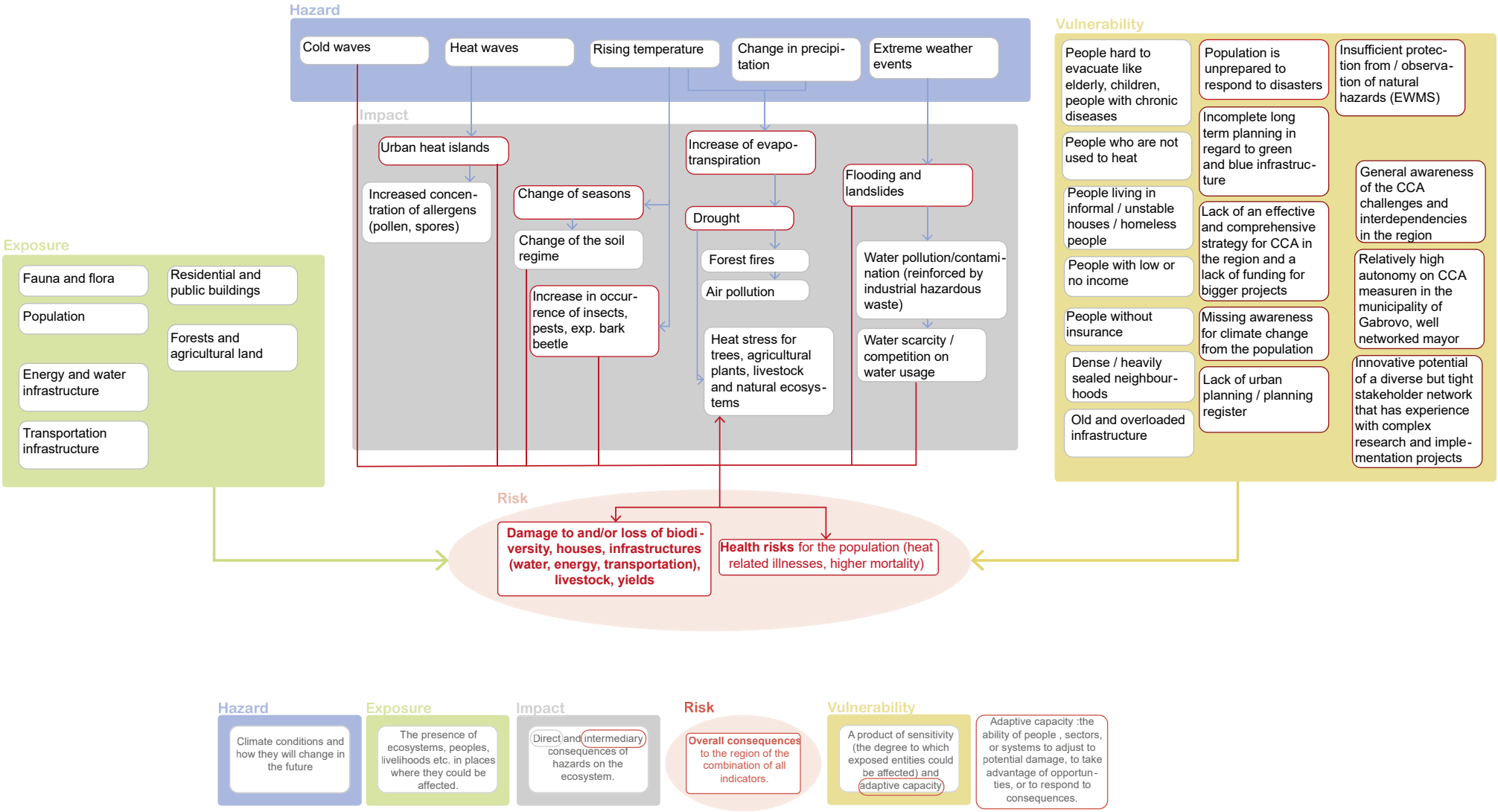

Figure 3. Gabrovo IC for extreme weather (ZSI, 2024) | *cf. chapter 11.2 for IC methodology*

1.3. Regional CCA governance

CCA activities should be well-embedded in the strategic objectives of a region and strike a balance between stakeholder inclusion and leadership. Accordingly, understanding the strategy framework and stakeholder landscape of regional CCA governance is important. This chapter identifies key regional CCA-related strategies, how CC and its consequences are problematized therein and how certain adaptation challenges are prioritized. It highlights the prevailing understanding of CCA and the emphasized approaches for tackling it, as well as the most important regional stakeholder groups, which is important for the design and implementation of concrete adaptation activities.

1.3.1. Strategy framework

EU legislation and international conventions function as the basis for CCA strategies and legal frameworks in Bulgaria. At the national level, the main strategic document for CCA is the "National Climate Change Adaptation Strategy and Action Plan until 2030", which builds on the "National Climate Change Risk and Vulnerability Assessment of the Bulgarian Economic Sectors (2015)". It is part of the overall climate change institutional framework set out in the Climate Change Mitigation Act (CCMA). While other strategies and programs tackle the topic of CC in general (the "Integrated Energy and Climate Plan of the Republic of Bulgaria 2021-2030 (2019)", the "Environmental Protection Act (EPP)", "Renewable Energy Sources Act)" but focus more on mitigation (Republic of Bulgaria 2019). The ministry of the environment and water is responsible for the national CCA work (GI4).

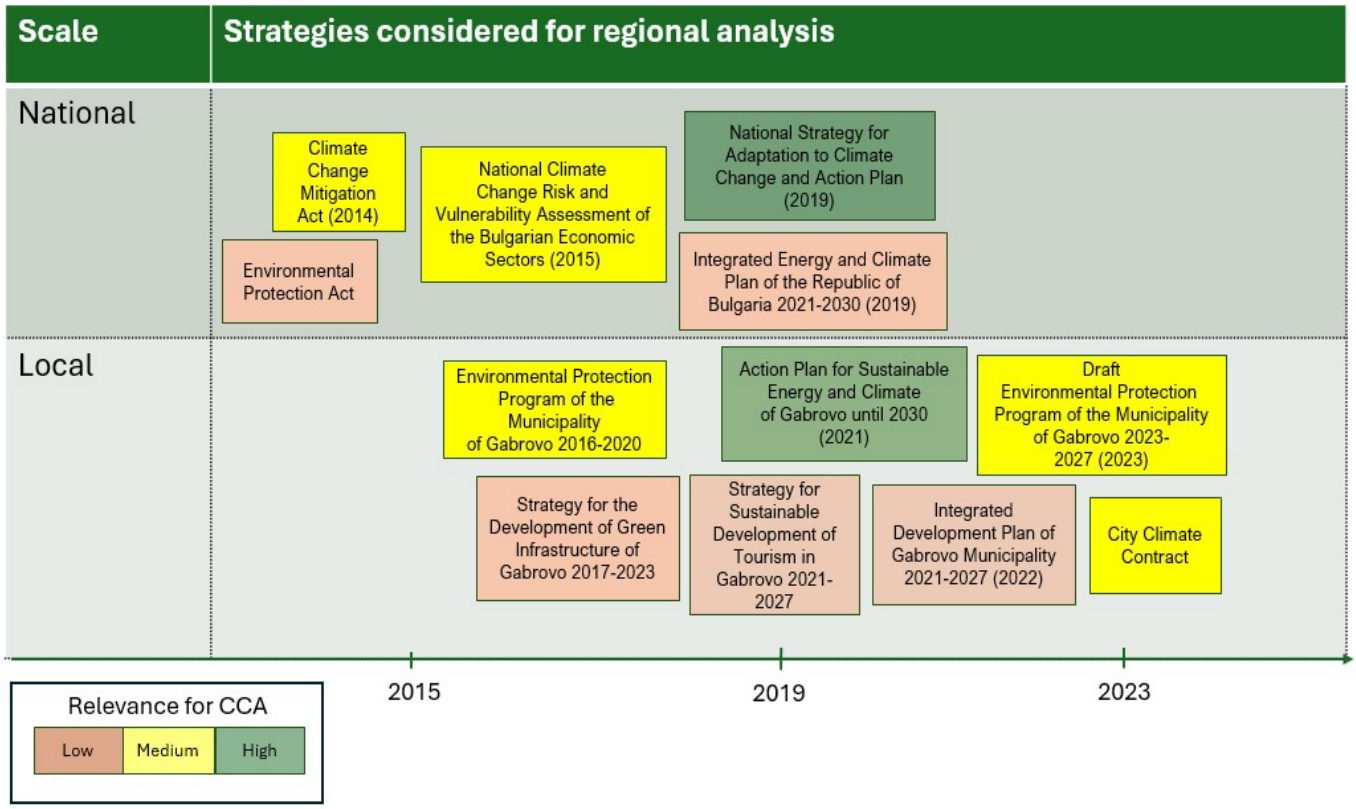

Figure 4. Overview of CCA-relevant strategies for Gabrovo (TU Wien, 2024)

In the municipality of Gabrovo, many sectoral strategies have been formulated to tackle CC, like the "Environmental Protection Program of the Municipality of Gabrovo 2016-2020" (a "Draft for the Programme for the Environmental Protection of Gabrovo Municipality 2023-2027 (2023)" has already been developed), the "Plan for Sustainable Urban Mobility of Gabrovo Municipality 2021-2030", the "Strategy for Sustainable Development of Tourism in Gabrovo

Municipality 2021-2027" and the "Strategy for the Development of the Green Infrastructure of the City of Gabrovo 2017-2023".

The most important strategy regarding CCA action is the "Sustainable Energy and Climate Action Plan for Gabrovo Municipality 2030" (SECAP), published in 2021 and based on the "Integrated Development Plan of Gabrovo Municipality 2021-2027" (2022) and the commitments to the "Convent of Mayors for 2030". The "Covenant of Mayors", involving local and regional governments, envisions, among other goals, the reduction of GHG emissions and the improvement of the capacity to adapt to CC. The municipality of Gabrovo has been a member of the "Convention of Mayors" since 2013. Additionally, Gabrovo is one of two Bulgarian cities approved to participate in the European Commission's mission to achieve 100 climate-neutral and smart cities by 2030 and is currently working on a "City Climate Contract", which they must sign until the end of the year 2024 (GI3).

The "SECAP" contains one chapter for CCA, discussing sectoral climate risks and vulnerabilities on a national level, setting strategic objectives and numerous measures, how Gabrovo municipality plans on tackling CCA until 2030 (Municipality of Gabrovo 2021, 75ff). However, the plan lacks a comprehensive risk analysis and objectives for the municipality itself.

1.3.2. Problem background and prioritized challenges

As stated in the above section on systemic risks, the key CCA challenges in Gabrovo lie in an increased risk of natural disasters, changing temperatures and precipitation. Resulting from these ecosystem changes, socio-economic vulnerabilities are being amplified, which causes a dire need for CCA in the future. The following table condenses the entanglement between ecological and socio-economic challenges regarding CCA to 3 main topics.

Table 2. Main CCA challenges for Gabrovo

Increased risk of natural disasters and threatened infrastructure	Fire and floods resulting from climate hazards, threatening citizens, economy and biodiversity are especially visible in the city because of the high degree of urbanisation (GI3). Increased periods of droughts lead to problems with the supply of water (GI2; GI3; (Municipality of Gabrovo 2021, p. 83) and to the death of trees in the city (GI3). A high degree of soil sealing is exacerbating these challenges, as well as the old and overloaded engineering infrastructure (GI3; Municipality of Gabrovo 2021, p. 83). In a broader scope, not only the engineering infrastructure, but also the energy infrastructure and the road and rail infrastructure are vulnerable to various climate stressors (Municipality of Gabrovo, p. 78ff). The current usage of drinking water for irrigation for urban green infrastructures is too expensive and exacerbates the problems (GI3). Opposed to floods and forest fires, for droughts no NbS exist (GI2).
Insufficient institutional CCA framework	To some extent, the current legislation hinders an effective CCA of the region (GI2). Although the "SECAP" suggests actions for a broad spectrum of branches (Municipality of Gabrovo 2021, p. 86ff), more detailed planning and policies concerning CCA are missing (GI3). The lack of financing for bigger demonstration projects hampers CCA action (GI3). As the regional administration is subordinate to the council, it only has limited capacity to counteract and develop its own policies (GI2).

Gaps in knowledge, cooperation and action	The lack of trust in institutions and knowledge on CC in the population is seen as a general challenge to initiate CCA action (GI2; GI4). The same holds true for a lack of communication between citizens and other stakeholder groups (GI4). The general perception is that CCA is the municipality's responsibility, which hinders transformative action. In the Programme for the Environmental Protection of Gabrovo Municipality (2023), gaps in knowledge about adaptation and NbS are mentioned as deficits that need to be tackled (Municipality of Gabrovo 2023, p. 54).

1.3.3. Prevailing understanding

CCA in Gabrovo is primarily interpreted as …

- **Societal adaptation to ecosystem change:** Most approaches in the "SECAP" aim at building adaptive capacity in a governmental or behavioural sense (creation of data bases, public registers, public enhancement measures), whereas only few measures tackle CCA in an ecological sense (protection of forest and river channels) (Municipality of Gabrovo 2021). Adaptation is also seen in close connection or interchangeably to other concepts like circular economy, CC mitigation and nature protection (GI2; GI3; Municipality of Gabrovo 2023, p. 118).

- **Green infrastructure preservation:** The maintenance of the city's green infrastructure (long-lasting woody vegetation) is an important factor in the region's CCA understanding (GI3; Municipality of Gabrovo 2021).

- **Incremental but constant deliberative change**: CCA is seen as a process of continuously analysing potential threats and take action to either reduce vulnerability or to mitigate negative impacts in a timely manner (Municipality of Gabrovo 2021, p. 76).

1.3.4. Emphasized approaches

Following the "SECAP" and the expert interviews, three regional CCA approaches could be identified that aim to counteract the previously mentioned regional challenges.

Innovative technological solutions and ecosystem-based approaches: Technical interventions, ecosystem-based approaches and NbS are mentioned to combat the effects of CC regarding natural disasters but also solutions to enhance the adaptive capacity and sustainability of the green and blue infrastructure system in Gabrovo's city. These include:

- the use of alternative methods for irrigation of the green system meaning the green infrastructure (GI3)
- the creation of a database and an app for "cold spots" in the city (Municipality of Gabrovo 2021, p. 94)
- the development of an early warning system for natural disasters (GI3)
- distinct green wedges in the city (Municipality of Gabrovo 2021, p. 84)
- the afforestation of areas (e.g. for abandoned agricultural land) (Municipality of Gabrovo 2021, p. 96)

Improved CCA governance: Approaches aiming at an improved governance for CCA are emphasized to increase the institutional capacity (GI3) and mainstream CCA in all sectors (Municipality of Gabrovo 2021). On the one hand, a strengthened policy framework with improved (knowledge and ecosystem) management is indicated (Municipality of Gabrovo 2021). On the other hand, an enhanced focus on cooperation with other municipalities and countries (GI3) and the establishment of working groups (inter-ministerial expert working group) (Municipality of Gabrovo 2021, p. 97) are envisioned.

Enhanced awareness and knowledge: Increasing the public awareness and knowledge of CCA is seen as a major driver to change citizens attitudes towards CC (Municipality of Gabrovo 2021, p. 98) and the protection of nature (GI4). To build the populations trust in institutions, time and education on the topic are necessary (GI4): "*We have the will for change but sometimes we need more information and time to understand things, and to become engaged – that's why information campaigns are really important*" (GI2).

Gabrovo focuses on measures increasing the involvement of the public, like information and education campaigns (GI2; GI4) and building a network of climate volunteers (Municipality of Gabrovo 2021, p. 97) as well as cooperation with private-public partnerships (GI4). Connected to the mission to become a climate-neutral and smart city by 2030, the objective for Gabrovo in the Programme of the Environmental Protection of Gabrovo Municipality (2023, p. 54) is as follows: "*The main task for the Municipality of Gabrovo, in connection with the mission, is in 2023 to form a climate team to work with citizens, businesses and the whole community to raise their awareness of the benefits of implementing measures, as well as educate all people (from the youngest to the elderly) and support the process of transitioning to climate neutrality through capacity building (training) of all stakeholders*". The focus on educating the civil society and strengthening the cooperation of all stakeholders by also forming a "climate team" aims to promote behavioural change.

1.3.5. Important stakeholder groups

Government: On the national scale, although the responsible institution for CCA strategy development is the Ministry of the Environment and Water (GI4), the different departments of the forestry agency have also been mentioned as important actors (GI4). Related to the ministries, different administrative institutions (e.g. regional bodies from the ministry of environment, the regional Inspectorate, the district governors) have been mentioned (GI2). On the province level, the RAM, the regional association of municipalities, supports local authorities with providing information, e.g. on climate change (GI2).

Concerning the municipality of Gabrovo, the collaboration between the key actors and their individual engagement are supportive tools for the CCA work in Gabrovo: "*Both the municipalities and the regional administrations, the businesses and companies, also researchers, institutes at the universities – all are quite engaged in the process*" (GI2). The municipality of Gabrovo, however, was identified as the main force, pushing the area of climate change (GI1; GI3; GI5).

Academy: With being one of the key players of the local economic development, the Technical University of Gabrovo, as an academic institution well connected with regional authorities and businesses, is also seen as an important lever for CCA (GI1). The "Regional Innovation Center (RIC) Ambitious Gabrovo" developed by regional companies, functions as an interface of industry and science and as initiator of many projects (GI2).

Community: With regards to the civil society, national NGOs in the field of environmental protection and climate change are active in Bulgaria, but not in the Province of Gabrovo (GI4). However, following the regional approach of the importance of including the citizens, the population of Gabrovo has been identified as a key actor group (GI3). The involvement of citizens in the decision-making processes (GI5) and a current changing perception of CC of young people (GI4) are increasingly perceived as important pillars for CCA.

Interestingly, in the stakeholder mapping of T1.3., no governmental body on national level was identified. However, on regional level, the Danube Region Basin Directorate, the Fire Fighting Department Gabrovo and North Central State Enterprise DP were depicted. In contrast, within the community sector, multiple institutions on national level were mentioned, that were not named in the interviews (namely, "Bulgarian Association of Municipal Environment Experts", "Bulgarka Nature Park", "Foundation Center for Energy Efficiency EnEffect", and "Association for the Earth"). With regards to academy, the Regional Department of Education was also mentioned.

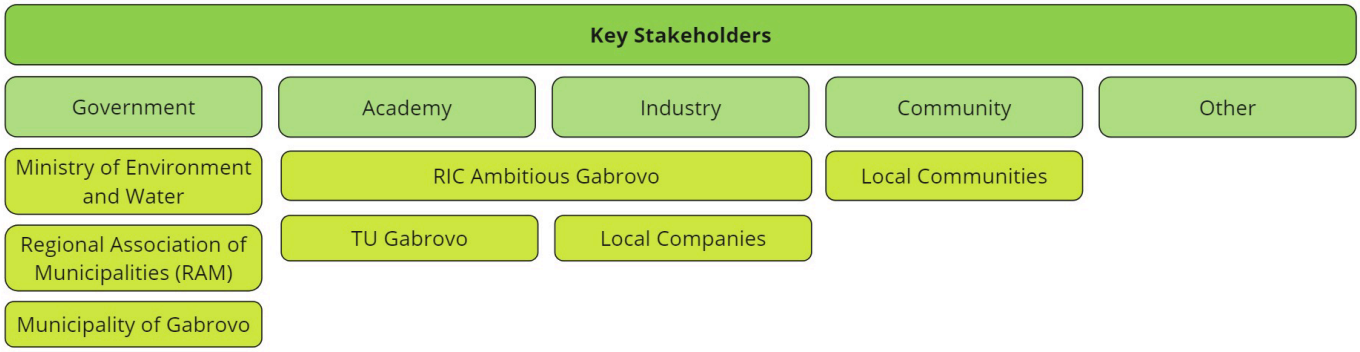

Figure 5. Key stakeholders in CCA in Gabrovo (TU Wien, 2024)

1.3.6. Assessment

On a strategic level and in contrast to other Bulgarian regions, Gabrovo municipality already plays a pioneering role with the "SECAP" and benefits from good cooperation and engaged individuals. Like other MountResilience regions, citizens are considered a key lever for CCA. In Gabrovo, it is further assumed that citizens have relatively low trust in institutions. This means that officials direly need to build this trust and engage citizens, which is already happening with respect to the many initiatives for CC awareness raising. On another note, technology-oriented CCA approaches are formulated quite clearly already and many cooperations are occupied with them. In contrast, nature-based, community, or governance approaches are rather vague and lack the same level of concreteness.

1.4. Key adaptation actions

This chapter introduces good practices that have already demonstrated how CCA can be approached in the region. These actions are not representing the full scale of approaches in the region but give a relevant overview of the priorities given to adaptation while pointing out different innovative solutions to address the specific challenges and risks that were induced by climate change.

Gabrovo has planned to implement or already implemented various projects in **energy efficiency** and **public enhancement.** While these projects are mostly oriented at climate change mitigation, they depict Gabrovo's efforts in citizen engagement and point to competencies and capacities that might as well be relevant for adaptation.

Gabrovo has issued a call to establish **Bulgaria's first renewable energy community:** The project aims to establish a new photovoltaic system on the site of the regional landfill for non-hazardous waste (GI1; GI2). The renewable energy community can function as a basis for expanding cooperation between key stakeholders in CC. (cf. Balkan Green Energy News) TU Gabrovo also collaborates in other projects on **energy efficiency**, for example with demo projects in local kindergartens (GI1).

The **modernization of street lighting** in the city was implemented through a centralized GPIS system. Results have been monitored already, showing a decrease in energy consumption of public lighting (GI1).

Green Gabrovo is an initiative to give out trees, shrubs and other plants to citizens who then can plant them in public parks, kindergartens or other green areas in the city (GI2). "Green Gabrovo" is a good practice for strengthening the awareness and involvement of the population in CC related topics. (cf. Green Gabrovo) Similarly, the "**Turning grey to green**" initiative supports the population with material and information on sustainability (GI2). For **International Earth Day**, different climate initiatives were developed to increase knowledge and awareness for sustainability and CC(A) related issues among citizens (GI2).

Different stakeholders have been involved in a project to **collect old phones**, which are then recycled. With the money, trees are being planted (GI2). In addition, a local company is commissioned to **reuse the material from old plastic toothpaste tubes** and to create flowerpots with it (GI2).

RESPONSE is an EU HORIZON 2020 project aimed at developing positive energy neighborhoods through innovative and integrated solutions in cities all around Europe. In the case of Gabrovo municipality, it is mentioned that Gabrovo Municipality is active in the “EcoEnergy network”, participates in "Earth Hour," and regularly collects outdated electronics, offering residents vouchers for energy-saving equipment. Under the "Regions for Growth 2014-2020" program, Gabrovo renovated parks and public spaces (cf. Response). The focus thus again is on incentives for citizen engagement and the sustainable maintenance of green infrastructure in the city.

1.4.1. Learnings

The above actions demonstrate Gabrovo’s experience with citizen engagement (particularly awareness raising initiatives, incentives, formation of networks and cooperation). Projects mostly address energy efficiency, recycling and circular economy, but also green infrastructure as an immediately adaptation-relevant area. Most importantly though, Gabrovo’s engagement to function as a model for other Bulgarian cities stands out and depicts its competence as transformation leader in and beyond Bulgaria.

1.5. Transformative pathways

The overview of regional structure, systemic climate risks and existing CCA governance, coupled with knowledge on the planned DA, allow a final assessment of the most relevant barriers and opportunities for transformative CCA in the region, as well as pointing to the key transformative capacities that need to be utilized or developed further. To this end, a validation workshop was held in the region to discuss barriers, opportunities and key transformative capacities with knowledgeable actors. This chapter elaborates on these aspects and concludes by providing concrete advice for transformative CCA in conjunction with the fields of action of the respective DA and beyond to facilitate transformative regional CCA.

1.5.1. Barriers and windows of opportunity for CCA

According to the interviews, the main barrier for successful CCA in Gabrovo is the missing awareness from the population (GI3; GI4) - “*a lack of the critical mass*” towards the development of the region (GI4), which is also reflected in a lack of trust in the institutions. It corresponds to the common attitude that CCA is a task of the public sector and therefore there is little motivation to increase the commitment of other stakeholder groups.

In terms of governance, CCA work is also hampered by a lack of effective and comprehensive strategies for CCA in the region and a lack of funding for bigger projects (GI3). In addition, the regional administration and the municipality of Gabrovo do not have the competence to independently develop CCA strategies in a comprehensive manner (GI2).

Contrary to the major barriers, a key opportunity for transformative CCA in Gabrovo municipality lies in innovative potential of a diverse but tight stakeholder network that has experience with complex research and implementation projects – from local citizen-oriented endeavors aimed at increasing engagement to transnational research projects oriented at R&D (GI2; GI4). As one regional expert put it, “*Gabrovo started engaging from the very start*” (GI2). The municipality is comparatively active concerning the development of strategies, and it profits a lot form the cooperation with TU Gabrovo, one of the largest technical universities in Bulgaria, (GI1). In addition, Gabrovo's mayor, the head of the municipality, is very well connected nationally and internationally (GI2). Gabrovo therefore has good leadership for engagement in transformative CCA, which can and should be further developed.

Looking at the province of Gabrovo, it has been stated, that the communication between the most important stakeholders is manageable, as the area is quite depopulated without major industries in the case of the Central Balkan National Park (GI4) which can function as a facilitator for effective CCA work.

1.5.2. Regional validation workshop

The regional validation workshop aimed at presenting, critically discussing, and further developing initial hypotheses and interim findings on transformative adaptation with knowledgeable regional actors. The workshop hence consisted of two parts: In a first session, regional CCA measures, challenges and opportunities deriving from the previous analysis were presented and subsequently debated in smaller groups as well as in the plenum. In the second session, regional transformative capacities that were identified as relevant by the research team were introduced and put up for discussion. This gave participants the opportunity to share feedback, give concrete examples stemming from their own experience or bring in new ideas for effective CCA governance.

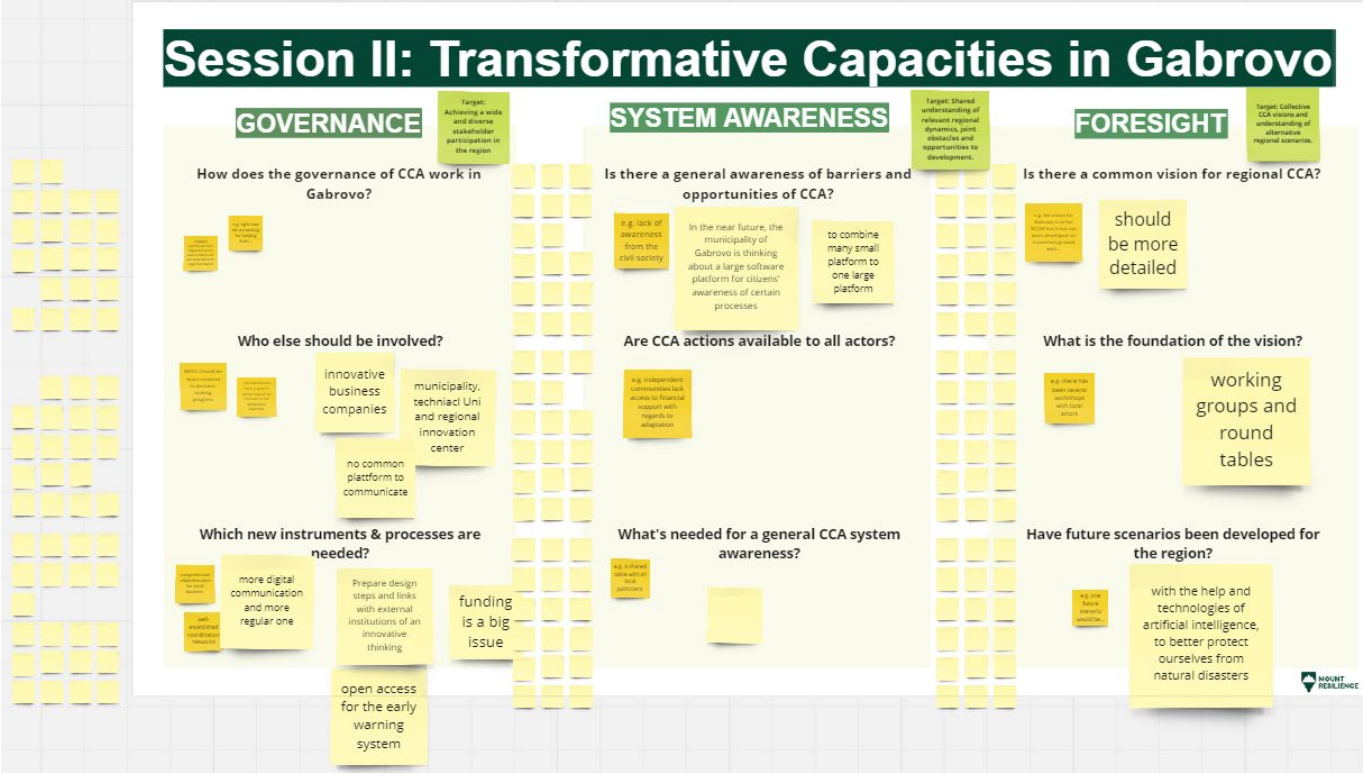

Figure 6. Accompanying Miro Board from VDWS in Gabrovo

The workshop participants addressed key stakeholders and new (technical) tools as particularly relevant topics. In order to successfully drive transformation in the municipality, participants indicated the engagement of citizens as key actors, ensuring they are informed about the benefits of proposed solutions through a targeted information campaign that clearly communicates the cost-benefit analysis. A robust monitoring system should be implemented, utilizing best practices and technical solutions to support the municipality's adaptation efforts. During the discussion on governance in Gabrovo, it was highlighted that the municipality benefits from strong multi-level governance connections, particularly with ministries, and a proactive municipal leadership that has fostered numerous partnerships and projects. While many stakeholders, including the Technical University, the "RIC", and the municipality, are already involved, there is a need for better communication and coordination through a shared

platform to enhance collaboration and initiate joint actions. A focus is placed also on external institutions: "*Prepare design steps and links with external institutions of an innovative thinking*". The participants emphasized the municipality's goal to achieve carbon neutrality by 2030 and their wish for a more detailed common vision in the region. A relevant topic was also the use of technology and AI to use for example in the early warning systems for natural disasters.

The workshop was conducted in an online format on June 19, 2024, from 14:30 to 16:30 (EEST) with an audience of 35 participants. The online tool Miro was used to facilitate visualization of discussion points.

1.5.3. Regional transformative capacities

Overcoming a focus on mere adaptation responses towards more long-term transformative change, the concept of transformative regional capacities offers a perspective on the wider interplay, forming a more systemic perspective. The last step of the regional CCA analysis aimed at the identification of regional strengths and transformative capacities by assessing regional/local implementation barriers and existing regional capacities. Building on the analysis results and workshop responses (conducted in June 2024), transformative regional capacities were determined. The framework proposed by Wolfram's (2016) of ten adaptive capacities addresses organisational visions, work culture, structures, skills, human and material resources, but also community participation, relations, networks and institutions, and the understanding of existing systems. For the regional climate change analysis, the most relevant transformative capacities were identified to guide adaptation action, particularly with regards to the regional Demo Activities (DAs).

Table 3. Transformative capacities for effective CCA in Gabrovo

Inclusive and Multiform Governance	The local self-government of Gabrovo allows the municipality a relatively autonomous approach to CCA within a certain framework. As the mayor of Gabrovo is well networked and the municipality can draw knowledge from developing strategies and applying for (EU) funding (GI2), the foundation for an improved capacity for inclusive and diverse CCA governance is already in place. However, to utilize the full potential of Gabrovo's CCA capacities, also regarding the good cooperation with TU Gabrovo and Gabrovo's "RIC", the communication within and outside of major institutions is in need of a common platform (GVDWS). Gabrovo has a tradition of bringing forward innovative business (ideas). Through an enhanced involvement of these companies, more precisely, with concrete *"design steps and links with external institutions of an innovative thinking"* (GVDWS), the region could institutionalize innovative CCA development (GVDWS). It is also important to note the need for open access to technical solutions, such as the planned early warning system (GVDWS).
Shared Understanding, Memory and System Awareness	The scope of "SECAP" and Gabrovo's unique engagement to sustainability in Bulgaria indicates an awareness of the CCA challenges and interdependencies in the region. One lever to CCA and potential for building a general system awareness is seen in the citizens' values and engagement (GVDWS). Concerning that, the municipality of Gabrovo is thinking about one large software platform for citizens' awareness of certain processes to combine the many small platforms (GVDWS).

	Nonetheless, the approach to CCA as a societal adaptation of the citizens should be seen as one of several pillars. Current CCA action can mainly be categorized as technological innovations, public awareness measures and improved governance, where the latter lacks more concrete analysis of Gabrovo's system dynamics and path dependencies, seen for example in the lack of funding for bigger projects (GVDWS).
Foresight and Shared Vision	Gabrovo's climate targets, the "SECAP" and multiple other strategies (additionally the "City Climate Contract" in the future) provide the baseline for regional activities regarding CC action. The objectives have been compiled in working groups and round tables (GVDWS). One focus of the vision is to use AI, *"to better protect ourselves from natural disasters"* (GVDWS). A collective positive future vision and foresight methods should be more detailed in relation to CCA (GVDWS). While current strategies and the image conveyed by municipalities tend to focus on sustainability, the CCA vision remains vague. A clear vision with alternative scenarios would not only improve the perception of the importance of CCA in the corporate sector, but also among citizens.

1.5.4. Concrete advice for the DA and beyond

Utilize and expand existing coordination between public sector & R&D: To improve the cooperation between Gabrovo's main institutions regarding CCA and especially the technological innovations envisioned by the DA (particularly, an integrated irrigation system, and an early-warning system for natural disasters), namely the Municipality, TU Gabrovo and "RIC Gabrovo", the development of a common platform to facilitate the communication and coordination between the institutions is needed. In line with technological innovations, a greater focus on open access to technical solutions is needed, for example for the planned early-warning system for natural disasters. This will benefit smaller businesses but also allows citizens to inform themselves on regional CC(A) work.

Scale-up (funding for) green infrastructure projects: As envisioned by the DA, a new "Green Infrastructure Strategy" should include a comprehensive plan for funding opportunities to finance bigger projects. Following this, the DA has the potential to implement projects that serve the whole municipality and beyond, as mentioned in the interviews.

Strengthen the local strategic framework: Innovative technical solutions and measures for the participation of the civil society can only unfold their full potential when integrated in a comprehensive strategic framework, that tackles regional specific challenges and strengths. The municipality of Gabrovo plays a key role in CCA efforts in the region and the provision of its expertise in strategic planning is essential for advancing the region's CCA initiatives.

Involve citizens to strengthen awareness and engagement: The involvement of the citizens in the development process was cited as a decisive lever. It is advised to expand the planned DA activities for citizen engagement and to conceptualize the involvement of the population from the start, with the objectives of the development process to the decision-making process.

Further suggestions

The municipality's targeted approaches already serve as a starting point for effective climate change adaptation. However, to comprehensively address its vulnerabilities (as addressed in the systemic risk assessment) and

implement transformative adaptation, a broader range of measures and new planning approaches should be considered. For example, this might include not just the maintenance but also expansion of urban green and blue infrastructures in the municipality to reduce heat island effects, improve air quality and provide recreational areas for citizens, especially in areas where the share of vulnerable groups is comparably higher.

It is also suggested to expand public awareness projects to measures, that partly transfer CCA governance to the population This ensures that an empowered community involved in the decision-making process endorses strategies that are locally relevant and widely supported. Offering workshops and training sessions for local farmers, business owners, and residents on CCA practices, disaster preparedness, and resource management can function as first steps in this regard.

2. Baseline – Lapland

2.1. Regional profile

Regional structures, political competencies and development objectives profoundly influence the potential pathways for regional CCA. This chapter introduces the topographic, functional, environmental, and socio-economic characteristics that shape the region structurally, briefly introduces the territorial governance framework to illustrate the region's formal competencies for implementing CCA autonomously and outlines the dominant self-image to sketch the normative starting point for regional CCA.

Finland's temperature has already increased twice as much as the average global temperature has risen since the middle of the 19th century with great effects, especially on the winter conditions. The effects include a decrease in the permanent snow and ice cover, an increase in heat waves as well as changes in precipitation (Ministry of Agriculture and Forestry, 2022, p. 15 f). The project region Lapland, amounting to a third of Finland's land area in the North and home region of the indigenous people of Sámi in the northernmost part, is especially vulnerable to climate change. Most of the province is located north of the Arctic Circle, leading to its specific arctic nature conditions and nature-dependent livelihoods, tourism and reindeer herding (The Finnish Climate Change Panel, 2021, p. 51). Climate change is expected to warm Lapland significantly, with average temperatures rising by 2.0-3.2°C by mid-century, and annual rainfall increasing by 6-11%. Apart from the CC-effects jeopardizing the local economies directly, Lapland is also exposed to an enhanced risk of floods with Pori and Rovaniemi being the most significant flood-risk areas (The Finnish Climate Change Panel, 2021, p. 95).

Although the MountResilience Demonstration Activity will be located in Northern Lapland, the Regional Baseline explores Lapland as a whole region. However, some descriptions and analyses are focused on Northern Lapland as MountResilience specializes in the specific livelihoods of this area.

2.1.1. Structural characteristics

Overview to topographic and functional characteristics

Lapland is the northernmost region of Finland and amounts almost one-third of the total area of Finland. Lapland borders with three countries: Norway (more than 700km), Sweden (more than 600km) and Russia (almost400 km). Several large rivers run through Lapland, among others the longest river of Finland, Kemijoki (Lapin Litto, n.d.-b). The northern part of Lapland, Sápmi, is the traditional territory of the indigenous Sámi people, which functions as a transnational region extending from northern Norway through Sweden and Finland to northwestern Russia (cf. Figure 1). Currently, over 60 percent of the Sámi population resides outside their native regions, with significant communities in urban areas such as Rovaniemi, Oulu, and the Helsinki region (Lapin Litto, n.d.-b).

The municipalities of Enontekiö and Utsjoki cover a vast area with around 0.22 inhabitants per square kilometre. There are a few urban centres, such as Rovaniemi, the capital, but most of the region is very rural. 36% of the population live in sparsely populated rural areas or rural heartland, with another 4% living in rural areas close to an urban area. This population is exposed a higher risk to climate change, especially in events of extreme events or other effects of climate change as they are further away from accessing essential services (Regional Council of Lapland, n.d.).

The Sámi are the only recognised indigenous people in Europe and are recognised as such in Finland. Reindeer husbandry is one of the key aspects of their culture and tradition, and it also provides an income. The crucial role of reindeer is also reflected in the Sámi language, which has around 1500 words related to reindeer work (Tennberg et

al., 2017). Reindeer herding is community-based and preserves traditional Sámi culture and language. In the 2000s, all Sámi languages have been classified as endangered. Increasingly difficult conditions make it harder to retain the traditional lifestyle and ways of reindeer herding, which is based on grazing rotations. For example, reindeer pastures have become fragmented and reduced, due to increase in forestry, mining and energy industries and tourism and construction of transport infrastructure. Quality of winter lichen, the main food source for reindeer in winter has also decreased in recent years which has led to some herders being forced to supplement with bought fodder, which is not the traditional way and also makes reindeer herding less economically viable (Tennberg et al., 2017).

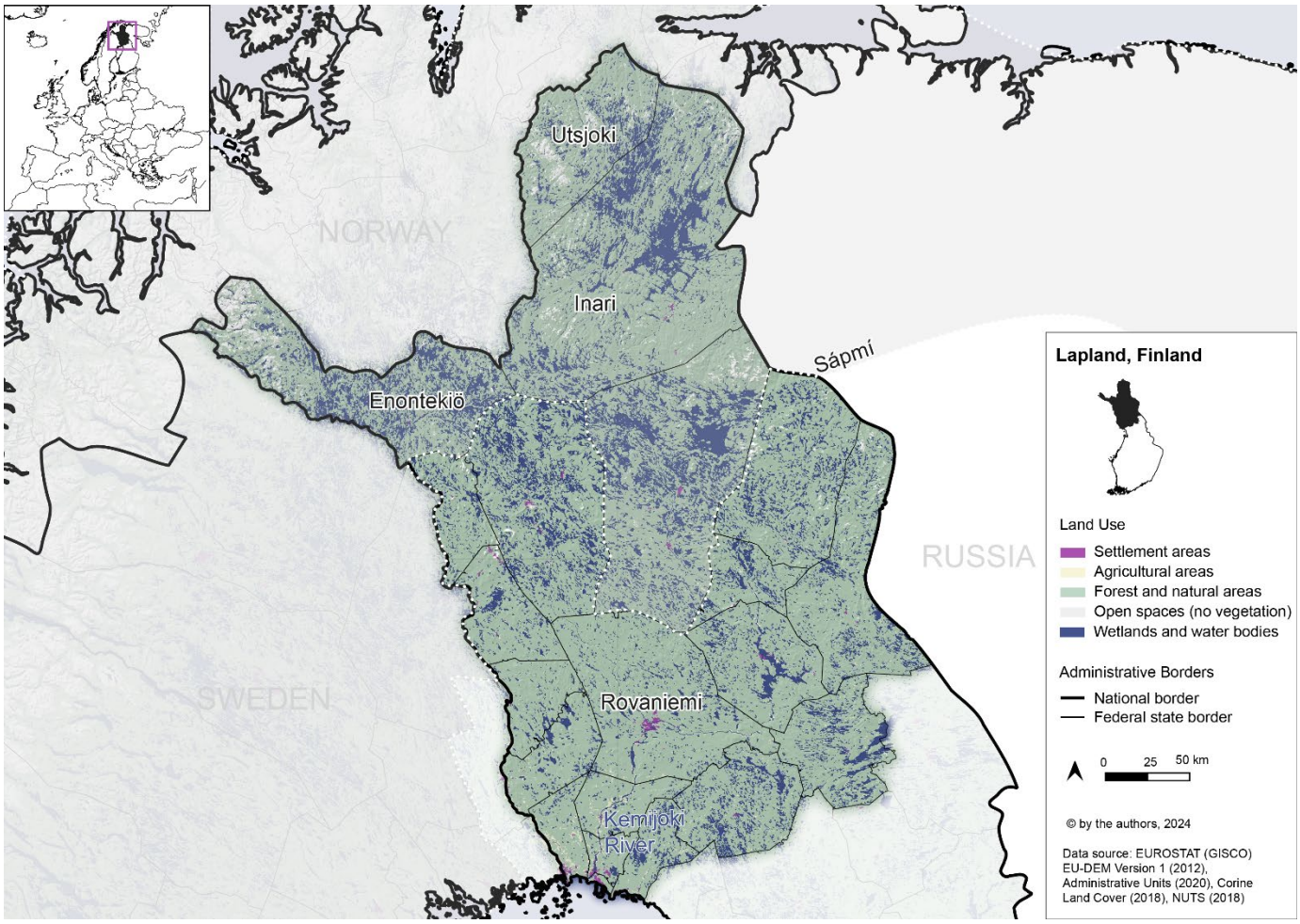

Figure 7. Map of Lapland (TU Wien, 2024)

Overview of ecosystem and environmental characteristics

Most of Lapland's area is located north of the Arctic Circle, within the middle and northern boreal zones (Lapin Litto, n.d.-b). Therefore, Lapland is the coldest region in Finland, its average daily maximum temperature amounts only to 5 degrees (Finnish Meteorological Institute, n.d.). Northern Lapland's climate is mainly continental but gains maritime features near Enontekiö and Utsjoki due to the Arctic Ocean, with temperatures from -0.5°C to -3°C and rainfall around 400-600mm (The Finnish Climate Change Panel, 2021, p. 95). Winter begins in mid-October in Lapland and lasts for about 200 days (6.5 months), compared to 100 days in southwestern Finland. In winter, the average temperature does not rise above 0°C. In the summer, the average temperature is between 6°C and 16°C. Summer starts in June and ends in August. In summer, the region also experiences the polar day, where it does not get dark (Finnish Meteorological Institute, n.d.). The northernmost regions experience 73 polar days. The warmest day is

around July 20, with inland temperatures reaching 32°C to 35°C. Heat waves and thunderstorms are common, especially inland (Finnish Meteorological Institute, n.d.).

Fells are a unique landscape feature in Northern Lapland. They are mountainous areas that are characterised by unique biodiversity. Mostly, they are not covered by trees, apart from some areas with a specific birch tree. This is unique in Finland, where 70% of the land area is covered in forest and forestry plays an important economic role (Forestry in Finland, n.d.). The highest mountain in Lapland, and in whole Finland, is Halti with 1,365m (Lapland, n.d.).

Description and key indicators for socio-economic profile

In Lapland the total population in the year 2022 amounts to 176,494 inhabitants (Eurostat, 2022f) following a population decline of -4.0 inhabitants in the same year (crude rate of total population change per 1 000 inhabitants) (Eurostat, 2022). The rate of migration differs depending on rural or urbanized municipalities, with urbanized municipalities like Rovaniemi recording a slight increase of immigration. Similarly with regards to the gender balance, Lapland has an overall deficit of women in the rural and peripheral areas. However, on a regional scope, compared to surrounding regions in Sweden and Norway, Lapland registers the most balanced gender situation (Grunfelder et al., 2017). Lapland has one of the lowest population densities in the EU with 1.9 persons per km² (Eurostat, 2022). As in many rural areas, younger people tend to migrate towards cities, leading to a higher old age dependency rate across Lapland (Grunfelder et al., 2017). In North and East-Finland though, the medium age of the population was estimated 45.2 years in 2022, relatively similar to the overall EU-average of 44.5 (Eurostat, 2022).

Lapland's total employment rate amounts to 71.5% in the age group of 15 to 64 years and differs by only 0.3% by gender (Eurostat, 2022). In comparison to whole Finland, the unemployment rate is 15% higher in Lapland (The Finnish Climate Change Panel, 2021, p. 51). In 2021, the regional GDP of Lapland amounts to € 7,066.43 million in the year 2022 which figures 2.82% of the national GDP (Eurostat, 2022). In North and East Finland, the Purchasing Power Standard (PPS) is € 33,500 PPS per inhabitant in 2022 (Eurostat, 2022), being only slightly below the EU-average of € 35,400 PPS per inhabitant. The risk of poverty and social exclusion was estimated 17.3% of the population (Eurostat, 2022).

Table 4. Socio-economic data for Lapland compared to EU average (Source: Eurostat 2022)

	Population density *(per km²)*	**Median age** *(in years)*	**Population change** *(in % from 2021 to 2022)*	**PPS per capita** *(in €)*	**Employment rate** *(in %)*	**Risk of poverty** *(in %)*
Lapland (2022)	1.9	45.2*	-4.0	33,500*	71.5*	17.3*
EU-average (2022)	109.1	44.5	+4.0	35,400	74.4	22.0

**ref. North & East Finland*

Lapland's economy consists mainly of tourism, forest bioeconomy, mining and metal industries and agriculture, including reindeer husbandry (Regional Council of Lapland, n.d.). Tourism accounts for 5.7% of regional GDP. 50% of tourists are from outside of the country, which is higher than the Finnish average. Pre-pandemic, the sector was also growing faster in Lapland than in the rest of Finland. Most overnight stays are counted in winter, which is also when most international tourists come to Lapland. Christmas is a particularly busy time, with specific activities tailored

to meeting Santa Claus (Visit Rovaniemi, n.d.). Tourism is an important employer, 8% of the workforce works in tourism, including many young people. Tourism is especially important to provide employment outside of urban centers (Regional Council of Lapland, 2017). Generally, tourism has a strong social license in Lapland and is perceived to bring more benefits than disadvantages.

2.1.2. Governance framework

Governance in Lapland is composed of multiple authorities. The statutory local government of Lapland, like all Finnish regions, are the Regional Councils, owned by all municipalities in the region and responsible for regional development (Hildén et al., 2022, p. 41). The highest decision-making body in the Regional Council is the Assembly of the Council, composed by municipal councillors that depend on the number of municipal residents. The Board of the Council, including municipal representative and one expert member of the Sámi parliament, is responsible for the practical work (Lapin Litto, n.d.-a). The 21 municipalities in Lapland each have their own local government and are governing social, planning and ecological services, CCA related examples include education and culture, urban planning and land use, water supply and waste management as well as fire and rescue services (Hildén et al., 2022, p. 46).

As the northernmost area of Lapland is located in the homelands of the Sámi, the governance of Lapland also involves the associated Sámi authorities. The Sámi Parliament is the supreme political body of the Sámi in Finland and has the mandate to represent the Sámi in Finland nationally and internationally, to protect the cultural heritage of Sámi and to issue matters important for the Sámi. This is established in the Sámi Parliament Act article 9, which requires all authorities in Finland to involve Sámi people on measure that impact Sámi homeland or their status as an Indigenous people. The legal framework of the self-administrating Sámi remains controversial though, as the Sámi parliament lacks the authority to advance their status as indigenous communities with land rights on Sámi territories. Currently, their work is subordinated to the Finnish Parliament and does not go beyond influencing political decisions (Kuokkanen, 2024).

2.1.3. Identity and self-image

Lapland considers itself capable of responding to climate change in a resourceful way, as stated in the Lapland Climate Strategy (2011, p. 24): "*Lapland is a successful region that seizes the opportunities of climate change and responds to threats and challenges*".

Figure 8. Touristic advertisement of Lapland (Source: mediabank.businessfinland.fi/l/ pxrK7TZZ6NgG)

In Northern Lapland, the multiculturality, especially the Sámi culture, functions as the most distinctive feature mentioned in multiple expert interviews (LI1; LI2; LI3; LI7; LI8). In the scope of wide distances and remoteness of dwellings, even the national borders to Sweden and Norway become blurry to the population, and it seems natural that families live on both sides of the borders (LI7). The municipality Inari has the unique selling point of being the only municipality in Finland, where all four cultures and language groups are represented (Skolt Sámi, Inari Sámi, Northern Sámi and Finnish) (LI7). Sámi culture has its own societal values, understanding of traditional landscape and sacred places (LI8), which is also reflected in Lapland's general close connection and dependency on the specific conditions of the arctic nature. The clear distinct climate of very cold winters as well as the variability in light levels in the seasons impact the population's annual cycle (LI3; LI5) and, with a view to the numerous tourism companies, is also being commercialized: "*Home of Santa Claus, the last wilderness in Europe, and part of the Sámi homeland. Lapland is a destination above ordinary, full of contrasts and unique natural phenomena: Midnight Sun, Polar Nights, autumn colors, Northern Lights, and Arctic cites nestled among Ice Age fells*" (House of Lapland, n.d.).

Reindeer husbandry plays a crucial role in the region's identity as it is not only an important economic branch and keeps remote areas inhabited, but also forms and preserves trans-generational values, traditions and indigenous rights (Rasmus et al., 2021, p. 1). Other traditional livelihoods of Sámi include hunting, fishing, handicrafts and gathering natural products (LI8). For the inhabitants, it is crucial that the Sámi culture is represented authentically and in a respectful way (LI2).

2.2. Systemic climate risks

The most important factors determining the directionality and design of CCA are concrete regional climate hazards and consequent systemic risks. This chapter overviews the main climate risks and relevant climate impact chains, pointing to the challenges for regional adaptation.

2.2.1. Main climate hazards and intermediate impacts

In a low emissions scenario (RCP2.6 or lower), temperatures in Lapland would still rise by 3-4°C by the end of the century. The current trajectory points to 4-5°C warming in Lapland. Other studies suggest that the Arctic area might warm up 3 or 4 times more than the rest of the globe. Climate change will have a greater effect on weather during the winter than during the summer. In winter months, temperatures might warm up by 3-4°C, while in the summer months it might be 2°C by mid-century (RCP4.5). Precipitation is also likely to increase more in the summer than in the winter. Heat waves will become more frequent (200-300% increase in heat days RCP2.6). However, heat stress on population is likely to remain very low or low, due to adaptive capacities among others (ESPON Climate Update 2022., n.d.). In winter, the rising temperatures will influence snow cover. Increase in precipitation could thicken the snow cover, depending on the temperature. However, the biggest change is that the snowy season will become shorter, by ca. one to three days per decade each at the beginning of the season in autumn and at the end in spring. Extreme weather events will become more frequent, causing flooding, especially in urban areas (Regional Council of Lapland, n.d.). However, considering exposure, vulnerabilities and adaptive capacity, (see Annex with explanation of system risk factors), the flood risk is set to decrease meaning that regional capacities will allow for sufficient preparation to prevent or cope with such events in urban areas (ESPON Climate Update 2022.). In the municipality of Enontekiö, it is likely that there will be more snow as the result of climate change, which may have positive effects for biodiversity and tourism. In Utsjöki, snow cover is set to decline.

2.2.2. Climate Impact Chains

We have developed two climate impact chains for the region of Lapland, one for the tourism sector and one for reindeer herding in Lapland (cf. figures below).

Reindeer herding is particularly prevalent in the North of Lapland, whereas the South is characterised by more traditional agriculture. The climate impact chain focuses on the risks to both, the health and life of reindeer, and on the loss of lifestyle and tradition for Sámi people. Changes in summer and in winter both affect reindeer husbandry, and thus the economic viability and continuation of traditional Sámi lifestyles. Higher temperatures and heat waves in the summer may increase heat stress for reindeer as well as enabling more blood sucking or disease carrying insects to impact the reindeer. No coping strategies have been developed yet to assist reindeer in coping with heat (LI5). Usually, there is no active herding in the summer and the animals are free to roam. Calves tend to get marked after birth to identify them in autumn, however, in the heat this is too stressful. Therefore, if the calves do not stay with their mother, it is impossible to identify which herder they belong to.

In addition, the change of precipitation, where rain that freezes and snow interchange, makes it harder for reindeer to feed on winter lichen. As rain freezes on the ground, it creates a layer of ice that is hard to penetrate for the reindeer and they cannot reach the lichen. Wet conditions in the onset of winter can also lead to mouldy lichen, which leads to stomach problems of reindeer. As the tree line moves further north, the conditions for lichens are less favourable. They need light and therefore cannot grow as well in forests.

In addition, there are several industries competing for land use; tourism, hunting, fishing, hiking reindeer herding, and forestry (LI1; LI3). Each of these industries interfere with reindeer husbandry and the reindeer's free use of grazing grounds. Wind parks disrupt the grazing habits of reindeer as they are disturbed by them and will avoid areas with wind turbines (LI1). However, since Sámi associations are involved in many land-use decisions, there are very few wind turbines so far in Lapland (LI3). Sámi are especially protective of sacred spaces, that could be completely "ruined" by wind parks. In addition, the traditional knowledge specific to a certain place and its biodiversity would be lost (LI8).

Since reindeer are afraid of dogs, dog sledging will keep reindeer away from the paths of dog sledging tours (LI1; LI7). In addition, hunters, who are mostly active in autumn, bring their dogs. When reindeers stay closer together due to being afraid of dogs, they do not eat enough mushrooms in that season which makes them more vulnerable to food shortages later in winter (LI8).

These factors combined add more pressure on land use, which means that traditional grazing patterns and routines can no longer be implemented. As the space for rotational grazing diminishes, the grazing itself also adds to the pressure on the land and biodiversity as there is less time for soil and plants to recover (Climate Guide, n.d.). All the above-mentioned factors have meant that many reindeer herders have had to supplement grazing with extra fodder, which increases the cost. Due to increasingly slippery conditions, accidents of reindeer and herders have become more common.

These impacts can already be felt now and are set to increase with progressing climate change. Reindeer husbandry is already less economically viable than it was a few decades ago and many herders supplement their incomes with other jobs, for example in tourism. They also receive subsidies (LI4). There is a direct risk to the traditional culture, identity and lifestyle of the Sámi. In addition, reindeer need to be trained to be able to interact with tourists. Discussions revolve around how Sámi culture can be authentically represented. It is presumed that the number of Sámi abandoning traditional lifestyle and language or even living outside of their homelands will increase (Tennberg et al., 2017). In addition, reindeer and Sámi are one of the key selling points of tourism in Lapland, on which this would also have an effect.

The second Climate Impact Chain revolves around the tourism sector. Shorter winter seasons with delayed onset of the snowy season, sudden changes in temperature during the season and strong wind and storms are likely to affect the nature-based tourism activities predominant in Lapland. A lot of international tourism relies on activities with snow, particularly around Christmas. Tourists expect a winter wonderland. Especially early in the season (and around Christmastime), snow can no longer be relied on, which affects Lapland's reputation as a snow-safe destination (LI2;

LI4). However, as this will be a very slow development, tourism operators should have enough time to adapt to these changes (Tennberg et al., 2017). An exception to this development is the municipality of Enontekiö, which can expect more and longer snow cover, which could have positive effects on tourism (LI7).

Temperature increases will also lead to changes in vegetation and animal populations, for example in the unique fell landscape in the north of Lapland. While some of the flora and fauna have a wide range to cope with increases in temperatures, others might not. In addition, with the tree line further North, uncharacteristic trees may start growing on fells, changing the unique landscape feature optically, but also threatening its unique biodiversity (Climate Guide, n.d.; LI3). Beyond effects on biodiversity, it might also impact tourism activities such as fishing or hunting. In addition, due to thinning ice cover, some hiking facilities can no longer be serviced via the routes that allowed driving on rivers. Some providers have now started to use helicopters (LI1).

Slippery conditions, including on highways and roads, as well as tracks might lead to accidents or accessibility becomes unreliable, with impacts on the local population as well as tourism activities. Hunting and fishing become more dangerous or cannot take place. More variability in weather conditions in general might increase the days with cloud cover, which makes it harder to see Northern lights, another big pull-factor for tourism in Lapland. Supply of local products, such as reindeer meat, mushrooms or berries are at risk, as well as the supply for traditional handicrafts. In combination, these factors could hurt the local tourism industry, without any adaptation activities are taken up.

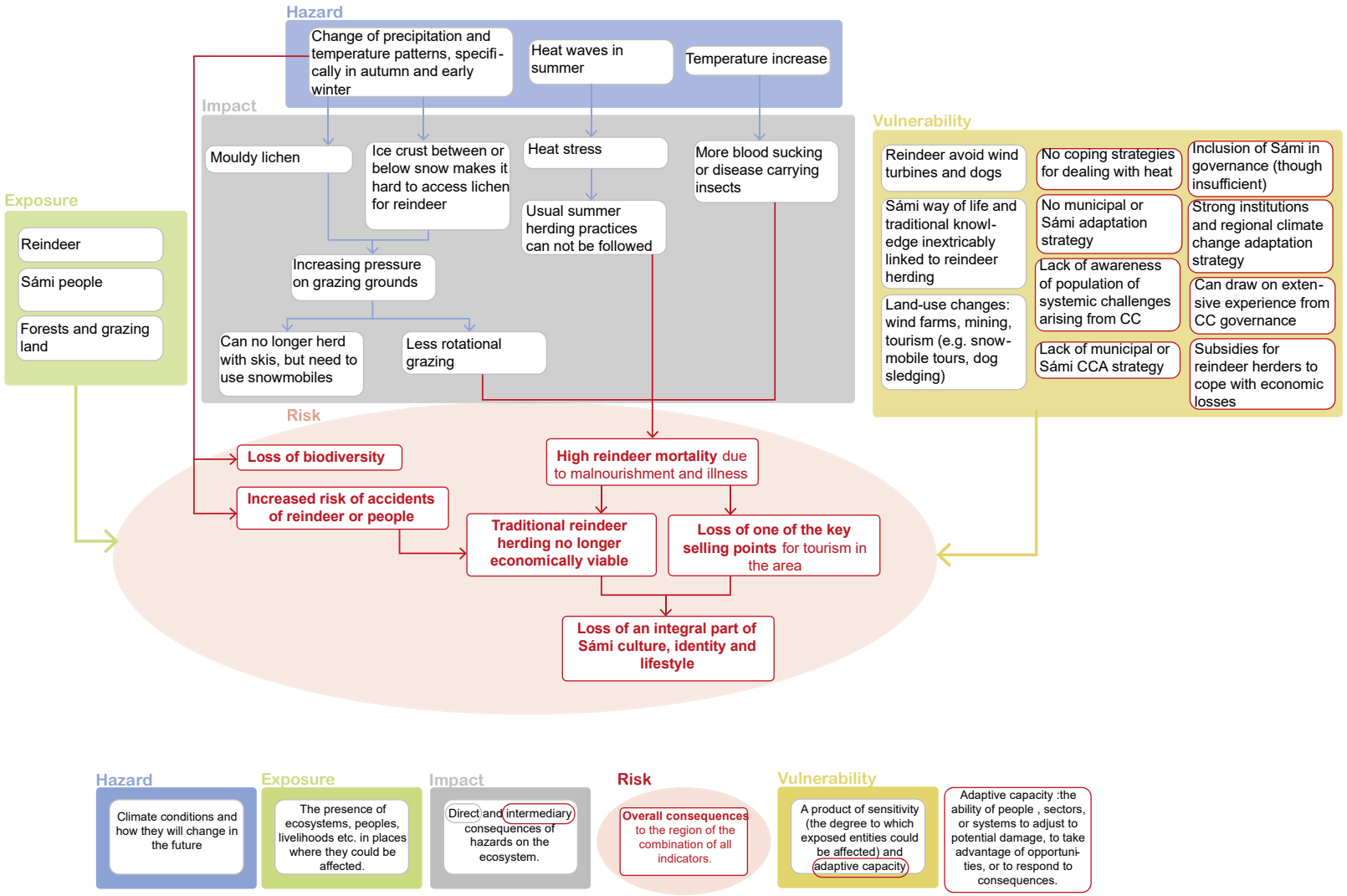

Figure 9. Lapland IC for reindeer herding (ZSI, 2024) | *cf. chapter 11.2 for IC methodology*

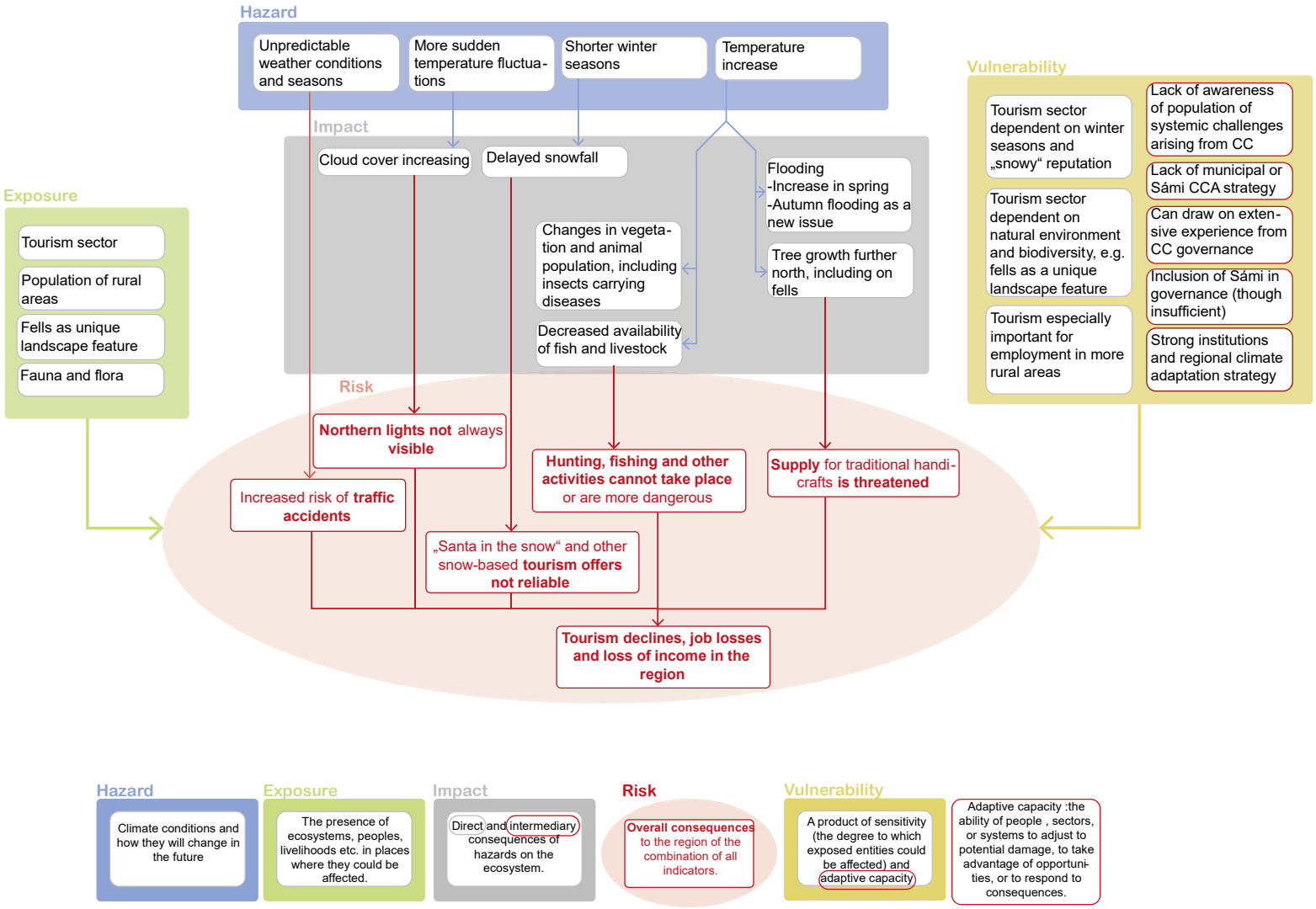

Figure 10. Lapland IC for tourism (ZSI, 2024) | *cf. chapter 11.2 for IC methodology*

2.3. Regional CCA governance

CCA activities should be well-embedded in the strategic objectives of a region and strike a balance between stakeholder inclusion and leadership. Accordingly, understanding the strategy framework and stakeholder landscape of regional CCA governance is important. This chapter identifies key regional CCA-related strategies, how CC and its consequences are problematized therein and how certain adaptation challenges are prioritized. It highlights the prevailing understanding of CCA and the emphasized approaches for tackling it, as well as the most important regional stakeholder groups, which is important for the design and implementation of concrete adaptation activities.

2.3.1. Strategy framework

Being in line with international and European strategic frameworks, such as the Paris Agreement (2015), the United Nations Agenda 2030 (2015), the European Strategy for Adaptation to Climate Change (2013[2021]) or the EUs Green Deal (2019), there are several national, regional, local and sectoral strategies to combat climate change and support sustainable development in Finland.

In Finland, adaptation to climate change has been issued since the beginning of the 21st century, with the first "National Strategy for Adaptation to Climate Change (NAS)" published in 2005 (Ministry of Agriculture and Forestry, 2005) followed by "Finland's National Climate Change Adaptation Plan (2022)" published in 2014 (Ministry of Agriculture and Forestry, 2014). The Ministry of Agriculture and Forestry is responsible for the national coordination of climate change adaptation work (Ministry of Agriculture and Forestry, n.d.). However, Finland has the premise to counteract climate change with considering adaptation policy in all sectors and branches which is developed in different ways and stages (Hildén et al., 2022).

The current strategic framework for CCA is "Finland's National Climate Change Adaptation Plan (2030)" (Ministry of Agriculture and Forestry, 2022). It builds on the climate policy planning system according to the revised Climate Act (423/2022), which aims to enhance the planning, implementation and monitoring of measures for climate change adaptation and mitigation (Ministry of the Environment, n.d.). The reform of the Finnish Climate Act emphasizes mainstreaming and the importance of strong rights of the indigenous peoples. Both revisions are seen to support the adaptation to climate change. The Ministry of Environment and the Ministry of Social Affairs and Health also developed separate adaptation strategy: "Climate change in the social and health sector: Ministry of Social Affairs and Health's climate change adaptation plan (2021-2031) (2021)".

Therefore, in comparison to other countries, Finland can demonstrate a cross-sectoral and long-term approach to CCA strategies. However, it has been criticized that adaptation measures on a national level have concerned mostly their governance and regulation (Hildén et al., 2022, p. 52). Observed obstacles to successful CCA of Finland are missing legal bindings and interdependencies across different administrative sectors in their practical adaptation. This shows in the lack of concrete quantitative goals for adaptation, which leads to uncertain shares of responsibilities between the respective administrative sectors (Hildén et al., 2022, p. 37ff).

On a regional scale, adaptation and mitigation of climate change as part of regional development and duty of regional councils is determined in the Regional Development Act (756/2021) (Hildén et al., 2022). Strategy wise, Lapland formulated various sectoral plans tackling climate change, even if only on the margins, like "Lapland's Tourism Strategy 2020-2030 (2019)" and "Lapland's Sustainable Smart Specialization Strategy 2023-2027 (2023)". In 2011**,** **"**Lapland's Climate Strategy 2030" was proposed as a first strategy dedicated to climate change in the region, whereas it focuses mostly on CC effects and mitigation. Within the development of the Climate Strategy, the city of Rovaniemi prepared its own "climate program for the forest sector" (United Nations et al., 2014). Although "Lapland's Climate Strategy 2030" has not been renewed yet, regional climate forecasts are being used in regional planning and CC has a high priority in terms of funding which could be indicated in almost all current funding decisions (The Finnish Climate Change Panel, 2021, p. 51f). The "Green Deal Roadmap", which was developed in part with the "Tourism

Board", functions as Lapland's baseline in the framework of the EU's Green Deal targets but must be categorized as a voluntary strategic plan (Lapin Litto, n.d.-c).

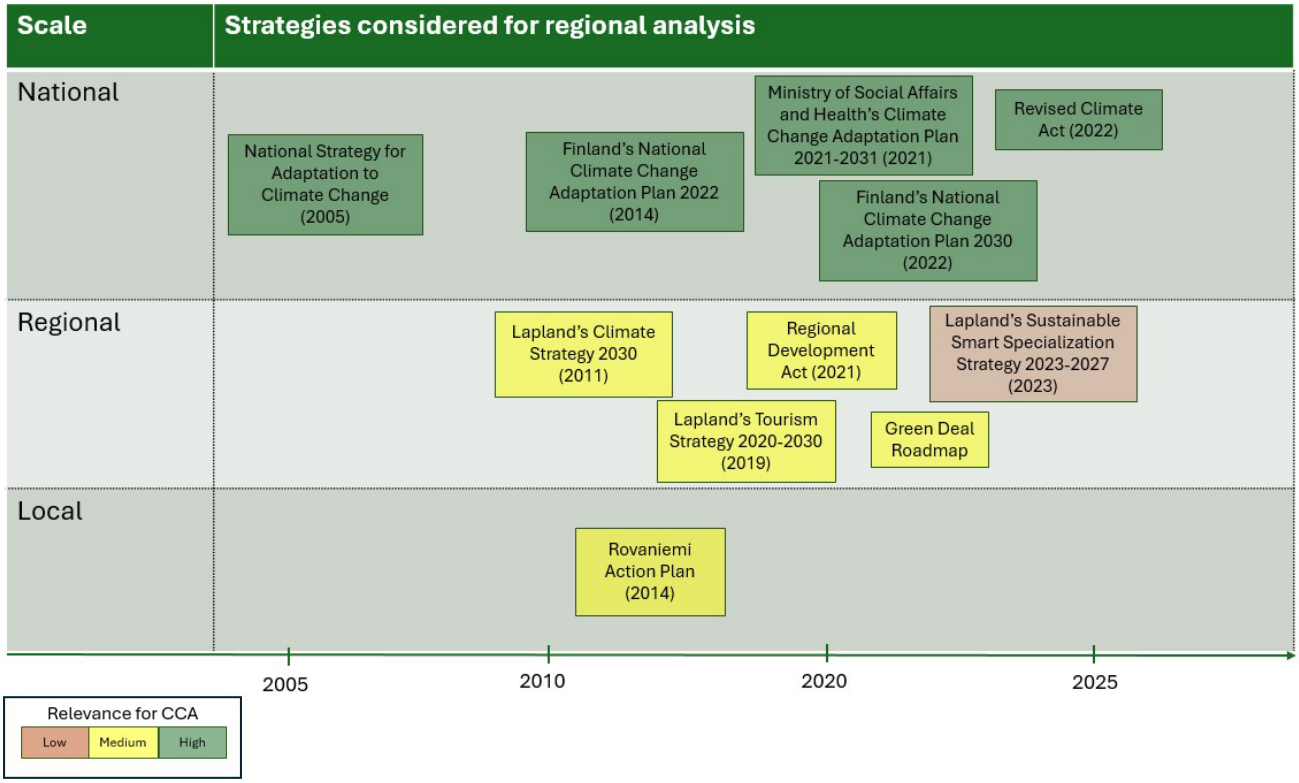

Figure 11. Overview of CCA-relevant strategies for Lapland (TU Wien, 2024)

2.3.2. Problem background and prioritized challenges

The region of Lapland with its distinctive arctic climate faces numerous interrelated challenges due to CC. Global warming is proceeding much faster than in other regions and the arctic nature is more vulnerable and fragile towards changing temperatures and other effects of CC (LI1). With regards to the expert interviews, the LVDWS and the systemic climate risks, the following socio-economic challenges, resulting from the impacts of CC, have been identified and prioritized in terms of CCA.

In Lapland's climate strategy (2011), the needs for adaptation are identified in the operating conditions of agriculture and forestry, in the snow dependency of the tourism industry as well as in (winter) flooding and in changed fishing conditions due to heat waves (The Finnish Climate Change Panel, 2021, p. 51f). Nowadays, CCA has become more urgent and its requirements more complex.

Rising temperatures lead to changes in snow availability and water bodies in the northern parts (LVDWS). When snow comes earlier than it used to be, the icing of lakes and rivers, important surfaces for humans and animals, is too thin and leads to dangerous paths and an increased risk of incidents (LI7; LI9). The higher temperatures also increase the melting of peatlands ice, resulting in the release of carbon and loss of habitats for distinctive species (LI3). Invasive species appear more and more and are threatening the availability of vegetation (LI5; LVDWS). The forest line on top of the fells is rising due to increasing temperatures, especially pine trees seem to spread out (LI4).

Table 5. Main CCA challenges for Lapland

Vulnerable (traditional) livelihoods and living conditions	With reindeer herding and tourism as the main livelihoods in Northern Lapland, the region is dependent on specific climate conditions, such as sufficient icing of lakes, availability of snow and sparsely wooded areas. Climate change effects threaten these livelihoods through rising temperatures, changes in precipitation and snow and other direct and indirect effects. All beings are exposed to an increased risk of incidents. Adapting these livelihoods, which are so closely connected to the arctic nature, is one of the main challenges for Lapland.
Absence of CCA governance and inclusion of independent communities	Although on a national level, current strategies formulate adaptation measures, the CCA governance on a regional or even local level is insufficient due to lack of funding, clear share of responsibilities and political prioritization. CCA governance on a national or EU level also misses an adequate representation of independent communities, with regards to Sámi culture but also broader speaking of all communities in Lapland, living in very specific conditions.
Intensification of existing land use conflicts	Strongly connected with CCA of the traditional livelihoods, the use of land in Northern Lapland is conflicted. Many industries are dependent on tilling it in different ways whereas Sámi people rely on an intact nature to follow their traditional way of living. With CC and CC mitigation goals, such as the expansion of renewable energies, these conflicts intensify.
Action and knowledge gaps	For many impacts of CC, such as warm summers, the knowledge of herders on how to adapt does not exist yet. This challenge relates to missing CCA governance. Although CCA actions on an individual level are already taken out of the simple need for them, for many CC effects further knowledge and a cooperative approach to CCA is required.

As elaborated in the chapter on SCR in Lapland, the ecological changes are particularly harmful in Northern Lapland regarding the socio-economic effects at the two main livelihoods. Tourism and especially reindeer herding are strongly dependent on the specific arctic nature conditions and therefore especially vulnerable sectors. The icing of the ground, but also the decreased availability of lichen (LI8), an important food source for reindeer, impede the economic viability of the reindeer businesses. The rising temperatures lead to an increased risk of heat-related diseases like bird influenza for animals (LI8) and herders lack of an adaptation strategy for this hazard, especially in summer (LI5). The need for CCA is for the Sámi simultaneously a need for a cultural change as their traditional living connected so strongly with the arctic nature (LI9). In terms of tourism, a need for a different infrastructure arises as snow conditions become more poorly (LVDWS). On the one side, an enhanced approach to summer and all-year round tourism calls for alternative activities for tourists. On the other side, tourist activities, especially dog sledding, have a negative effect on the traditional reindeer herding (LI7). Generally, existing land use conflicts are getting reinforced with CC. The adaptation of the traditional livelihoods and views, for example with regards to sacred mountains, clashes with the green transition land use models (windmill parks, solar power, mining) (LI7, LI9). The objectives of the green transition in Finland face other obstacles in the arctic nature than on more southern parts of the country: the remoteness and the minus degrees hamper the enhanced use of electric vehicles and green energy for heating the buildings (LI7).

On a governance level, regional experts asses the CCA challenges in (northern) Lapland mainly as a lack of human resources, time and money to prepare a comprehensive CCA strategy on the one side (LI6; LI7), and on the other side as a lack of political will (LI8) and cooperation between district level and municipality level (LI5). This is reflected also in the impression that the CC regulations are more voluntary than binding (LI4). Additionally, the lack of political representation in Helsinki seems to hamper the regional capacity CCA (LI7). CCA within the Sámi culture currently is happening spontaneously, without separate support or resources of the Lappish society (LI9). The CCA governance seems fragmented, as some sectors are already doing CCA action (the Arctic Forest Management Metsähallitus has its own adaptation mechanisms in the business department of their organisation (LI1)), while others do not. Four summarized regional challenges for short and long-term CCA could be identified, being presented in the table below.

2.3.3. Prevailing understanding

Climate change adaptation action in the region is strongly understood as …

- ***CC mitigation**:* Mitigation and adaptation are partly understood and used interchangeably, for example the electrification of traffic as a CCA measure (LVDWS). Additionally, it has been mentioned that municipalities that are frontrunners in mitigation are not necessarily equally engaged or successful in adaptation (LI6). Although on an academic level, CCA has been tackled for 20 years (LI5) and Finland has been the first EU member state to publish an adaptation strategy (The Finnish Climate Change Panel, 2021, p. 7), the focus still is mostly on mitigation. "*We have talked about mitigation for 30-40 years; people have learned what it means. Adaptation is very hard to understand, we started talking about it not even five years ago."* (LI6) This is also due to the self-evident sustainable lifestyle for the Finnish and the Sámi population (LI2) as seen in the enhanced importance of self-resilience (local food production) (LVDWS).

- ***Preservative towards regional economies**:* The importance of obtaining especially tourism as an important economic branch indicates at least partly a preservative understanding of CCA in Lapland. Expanding tourism to all four seasons and developing activities without snow are meant to stabilize the economic value deriving from the tourism sector (LI2). A preservative understanding is in contrast to a transformational approach, which goes beyond measures for the preservation of the status-quo.

- ***A transformational change of all sectors**:* A uniform understanding of CCA in the region is that of a holistic, even transformational adaptation that spans all sectors right down to the individual (LI2). Especially Sámi people wish for a holistic approach (LI8). The sectors tourism, agriculture and forestry are the most vulnerable sectors economically and are meant to push their CCA as first sectors (LI4).

- ***Reactive:*** Currently CCA work is rather composed of reactions to CC induced changes, but without long term CCA planning (LVDWS). This is reflected for example in the fact that despite the absence of a comprehensive and up-to date CCA strategy for the region, local herders are already developing CCA actions based on their work experience.

2.3.4. Emphasized approaches

Improved CCA governance, representation of independent communities, and financing CCA: Improved governance of CCA is envisioned as *"high-level political agenda and strategies"* (LI6) and are for example formulated as the need for a comprehensive strategy for respective livelihoods, for example for reindeer herders (LI4). The basis for the development of CCA strategies lies, among others, in the need for funding, for which the Regional Council of Lapland is waiting currently (LI6). In financial aspects, financial subsidies for herders to cover losses (LI4) and

compensation programs of tourist companies to balance out their ecological footprint (LI1) have also been mentioned in the expert interviews. Establishing binding and ambitious targets for climate visions, the protection of biodiversity and the traditional knowledge of Sámi is envisioned as well (LI9).

CCA governance also includes the development of new kinds of collaborations from different stakeholders (LI9), for example between districts and herders (LI1) or business related cooperations as between snow mobile companies and herders (LI8). With respect to the Sámi Climate Council, a regional CCA strategy must be based on scientific findings and traditional knowledge in equal measure and supports climate action for the Sámi population, entrepreneurs and the municipal services (LI9).

Resilient livelihoods and safe living conditions: Although strongly dependent on an improved governance of CCA, resilience building in tourism and reindeer herding comprises a broader spectrum of approaches and actions from the affected parties. Key adaptation efforts include the development of concrete adaptation measures, diversification of CCA strategies and a focus on capacity building support. "*There is quite a lot of information about how the global warming is proceeding and now we should be able to make more practical changes"* (LI1).

Strengthening public participation in land use decisions: To combat the aggravation of the ongoing land use conflicts, the role of a neutral higher governing body should be strengthened: "*somebody who is higher and neutral could be useful, like municipality*" (LI5). Closely correlated with reindeer herding, land use planning is one of the strongest tools to support or undermined the adaptation in Lapland (Rasmus et al., 2023). In that sense, participatory environmental governance and public participation are necessary to successfully recognize herding practices and involve herders' perception of the environment which forms their base of acting accordingly (Rasmus et al., 2021, p. 15).

Filling action and knowledge gaps: Enhancement of monitoring CCA actions, making them – as well as (project) results from (academic) research (LI5) - accessible to all interested actors is seen as crucial step for successful CCA, for example local actions as adapted fishing or actions from herders (LI8). An enhanced general awareness and initiative of all parts is missing (LI3,), which results in the need for a shared table to exchange information and knowledge (LVDWS; LI4) and climate education (LI3, LI9). Additionally, the identification of means and resources to achieve set climate goals plays a role in filling knowledge gaps (LI9).

2.3.5. Important stakeholder groups

Government: The Regional Council of Lapland is seen as one of the most important stakeholders in Lapland. The Council is in part responsible for financing projects (LI1) and has therefore a great potential to push CCA: The "*Regional Council of Lapland has a strong role there on the strategical part but also in terms of funding – they are the decision-makers and can help the development*" (LI2). For the area of the Sámi, the Sámi Parliament, located in Inari, represents the Sámi's interest in CCA, is the main governing body (LI8). The Sámi Climate Council, an independent expert body, has started its work (LI5).

Regional (Land) Management: State administrative agencies for regional management are seen on the same level of importance as the Regional Council of Lapland as they are the biggest landowners in Lapland and responsible for the management and maintenance of natural areas. On the one hand, the ELY Center Lapland (Centre for Economic Development, Transport and the Environment) plays a crucial role at implementing national policies at a regional level. It is concerned with statutory managing environmental protection, monitoring and controlling environmental changes. In terms of adaptation, important sectors of responsibility are the functionality of the transport system, biodiversity protection, land use and flood risk/water management (Hildén et al., 2022, p. 41). The ELY Center Lapland is also currently part of a "Climate Change Expert group" (Organisation fo climate work at ELY) (LI5). On the other hand, the state-owned enterprise Metsähallitus is responsible for the management and planning of forest areas

and biodiversity/natural habitats. Metsähallitus collaborates with the Sámi people and other local communities to support traditional reindeer herding practices, but are also occupied by maintaining tourism infrastructure, e.g. hiking trails (LI1).

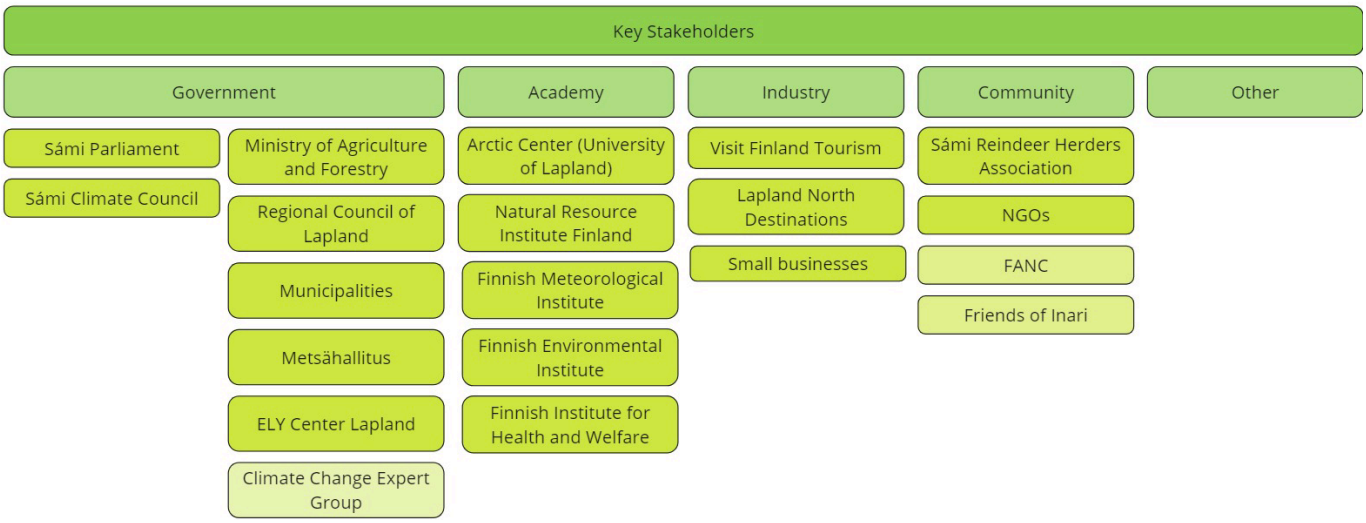

Figure 12. Key stakeholders in CCA in Lapland (TU Wien, 2024)

Academy: As many academic projects have already been implemented in the area, the University of Lapland has been mentioned as a crucial actor, especially their Arctic Center. Further Research Institutes include the Finnish Meteorological Institute, the Finnish Environment Institute, the Finnish Institute for Health and Welfare and the Natural Resource Institute Finland (LUKE) with the latter being indicated as one of the main drivers of CCA work in the region (LI5).

Community: In terms of reindeer herding, the 8 Sámi Reindeer Herder's Associations, as well as the Reindeer Herder's Associations in Southern Lapland must be included in CCA work (LI1). The environmental NGOs in the region, "Finnish Association for Nature Conversation (FANC)" and "Nature Friends of Inari", play only a subordinate role (LI3).

Industry: The influence of the tourism sector as the main employer in Lapland is recognized as crucial for CCA work: *local tourism companies and destination management organisations (those are strong) have the key role at working on practical adaptation, they do marketing work, but also strategical work, some are quite strong and big" (LI4).* Those include the national organisation "Visit Finland", the "Tourism Board" and smaller tourism companies as well as destination management organisations.

On a regional level, the cooperation works quite well as not so many actors are involved in the topic (LI4). In contrast, the cooperation with the national and EU-wide level is complex (LI4), as conditions in Lapland differ a lot from other regions and the Lappish and especially the Sámi people do not feel heard (LI8) enough by these higher political levels (LI8).

Furthermore, as part of the stakeholder mapping in T1.3, public cooperation bodies (e.g. the Tunturi-Lapin Kehitys ry.) and research stations (e.g. the Kilpisjärvi Biological station) on a local level are depicted that were not mentioned in the interviews.

2.3.6. Assessment

Although Lapland has been involved with CC for a comparatively long time with regards to academic research and mitigation, the region misses an up-to-date and comprehensive CCA strategy due to lack of funding and human resources. Lapland is therefore no exception compared to the other regions when it comes to the challenges associated with CCA governance. Following the results from the expert interviews, it can be positively noted, that all stakeholder groups are aware of the need for CCA action and willing for change, although the extent of a transformative CCA approach differs. However, it is worth noting that the stakeholders already know relatively precisely which challenges the region needs to deal with and which approaches are appropriate. What is missing are legal ties to make the decision-makers capable of acting and the knowledge on concrete local actions for individuals.

2.4. Key adaptation actions

This chapter introduces good practices that have already demonstrated how CCA can be approached in the region. These actions are not representing the full scale of approaches in the region but give a relevant overview of the priorities given to adaptation while pointing out different innovative solutions to address the specific challenges and risks that were induced by climate change.

Compared to other regions, many (international) projects have already been conducted in Lapland, exploring CC-induced changes in the arctic nature, its implications on local communities and possible solutions. According to the interviews, research projects in Lapland concerning CC began with collecting experiences and climate impacts, currently, a greater focus lies on adaptation measures (LI5). The three projects that were mentioned in the interviews most frequently are depicted below.

However, local CCA actions are already taking place simply out of the necessity to adapt. These include:

- *The modification of the (additional)* ***feeding and mobility of reindeers*** *(LI8). As an example, to combat the spread of pine trees in higher fells and therefore the decrease of available lichen, reindeers are herded into these areas, where they scratch their heads on the young trees, causing them to die (LI8). Reindeer herders are also using GPS trackers attached to the reindeer to facilitate following their paths as the changing weather conditions lead to changed routes of the reindeer (LI8).*
- ***Nature-based solutions*** *are already used for roads and floods, as flood protection is built by natural materials (sand with planted trees) (LI4).*
- *The* ***tourism sector*** *in Lapland has already undergone adaptations in terms of the advertisement of summer holidays, offering summer versions of dog sledging like activities with puppies or cards with wheels as well as the advertisement of the polar lights, that do not only happen in winter (LI2).*

CLIMINI - Adaptation of reindeer management to climate change: The “CLIMINI” project (2020-2023), funded by the European Regional Development Fund and conducted by the University of Lapland, the Finnish Meteorological Institute, and the Natural Resources Institute Finland (LUKE), investigated adaptation strategies in reindeer husbandry. Through literature reviews, data analysis, interviews, and workshops, new insights were gained, and policy recommendations were developed. Four reindeer herding cooperatives participated in piloting practical adaptation models. The project emphasizes the need for planned, proactive adaptation and strengthening the adaptive capacity of reindeer husbandry. It calls for improvements in legislation regarding compensation for environmental losses and adjustments in land use planning. Additionally, systems for monitoring critical environmental conditions and the development of competence and cooperation networks should be enhanced. Both traditional knowledge and education play crucial roles (Rasmus et al., 2023). (cf. CLIMINI)

CHARTER - Drivers and Feedbacks of Changes in Arctic Terrestrial Biodiversity: The EU Horizon 2020 project “CHARTER” is managed by the Arctic Centre at the University of Lapland and aims to advance the adaptive capacity

of Arctic communities to climatic and biodiversity changes with combining Earth System science and biodiversity studies within a social-ecological system framework. A focus lies also on a strong participatory approach with strategies co-developed with indigenous and local communities. (cf. Charter Arctic)

AKWÉ: Kon model: The Akwé: Kon Guidelines are "voluntary guidelines for the conduct of cultural, environmental and social impact assessments regarding developments proposed to take place on, or which are likely to impact on, sacred sites and on lands and waters traditionally occupied or used by indigenous and local communities" (IPBES, n.d.), formulated by the UN Convention on Biological Diversity. Since 2011, Metsähallitus and the Sámi Parliament jointly use the operating model for planning the management and use of the region's conservation and wilderness areas. (cf. Cooperation Metsähallitus Akwe Kon)

2.4.1. Learnings

Lapland's experience with CCA includes on the one hand practical adaptations by local reindeer herders as well as CCA measure of the tourism companies. On the other hand, various (big scale) projects have already been conducted tackling the impacts of climate change on the specific natural conditions above the arctic circle and additionally the inclusion of indigenous communities. The region's competence deriving from CCA actions therefore lies in the diversity of actors and levels that push CCA. A thematic focus is placed on reindeer herding and land use planning, as well as arctic and indigenous communities.

2.5. Transformative pathways

The overview of regional structure, systemic climate risks and existing CCA governance, coupled with knowledge on the planned DA, allow a final assessment of the most relevant barriers and opportunities for transformative CCA in the region, as well as pointing to the key transformative capacities that need to be utilized or developed further. To this end, a validation workshop was held in the region to discuss barriers, opportunities and key transformative capacities with knowledgeable actors. This chapter elaborates on these aspects and concludes by providing concrete advice for transformative CCA in conjunction with the fields of action of the respective DA and beyond to facilitate transformative regional CCA.

2.5.1. Barriers and windows of opportunity for CCA

In Lapland, CC not only leads to challenges, but also to changes in the environment that have a positive impact for Lapland's society, especially in economic terms. Lapland's climate conditions harbour the possibility of an even greater expansion of tourism, especially in summer as the rest of Europe suffers from extreme heat (LI7). The changed availability of snow is also leading to more snow in some areas, like for example in the municipality of Enontekiö, producing a *"bright view on the future*" (LI7).

In addition, the region profits from its sparse population, as the number of stakeholders and decision-makers involved in CCA work appears manageable. Compared to other regions, which are characterised by a complicated situation with many CCA actors in various sectors, the cooperation in Lapland profits from a clear cooperation network. "*In Lapland the cooperation between the stakeholders works very well because there are not so many actors working on that issue – a tight network and it works quite well"* (LI4).

On the other side, tourism is also seen as a barrier for a successful CCA as the ecological impacts of overtourism cannot be denied (LI1). The feeling of resignation and limited power of individuals was also mentioned in terms of barriers (LI4). The main obstacle in this regard is the lack of communication towards the population: *"People don't know what adaptation means and what it could mean at a concrete level*" (LI6) – following this perception, the introduction of pilot projects on a regional level could contribute to an improved understanding (LI6). "*The old problems*" (LI7) with regards to land use and tourism could hamper CCA action, meaning a critical view on development (LI7). However, with time, new herders and entrepreneurs in the tourism industry are more intertwined

than in the past, one person might even have both professions, which is helpful to build trust between the sectors (LI7).

2.5.2. Regional validation workshop

The regional validation workshop aimed at presenting, critically discussing, and further developing initial hypotheses and interim findings on transformative adaptation with knowledgeable regional actors. The workshop hence consisted of two parts: In a first session, regional CCA measures, challenges and opportunities deriving from the previous analysis were presented and subsequently debated in smaller groups as well as in the plenum. In the second session, regional transformative capacities that were identified as relevant by the research team were introduced and put up for discussion. This gave participants the opportunity to share feedback, give concrete examples stemming from their own experience or bring in new ideas for effective CCA governance.

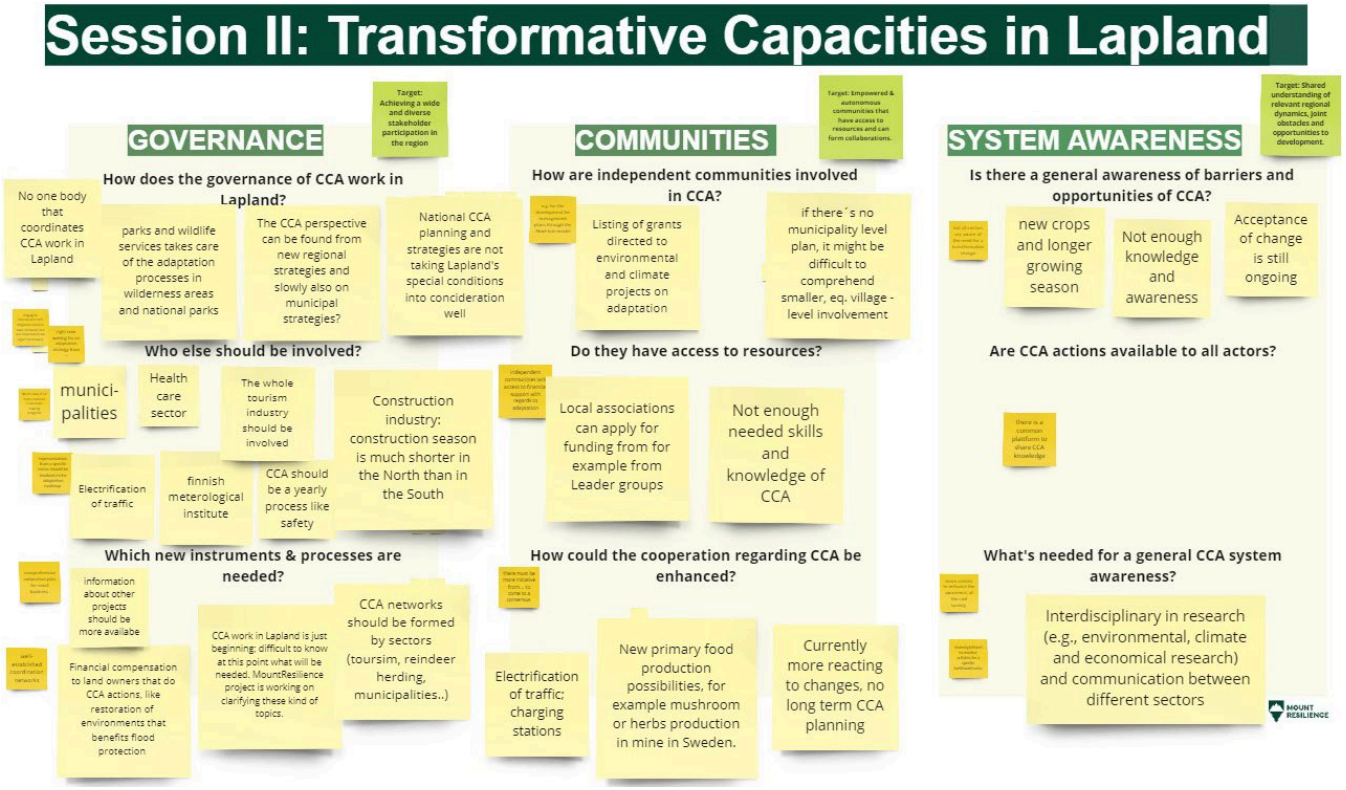

Figure 13. Accompanying Miro Board from VDWS in Lapland.

Particularly relevant topics that were addressed include CCA strategies and coordination, the scope for action of independent communities and regional specific windows of opportunities. The participants in the workshop addressed that CCA efforts in Lapland are fragmented with no central coordination despite many ongoing projects. It was stated, that although there is a network for CCA research that meets regularly, there's a need for better information sharing and building connections. With regards to governance on a national level the following quote reflects a need for better representation of the region: "*National CCA planning and strategies are not taking Lapland's special conditions into consideration well*" (LVDWS). For small communities, taking on a bigger role is challenging if municipalities are not proactive: "*Currently more reacting to changes, no long term CCA planning*" (LVDWS). Although these communities may have access to resources, they often lack the capacity to participate fully, and there's a need for their voices to be heard more actively. In terms of system awareness, the participants indicated a need for "*Interdisciplinary in*

research (e.g. environmental, climate and economical research) and communication between different sectors" (LVDWS).

The workshop was conducted in an online format on June 17, 2024, from 14:00 to 16:00 (EEST) with an audience of 21 participants. The online tool Miro was used to facilitate visualization of discussion points.

2.5.3. Regional transformative capacities

Overcoming a focus on mere adaptation responses towards more long-term transformative change, the concept of transformative regional capacities offers a perspective on the wider interplay, forming a more systemic perspective. The last step of the regional CCA analysis aimed at the identification of regional strengths and transformative capacities by assessing regional/local implementation barriers and existing regional capacities. Building on the analysis results and workshop responses (conducted in June 2024), transformative regional capacities were determined. The framework proposed by Wolfram's (2016) of ten adaptive capacities addresses organisational visions, work culture, structures, skills, human and material resources, but also community participation, relations, networks and institutions, and the understanding of existing systems. For the regional climate change analysis, the most relevant transformative capacities were identified to guide adaptation action, particularly with regards to the regional Demo Activities (DAs).

Table 6. Transformative capacities for effective CCA in Lapland

Inclusive and Multiform Governance	Lapland is a region that can draw knowledge from the broad governance on CC mitigation. To accelerate Lapland's transformative capacity regarding an improved governance on adaptation, a coordinated approach for CCA in Lapland with a supportive legal framework is needed (LVDWS). An institutionalization of CCA to form it to a yearly process (similar to the topic safety) could be a lever for regional CCA (LVDWS). The Sámi parliament, representing the Sámi communities, is formally involved in political decisions and works autonomously in the field of CC. However, the Sámi's demands for CC work are not sufficiently recognized from higher political levels. The whole region of Lapland can profit from an intensified cooperation and inclusion of the Sámi community. Furthermore, a wide stakeholder participation must include representatives from all sectors: the whole tourism industry and the health care sector, as well as NGOs, which should be more involved in the decision-making process, have been mentioned specifically (LI3; LVDWS). Facilitating a wide stakeholder participation formed by sectors, as in CCA networks, are needed (LVDWS). As crucial step for an ameliorated CCA governance, comprehensive adaptation plans for Lapland's typical small business have been noted (LVDWS). Additionally, incentives, like financial compensation, could trigger landowners to begin with more concrete CCA work, like the restoration of the environment to support flood protection (LVDWS).

Empowered & Autonomous Communities	With regards to the independent indigenous Sámi people, a special focus of CCA must lie on the empowerment of autonomous communities in Lapland. Currently, independent communities are involved in CCA through a listing of grants directed to environmental and climate projects on adaptation (LVDWS). Local associations can apply for funding, for example from leader groups (LVDWS). The Akwé: Kon model for the participation of Sámi in the management and use of wilderness area and natural resources is already a used tool. Strongly connected to the focus on inclusive governance, communities would benefit from a strategy on municipal level to comprehend smaller or village-level involvement (LVDWS). Similarly, there is not enough skills and knowledge of CCA in independent communities (LVDWS), which could be counteracted with comprehensive plans.
Shared Understanding, Memory and System Awareness	Based on the complexity of Lapland's CCA situation with regards to the multiculturality and different requirements of land use, a shared understanding of relevant systems in relation with CCA is indispensable. The common awareness for rising CC-induced challenges and the self-evident sustainable lifestyle of the inhabitants can function as an opportunity to build this awareness similarly to CCA. For a shared understanding and system awareness, interdisciplinary research (e.g. environmental, climate and economical research) and communication between different sectors is needed (LVDWS). Similarly, accessibility to information can function as a CCA lever, like enhancing the dissemination of projects. (LVDWS).

2.5.4. Concrete advice for the DA and beyond

Profit from the knowledge of prior projects: Lapland can already draw knowledge with regards to CC from various projects conducted in the region, especially in cooperation with reindeer herders. As working with herders requires an enhanced focus on the inclusion of their reality of life (their annual cycle, native languages, practicality of approaching work), this knowledge base can function as facilitator for future access to herders and the public in general, also with regard to the DA envisioned by the region, a PPGIS to map citizen's CC-experiences.

Utilize existing local CCA knowledge: The DA plans on creating models of company-specific adaptation plans to increase the know-how in the reindeer herding and tourism sectors. As described above, herders and herders' associations already implement local CCA to combat changing conditions and remain profitable business-wise. It is advised that the DA models are based on the local (and indigenous) knowledge of the population and developed in close cooperation with local stakeholders.

Adress the needs of the indigenous communities: It appears especially important for the tourism sector to incorporate Sámi's requirements of CCA action. In terms of DA, the adaptation model for tourism entrepreneurs can benefit from the now intertwined link between the traditional livelihoods of entrepreneurs and tourism stakeholders in the region.

Expand cooperation between the administrative authorities, local businesses and academia: Due to the sparse population in (Northern) Lapland, authorities and important stakeholders are clearly allocated and can benefit

from a comparatively direct communication. An enhanced focus on intermediary actors, like academic or regional planning institutions, could help with the DA of creating adaptation coaching.

Further suggestions

Lapland's Arctic ecosystems, including vast peatlands, boreal forests, and tundra, play a critical role in maintaining global, regional and local climate balance. A crucial step in transformative adaptation is to protect and restore these natural habitats with ecosystem-based approaches. Restoring degraded peatlands, which are vital carbon sinks, and conserving boreal forests, which support diverse wildlife, are essential for enhancing the region's natural climate resilience. Tourism and all other business sectors are required to build economic structures that respect the local ecosystems and contribute to their preservation. This calls for an economic diversification of the region: “Green businesses”, including those in green tech, sustainable agriculture, and eco-friendly crafts, can create new economic opportunities that are aligned with such objectives. Sustainable fisheries, which adapt to changing fish populations, are also key to preserving the region’s biodiversity and ensuring food security.

Moreover, as Lapland is experiencing more extreme weather conditions, there is a pressing need to redesign infrastructures to make them more climate resilient. Financing these efforts requires a multi-faceted approach that combines public funding, private investments and international support. Introducing a tourism tax in Lapland (the proceeds of which would be earmarked for climate change adaptation projects), especially those that help preserve the natural environment that attracts visitors, would be an effective and simple way to include tourism revenue.

3. Baseline – Piedmont

3.1. Regional profile

Regional structures, political competencies and development objectives profoundly influence the potential pathways for regional CCA. This chapter introduces the topographic, functional, environmental, and socio-economic characteristics that shape the region structurally, briefly introduces the territorial governance framework to illustrate the region's formal competencies for implementing CCA autonomously and outlines the dominant self-image to sketch the normative starting point for regional CCA.

Italy faces significant climate change related challenges, including the increase of natural risks due to drought, hydrogeological instability, floods, forest fires or coastal erosion (CMCC, 2020). In the last twenty years the higher-than-average temperatures and the intensification of extreme weather events have increased the probability of being affected by climate hazards by 9%. This trend is also observable in the MountResilience Demonstrator Region of Piedmont. The region is situated in the Po Valley, named after Italy's longest river, that originates in the Cottian Alps at the French border and streams to the Adriatic Sea. It is Italy's agricultural heartland and the centre of most of Italian industry (Monteleone & Borzí, 2024). Piedmont has experienced an increase of 2°C in daily maximum temperatures over the past 60 years and a 1.5°C increase in minimum temperatures (SRCC, 2022, p. 10). Data on climate variables demonstrate the increased frequency of extreme weather events (heat waves, intense rainfall and prolonged periods of drought) and the already significant extent of territorial exposure of the region to these effects, causing economic and ecosystem damage, affecting local production systems and the overall health of the population.

3.1.1. Structural characteristics

Overview of topographic and functional characteristics

Piedmont is an Italian northwestern Alpine region, landlocked, with no direct access to the sea, adjacent to France and Switzerland (Lella & Stamos, 2023). It is formed by 43% mountainous territory (the Alps and Apennines), 31% hilly territory and home to more than 4 million inhabitants (OECD, 2021). The region is divided into 7 provinces (Verbano, Cusio Ossola, Novara, Vercelli, Biella, Alessandria, Asti, Cuneo) and one metropolitan city (Turin). Overall, the region is characterized by a high number of municipalities (1,181 in total), of which 28% are located in mountain areas (Lella & Stamos, 2023, p. 7). The heterogeneous landscape differs strongly with regards to its land cover (43% mountains) but also its socio-economic and environmental features, comprising of urban regions (medium and large cities) and rather remote, mountain and rural areas (ibid. p. 11) Furthermore, the metropolitan city area is characterised by natural resources, important cultural heritage, agricultural activities as well as densely urbanized areas and industrial brownfields (ESPON, 2017). Alongside with livestock farming, the region is characterized by water intensive agriculture, with rice, wine, fruit and annual crop production, in particular in the south-eastern regions along the river beds (Sapino, Pérez-Blanco, Gutiérrez-Martín, & Frontuto, 2020, p. 8, 3). The Po Valley is the largest agricultural area in Italy, as well as a main industrial area, and responsible for more than a third of Italian agricultural production. Agriculture plays a significant role in the region both economically and spatially, thus facing unique challenges with regards to climate change. Agriculture determines the land cover for much of Piedmont. 36% of the region's territory is devoted to agricultural production, amounting to 923,428 hectares of UAA (Utilised Agricultural Area), which is historically fragmented both from a farm (an average of 21 ha per farm) and sectoral point of view. In mountainous areas of Piedmont, grassland is the most relevant crop/land cover, used mainly for grazing and fodder for livestock, and represents 8% of Piedmont 's agricultural area (Sapino et al., 2020). About 41% of the Po basin land use is agriculture. The Po basin hosts a large livestock population, approximately 3.1 million cattle (around 50% of the national stock) and 6 million pigs (around 65% of the national stock). The most important agricultural products

in Piedmont are cereals (e.g. rice, corn) and livestock, the latter of which makes up nearly half of final agricultural production in Piedmont (ESTAT, 2004). The region is in the top 20% of OECD regional economies based on size, where manufacturing and agriculture are key economic sectors (e.g. FIAT has its seat in Torino, as well as Ferrero in the region) (OECD, 2021).

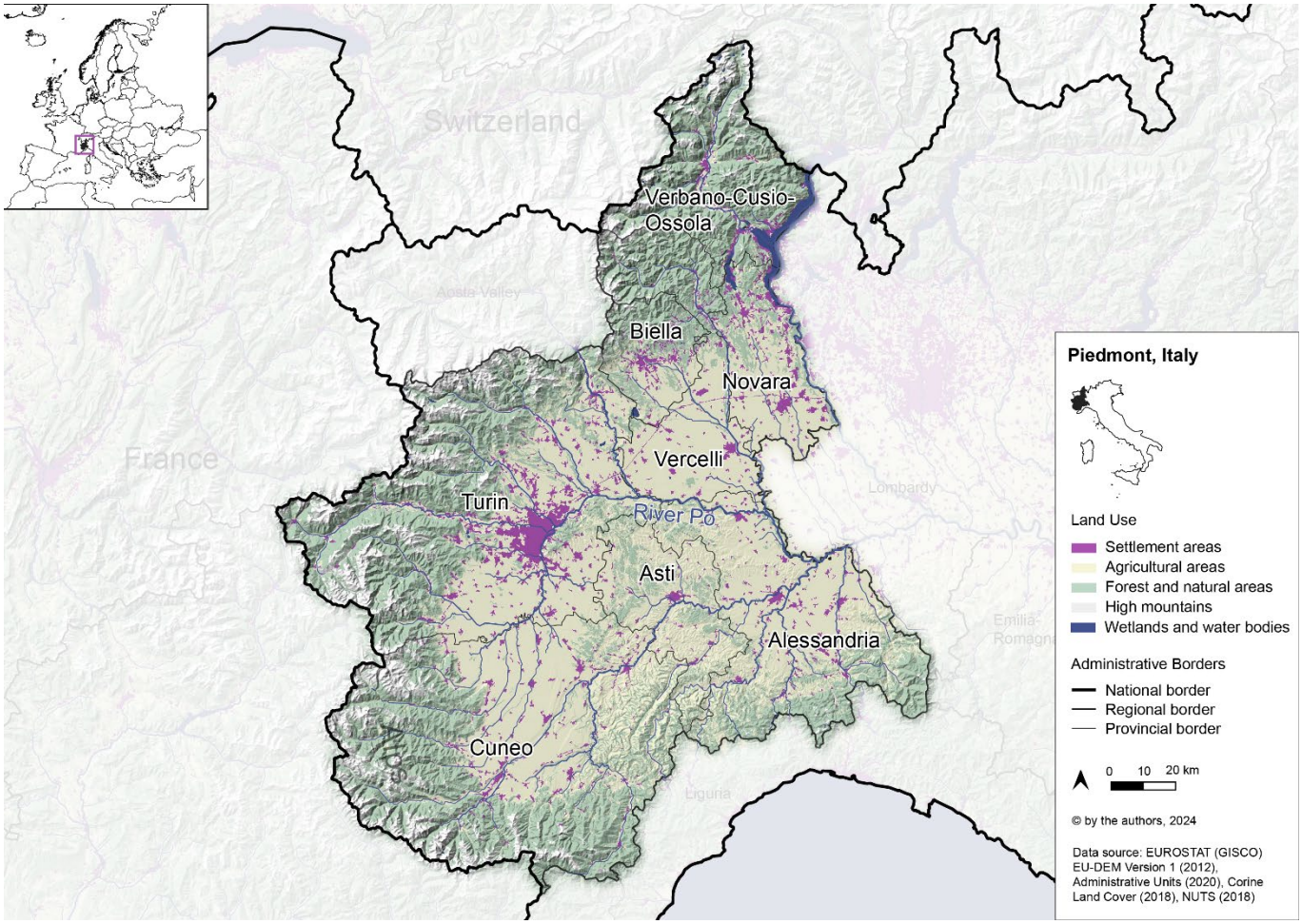

Figure 14. Map of Piedmont (TU Wien, 2024)

Overview of ecosystem and environmental characteristics

Piedmont's climate is influenced by both Continental and Mediterranean regimes, resulting in a unique combination of climatic conditions that contribute to the rich biodiversity and productive agricultural practices observed in the area (Meri, Ronchi, Sardonini, & Viaggi, 2007). Piedmont is also home to the Po Basin, which has a drainage area of 70,000km² in Italy (with an additional 4,000km² located in Switzerland and France), of which 41,000km² is in montane ecosystems and 29,000km² on the plain. The area along the Po Basin is also highly biodiverse and is one of the last areas with riparian woodlands and wetlands, the latter being a very important breeding and feeding spot for many bird species (One Earth, 2024). As the Italian region with the second highest number of species protected by the Habitats Directive, Piedmont is a plant and animal hotspot in Italy (Pollo et al., 2022). This biodiversity reflects geo-morphological and bio-climatic features of the area, such as the presence of three biogeographical regions (Alpine, Continental and Mediterranean) as well as high gradients in latitude and in altitude. However, due to the above average continuous warming trend in the region, present and expected impacts, as well as the interdependence

between the climate crisis and the loss of biodiversity puts both the biodiversity and local ecosystems under significant thread of climate change risks.

Description and key indicators for socio-economic profile

In 2022, the total Piedmont population was 4,256,350 inhabitants, following a slow population decline (crude rate of total population change of -1.2 per 1,000 inhabitants), a relatively moderate net migration rate of (6.6 per 1,000 inhabitants), and a rather high rate of natural change of population (7.7 per 1,000 inhabitants) compared to other European regions (Eurostat, 2022). Overall, in 2022 the median age of population was estimated 49.8 years (Eurostat, 2022), with most of the Piedmont population between 25-64 years having completed a medium (44%) to low (36%) educational attainment, and 20% having a tertiary education degree (Eurostat, 2022). The labour market situation of the population aged 15-74 years, as of 2022, showed an unemployment rate of 6.5%, however, with a strong youth unemployment rate (15-29 years) of 15.2%. The overall employment rate differs among the regional working population (20-64 years), with 78.5% of men and 64.1% of women in an employment (Eurostat, 2022). The regional GDP amounts of € 145,913.79 million, with a share in total national GDP of 7.5%, and a slightly higher Purchasing Power Standard (PPS) of € 35,700 PPS per inhabitant than the national average (€ 34,400PPS per inhabitants for Italy) (Eurostat, 2022).

Table 7. Socio-economic data for Piedmont, compared to EU average (Source: Eurostat 2022).

	Population density *(per km²)*	**Median age** *(in years)*	**Population change** *(in % from 2021 to 2022)*	**PPS per capita** *(in €)*	**Employment rate** *(in %)*	**Risk of poverty** *(in %)*
Piedmont (2022)	169.1	49.8	-1.2	35,700	66.3	16.5
EU-average (2022)	109.1	44.5	+4.0	35,400	74.4	22.0

In terms of the economic structure the region has experienced shifts over the last few decades. Over the last 30 years there has been a drastic decline in the number of livestock farms (−74%), while livestock concentration in larger farms has also been trending upwards. The decline was particularly evident in the hills (−26%) and mountains (−36%) (Regione Piemonte, 2017). Over the last 5 years, the trend has continued, but employment has remained stable, generally only slightly decreasing, while also seeing a growth in farm owners under the age of 40 years. Additionally, there has been a heavy period of industrialisation over the last decades, which has generally also seen a larger shift towards more people moving to industrial centres (Regione Piemonte, 2020). However, this trend has generally led to changes in the landscape, with more abandoned and unused agriculture land, causing concern regarding land maintenance and ecosystem management. The annual nitrate load exported from the Po River basin has increased 2–3-fold over two decades. Agriculture and livestock together contribute about 80% of the total nitrogen load of the Po River basin, which has led to significant pressure to both surface and groundwater water bodies. Additionally, there has also been a decline in alpine nomadic pastoralism in the area, who often have their livestock (mainly sheep) graze on fallow, abandoned, or unused agriculture land, which helped remove dry biomass and inhibit unchecked growth of shrubs.

3.1.2. Governance framework

Different to other EU Member States, regional adaptation strategies and plans are not mandatory in Italy (Pollo et al., 2022), however, general guidelines to adaptation are formulated by Italian Ministero dell'Ambiente e della Sicurezza Energetica (Ministry of Environment and Energy Security). The regional responsibilities are divided among different entities, such as the Piedmont Regional Authority, the Metropolitan City Region of Turin, provinces, and the municipalities. In 2014, the Delrio Reform (Law 56/2014), intended to reduce the number of small and scarcely populated municipalities, has led the formation of 14 metropolitan city regions, one of them being the metropolitan city of Turin (ESPON, 2017, p. 4).

This resulted in a redistribution of power, resources, and competences between different administrative layers through the partial abolition of the provinces as territorial authorities and the introduction of the institution of metropolitan cities, with a promotion of the associations and a merger of small municipalities. Accordingly, these reforms led to relevant changes for the regional territorial development framework, where the new metropolitan cities play a key role in providing a layer for coordinating territorial development while the remaining provinces, not replaced by metropolitan cities, remain in a position with drastically reduced resources and competences – increasing administrative fragmentation regionally (ibid. p. 17f.).

Given these changes, at present, the Piedmont Regional Authority is required to play a twofold role concerning the promotion and coordination of regional development on the one hand exploring its relationship with the Metropolitan City of Turin whilst, when acting outside the metropolitan city, it needs to directly interact with the municipalities as it can no longer rely on the role of the provinces regarding the coordination and implementation activities.

3.1.3. Identity and self-image

The region strongly defines its identity along its rich natural and cultural heritage, but also along its awareness of the heterogeneity between the northern and southern part of Piedmont, one of the interviewees pointing out that there are various "*geographical differences in terms of challenges and also adaptation requirements*" (PI1). There are differences in water management (in the North there are more consortia), but in any case, good practices for reducing consumption are being tested across all regions. The Metropolitan City of Turin takes a dominant role in the region's representation as former industrial hub, well-known for its FIAT Lingotto factory where FIAT cars were manufactured from 1923 to 1982.

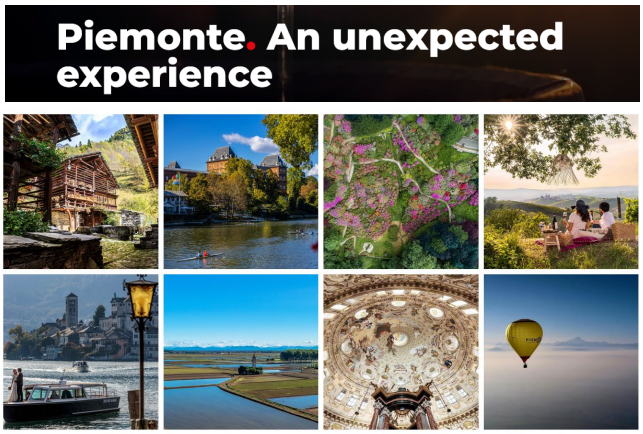

Figure 15. Touristic advertisement praising Piedmont's diversity (Source: Piedmont, 2024)

Apart from its orientation on tourism, Turin is increasingly promoting its innovative industrial transition towards dynamic innovation ecosystems, high-value sectors and transportation infrastructure (c. f. Metropolitan Turin 2025 plan), which is in stark contrast to the mountainous and lesser populated North and the agricultural sites in the South. While the North is known for its mountains (e.g. Monte Viso) and lakes (e.g. Lago Maggiore) as important (winter)tourism sites, the South is particularly known (and marketed) for its wine production, especially for Barolo and Barbaresco wine. The south-western parts of the region are more strongly focused on agricultural production (e.g. fruit, crops, rice, cattle). The overall image is also strongly oriented along a rich food culture, medieval heritage and villages, wineries and terraces attracting hiking and leisure tourism.

3.2. Systemic climate risks

The most important factors determining the directionality and design of CCA are concrete regional climate hazards and consequent systemic risks. This chapter overviews the main climate risks and relevant climate impact chains, pointing to the challenges for regional adaptation.

3.2.1. Main climate hazards and intermediate impacts

Main climate hazards: The core climate hazards for the region are an increase in temperature (mainly for higher elevations above 1500m where temperature rises by up three tenths of a degree) and changing precipitation patterns (Arpa & Regione Piemonte, 2020). Changing precipitation patterns pose a large hazard for the region. In overall precipitation, Piedmont will experience a slight downward trend over the next half century. However, the most pressing aspect is the longer periods of no precipitation, especially in summer and spring. Together with higher evapotranspiration due to the high temperatures, this increases drought risk (Navarro et al., 2022). Paired with more periods of increasingly intense rains this also increases the risk of flooding, and to a lesser extent, landslides (Navarro et al., 2022; Tiranti & Ronchi, 2023).

Systemic risks: The changing climatic conditions significantly increase the risk of drought in Piedmont, bringing the topic of water scarcity to the forefront. As the largest use of water in Piedmont, the agriculture sector faces significant pressure from the climate risks but is also a key component adding to the system risk. There are a few aspects playing into this risk.

Low ground- and surface water availability (e.g. natural reservoirs for water): Due to the changing climate patterns, there is overall less water available during the planting season (spring) which can hurt the agricultural yield. In particular, the shortened precipitation period compounded with high nitrate runoff from industrialized agricultural practices and intensified livestock husbandry leads to lower availability of groundwater.

Water-intensive agricultural products make up the sector profile of Piedmont: The agriculture sector in the region is dominated by cereals/grains and livestock husbandry, both in land use and economic value. The most water intensive cereals are typically used in primary (e.g. rice-dominated monoculture) and secondary (e.g. grazing pastures and corn) production. Rice is reliant on water intensive irrigation practices (e.g. flooding) which require a large amount of water in a short period of time. Other practices for rice production, such as “dry rice” and other irrigation techniques, have been tested but have been proved ineffective. Corn and Grazing pastures, although less water intensive on average compared to rice, are often used for livestock feed and take up more land, requiring significant amounts of water for maintenance.

While some experts argue for more crop diversification as the best solution, other suggests that due to the strong economic profile of the agricultural industry and complex agrifood system chains, the region is in economic lock-in when it comes to the switch of crops, especially regarding the reduction of meat-based products.

Inefficient water usage practices in agricultural and pricing models/regulation: Similarly, certain practices in the agricultural system, especially in irrigation, also play a role in water scarcity. Generally, there is major lack of coordination (through monitoring and regulation) among the estimated 18,000 water users in the region, and excessive water withdrawal during times of water scarcity and many farmers tend to draw more water than they need.

There is a general belief among many farmers that any excess water they use for their production will just seep down back into the groundwater supply and be available for further use in time. This is not the case and excess water is actually just wasted, not ending up back in the ground water supply. However, there is also a general lack of tools and known practices for measuring the amount of water extracted, thus it is difficult for farmers to report it in the first place as well as to build an overarching monitoring system around it.

Water prices are currently the mechanism to regulate the extraction of water across water users. The price that farmers pay for water is low, especially compared to the prices paid by other users (e.g. water as primary consumption and energy/industry). It doesn't sufficiently cover the environmental and water scarcity costs of the high-water use.

Destruction of ecosystems around the Po Basin: The ecosystems around the Po River are highly biodiverse and have provided the rich soil and other ecosystem benefits which allowed agriculture to thrive over the last centuries. Along with the climate hazards, the heavy industrialization of the surrounding area as well as the agricultural runoff puts pressure on the ecosystem. Similarly, the development of new irrigation infrastructure, in particular in the south-west of Piedmont region where the infrastructure is considered inefficient/loses water during delivery, would mean further destruction of the biodiversity and conservation in the area.

3.2.2. Climate impact chain

This climate impact chain deals with the risk of water scarcity and conflicts around water use. The three relevant climate hazards are the increase in temperature, decreasing precipitation in summer and the change in snowmelt and precipitation patterns. Together, these hazards lead to an upward moving snowline, glaciers melting and higher evapotranspiration. This will lead to impacts such as temporary water scarcity, as described above, as well as natural disasters such as landslides, rockfall or floods. Due to the strong glacier-melting projected for the first half of the century, there is higher likelihood of floods and greater water availability within this timespan. However, this does not eradicate the risk of temporary scarcity, especially later in the summer when there is no more supply from snow and glaciers melting.

Water needs are projected to rise in a business-as-usual scenario, especially in urban areas and in the keeping of livestock. There are several elements of the regional system that are exposed to these changes. Hydropower production requires the largest amount of water. Agriculture requires water especially when precipitation is lowest and water most scarce in the region, during the summer and autumn. This includes both, commercial agriculture and small scale and traditional farming. The situation will be exacerbated by the fact that an earlier onset of the snowmelt will lead to an earlier peak in water availability in rivers, removed from the peak of water needs in agriculture later in the summer. Residential areas require water, too. Depending on the municipality, some have separate systems for drinking water and water for irrigation, while in others drinking water is used for all purposes. Finally, tourism also requires large amounts of water, especially for snowmaking for winter sports.

One of the greatest weaknesses and main source of the vulnerability in the region is the lack of cooperation when it comes to water management, between the municipalities and between other stakeholders.

Figure 4 shows the Systemic Risk Assessment for Climate Impact Chains in the agricultural sector, with a particular focus on water scarcity. The main climate change induced risks identified are the loss of biodiversity (e.g. near river

basins), increased crop stress and the following economic losses for local businesses and potential conflicts of interests between different sectors (e.g. agriculture, industry, infrastructure), environmental and public bodies.

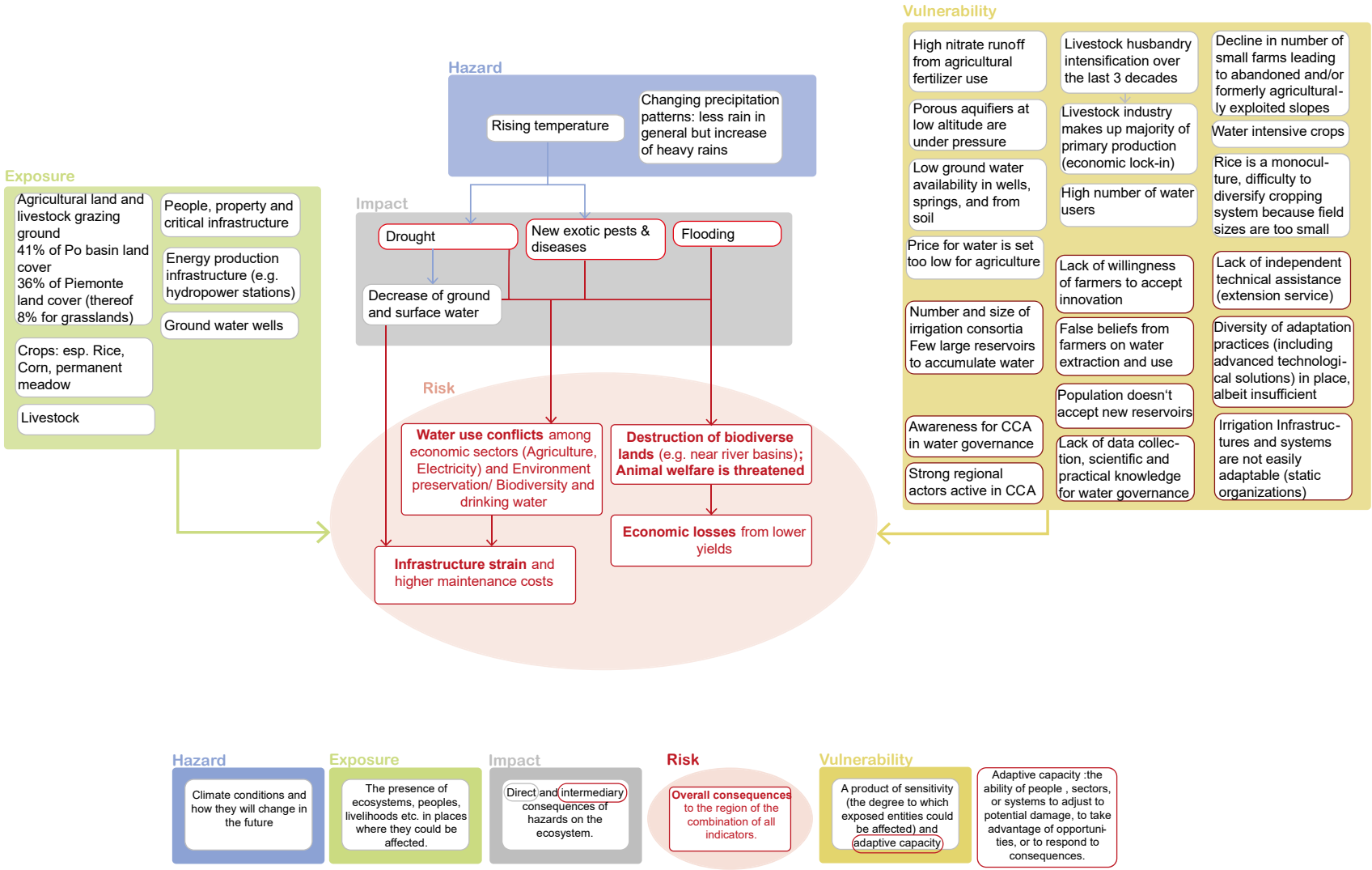

Figure 16. Piedmont IC for water scarcity in agriculture (ZSI, 2024) | *cf. chapter 11.2 for IC methodology*

3.3. Regional CCA governance

CCA activities should be well-embedded in the strategic objectives of a region and strike a balance between stakeholder inclusion and leadership. Accordingly, understanding the strategy framework and stakeholder landscape of regional CCA governance is important. This chapter identifies key regional CCA-related strategies, how CC and its consequences are problematized therein and how certain adaptation challenges are prioritized. It highlights the prevailing understanding of CCA and the emphasized approaches for tackling it, as well as the most important regional stakeholder groups, which is important for the design and implementation of concrete adaptation activities.

3.3.1. Strategy framework

Being in line with international and European strategic frameworks, such as the Paris Agreement (2015), the United Nations Agenda 2030 (2015), the European Strategy for Adaptation to Climate Change (2013[2021]) or the EUs Green Deal (2019), there are several national, regional, local and sectoral strategies to combat climate change and support sustainable development in Italy.

Our analysis focussed on the most relevant documents targeting climate change *adaptation* for the region of Piedmont (**Figure 4**) to identify the most relevant challenges and the CCA understanding.

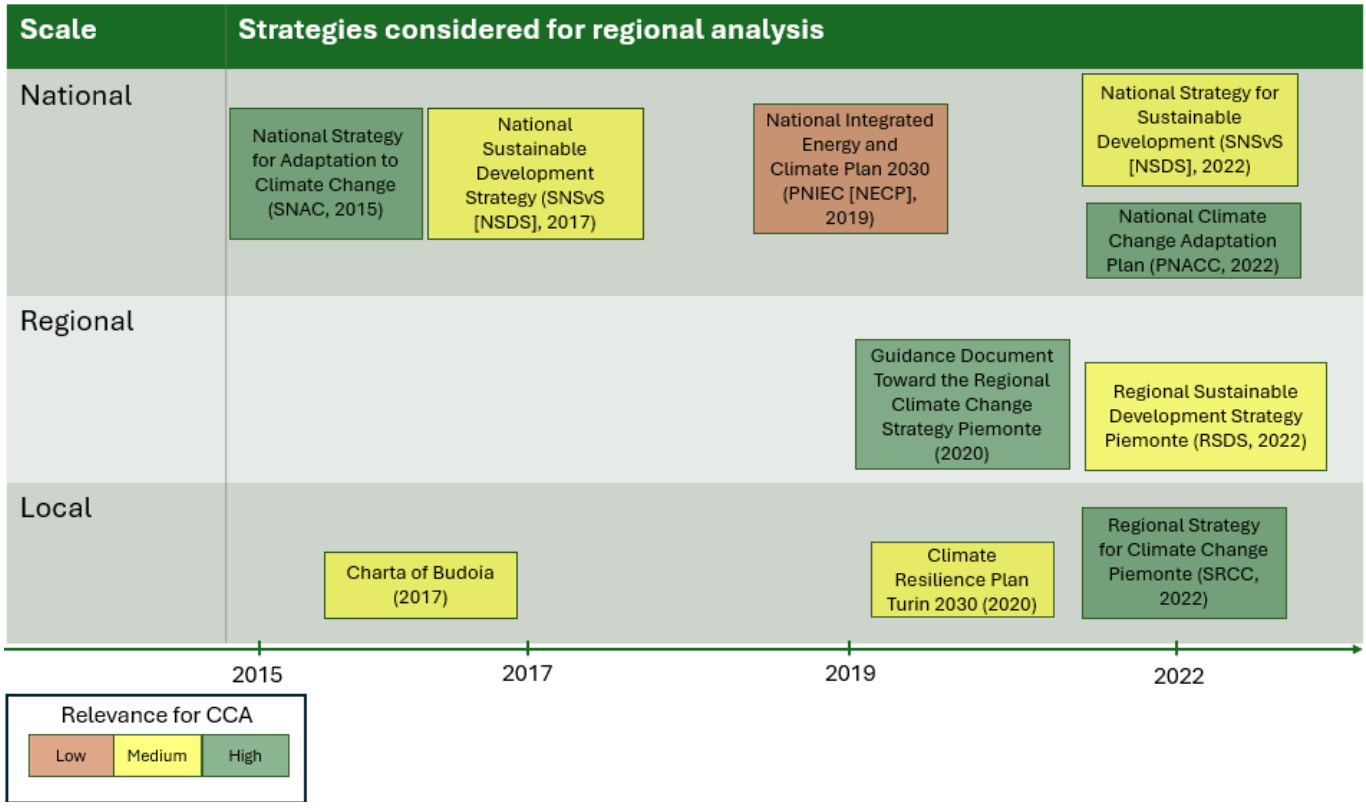

Figure 17. Overview of CCA-relevant strategies in Piedmont (TU Wien, 2024)

At **national level**, the “National Climate Change Adaptation Strategy” (SNAC, 2015) serves as an important guiding strategy for adaptation measures. Also, in 2022 the implementation plan was released, titled the “National Plan for Adaptation to Climate Change” (PNACC, 2022), to complement the SNAC and support its enforcement. Additional relevant guiding strategies, though not explicitly targeting CCA, are also the “National Strategy for Sustainable Development” (SNSvS, 2017; SNSvS, 2022), the “National Integrated Energy and Climate Plan 2030” (PNIEC, 2019), the “Transition 4.0 Plan” (2021), the “National Recovery and Resilience Plan” (PNRR, 2021), the “National Strategic

Plan for the Common Agriculture 2023-2027" (PAC, 2022), the "National Waste Management Program" (2022), and the "National Strategy for Circular Economy" (2021).

At **regional level**, the region of Piedmont formulated several regional and sectoral guidelines to CCA. In 2020 the "Guidance Document Toward the Regional Climate Change Strategy" (Arpa & Regione Piemonte, 2020) was proposed as a basis for the later approved "Regional Strategy on Climate Change" (SRCC, 2022) that together with the "Regional Sustainable Development Strategy Piedmont" (RSDS, 2022) serves as important regional foundation for the understanding of CCA and climate change mitigation.

While fewer strategies exist on the **local level**, the "Climate Resilience Plan Turin 2030" (Citta' di Torino, 2020) of the metropolitan region, or the "Charta of Budoia" (Alliance in the Alps, 2017) (guided by the Alliance in the Alps comprising the two Piedmont provinces Ostana and Usseaux) are noteworthy for addressing CCA challenges locally.

Additionally, numerous **sectoral guidelines** at regional level (e.g. "Regional Municipal Waste and Sewage Sludge Management Plan" (2016), "Regional Forestry Plan" (2017), "Regional Mobility and Transportation Plan" (RMPT, 2018), "Regional Environmental Energy Plan" (PEAR, 2018[2020]), "Regional Air Quality Plan" (PRQA, 2019), or the "Water Protection Plan" (2021)) help, together with regional environmental reports and scenario analyses, to guide regional adaptation strategies and serve as important tools for implementing the international, European and Italian level CCA-directions, particularly in line with the SNAC as well as the SNSvS.

Policy awareness towards CCA-governance has been notably increased since the SNAC (2015) strategy was adopted. However, reginal strategies followed rather recently, in particular with the release of the Guidance Document (Arpa & Regione Piemonte, 2020) on CCA in 2020.

3.3.2. Problem background and prioritized challenges

Along with the identified systemic risks, the key challenges addressed in Piedmont throughout the regional documents are on the one hand strongly related to ecological aspects, particularly along water availability through the increased exposure to extreme weather events, while on the other hand also associated with regional socio-economic aspects (e.g. population loss and demographic change) (RSDS, 2022; SRCC, 2022). With the ecological challenges, also regional social and economic vulnerabilities are increasing. In the conducted interviews, regional actors further referred to threatened regional and local economies (such as tourism and agriculture) as well as non-coherent governance structures, loosely defined roles and responsibilities, together with a problem awareness that is lacking adequate action limit the overall CCA responses (PI1; PI2. PI4, PI6). In line with the official regional CCA strategies, overall the needs for adaptation are identified in different areas such as: agriculture; geological, hydrogeological and water resources; biodiversity and ecosystems; energy production; forests; industry and infrastructure; urban settlements; cultural heritage; sports; transport; health and tourism (Arpa & Regione Piemonte, 2020; SNSvS, 2017).

The **Piedmont region faces complex challenges in water management** and climate change adaptation. In particular, the regional irrigation systems are pivotal in water management but confronted with significant governance and efficiency challenges. While the northeastern part of Piedmont, with larger consortia, is pointed out to adapt more effectively to water scarcity, the southwestern part is challenged by less water, lack of storage capacity, and inefficient water channels. One interviewed stakeholder also pointed out that *"there are geographical differences between North and South, also from an agricultural perspective: the rice fields in the northern part (Novara, Vercelli) while in the South (Cuneo, from Turin downwards) has a different vocation, also linked to livestock farming"* (PI6). Overall, the irrigation infrastructure is largely characterised by a fragmented system of public and private consortia, with some bigger and numerous small ones that are lacking the capacity for large-scale investments (PI2; PI5). This fragmentation leads to inefficient delivery and water losses – particularly in the south-west, with "*[…] some hundreds*

of isolated areas in the province of Cuneo; there are probably over 300 irrigation consortiums that manage the collective irrigation system. All this activity is carried out even though the sewers are almost always not visible […] and across a system that is still based on a fixed tournament" (PI2). While attempts have been made to consolidate the consortia, progress is slow and the coordination among stakeholders is often lacking (PI8; PI2). One stakeholder pointed out that "*In this moment of great complexity and uncertainty, strengthening institutional governance and discussion with all stakeholders for the management of water resources are two absolute priorities. The greatest difficulty encountered is that of understanding in a conscious and responsible way how to change the model of use of water and land at a district scale, adopted so far, following a sustainable development approach, accepting the costs/limitations that may derive from it short term for some private sectors, also from an economic point of view, to obtain collective and lasting benefits in the long term*" (PI8).

The interviews also highlighted that the involved stakeholders, including larger energy producers, irrigation consortia, and households, are often even following conflicting interests (PI1; PI8). Further it was stressed that the water pricing policies remain problematic in the region, with political reluctance to increase prices despite water scarcity (PI4; PI5). This leads to *"[…] a big confusion about who makes the prices, but the consortia make them at the moment and the pricing is very different*" (PI1). Farmers typically pay for irrigation system management rather than the water itself, which further complicates the overall acceptance of water pricing. Another significant obstacle to adaptation is the lack of effective (real-time) monitoring instruments, with a prevalence of numerous, non-registered small-scale water withdrawals in agriculture that significantly complicate monitoring and governance (PI4).

Local and regional economies are affected in different ways. The Piedmont region faces challenges with changing snow precipitation patterns, leading to water shortages in summer and increased economic losses in agriculture. *"[…] [I]n the Alps the snow is [a] key factor for water availability for agriculture, but the progressive melting of the snow [….] [and with an] increase of temperature, especially in winter, [that] has decreased the snow cover in the mountains, and they have less water in spring and summer when farmers need it to irrigate the crops*" (PI5). This statement underscores that the main challenge for local economies is often water storage and availability, as intense rainfall followed by drought periods limits soil absorption and aquifer recharge (PI6). Regional agricultural production is especially challenged when it comes to water intensive crops, like wine and rice. For example, Piedmonts wines, particularly non-irrigated vineyards, have faced significant stress due to changing water availability, raising concerns about future production scenarios (PI 1; PI2; PI3; PI4; PI6). Concerns point to the fact that *"[i]n the next 20 years, some say, there will be no wine production in Barolo area, they have to move because of climate change […] to think about 20 years is a very long time* (PI1)*."* Also, with difficulties to change crop types, one interviewee pointed out that "*you cannot just switch from maize to peanuts. Keep in mind the interlinkages and feedback loops in the agrifood chain, that market segments are difficult to create and expand, and that this creates lock-in effects"* (PI2). Furthermore, the tourism sector, where summer tourism is affected by more heatwaves and winter tourism by a lack of snow throughout the season, is under threat, endangering local livelihoods. It is important to understand *"how tourism can continue because there will be less and less snow. Here there is also the great issue of artificial snow, with the damage that it can do to the environment for example by taking the water from rivers"* (PI6). Overall, in the long run, with geographical differences in water management as well as differing agricultural practices between the northern (rice fields) and southern parts (stronger livestock farming) of Piedmont, the interviewed stakeholders pointed towards a challenge when it comes to local capacities and acceptance of adaptation actions, with a need of changing local practices (IP6; PI5; PI4).

Local natural and cultural heritage as well as the communities are strongly affected by processes of climate change. It was pointed out that *"some farmers with a longer vision are already purchasing land in Northern Europe or moving their cultures at higher altitudes to anticipate the change in temperatures. This also results in important changes in landscapes in mountain areas"* (PI2). Due to population losses particularly in the mountainous regions and non-sustainable practices, local environments are threatened (PI2; PI6). With one interviewee noting that *"[o]ver the years […] the water available for the mountains is always less and now it poses an unsolved problem [for]*

economic sustainability […] [and] change in the landscape context […] [,] the floral compositions and of what is the environmental mosaic of the Alps" (PI2). It was also highlighted that it is necessary to encourage citizens to live in the mountains *to "reduce depopulation, also from the perspective that an abandoned territory produces downstream effects, such as landslides* (PI6). Furthermore, regional approaches to water shortage also need to take better into account the ecological implications of potential solutions (PI6). Especially solutions to water and energy related challenges, concerning the regional hydropower plants, play an important role, as e. g. "*hydropower plants [are] a big economic factor in the region* (PI4), but at the same time, building new dams threatens local biodiversity and ecosystems (PI5).

Despite an overall high **level of awareness** about water scarcity-related challenges, particularly in the agricultural sector, there is a pressing need for better monitoring and optimization of water usage at the individual level. It was pointed out that while *"consciousness is at an all-time high […]"* (PI2), the difficulty remains in the combination of effective and efficient approaches (PI1; PI2; PI3, PI4). Education, knowledge creation, and behavioural change are crucial pillars for sustainable development in water resource management, as e.g. *"especially small farmers don't mind if they withdrawal too much […] the Farmers value water only when it is not there"* (PI4). *However*, while the awareness of the hydraulic sector's situation, especially within agriculture, is increasing, translating this awareness into actionable knowledge for farmers is crucial (PI1; PI6; PI4). Still, *"farmers lack awareness and knowledge. A big lever is to build networks and promote knowledge transfer among farmers"* while also an increase in the levels of collaboration is needed (PI1). Furthermore, better coordination between government authorities and irrigation consortia is needed to enhance the decision-making process around water management (PI8; PI1). One interviewee therefore pointed out that there is a general *"[…] need for a change in administrations and authorities, to have competent and aware people, and with more sensitivity. There will be crucial years for climate change before 2030, and we have several delays accumulated over the years; it is therefore necessary to implement strategies and plans for climate adaptation"* (PI6).

Based on our analysis, we point out four interrelated regional challenges as main fields for short and long-term CCA action, also relevant for the DAs.

Table 8. Main CCA challenges for Piedmont

Fragmented CCA and water governance	The water management system in Piedmont is too complex, with differences between the northern and southern parts of the region. In the North, there are larger water consortia that have more technical and financial capacity to invest in infrastructure. In the South, the system is more fragmented with many small, isolated irrigation consortia, leading to high water losses in the distribution network. Adapting the water management system to climate change is seen a key priority.
Vulnerable local/regional economies	The region is characterized by diverse agricultural activities, including intensive cereal, grain, and maize production for animal feed, as well as important fruit, wine, and rice production areas. Climate change impacts, such as heat waves, droughts, and changes in precipitation patterns, pose serious threats to these agricultural systems. Also, regional tourism is affected by heatwaves and extreme weather in the summer and low snow cover in the winter.
Loss of biodiversity and cultural landscapes	The mountain areas are experiencing a decline in traditional agricultural and pastural activities, as well as depopulation, which can have downstream effects like

	landslides. Additionally, biodiversity loss is affecting local communities, native flora and fauna.
Cooperation, knowledge and action gaps	Establishing effective CCA requires a comprehensive knowledge base on the potential impacts on various sectors. With prevailing knowledge and action gaps, the need for further awareness building, through education and training, and the active contribution of individuals, together with the dissemination of good practices is crucial for successful CCA implementation.

3.3.3. Prevailing understanding

- ***Anticipatory/reactive CCA approach:*** *When natural disasters, risks, or stressful CC events occur that threaten ecosystems and society, relevant measures are taken to address these at reginal and local levels (e.g. droughts, heat stress, flooding, soil erosion etc.).*
- ***Preservative CCA approach:*** *Ecosystem preservation is already a relevant topic, particularly because changing flora and fauna (e.g. in the alps) that is threatening local livelihoods. Approaches like agrotourism and protected areas appear as local/regional responses.*
- ***Incremental CCA approach:*** *Overall, given the regional CC challenges, smaller adaptation approaches have already been put in place, like adapting regional irrigation systems or changing water intense farming and improving lacking infrastructure (e.g. new/improved dams, planting new crops).*

Overall, e.g. the National Strategy for Adaptation to Climate Change identifies "*actions and directions to minimize risks from climate change, protect the health well-being and assets of the population, preserve the natural heritage, maintain or improve the resilience and adaptive capacity of natural, social and economic systems as well as take advantage of any opportunities that may arise under new climate conditions*" (SNAC, 2015, p. 11). Being more optimistic on adaptation than mitigation one interviewee emphasised that adaptation is "*a) trying to find the right governance tools […] [and] b) reduce the vulnerability of the territory, even with the creation of new jobs, to preserve and protect the nature, the ecosystem for the region [and] c) increasing awareness of the people*" (I5). This points out the complexity of adaptation challenges in region and indicates a strong focus on preservation and vulnerability reduction.

3.3.4. Emphasized approaches

According to the Regional Strategy on Climate Change (SRCC, 2022, p. 7), three general objectives are emphasised for adaptation. These include (1) an increase in adaptive capacity (of tangible and intangible resources), (2) the reduction of vulnerability (environment and socioeconomic system), (3) reduction of exposure of people, assets and natural capital to climate. The SRCC mitigation and adaptation measures further identify 10 transversal goals, such as: knowledge building; inclusive governance structures; coherence and active regional climate action; training and new professional opportunities; research on needs and new sustainable economy; people-centred approaches to increase the quality of life and protection of vulnerable groups; promotion of technical and administrative tools for CCA; safeguarding of natural capital and ecosystem services; and a definition of thematic measures, roles and responsibilities together with an regional impact analysis, that supports local adaptation measures (ibid., p. 8f.).

Improved water governance, policy coherence and coordination: The interviewed stakeholders see a big need in making the water delivery more flexible, rational, and optimized, that allows water availability to farmers when actually needed, rather than remaining in the current system which assigns farmers fixed timeslots for water usage.

It was further pointed out that there is a need for more diverse strategies such as changing irrigation techniques, introducing new crops, and enhancing water storage capacity, to tackle current shortages (PI2; PI4). Therefore, regional governance is one of the key issues addressed throughout the interviews. Governance challenges include overly complex regulations, difficulty implementing water pricing policies, and the need for better coordination among stakeholders (PI1; PI2; PI3 PI4; PI6; PI8). One actor pointed out that *"operating in contexts strongly impacted by climate change requires new development paradigms and therefore requires innovation and shared, adaptive, flexible but specific, effective and rapid solutions, and strongly shared within institutional governance and with stakeholders"* (PI8).

Resilient local and regional economies: Supporting local economic actors is seen as key action for CCA implementation (PI6; PI4; PI1). As for example "*farmers are rather resigned to this fate and feel rather powerless*" one interviewee point out that supporting a "*generational change might help since older farmers that have always done things in a certain way have less willingness/capacity to innovate or change radically – generating lock-in effects*" (PI2). As current practices are often strongly embedded in cultural-historical roots and local traditions, a cultural transition along with capacity building measures are required for developing new techniques and resilient economic practices (PI6; PI2). *"[The] idea is to make a kind of training in the field, identify some needs of the farmers in terms of innovation, the technicians give the training in the field and there is also system of coaching, so single farmers can give questions"* (PI1). Also, better infrastructure, enhanced ecosystem services and production of higher quality products (e.g. for eco- and agritourism) could help to develop regional potentials further (PI1; PI2; PI6). Pointing out that local actors and "*even local companies, such as agritourism, often run by young people, are necessary actors. For example: the municipality of Ostana which has brought a village back to life where there was nothing left, with people who have returned to live there and activities which have been reborn*" (PI6).

Enhanced landscape, environment and architectural heritage and strong local communities: Local communities are also seen as important key-actors. It was being pointed out that "*the territory has very strong communities and also entities (park authorities, mountain communities, protected areas), with a lot of attention to green areas and environmental protection"* (PI6). Thereby the region is already exploring a range of solutions, including the construction of new aqueducts, sustainable development projects like the "Caravan of the Alps," targeting sustainable approaches in mountain municipalities, to protect the environment (PI6). However, a stronger collaborative approach is needed, involving local communities and stakeholders to ensure the resilience and long-term sustainability of mountain regions (PI6; PI5). Encouraging citizens to reside in the mountains could be by providing better infrastructure, as e.g. *"digitalization of villages is also necessary. Life is better in the mountains, if you prepare the camp people want to go back. Inputs can come from national or international projects, but the key forces are local. […] There are many entities that work well at a local level, for example, the municipality of Balme in Piedmont, in the Beyond Snow project, has a mayor who has worked well by involving the community and local authorities, regulating traffic, limiting tourists, educating visitors, and showing that the actions brought benefits to everyone. Acting in this way protected the territory"* (PI6). Furthermore, rather than building new infrastructure, more efficient and flexible water use is seen as key priority, using the existing infrastructure and making use of existing local practices and potential win-win solutions. *"For example, building a dam is nice, but building a dam has an impact on the biodiversity, on the ecosystem, on the economy, so it could not be the best solution"* (PI5).

Active networks, improved knowledge-transfer and mutual problem awareness: Establishing networks and promoting knowledge transfer among farmers is seen as a key lever for improvement (PI1; PI3; PI8). Also, the results of research projects on CCA must be more effectively communicated and implemented to reach the target groups, with one stakeholder noting that "*farmers training and knowledge transfer [is] what they need […] [while also] the training activity [and] the information activity must be implemented in order to give the farmer the possibility to [improve their] work*" (PI1). Measures, such as the AKIS (Agricultural Knowledge and Innovation System) knowledge sharing system, involving various stakeholders, including producers, researchers, and advisors, therefore can play an important role in this knowledge transfer process (PI1). Different communication channels, such as websites and

mobile messaging, are used to disseminate information to farmers (PI1; PI2; PI3). The decision-making process around water management also involves coordination between government authorities and irrigation consortia, who regularly meet to discuss water availability and usage. While there is a high level of awareness about the water scarcity challenges, still, further education, knowledge creation, and behavioural change are seen as crucial pillars for sustainable development in the region's water resources management (PI6; PI8). Therefore, it was stated that *"what they need is not just measures on rivers and lakes but also to push people and companies to do different behaviours in industrial strategies and also individual behaviours"* (PI4*).* In general, enhancing the decision-making process and fostering collaboration among stakeholders were pointed out as important measures to support the region in addressing its climate change related challenges more effectively (PI1; PI3; PI4). The interviewed stakeholders emphasised, that regional strategies must strongly acknowledge the importance of participatory (local) planning, including active engagement from various regional entities, local authorities, and civil society (PI8; PI6). One interviewee stated that "*these actions cannot be imposed from above, we need the accompaniment of citizens, using tools such as mountain help desks. We also need to involve the many local associations we have, which make the region's work possible. Finally, the economic part is also fundamental and must work together with the citizens*" (PI6). It was also mentioned that there is a notable gap in information and knowledge exchange among stakeholders, such as agricultural and forestry entrepreneurs regarding climate change mitigation and adaptation techniques (PI1; PI8). Therefore, the "*need for a better exchange and knowledge transfer is evident, where a negotiation with "all private stakeholders" is possible and "shared knowledge frameworks" are installed and manage any conflicts or synergies of interests*" (PI8). Many projects focus on research related to sustainable agricultural practices, but effective communication and implementation of these findings are necessary to empower local actors (PI1; PI8). With the documents also highlighting, that solutions like establishing a "Piedmont system" for designing, implementing, and evaluating climate policies is vital for facilitating dialogue and addressing concerns, particularly those of younger generations in Piedmont (Arpa & Regione Piemonte, 2020, p. 22).

Based on the document analysis and the conducted interviews the following four approaches can be identified for further CCA measures in the region.

Table 9. Current CCA approaches in Piedmont

Improved water and CCA governance, policy coherence & coordination	Coherent responses (policies) to water and CCA governance and strong cooperation across various actor groups (e.g. irrigation consortia).
Resilient local/regional economies	Build resilience in local economies – diversification of adaptation strategies, technical and capacity building support (training etc.) and new technologies.
Enhanced landscape, environment, cultural heritage and community	Strengthening vulnerable communities, comprehensive preservation strategies as well as active support of local livelihoods through infrastructure, knowledge and resilience building.
Active networks and improved knowledge transfer	Improving local and regional networks, activity monitoring and evaluation of impacts as well as adaptation measures, e.g. through support exchange structures, knowledge and resource management.

3.3.5. Important stakeholder groups

The documents and interviews emphasise the importance of active citizen participation and the involvement of both public and private sector stakeholders in climate change adaptation efforts. Key organisations and stakeholder groups involved in CCA include the following actors.

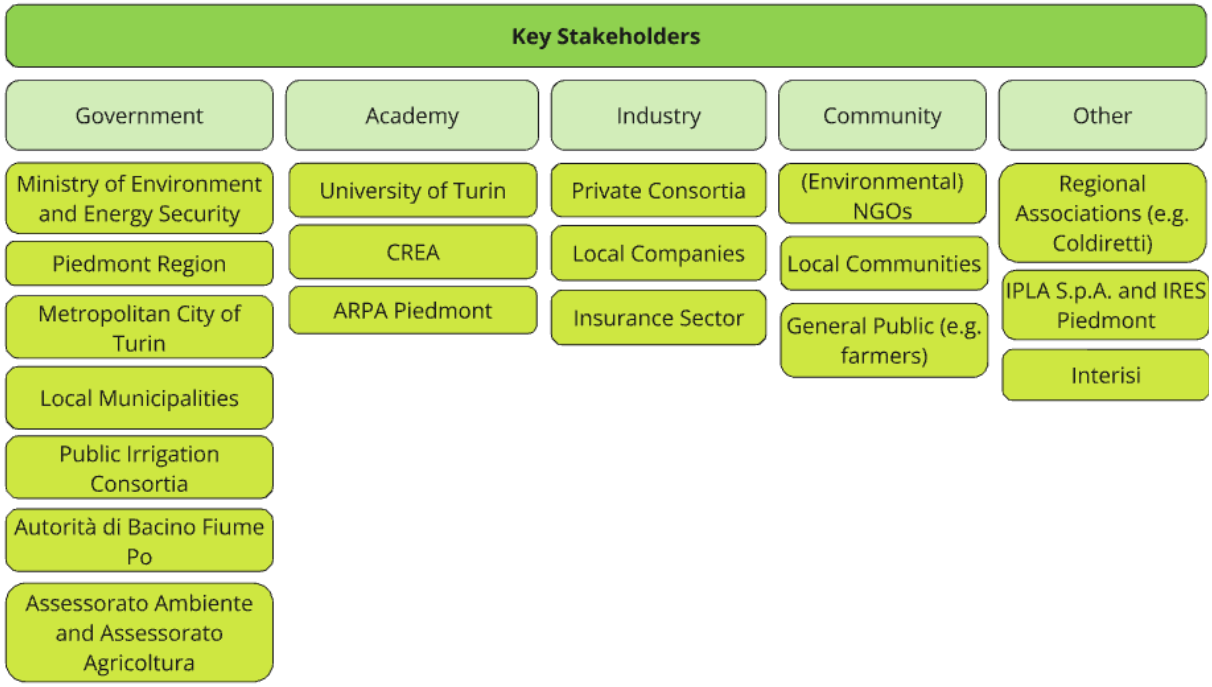

Figure 18. Key stakeholders in CCA in Piedmont (TU Wien, 2024)

Government (Public): Ministry of Environment and Energy Security; Metropolitan City of Turin; Piedmont Region (significant role in internal governance and collaboration on climate adaptation strategies); Assessorato Ambiente and Assessorato Agricoltura (environmental and Agricultural Bureaus of Piedmont Region and key regional governance bodies in environmental and agricultural policy); Public Irrigation Consortia (e.g. "consorzi di bonifica," gaining power to modify and coordinate water management systems); Autorità di Bacino Fiume Po (responsible for monitoring and declaring water scarcity or crisis periods and coordinating a network of stakeholders);.

Academy: University of Turin; ARPA Piedmont (provides scientific support and data analysis, particularly in water management; CREA (conducts research and supports innovation transfer in various agricultural sectors, including rice, wine, and forestry).

Industry: Private Irrigation Consortia (significant stakeholders in water management, with potential to influence the system and coordinate smaller consortia); Local Companies (expected to support the transition towards sustainable water use); Insurance Sector (like national insurance for general and climate-specific risks).

Communities and Civil Society: Local Communities; Organisations; Environmental NGOs.

Other: Regional associations (e.g. Coldiretti: main farmers' union in Italy, representing farmers' interests and acting as an intermediary between farmers and the government); IPLA S.p.A. and IRES Piedmont (important for governance and policy support); Interisi (specializes in fruticulture and agriculture, supporting innovation transfer).

In comparison, the regional stakeholder mapping that was conducted in T1.3 of the MountResilience project by the regional partners themselves, other identified stakeholders beyond those listed above were the individual provinces or communes as well as Ente Nazionale Risi, Unione Montana/Alpi/del mare, Istituto Tecnico Agrario, Confederazione Italiana Agricoltori, Azienda Agricola, Riso Buono, Azienda Agricola Falasco, Azienda Agricola Santarosa, Associazione Legambiente, Informatore Agrario, La Voce il tempo, Rete Fiumi, Riseria Vignola, Notizie Oggi, La Sesia, Local/regional radio stations, La Stampa, and Agro Magazine. These point to the significance of the agricultural sector as a key stakeholder group for CCA in Piedmont, as well as several community or other (in this case, media) groups that should be considered in transformative endeavors.

3.3.6. Assessment

The overall assessment demonstrates that an improved water governance and policy coherence are crucial for addressing water shortages in Piedmont. Stakeholders emphasize the need for more flexible water delivery, diverse strategies like changing irrigation techniques, and enhancing water storage capacity. However, regional water governance faces challenges such as complex regulations and poor coordination/cooperation among stakeholders. Effective governance according to the interviewed actors requires more innovation and adaptive solutions helping to react to water shortages more adequately. Efficient and flexible water use is prioritized over new infrastructure to minimize environmental impacts. Also, through capacity building and networking activities local economies shall be supported, fostering an intergenerational change, and changing mindsets among actors. Developing better infrastructure in remote regions and enhancing ecosystem services are pointed out as necessary activities, while also promoting higher-quality products to further enhance regional potentials and support local livelihoods. Therefore, for example better (digital) infrastructure was highlighted as one potential action, helping to encourage residents to remain in mountain areas. With active networks and improved knowledge transfer being vital for CCA, regional activities must strongly focus on establishing networks among farmers and different stakeholders, while an effective communication of research, and the use of knowledge-sharing systems are also considered important. Local communities are key actors in environmental protection. Strong local entities and collaborative approaches involving local communities and stakeholders are perceived as needed for successful long-term sustainability approaches. Therefore, also stronger participatory planning and collaboration-oriented approaches among stakeholders should be prioritised to address climate challenges more effectively. More comprehensive approaches to CCA governance, like establishing a "Piedmont system" for climate policy design, implementation, and evaluation can help to facilitate dialogue and address local concerns.

3.4. Key adaptation actions

This chapter introduces good practices that have already demonstrated how CCA can be approached in the region. These actions are not representing the full scale of approaches in the region but give a relevant overview of the priorities given to adaptation while pointing out different innovative solutions to address the specific challenges and risks that were induced by climate change.

Agricultural Knowledge and Innovation System (AKIS): The EU project targeted the establishment of a “Agricultural Knowledge and Innovation Systems” (AKIS). The System aimed at fostering the exchange between agriculture, forestry and rural communities, supporting innovation and exchanging knowledge between advisors, farmers and foresters, researchers, rural networks, national and regional authorities, media, all people involved in education and training, as well as consumers (cf. epi-agri 2024). After having been transferred to the EU CAP Network, it continues to offer an overview on existing national and EU networks and network activities, events for exchange and capacity building, giving an overview on good practices and overall country data, while also announcing calls for project funding under its assigned priorities. (cf. EU-CAP Network, 2024).

BeyondSnow - Enhancing the Resilience of Alpine Space Snow Tourism Destinations and Communities to Climate Change: The EU Interreg Alpine Space project addresses the ecological and socio-economic impacts of climate change in Alpine regions in six Alpine countries. Targeting especially small medium-altitude snow tourism destinations and their communities, dealing with the socio-economic consequences of the diminishment of snow coverage, it aims to increase the socio-ecological climate resilience of snow tourism destinations and enable to retain or even increase the regional attractiveness. Trainings and awareness-raising activities, for citizens and decision-makers at different technical and political levels are being involved, while project partners aim to build an innovative and easy to use resilience decision-making digital tool. The Resilience Decision-Making Digital Tool (RDMDT) represents an automated assessment tool for aware decision-making of local and regional authorities, development agencies and local stakeholders. It enables stakeholders to analyse local characteristics, data and resources in relation to current CC trends and future scenarios, highlight the various development options and recommendations. The tool will be made freely available and publicly accessible throughout the Alpine community one the project is completed. (cf. tourism4-0, 2024).

Developing Strategies by integrating Mitigation, Adaptation and Participation to Climate Change Risks-DISTENDER – Case Study Turin: DISTENDER is also an EU-funded project developing actionable strategies for climate change mitigation and adaptation. The strategies will result from the integration of climate change adaptation and mitigation actions with participatory approaches bringing scientists, businesses, governments, policy makers and citizens together, building on five case studies. The project addresses different sectoral solutions, such as agriculture (crop variety, soil and water conservation and salt tolerant crops), but also topics related to Biodiversity (Nature-based solutions, green infrastructure, reforestation), Energy, Finance, Forestry, Health, Quality of Life, Transport, Urban challenges and water related issues (Flooding, Water Management or drainage). Finally, a “Decision Support System” (DSS) will be developed, as an multicriteria analysis tool taking into account Pros and Cons of different regional approaches and make a final classification of the different proposed robust strategies. The project builds on mathematical model tools and policy maker strategies. It should help policy makers to take the most out of the knowledge, tools and recommendations and further replicate best practices (cf. DISTENDER, 2024).

Life Climax Po: The LIFE CLIMAX PO project promotes adaptation to climate change through intelligent management of water resources in the river basin district of the PO river. The 9-year EU Life project involves the four regions of the Po area, Arpa, water consortia, ANBI (drainage actor) and universities, implementing the measures of the national strategy of adaptation to climate change, adapted to local characteristics and climatic peculiarities on a district scale. It deals with both climate scenarios and social and economic aspects, including the perception of citizens and stakeholders involved, with the objective to return a CCA strategy for the Po river. (cf. lifeclimaxpo, 2024).

3.4.1. Learnings

The key-adaptation actions in the region demonstrate experiences and competences in the field of knowledge exchange and data management and network activities, community resilience building as well as nature-based solutions directed at biodiversity and water management. Reflecting on the regional challenges, it becomes evident that major challenges to CCA governance and implementation are already targeted and thereby enhancing regional transformative capacities.

3.5. Transformative pathways

The overview of regional structure, systemic climate risks and existing CCA governance, coupled with knowledge on the planned DA, allow a final assessment of the most relevant barriers and opportunities for transformative CCA in the region, as well as pointing to the key transformative capacities that need to be utilized or developed further. To this end, a validation workshop was held in the region to discuss barriers, opportunities

and key transformative capacities with knowledgeable actors. This chapter elaborates on these aspects and concludes by providing concrete advice for transformative CCA in conjunction with the fields of action of the respective DA and beyond to facilitate transformative regional CCA.

3.5.1. Barriers and windows of opportunity for CCA

The analysis overall highlights several barriers and windows of opportunity regarding CCA water governance, regional economic resilience, aspects of environmental sustainability as pointed out in the systemic risk assessment, and knowledge transfer. There is a need for optimisation and more sustainable use of water in the region, with flexible, rational, and optimised water delivery system to provide water to farmers. This includes adopting diverse strategies like changing irrigation techniques, introducing new crops, and enhancing water storage capacity. Governance challenges are significant, with overly complex regulations, difficulty in implementing water pricing policies, and a need for better coordination among stakeholders. Addressing climate change impacts necessitates innovative, adaptive, and sustainable solutions shared within effective institutional governance and among stakeholders. Furthermore, supporting local economic actors, for example in adopting nature-based solutions, is critical for CCA implementation. Current agricultural practices are deeply embedded in cultural-historical roots, requiring a cultural transition and capacity-building measures to develop new techniques and resilient economic practices. Initiatives such as in-field training and coaching for farmers, improving infrastructure, enhancing ecosystem services, and producing higher-quality products (e.g. eco- and agritourism) are proposed to develop regional potentials further. Young entrepreneurs and local communities are seen as essential actors in revitalising rural areas, exemplified by successful projects like in the municipality of Ostana. Also, local communities are crucial in exploring solutions like constructing new aqueducts and sustainable development projects. However, a stronger collaborative approach involving local communities and stakeholders is necessary to ensure the resilience and long-term sustainability, particularly in mountain regions. Encouraging mountain residency through better infrastructure, such as digitalisation, and utilizing existing infrastructure more efficiently are emphasized. Finally, also the establishment of active networks and promoting knowledge transfer among farmers is identified as a key lever for improvement. Effective communication of research findings on CCA and implementing knowledge-sharing systems are seen as important measures to CCA. Coordination between government authorities and irrigation consortia, regular discussions on water availability and usage, and fostering collaboration among stakeholders are further highlighted as important measures. Regional strategies should emphasise participatory planning, involving various regional entities, local authorities, and civil society for successful CCA implementation.

3.5.2. Regional validation workshop

The regional validation workshop aimed at presenting, critically discussing, and further developing initial hypotheses and interim findings on transformative adaptation with knowledgeable regional actors. The workshop hence consisted of two parts: In a first session, regional CCA measures, challenges and opportunities deriving from the previous analysis were presented and subsequently debated in smaller groups as well as in the plenum. In the second session, regional transformative capacities that were identified as relevant by the research team were introduced and put up for discussion. This gave participants the opportunity to share feedback, give concrete examples stemming from their own experience or bring in new ideas for effective CCA governance.

Main topics discussed were based on the identified problem background as well as the emphasised approaches, particularly addressing challenges of a fragmented regional water governance. The participants elaborated the need for better cooperation, coordination and knowledge exchange amongst actors. With great complexity related to regional water governance, participants emphasised the need for more *"coherent [and] coordinated leadership in a bottom-up approach from the very beginning*" (PVDWS*)*. Also, the discussion centred on the need better knowledge transfer, data collection and monitoring management to enhance common CCA knowledge. It was mentioned that "*irrigation techniques are stuck for centuries*", therefore lacking efficiency. With a general lack and often only one-dimensional data "*irrigation consortia knowledge should be combined with farmer best practices*" (PVDWS) to gain

better understanding of new solutions that are already tested. Overall, addressing issues of governance, local economies, biodiversity and knowledge building, the discussions then evolved along the proposed transformative capacities, introduced in the following chapter.

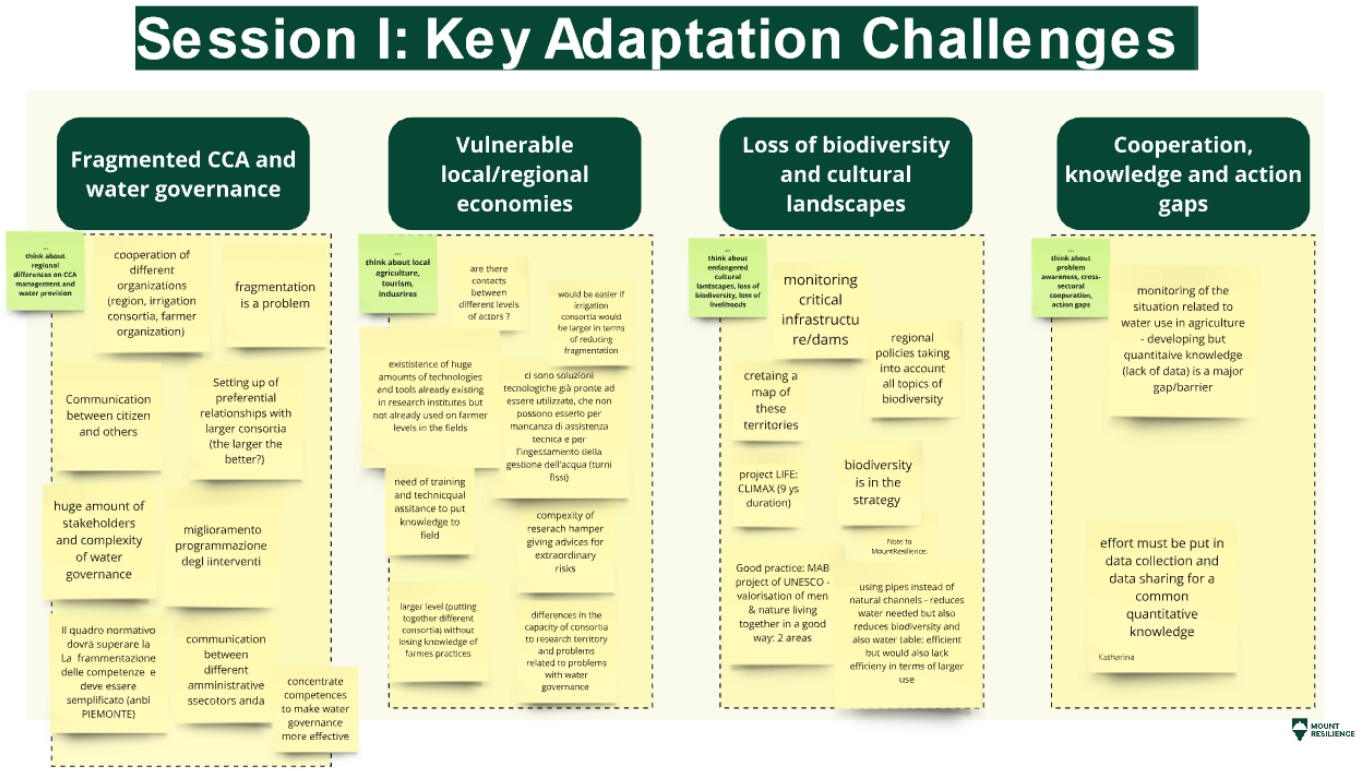

Figure 19. Accompanying Miro Board from VDWS in Piedmont.

The workshop was conducted in an online format on June 18, 2024, from 11:00 to 13:00 (EEST) with an audience of 26 participants. The online tool Miro was used to facilitate visualization of discussion points.

3.5.3. Regional transformative capacities

Overcoming a focus on mere adaptation responses towards more long-term transformative change, the concept of transformative regional capacities offers a perspective on the wider interplay, forming a more systemic perspective. The last step of the regional CCA analysis aimed at the identification of regional strengths and transformative capacities by assessing regional/local implementation barriers and existing regional capacities. Building on the analysis results and workshop responses (conducted in June 2024), transformative regional capacities were determined. The framework proposed by Wolfram's (2016) of ten adaptive capacities addresses organisational visions, work culture, structures, skills, human and material resources, but also community participation, relations, networks and institutions, and the understanding of existing systems. For the regional climate change analysis, the most relevant transformative capacities were identified, based on the barriers and windows of opportunity for CCA, to guide adaptation action, particularly with regards to the regional Demo Activities (DAs). Based on our findings, successful CCA approaches should reflect the following transformative capacities: *CCA Leadership Distribution; CCA Projects and Practices; Openness for Innovations; Reflexivity and Learning*. These reflect actual regional potentials while mirroring present regional needs for improvement for CCA action (for the full list of TCs, see Annex).

Table 10. Transformative capacities for effective CCA in Piedmont

CCA Leadership Distribution	**Strong regional actors are already active in CCA**. However, improvement of current governance and leadership distribution with clear and coordinated roles and responsibilities are still needed (e.g. irrigation systems consortia). With strong awareness amongst the political institutions and numerous regional actors already involved, still the PVDWS participants pointed out the need for more policy and strategy coherence, coordination, common visions and more capacities (e.g. personal in smaller irrigation consortia), but also clearer guidelines and participation-oriented measures. Further, also "simpler" solutions should be emphasised to support implementation while decisions need a sound data base to develop clear strategies.
CCA Projects and Practices	**The region shows a diversity of adaptation practices**. However, there remains a need to try out new solutions, strategies and practices to provide for alternative economic pathways (agriculture, water management, tourism etc.). As there are already adaptive practices and CCA projects in the region, in the PVDWS the participants highlighted the greater focus and interconnection with farmer best practices and relevant CCA projects, with active testing and support of new solutions as well as an evaluation of the pros and cons of (new) solutions. Further, they considered an expansion of project partnerships as relevant, from the individual company to the university and the institutional body, to involve more relevant actors in actual implementation activities.
Openness for Innovations	**Piedmont already applies advanced technological solutions**, but greater openness for innovations is still needed, allowing for the protection of livelihoods, nature and cultural assets (e.g. storage capacity; alternative crops and production methods; changing farming practices; nature-based solutions or cross-border / cross-regional collaborations). Participants in the PVDWS highlighted that there is a great openness amongst innovative farmers to use new technologies, but still a need for the involvement of more pilot farms and projects. Also, since the solutions are context dependent, they should be better evaluated on a case-by-case basis. However, due to the still rather low technology's readiness and knowledge gap of farmers regarding new/emerging technologies, the need for more supportive measures was emphasised to help to raise openness and increase implementation efforts.
Reflexivity and Learning	**While there is already a strong awareness for CCA** in water governance, there is the need for improved monitoring and data collection, better understanding of actual and complex water needs, with efficient and equitable

solutions at regional scales. Enhanced scientific and practical knowledge would support actual sustainable development and adaptation measures.

With numerous CCA activities in the region, participants in the PVDWS point out the need for better long-term understanding of complex and interrelated challenges, especially regarding the water availability. Also, the emphasis was laid on the creation of a standard methodology for collecting data and implementing a common data-access repository, seen as an investment in long run. Further, an analysis of experiences in different contexts was considered important. This shall support reflexivity and learning, the development of relevant indicators, effects and solutions, to better supporting crop efficiency, biodiversity, drought risk resilience.

3.5.4. Concrete advice for the DA and beyond

Identifying systemic climate risks, challenges but also transformative capacities, takeaways and major issues that should be put under further consideration for the implementation of the DAs and for successful regional CCA are seen in the following needs.

Centralise coordination and simplify rule-setting. With a disparity in the resources and capacities of various irrigation consortia and an overly complex rule-setting, central coordination and simplification of local procedures are necessary for successful implementation.

Adopt stronger bottom-up, partnership-oriented approaches. With multifaceted local challenges in water management for agricultural sectors, particularly within irrigation consortia, it is imperative to adopt bottom-up approaches, that ensure that the various stakeholders, including NGOs, local pioneers in polit projects, technical institutions and administrative authorities, are all involved early in the planning and implementation process. Expanding project partnerships ideally include all relevant operators, from individual farmers to academic and institutional bodies. A stronger participatory and partnership-oriented framework would not only enhance the development of practical management solutions but also better reflect the need for simpler, yet effective, procedural guidelines that can address the complexities of water management.

Improve data and knowledge exchange. An improved data collection and management approach is needed to foster local knowledge-building and exchange while also help to improve implementation efforts. This should include the integration of (past/present) project experiences to develop robust strategies for water-saving management, that further translate in more efficient implementing activities. Establishing a standard methodology for data collection and creating a common data-access repository can significantly enhance long-term understanding and reflexivity in water management practices.

Reduce reluctance towards agricultural innovations and embrace transformative ideas. The agricultural sector must embrace change by updating irrigation techniques and increase local efficiency. Innovation and learning play crucial roles in bridging the knowledge-gap between traditional farming practices and emerging technologies. There is a critical need for pilot farms and projects to demonstrate the efficacy of tools such as decision support systems (DSS) and other innovations.

Further suggestions

Given the numerous actors involved, the regional heterogeneity, lacks in data management and limited collaboration among regional actors as well as the complex ecosystem challenges related especially to the regional water infrastructure, the region needs to **invest in and build strong regional CCA networks**. An intense, coordinated, and regular cross-sectoral, and cross-regional exchange would support the knowledge exchange, awareness building, and best-practices learning effects to enhance local decision making and implementation of transformative CCA actions. Furthermore, as addressed in the systemic risk assessment, with changing climatic conditions and the increased risk of drought in Piedmont, **water-intensive agricultural products need to be replaced** in the near future, together with **finding new ways of governing more efficient water usage** in private and agricultural practices and actively protect ground- and surface water availability.

4. Baseline – Râu Sadului

4.1. Regional profile

Regional structures, political competencies and development objectives profoundly influence the potential pathways for regional CCA. This chapter introduces the topographic, functional, environmental, and socio-economic characteristics that shape the region structurally, briefly introduces the territorial governance framework to illustrate the region's formal competencies for implementing CCA autonomously and outlines the dominant self-image to sketch the normative starting point for regional CCA.

Romania faces different challenges related to climate change, ranging from trends towards seasonal temperature rise, with a maximum duration of heat waves (at least two consecutive days in which the temperature is higher than 37°C) increasing in southern and western regions, with a progressive increase in air temperature, for all seasons, but more pronounced in summer and winter. Also, a decreasing trend the amount of seasonal precipitation with a reduction of the mountain snow cover, for example in southern and eastern regions, is observable. Pessimistic projections discuss a significant average monthly increase in temperature (up to 3°C in summer) and an average monthly reduction in the amount of precipitation (8-9% during the summer) until 2050 (Bojariu et al., 2021). These challenging dynamics are already observable in the project region of Râu Sadului, Sibiu County, central Romania. The Municipality of Sibiu is experiencing numerous climatic risks such as droughts (65 consecutive days with precipitation below 1l per m^2), with an average of almost 4 weeks, in combination with high temperatures such as heat waves, as well as other extremes such as heavy torrential rainfall, which is triggering landslides and affecting the annual agricultural production, forestry, local economies and livelihoods (Iojâ, Croitoru, Vavari, Benedek, & Sandu-Giprian, 2022, 36f.).

While the Mount Resilience Demonstration Activity in Romania will focus on the municipalities of Râu Sadului and Cristian, this study examines the NUTS2 region RO12 Centru, in which the two municipalities are located, for reasons of data availability and comparability. Nevertheless, analyses and statements are broken down to local aspects whenever possible and useful.

4.1.1. Structural characteristics

Overview of topographic and functional characteristics

Located in Sibiu County, about 35km distance from the county capital Sibiu to the North, Râu Sadului lies on the upper reaches of the Sadu river in the Sadu Valley and is constituted by several hamlets that make up the commune (Ciupari, Beberani, Maelaţi, Fundu Râului and Sădurel) (Commune of Râu Sadului, 2024). Lying at the foothills (at an altitude of 750-800m) of the Cindrel mountains, southern Carpathians, it is part of the Mărginimea Sibiului region (cf. Figure 1). Mărginimea Sibiului is located in the south-west of Sibiu County, between Sibiu and the Cindrel Mountains, with the term referring to the villages situated at the contact between mountain and the plain-like depression “on the outskirts” of Sibiu (Velcea, Toderas, Crăcea, & Negoescu, 2016, p. 87). The region is particularly known for its rich cultural, architectural-, and historical heritage (e.g. settled by different ethnicities and home to the Transylvanian Saxons), and is therefore gaining touristic significance in Romania. Strongly, shaped by agriculture forestry, animal farming, with a particular focus on sheep breeding, the Râu Sadului region is strongly connected to cultural, ethno-folkloric traditions and traditional crafts, recognised throughout the country (Commune of Râu Sadului, 2024; Sibiu Tourism, 2024; Velcea et al., 2016). Râu Sadului lies 21km from Tălmaciu, the nearest by bigger city, and 14km from Sadu, the nearest next commune, as well as 45km from Christian, and stretches along a street next to the Sadu River (7km), with no side streets (Commune of Râu Sadului, 2024).

Overview of ecosystem and environmental characteristics

Romania's overall climate is transitional temperate continental, with oceanic influences (western parts), Mediterranean influences (southwest) and strong continental effects (northeast) (UNFCCC, 2022, p. 29). Climatic variations are modulated by geographical characteristics such as the position of the Carpathians, the altitude or the proximity of the Black Sea. Climate changes in particular affect the alpine vegetation, with mountain areas being most vulnerable to environmental factors and anthropogenesis through uncontrolled pasturage and tourism (ibid. p. 28). In general, the Mărginimea Sibiului is known for its large forests and meadows, pastures and sheepfolds, providing one of the most important pastoral areas in the Carpathians (Kucsicsa et al., 2020). Romania's forest cover amounts of nearly 7.2 million ha of which 60% are located in mountain units, 35% in hilly and tableland units and only 5% in the plain areas and the Danube Delta (ibid. p. 473). The ring-like display of the Carpathian Mountain relief coupled with the climate features have affected in a diversity of soil resources and spatial distribution of the forest-cover in Romania, with significant regional differences. A rich biodiversity is represented by vegetation but also by local wild animals and birds (brown bears, wolves, fox, deer, wild goats, lynx, and many other). The agricultural lands represent 40% of the total area of Sibiu, with secondary meadows (63.06%) followed by non-irrigated arable land (32%) and permanent crop area (5%) (SPAASC, 2022, p. 36).

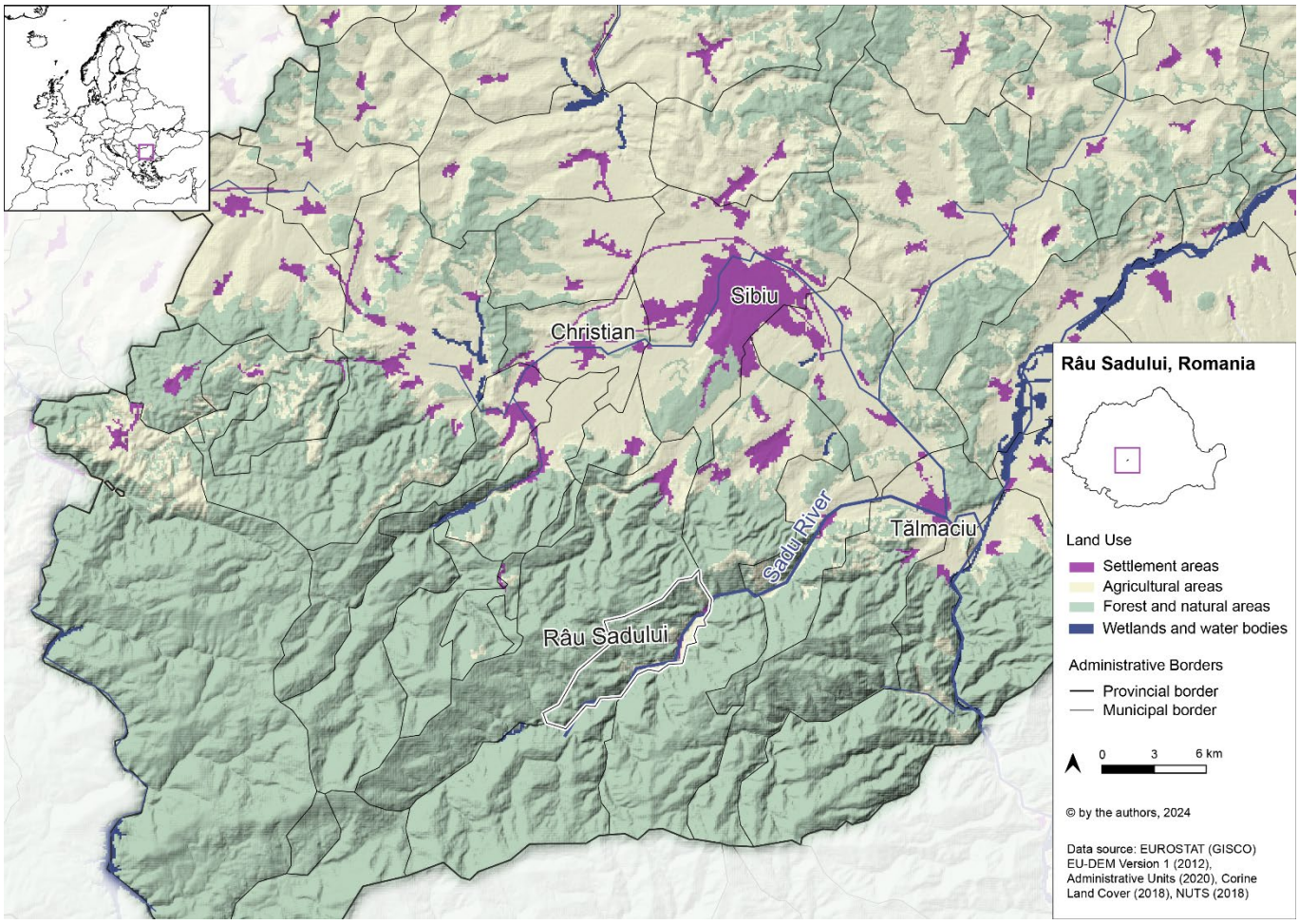

Figure 20. Map of Sibiu with Râu Sadului settlement (TU Wien, 2024)

Description and key indicators for socio-economic profile

The area is characterized by smaller villages, agricultural lands and touristic activities (Commune of Râu Sadului, 2024). In the past, inhabitants of the commune were engaged in fruit growing, brandy production, traders in cheese, meat and hides and they also fished from the rivers bordering the village. Today, the population is mainly involved in sheep herding, cattle breeding, fishing (there is a trout farm on the Pinului stream), forestry, and rural tourism. In general, the whole Sibiu County is involved in sectors such as the automotive industry, electronics manufacturing, IT&C, food industry, construction, wood processing, and tourism (c.f. sibiubusinessagency.org, 2024).

In 2022, Sibiu County had 388,898 inhabitants. After a strong **population** decrease in 2021 (crude rate of total population change of -28.7 per 1,000 inhabitants), the county showed a moderate population increase of 6.4 per 1,000 inhabitants again in 2022. Similar dynamics show with regards net migration rate, which, after a period of decline, increased again in 2022 – slightly above average Romanian national growth rates. The natural change of population amounted -2.6 per 1,000 inhabitants (Eurostat, 2022). Overall, in 2022 in the Centru region (NUTS 2), where the Sibiu district is located, the **median age of population** was 43 years (Eurostat, 2022), with most of the regional population between 25-64 years having completed a medium, upper-secondary or post-secondary **education** (62.2%), compared to the region's low educational attainments (18.9%) (Eurostat, 2022). The **labour market** situation of the population aged 15-74 years, as of 2022, showed a rather low unemployment rate of 5.4%, however, with strong youth unemployment of 16.1% for ages 15-29. The overall employment rate (20-64 years) differs among the regional working population, with 75.8% of men and only 59.2% of women being in employment (Eurostat, 2022). The **regional GDP** was €32,059.77 million, with a share of total national GDP of 11.3%, and a comparatively low Purchasing Power Standard (PPS) of €25,200 PPS per inhabitant (€26,700 PPS per inhabitant for Romania) (Eurostat, 2022).

Table 11. Socio-economic data for Sibiu County, compared to EU average (Source: Eurostat, 2022)

	Population density *(per km²)*	**Median age** *(in years)*	**Population change** *(in % from 2021 to 2022)*	**PPS per capita** *(in €)*	**Employment rate** *(in %)*	**Risk of poverty** *(in %)*
Sibiu County *(incl. Râu Sadului)* **(2022)**	72.2	43.0*	+6.4	25,200*	61.9*	31.7
EU-average (2022)	109.1	44.5	+4.0	35,400	74.4	22.0

** incl. Râu Sadului (located statistically in the EU NUTS 2 Region Centru).*

4.1.2. Governance framework

Romania, being an active EU member since 2007, underwent a significant reorganisation of spatial competences towards regionalisation (Bajtalan, 2017). General guidelines to adaptation are formulated by the Ministerul Mediului, Apelor și Pădurilor (Ministry of Environment, Waters and Forests, MMGA). Based on the existing administrative-territorial structure of the country, there are two levels of competences with (i) counties in the upper level, (ii) towns and communes (groups of villages) in the lower level (Benedek & Bajtalan, 2015; Benedek & Horváth, 2009). Râu Sadului is a commune in Sibiu County, at the lowest level of administrative subdivision (LAU status), governed by a mayor. Since Article 120 (1) of the public administration in territorial-administrative units defines the principles of

decentralisation, local autonomy, and de-concentration of public services, the county has a significant decision making and implementation competencies, also with regards to climate change adaptation measures and priorities.

4.1.3. Identity and self-image

Sibiu County's local identity and self-image are strongly shaped by culture- and nature-oriented components, that link traditional practices and its diverse cultural heritage. Romania's German-Saxon heritage is particularly present in Sibiu (Hermannstadt), becoming an important trade centre in the 14th century and the most important ethnic German city among the seven cities in Southern Transylvania, that gave Transylvania its German name Siebenbürgen (Romania Tourism, 2024). The Saxons came to Transylvania during the mid-1100s, gaining administrative regional autonomy for almost nine centuries and steering the regional prosperity. The region was also shaped the by the Ottoman- and the Austro-Hungarian Empires. This rich cultural diversity translates into well-preserved, quaint towns and fortified churches. Today this heritage, together with the omnipresence of the Carpathian Mountains is offering a vast portfolio for tourist attractions, shaping the regional identity. The regional marketing thus advertises "*Our destination is more than just a city, it's an entire county. Discovering Sibiu is really about immersing yourself in the unique culture, history and well-preserved traditions. It's in the magic of these places surrounded by the beauty of the Carpathian Mountains, where you'll find the heart of Transylvania, Sibiu" (c. f. visitsibiucounty 2024: n.d.).* Similar to that, Râu Sadului is oriented towards promoting its cultural heritage while being an important starting point for rural and outdoor tourism (e. g. hiking activities) (Commune of Râu Sadului, 2024).

Figure 21. Tourism marketing of Sibiu County (Source: visitsibiucounty, 2024; adapted by the authors)

4.2. Systemic climate risks

The most important factors determining the directionality and design of CCA are concrete regional climate hazards and consequent systemic risks. This chapter overviews the main climate risks and relevant climate impact chains, pointing to the challenges for regional adaptation.

4.2.1. Main climate hazards and intermediate impacts

The period from 2021 to 2050 is predicted to bring significant changes to the climate in Sibiu County, according to regional climate models. Under the moderate scenario (RCP4.5), the mean annual temperature is expected to rise to 10.2°C in Sibiu and 8.3 °C in Păltiniș. If greenhouse gas emissions continue at the current rate or higher (RCP8.5), temperatures could increase even more rapidly reaching 10.4°C in Sibiu and 8.4°C in Păltiniș (Iojâ et al., 2022).

Precipitation patterns are also projected to change. A decrease in both snow and rain is expected, leading to a reduction in snow cover and a shorter snowy period in winter (Ministry of Environment, 2017). At the same time, heavy rainfall events are likely to become more intense and frequent. In the Sibiu Municipality area, droughts can last from a few days to more than two months, with an average duration of almost four weeks, posing a high risk to agriculture (Navarro et al., 2022). Additionally, the risk of wildfires remains high under both low emissions (RCP2.6) and high emissions scenarios (RCP8.5).

Extreme weather events, such as heavy rainfall, will increase the risk of landslides, especially in urban areas that have expanded construction at the expense of agricultural lands (Iojâ et al., 2022). This aligns with national predictions indicating that mountain areas will experience rapid floods due to increased heavy rainfall (Ministry of Environment, 2017).

4.2.2. Climate impact chain

We developed a climate impact chain focusing on agriculture, because of the risks climate change is posing on that sector. Romania has a highly fragmented structure of agricultural land and land ownership, being mostly made up by fragmented small farms (Tebaldi & Gobjila, 2018). The agricultural sector in the mountainous areas of Sibiu County, specifically in the regions of Cristian and Râu Sadului, faces significant risks. These encompass lower agricultural yields and dangers to livestock, which contribute to the broader issue of depopulation and the abandonment of agricultural land, threatening the loss of local knowledge, traditions, and identity, forming a cascading risk effect within the agricultural sector.

The primary natural hazards driving these risks include emerging heat waves, extreme weather events, rising temperatures, and changes in precipitation patterns. The elevated temperatures and shortened growing seasons reduce the production of various agricultural goods. This environmental shift also leads to competition and displacement of species, causing a loss of biodiversity as heat-sensitive plants perish and invasive species proliferate. (Agora Est Consulting, 2016; RI4).

High temperatures and heat waves are thus expected to affect the entire annual agricultural production by reducing crop yields, increasing pest infestations and fertility loss. Droughts primarily influence the soil moisture regime, leading to higher evapotranspiration. This can slow down or halt many physical, biological, biochemical, and chemical processes dependent on water, shortening the growing season and reducing overall agricultural yields across Romania, especially in the case of non - irrigated land. This soil degradation also affects meadow composition, lowering the nutritional value of grass, which in turn diminishes livestock farming efficiency, negatively impacts animal health, and degrades food quality (Ministry of Environment, 2017). Droughts, which can last up to several weeks and months, also severely impact the already partly insecure water supply, creating significant deficits for irrigation and fostering soil degradation, marginalisation, and abandonment of agricultural land particularly in areas with light and

erosion-prone soils. Besides agriculture, water shortage also intensifies competition for water between industry, tourism and energy production.

National predictions indicate that mountain forests will suffer from rising temperatures, stronger winds, and reduced snow cover. Pests adapting to higher temperatures and drought will further destabilise forest ecosystems and increase the risk of forest fires (Ministry of Environment, 2017). The wildfire risk in Sibiu County is already high and is expected to remain so until the century's end (Navarro et al., 2022).

Conversely, increased heavy precipitation, melting snow and torrents lead to floods, landslides, and further soil erosion on sloping lands, particularly where soils are most vulnerable. This results in a loss of soil fertility, damaging both plant and grass growth and the land's infrastructure necessary for cultivation. Most Romanian farmers, particularly smallholders, lack the resources to effectively adapt to these challenges (Iojâ et al., 2022; Ministry of Environment, 2017; Navarro et al., 2022; World Bank Group, 2023; RI4).

Heatwaves contribute to heat stress in crops and livestock and are exacerbating the health risks for aging farmers. Increased temperatures also drive higher rates of evapotranspiration, leading to soil salination and further biodiversity loss (Roșca, Bilașco, Fodorean, & Iuliu, 2020). The health, productivity, and reproductive rates of farm animals suffer due to heat stress, water shortages, and decreased forage productivity from drought conditions. Additionally, as already described, during heatwaves the demand for irrigation water escalates (Gavriletea, 2018; Tebaldi & Gobjila, 2018; RI2).

As poorer population are often reliant on climate-sensitive sectors like agriculture and fishing, they are exposed more to natural hazards and climate risks, with a higher vulnerability to climate shocks. Small farmers are also facing a loss of appreciation, because they partly lack efficiency in agricultural practices, despite the value they are producing by taking care of the land and the traditions (RI5).

The below figure shows the Systemic Risk Assessment for Climate Impact Chains in the agricultural sector, with a particular focus on extreme weather events, related to heatwaves and flooding. The main regional risks identified, induced by climate change, are lower yields and livestock at risk, depopulation and abandonment of agricultural land as well an overall identity loss along with a loss of traditional knowledge and practices.

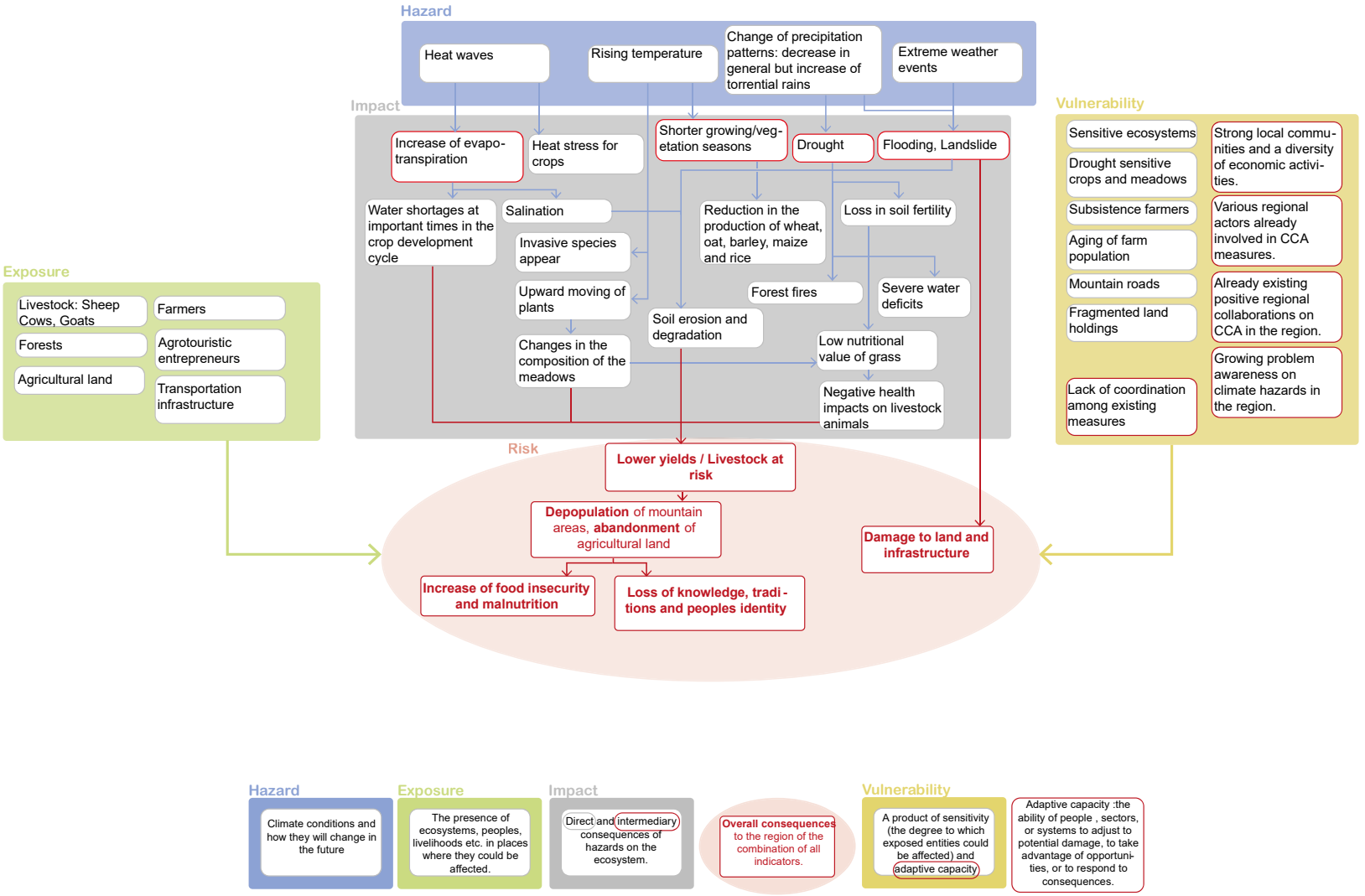

Figure 22. Râu Sadului IC for water scarcity in agriculture (ZSI, 2024) | *cf. chapter 11.2 for IC methodology*

4.3. Regional CCA governance

CCA activities should be well-embedded in the strategic objectives of a region and strike a balance between stakeholder inclusion and leadership. Accordingly, understanding the strategy framework and stakeholder landscape of regional CCA governance is important. This chapter identifies key regional CCA-related strategies, how CC and its consequences are problematized therein and how certain adaptation challenges are prioritized. It highlights the prevailing understanding of CCA and the emphasized approaches for tackling it, as well as the most important regional stakeholder groups, which is important for the design and implementation of concrete adaptation activities.

4.3.1. Strategy framework

Overall, the strategies are in line with international and European strategic frameworks, such as the Paris Agreement (2015), the United Nations Agenda 2030 (2015), the European Strategy for Adaptation to Climate Change (2013[2021]) or the EUs Green Deal (2019), there are several national, regional, local and sectoral strategies to combat climate change and support sustainable development in Romania. Our analysis focused on the most relevant documents targeting CCA for the region Sibiu, including Râu Sadului, to identify the most relevant challenges and the CCA understanding.

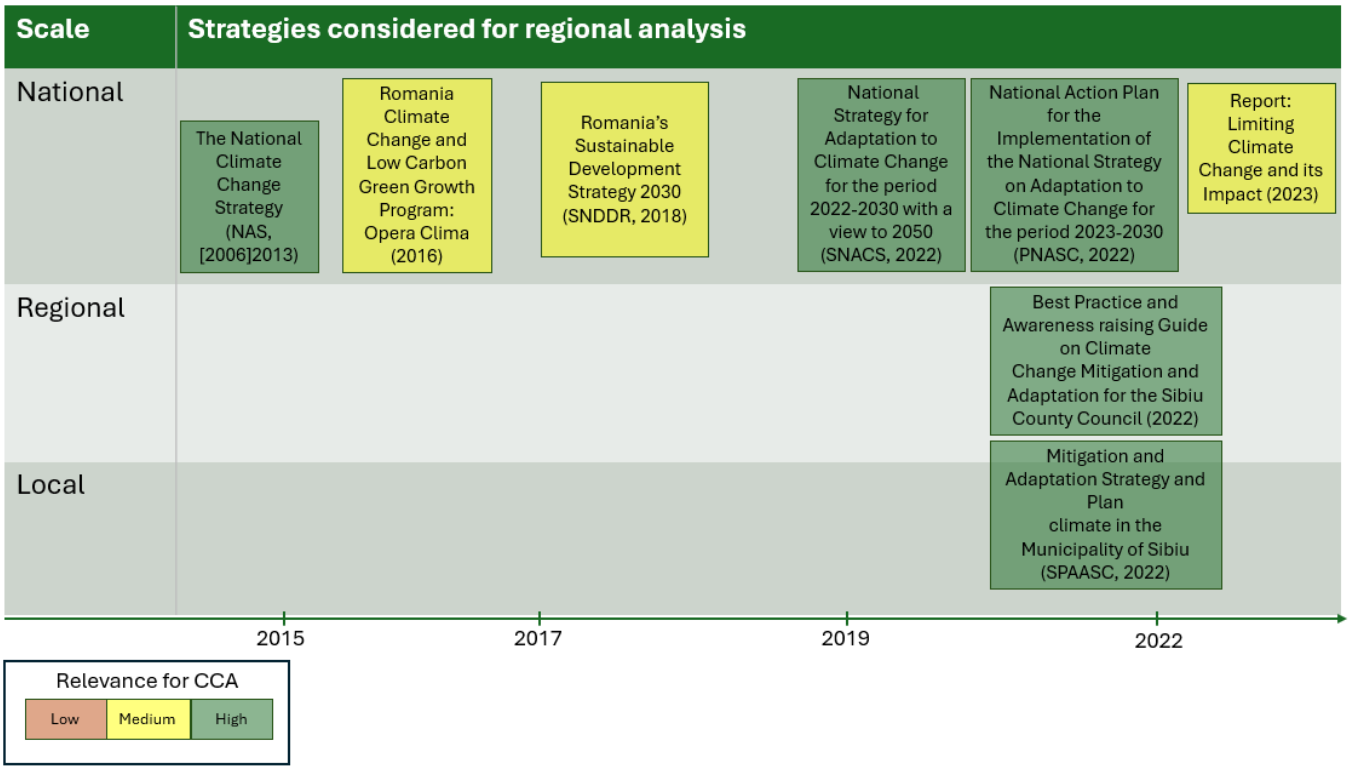

Figure 23. Overview of CCA-relevant strategies for Râu Sadului (TU Wien, 2024)

Romania has several national and regional strategies to Climate Change, Sustainable Development, Mitigation and Adaptation.

One of the first **national strategies** on climate change targeting adaptation is Romania's "National Strategy on Climate Change" (Ministry of Environment, 2006), delivered in accordance with the provisions of the Kyoto Protocol and addressing adaptation. Later the revised "National Strategy on Climate Change" (NAS, 2013), based on the "Climate Change Adaptation Guide" (2008), was released, establishing the post-Kyoto objectives, targets and actions for mitigation and adaptation (UNFCCC, 2022). In the following, the "National Climate Change and Low Carbon

Green Growth Strategy 2016-2030" (Ministry of Environment, 2016) and the associated "Action Plan on Climate Change 2016-2020" were adopted. In 2018 the "Sustainable Development Strategy 2030" (SNDDR, 2018) addressed the overall sustainable development concerns at national scale.

In 2022, the incumbent President of Romania established a working group on climate change, under the coordination of the climate and sustainability department of the presidency's administration, to identify the main challenges Romania is facing (UNFCCC, 2022). Particularly from 2022 onward, more pronounced strategies towards CCA were adopted. Thereby, the "National Action Plan for the Implementation of the National Strategy on Adaptation to Climate Change for the period 2023-2030" (PNASC, 2022) and the "National Strategy on Adaptation to Climate Change 2022-2030" (SNASC, 2022) were released.

Strategies relevant for the **regional/local scale**, are the "Strategy and Plan for Mitigating and Adapting to Climate Change in the Municipality of Sibiu" (SPAASC, 2022) and the "Best Practice and Awareness Raising Guide on Climate Change Mitigation and Adaptation for the Sibiu County Council" (Iojâ et al., 2022).

Furter relevant strategies are the "National Recovery and Resilience Plan" (PNRR, 2021), the "National Disaster Risk Management Plan 2023–2035" (PNRRD, 2023), as well as the "Integrated National Energy and Climate Plan 2021-2030" (PNIESC, 2020).

4.3.2. Problem background and prioritized challenges

Along with the identified systemic risks, the "National Action Plan on Adaptation to Climate Change" discusses the main objectives in areas such as water shortage related challenges, forestry, biodiversity and ecosystem services, agriculture and rural development, energy and transport, but also population, public health and air quality, education, awareness building, cultural heritage and challenges to urban systems (SNASC, 2022).

The region faces **threatened infrastructure (e.g. water & transport) and challenges in CCA governance**: Planning and governance in Romania is characterised by a top-down approach, with budgets and policies coming from the national government. This leads to inefficiencies, as individual actions often contradict spatial and CCA planning. The interviews point towards the challenge of regional conflicts between different stakeholders and the vulnerability of infrastructure when it comes to CCA management. With differences between administrative levels, but also between individual regional actors, such farmers and the tourism industry, successful adaptation measures are often hampered. Farmers are particularly emphasized as powerful and organized actors in the region, holding significant private land and influencing regional decisions. One interviewee therefore notes, that "*there is the conflict […] between the different administrative levels in the region and the community the municipalities …[and] for example the conflict about using the roads between the farmers and tourism, and the farmers are also organized quite strongly in the region, and there are many that have a lot of private land*" (RI1).

The analysis also shows that ineffective governance is also increasing the vulnerability of infrastructure, such as buildings, transport, and electrical lines, to climate change impacts like high temperatures, floods, and strong winds (RI; RI2; RI3.). Thereby, especially the quality of roads is noted, with issues like asphalt degradation and debris blocking during extreme weather events and the closure of high-altitude roads during winter (RI2). One interviewee stresses out that *"[…] the quality of the asphalt […] was not projected to be resilient for this weather"* (RI2). The interviews suggest that the regional climate change adaptation strategy did not adequately consider important measures such as ecosystem services or green infrastructures and see a need for improvement (RI2). Furthermore, water shortage due to droughts and lacking infrastructure poses a challenge for the region. One interviewee highlights that, "*in Râu Sadului they think they have enough water, but in reality they don't have enough water […] in the summertime this becomes a problem. We have discussed that with sheep farmers, they said in August and September there is not enough water in the mountains in 2000 m […]. Normally they don't expect this problem in the*

mountain area, but this problem goes also to the city, you need specific management of the water […]" (RI2). On the other hand, the risk of flooding has also increased in the region, with some areas vulnerable to overflows as a result of heavy rainfall (SPAASC, 2022, p. 42). The Sibiu Municipality notes that, due to climate extremes, there is a significant challenge of drinking water supply with uncontrolled quality and contamination risk in certain areas (SPAASC, 2022, p. 41). This comes also as a result of the discharge of untreated wastewater (ibid., p. 42).

Local **economies and local livelihoods (e.g. agriculture, forestry, tourism) are particularly vulnerable** to climate change. The agricultural sector in the Municipality of Sibiu is vulnerable to extreme weather events such as droughts, heat waves, and floods. These phenomena adversely affect both the quantity and quality of crop production. The regional SPAASC strategy points out that *"both livestock and crops are struggling to acclimatise to the rapidly changing climate. Intensified wind events (blizzards) and heavy snowfalls pose significant risks […] necessitating comprehensive risk management strategies to mitigate potential damages"* (SPAASC, 2022, p. 40). Additionally, indirect effects such as vegetation fires further exacerbate these challenges. The mitigation and adaptation strategy outlined for the municipality recognises the risk of diminished agricultural productivity due to these climatic stressors (SPAASC, 2022, p. 39). Interviews with local stakeholders highlight the negative impacts of increased temperatures, decreased precipitation, and the alternation between prolonged dry periods and torrential rains on agricultural activities (RI4, RI1). One interviewee emphasized, "*the challenge is, that the animals are not acclimatized to the new climate, but also the vegetables... developing new varieties takes longer than the speed of climate change*" (RI1). Therefore, capacity building activities are necessary, because *"[…] missing of skills in the economic area is a big barrier, they want to have more nature-based solutions or more smart solutions to climate change adaptation, but in reality, they don't have the companies and skills to do it* (RI2).

The municipality also faces risks to forest productivity and diversity, including the carbon storage capacity of forests (RI3, RI4). Climatic conditions such as high temperatures and droughts, alongside the increasing aggressiveness of pests, are shifting the boundaries between forests and pastures. Moreover, there is an elevated risk of natural forest fires during the hot season due to high temperatures and electrical discharges (SPAASC, 2022, p. 40). Also, an increased risk of windfall, due to the occurrence of wind intensifications (blizzards) or heavy snowfalls occurs more often (ibid.). The vulnerability of tourism and recreation sectors in the Municipality of Sibiu to climate change are emphasised out as well (RI1, RI2). Recreational activities are increasingly threatened by hazardous weather events. High maximum temperatures and heat waves pose significant risks, potentially deterring participation in outdoor activities and diminishing the overall quality of the tourist experience (SPAASC, 2022, p. 49). The region is nationally renowned for its winter sports tourism however, rising temperatures in the coming decades are expected to severely restrict winter tourism and recreational activities (ibid.). With the temperature increase threatening the length of the tourist season, an interviewee highlighted that economic pressures on tourism businesses are also harming the local environment by stating, "*if you want to be profitable, you have to have artificial snow, that means increased water consumption and energy consumption*" (RI2).

Further, some of the natural areas of special value do not have the status of a protected area (e.g. Padina Goalÿ, Padina Tiiÿelului, Fântâna Rece, Lunca Rusciorului), increasing their vulnerability in the context of the climate changes (SPAASC, 2022, p. 41). For example, the Păltiniș tourist region or the nature reserve Dumbrava Sibiului Natural Park are affected by multiple pressures, such as drought, high temperatures and heavy rainfall. With increasing human pressures, like the fragmentation of habitats or unbalanced visitor's programmes, local species of flora and fauna are put at considerable risk and require better protection of natural/cultural heritage (RI2; RI4).

There is an **insufficient problem awareness and acceptance of CCA measures.** One significant barrier to implementing alternative flood management solutions is the limited awareness and prevailing scepticism towards non-traditional methods (RI3, RI4, RI5). Traditional views favour conventional measures such as constructing channels and dikes. An interviewee noted, "*If you want another [alternative] solution... you are crazy and nobody trusts you*" (RI2), which also highlights a pervasive resistance within institutions to adopt innovative approaches.

There is also a noted deficiency in awareness-raising efforts in in general, which contributes to the public's uncertainty about appropriate actions to address climate change. An interviewee pointed out that "*people do not know what to do and the package of awareness raising somehow is missing in Romania*"(RI5). Overall, lack of training and awareness hampers effective climate adaptation strategies. This underscores the necessity of improving information dissemination and promoting innovative solutions in agriculture to manage climate risks effectively (RI4).

The region shows only **limited stakeholder collaboration and lack of CCA action**. The analysis identifies challenges in collaboration among different stakeholders within the Municipality of Sibiu (RI4; RI2). It was highlighted by one interviewee that "*the collaboration between different actors is not so good. The institutions in general are in competition and the collaboration is not an attribute or characteristic for the Romanian government or Romanian governance in general*" (RI2). This dynamic hinders the effective implementation of joint initiatives and projects. Another interviewee further noted, that additionally, stakeholders often lack awareness of each other's activities, highlighting a significant gap in coordination and emphasising that "*[…] farmers' associations, the agricultural directorate, the research institute, the mountain area development agency, universities, etc. […] [we] need a better collaboration and correlation [as] it happens[,] that they don't know what some stakeholders are doing*" (RI4). Further it was underscored, that there is an importance of integrating climate change adaptation considerations into investments and development (local / regional) plans (RI5). But also, local action, e.g. thought Local Action Groups (RI2; RI3; RI4) must be targeted stronger. While "*the authorities are putting more emphasis on the solutions for water management […] [,] the municipality must take measures to reduce the consumption of the household*" pointing out local action as central CCA component (RI3). Also, "*in general [environmental institutions] are completely weak, invisible, because the quality of the staff and also the power of this intuitions […] [is] completely limited"* (RI2). Together with the absence of a dedicated CCA strategy in Râu Sadului, the municipality relies on the national strategy. This poses significant limitations in enforcing environmental agreements and the implementation of environmental regulations as there is a lack of compliance from local actors (RI2).

Based on our analysis, we point out four interrelated regional challenges as main fields for short and long-term CCA action, also relevant for the DAs.

Table 12. Main CCA challenges for Râu Sadului

Threatened infrastructure (e.g. water & transport) and challenges to CCA governance	Governance and management of infrastructure, particularly roads and water, pose a particular challenge in the Râu Sadului, Sibiu region. With conflicts and debates between different administrative levels as well as between various stakeholders regarding the use and maintenance of the road network or the construction of dams, local CCA approaches are challenged.
Vulnerable economies and local livelihoods (e.g. agriculture, forestry, tourism)	The impacts of climate change pose a significant challenge for local economies and livelihoods. With increasing temperatures, extreme weather events, and water scarcity various local economic sectors are affected, such as agriculture, forestry and winter tourism.
Limited problem awareness & acceptance of CCA measures	Because of limited local CCA action, there is a need for awareness raising and behavioural change. With low public awareness and scepticism towards non-traditional methods amongst different groups, adaptation poses a particular challenge in the region.

Limited stakeholder collaboration and lacking CCA action	While there are some positive examples, the overall picture suggests a lack of effective collaboration amongst actors, both within and across sectors. Factors contributing to this include competition between institutions, limited power of environmental organizations and a lack of communication and coordination.

4.3.3. Prevailing understanding

Strategic documents frame national efforts as actions to protect Romania's "*environment, people and economic activities from climate change, especially from extreme events*", while emphasising the mainstreaming of climate policies and actions into smart, green, and inclusive growth strategies (Ministry of Environment, 2016, p. 2). According to the documents, the focus in planning policies and education should therefore be laid on strengthening the adaptation and resilience capacity to combat the impacts related to climate change and increase the public awareness (SNDDR, 2018)

However, the adaptation focus is strongly driven by a focus towards combatting climate hazards, with priorities being laid on reducing the impact of climate change on agriculture in particular, on rural development, water and on infrastructure (Ministry of Environment, 2016; SNDDR, 2018; SNSvS, 2022; SPAASC, 2022).

The overall the analysis shows that CCA action in the region is strongly oriented along the following categories:

- **Anticipatory/reactive CCA approach:** when natural disasters, risks, or stressful CC events occur that threaten ecosystems and society, relevant measures are taken to address these to combat climate induced risks and natural hazards (e.g. flood protection, local/regional measures to address forest fires, landslides, droughts etc.).

- **Preservative CCA approach:** ecosystem preservation is already present in some approaches, addressing challenges of changing flora and fauna that is threatening local livelihoods, regional practices, cultural and natural capital (e.g. protective measures in touristic areas).

- **Incremental CCA approach:** overall, smaller adaptation approaches are already put in place in regions affected by climate change risks (e.g. water management, agricultural practices, waste disposal regulations).

4.3.4. Emphasized approaches

The analysis of the interviews and the documents reveals the following interrelated and most relevant four adaptation approaches for the region.

Efficient CCA governance and coherent responses (policies) to infrastructure provision: The National Climate-Change and Low Carbon Green Growth Strategy (Ministry of Environment, 2016) underscores the necessity of providing farmers with enhanced information on land management and water use to mitigate excessive costs during extreme events and to foster the adoption of innovative solutions (Ministry of Environment, 2016, p. 8). National programs, such as the National Plan for Recovery and Resilience, include measures for efficient water management, reforestation, and the expansion of green spaces in urban areas (RI3). Authorities emphasise water management solutions, especially in regions like Centru, where public water systems are insufficient during summer, necessitating municipal measures to reduce household consumption (RI3). Additionally, rural areas benefit from a national strategic plan supported by the EU Common Agricultural Policy, which provides funds for primary agriculture, rural economy diversification, direct payments, and infrastructure transformation such as roads (RI3). In general "*climate change and the environment are priorities in the regional development plan and they are transforming it […] but the regional*

program doesn't have a specific target to climate change or adaptation - but they do have specific measures under the policy objectives to a greener Europe, they have a regional priority in this programme and will support together with energy efficiency […] which could be measures to adaptation" highlights one interviewee, pointing towards the need of better coordination amongst existing measures (RI3). Also, there is an emphasises on the importance of providing farmers with better information on land management and water use. This approach aims to prevent excessive costs during extreme events and promotes the adoption of more efficient, innovative, intrinsically justified solutions (Ministry of Environment, 2016, p. 8).

Resilience building in local economies and support of local livelihoods: Better information on land management and water use is critical to helping farmers avoid excessive costs during extreme events while promoting innovative solutions (Ministry of Environment, 2016). Emphasis should be placed also on training programs for local government officials and other stakeholders to integrate climate data and services into policies and regulations. Providing farmers with sustainable technical solutions to enhance the economic efficiency of agricultural activities, alongside consultancy and support for exploiting ecosystem services such as carbon certificates, is essential. Additionally, assistance for certifying and promoting mountain products through agrotourism is vital (RI4). Necessary steps towards halting deforestation to support mountain farmers are more efficient agricultural land management and improved knowledge of agriculture's link with climate change (RI4). Future success of initiatives depends on better organization and education of small farmers to prevent the abandonment of mountain areas (RI5). One interviewee note that "*new technology, if you use this kind of solution your work is easier, so farmers are open to that, some already use drones to monitor the herd and they use it and are open. […] especially in this area the agriculture is a real business connected with ecotourism and others […] farmers there are not people "in the mountains" but bosses and they are completely interested in having different solutions to decrease the cost, to decrease damage, to have more money with a small investment – this region is recognized with this entrepreneurial spirit*" (RI2). Developing new agricultural varieties to withstand climate changes should be made a priority, as it is progressing more slowly, than the rate of climate change. In building local capacities and more knowledge, better connecting climate information with nature-based solutions (NbS) through discussions with influential local groups, better more effective local solutions can be targeted, though it is also necessary to find new ways to overcome the lack of time in municipalities for such engagement (RI2).

Mutual problem awareness, trust building and comprehensive local strategies: This includes local awareness raising towards measures such as the use of climate-friendly materials, incorporating shading and water features, but also and improving trust and engagement of the private sector in CCA efforts. Emphasis should be placed on solutions for individual water management and measures to reduce household water consumption (RI3). It was highlighted that due to engagement in European projects "*in the last 8-10 years, the County Council has been actively involved in environmental issues, [like] selective waste collection, waste treatment stations, closing landfills and building compliant warehouses, banning the use of plastic, promoting and financing activities/projects that respect the principles of sustainable development*", resulting in best practice exchanges and good practice guides (RI4). This demonstrates an increasing awareness but it also needs better communication to the public to overcome institutional scepticism towards new measures. It was pointed out that "*everyone will need to do it, from public to the private sector to all the citizens, as soon as the citizens are informed and they know the product it is affecting also the producer, that means that these systems are working and it is almost impossible to leave somebody out in such general objective for everyone*", highlighting holistic approaches (RI5). Overall, an enhanced public awareness (e.g. by facilitating the exchange of adaptive agricultural practices) is seen as a critical step for building resilience against climate change impacts.

Outreach and stakeholder collaboration: Research institutions, universities, and private actors, often in collaboration with NGOs, play a critical role in sustainable development and environmental activities in Sibiu. Still, conflicts of interest arise, especially in mountainous areas, not aligning with e.g. traditional village aesthetics or local views (RI4). Collaboration between the county and local stakeholders, including local municipalities, private

companies, and NGOs, is crucial for integrating climate change adaptation locally, also supporting direct investments. As understanding of CCA grows, actors such as Local Action Groups (funded by the EU LEADER program) need to be identified and can serve as facilitators to support regional collaboration and joint projects (RI2). These groups are more active than other initiatives and already receive priority funding from the government. Further, also local communities, such as the Sado River community, are important multipliers and exemplify advanced climate adaptation practices by focusing on resilient agricultural practices and crop acclimatization (RI1). Enhanced collaboration among diverse stakeholders, including farmers' associations, the agricultural directorate, research institutes, mountain area development agencies, and universities, is essential for effective regional CCA measures across multiple sectors and should thus be stronger targeted in the region (RI2).

Table 13. Current CCA approaches in Râu Sadului

Efficient CCA governance and coherent responses (policies) to infrastructure provision	Coordinated water, road, energy governance (e.g. in emergency situations), and increased coherence between the different administrative levels and various stakeholders (farmers, tourism, industry, etc.).
Resilience building in local economies and support of local livelihoods	Maintenance of ecologically, environmentally friendly farming, forestry and tourism while improving economic viability and supporting new technological solutions, with efforts to support local actors in CCA implementation (training and capacity building).
Mutual problem awareness, trust building and comprehensive local strategies	Development of new forms of cooperation, subsidies, awareness-raising campaigns, and changes in behaviour, increasing public awareness through information campaigns and advisory services (particularly for farmers) to drive meaningful action on climate change in the region.
Outreach and stakeholder collaboration	Improved collaboration frameworks, particularly between different actors and sectors, to address complex issues (more) effectively.

4.3.5. Important stakeholder groups

The documents and interviews emphasise the importance of active citizen participation and the involvement of both public and private sector stakeholders in climate change adaptation efforts. Key organizations and stakeholder groups include:

Government: Key public entities for CCA are the Ministry of Environment, Waters and Forests, the County Council Sibiu, several government authorities (for example, central and local public authorities like the Forestry Department and several Regional Councils), the Inter-Community Development Association ECO SIBIU, the Agricultural Directorate, the National Agency of the Mountain Zone, and the National Agency for Natural Protected Areas.

Academy: Key stakeholders that were mentioned in research are the University of Sibiu and the Research and Development Institute for Mountainology in Cristian – Sibiu.

Industry: Influential business actors are the producer/farmer associations, as well as business and professional associations, and water companies.

Community: Relevant NGOs are, among others, the Văcăre ti Nature Park Association, but there are as well several environmental institutions, civic initiatives, Local Action Groups ("GAL"), and Environmental Guards.

Other: The County Tourism Association, Environmental Protection Agency, and several international and regional initiatives such as the Covent of Mayors on Climate and Energy were mentioned as relevant.

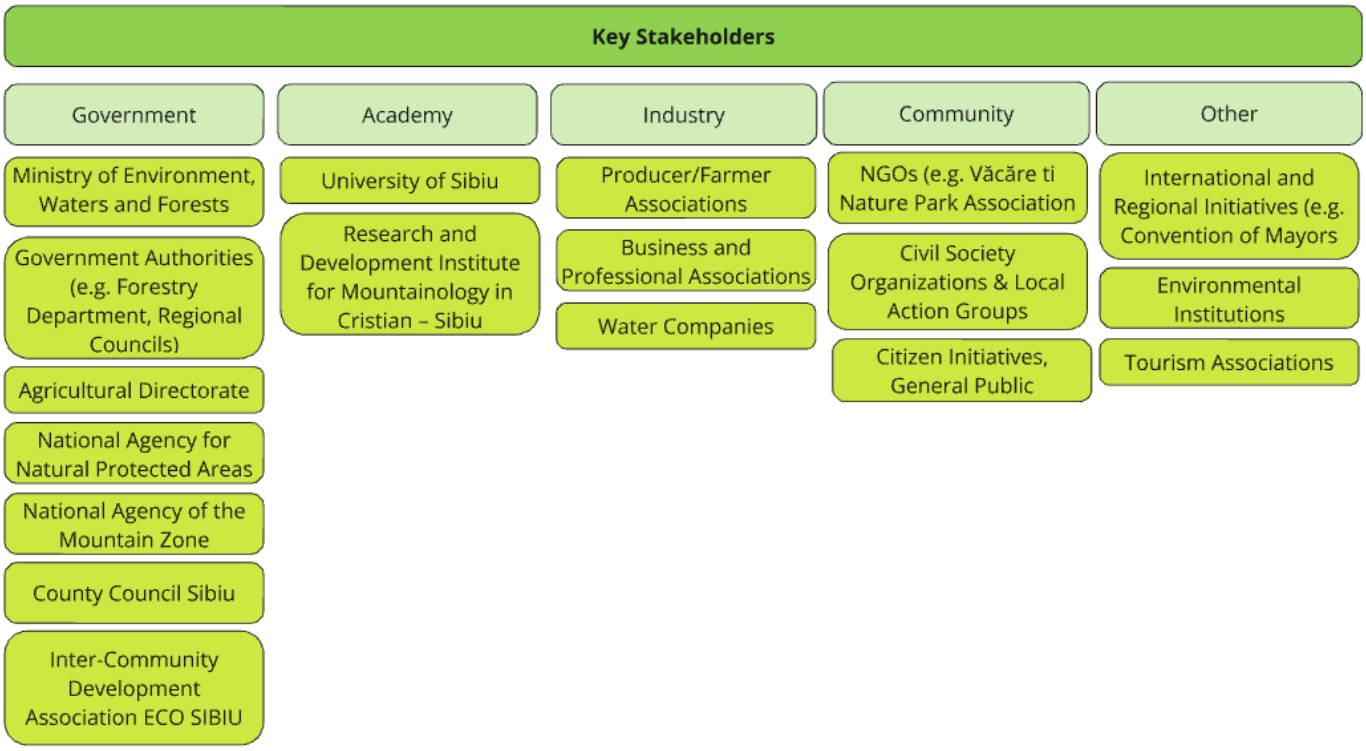

Figure 24. Key stakeholders in CCA in Râu Sadului (TU Wien, 2024)

4.3.6. Assessment

Climate change adaptation governance and infrastructure management face significant challenges. The national government's top-down approach to planning and budgeting often leads to inefficiencies, as regional actions frequently contradict broader spatial and CCA plans. Interviews reveal that regional conflicts among stakeholders, such as farmers and the tourism industry, further complicate adaptation efforts. Differing interests between actors exacerbate the conflicts between administrative levels and local communities, particularly regarding road usage and infrastructure vulnerability. An ineffective governance increases the susceptibility of infrastructure to climate impacts like high temperatures, floods, and strong winds. Poor road quality, for instance, is highlighted as a critical issue, with asphalt degradation and debris blockage during extreme weather events being commonplace. Additionally, water shortages due to drought and inadequate infrastructure pose substantial challenges. The need for better integration of ecosystem services and green infrastructure into regional strategies is evident, as current plans inadequately address these crucial elements. Also, agriculture in the Municipality of Sibiu is increasingly vulnerable to extreme weather, impacting crop quality and quantity. Livestock and crops struggle to adapt to rapid climate changes, necessitating comprehensive risk management strategies. Forests face similar threats, with high temperatures and droughts, alongside aggressive pests, shifting the boundaries between forests and pastures and increasing the risk of natural fires and windfalls. As an important tourism region, the tourism sector is also at risk, with rising temperatures shortening the winter sports season and increasing pressures on water and energy resources. Overall, limited awareness and acceptance of CCA measures hinders the implementation of alternative CCA solutions. Traditional

views favour conventional methods, and there is a significant gap in public education on climate adaptation. Collaboration among stakeholders is considered weak in the Râu Sadului region, with competition between institutions and a lack of coordination hampering effective local strategies. Despite these challenges, there are efforts to improve governance and infrastructure resilience through better land management information, water use strategies, and integration of climate data into policies. Training programs and innovative solutions, such as nature-based approaches, are emphasised. Enhancing public awareness and stakeholder collaboration is crucial for building a comprehensive local CCA strategy. Finally, effective engagement of research institutions, private actors, and NGOs is essential for fostering sustainable development and resilience in the region.

4.4. Key adaptation actions

This chapter introduces good practices that have already demonstrated how CCA can be approached in the region. These actions are not representing the full scale of approaches in the region but give a relevant overview of the priorities given to adaptation while pointing out different innovative solutions to address the specific challenges and risks that were induced by climate change.

Platform RO-Adapt: Romania's Climate Change Adaptation Platform, “RO-ADAPT”, is an innovative tool underpinning national climate change policies and strategy. The tool serves national policies and strategy development, as well the sectoral approaches to climate change adaptation and action planning. The platform supplies a virtual working environment with access to: a database updated in real time with climate and non-climate data, accessible through standardized services; an interactive map, with an intuitive bilingual interface (in Romanian and in English), allowing the exploration of the data sets published on the platform; and a geoportal with advanced GIS functionalities for data analysis and visualization. Also, a collection of studies on the categories of products and services, specific to the different sectors (e.g. climate indicators for water, forestry, biodiversity and ecosystem-services, health, education, cultural heritage, agriculture, energy, transport or industry) is provided to improve ecosystem services and select and prioritize adaptation measures (c. f. roadapt.ro, 2024).

CARMINE: Climate-Resilient Development Pathways in Metropolitan Regions of Europe (incl. Sibiu and Brascov): The EU Horizon project “CARMINE” carries out its approach in eight Case Study Areas, in which the project established Living Labs and analysed climate risks and socio-economic vulnerabilities, to co-develop sectoral Digital Twin use cases and co-design decision-support tools to propose climate-resilient development pathways (e.g. nature-based solutions). The Case Study Areas are located in eight countries, focusing on diverse socio-economic profiles, types of communities, vulnerabilities, climate impacts drivers and geographical distribution across Europe. The project proposes instruments such as living labs, digital twins, stakeholder community hubs, atlas of climate resilience, or impact-based decision supporting services. It aims cooperate closely with local to regional communities (stakeholders and users), decision-, and policymakers (local authorities) to co-develop cross-sectoral frameworks for adaptation and mitigation actions (c. f. carmine-project, 2024)

Green Path to Sustainable Development: The general objective of the programme is obtaining a reduced human and ecosystem vulnerability to climate change, aiming to share and promote best practices on adaptation. The entire programme is implemented by APM Sibiu in partnership with the Norwegian Association of Local and Regional Authorities (KS), the National Administration of Meteorology, Sibiu City Hall, Brasov City Hall, Targu Mures City Hall and Lucian Blaga University of Sibiu. Main activities involved in this project are: adapting the headquarters of the Environment Protection Agency in Sibiu to climate change, studies on energy efficiency and climate change adaptation, underground laying of cables to cover the electricity and communication needs, using weather stations to allow accurate measurement and monitoring of the meteorological parameters, developing strategies and action plans on climate change in the vulnerable sectors as well as training and communication activities (c. f. caleaverde.ro, 2024.

Hiking Years: The project, funded by the EU under the Erasmus+ program, is a pilot program, featuring a system of integrated measures for the entire county, aimed at promoting responsible, sustainable, active tourism, through hiking, horseback riding, cycling, etc. It engages with rural communities with tangible and intangible heritage, the gastronomy, traditional products, local producers and short chains, customs, traditions, landscapes, etc. It also provides education for the protection of natural heritage, biodiversity, forests and meadows, the environment, including for integrated waste management and promotion for healthy lifestyles. The project is directed at tourists, residents, children and young people, aiming for Sibiu County to become a certified Green Destination by 2030 (c.f. hike-project, 2024 and visitsibiucounty, 2024).

4.4.1. Learnings

The key-adaptation actions in the region demonstrate experiences and competences in the field of knowledge exchange, data management, network activities, training and communication activities, nature-based solutions as well as community resilience building. Thereby, reflecting on the regional challenges, it becomes evident that major challenges to CCA governance and implementation are already targeted and thereby enhance regional transformative capacities.

4.5. Transformative pathways

The overview of regional structure, systemic climate risks and existing CCA governance, coupled with knowledge on the planned DA, allow a final assessment of the most relevant barriers and opportunities for transformative CCA in the region, as well as pointing to the key transformative capacities that need to be utilized or developed further. To this end, a validation workshop was held in the region to discuss barriers, opportunities and key transformative capacities with knowledgeable actors. This chapter elaborates on these aspects and concludes by providing concrete advice for transformative CCA in conjunction with the fields of action of the respective DA and beyond to facilitate transformative regional CCA.

4.5.1. Barriers and windows of opportunity for CCA

National strategies already emphasise the need for enhanced information on land management and water use, to reduce excessive costs during extreme weather events and promote innovative solutions. Furthermore, efficient CCA governance and coherent policy responses in infrastructure provision are essential for local resilience. Programs, such as the National Plan for Recovery and Resilience (PNRR, 2021), support efficient water management, forestation, and the expansion of urban green spaces to address water loss and declining green spaces due to urban development. Authorities in regions like Centru focus on water management solutions to address insufficient public water systems, while rural areas benefit more from the EU Common Agricultural Policy, which provides funds for agricultural and infrastructure development. Despite these efforts, better coordination among existing measures is needed to integrate climate change and adaptation more effectively into regional development plans. Also, resilience building in local economies and support for local livelihoods require improved information on land management and water use to help farmers avoid excessive costs during extreme events. Training programs for local government officials and stakeholders are necessary to integrate climate data into policies and regulations. Sustainable technical solutions and consultancy services for farmers, along with support for exploiting ecosystem services and promoting agrotourism, are crucial. Better organisation and education of small farmers are needed to prevent the abandonment of mountain areas. Developing new agricultural varieties to withstand climate changes should be prioritised, while also better connecting climate information with nature-based solutions (NbS) through local discussions can enhance local adaptation efforts. Furthermore, mutual problem awareness, trust-building, and comprehensive local strategies involve raising awareness of climate-friendly measures and improving engagement with the private sector. Emphasizing individual water management and reducing household water consumption are key measures improving regional CCA. The County Council's involvement in environmental initiatives demonstrates growing awareness, but better communication is needed to overcome public scepticism. Holistic approaches that engage all sectors and

facilitate the exchange of adaptive practices are essential for building climate resilience. Also, outreach and stakeholder collaboration are critical for sustainable development. Collaboration between county authorities, local municipalities, private companies, and NGOs is necessary for integrating CCA locally and supporting direct investments. Local Action Groups, funded by the EU LEADER program, can facilitate regional collaboration and joint projects. Enhanced collaboration among diverse stakeholders, including farmers' associations, research institutes, and development agencies, is essential for effective regional CCA measures and should be more strongly targeted.

4.5.2. Regional validation workshop

The regional validation workshop aimed at presenting, critically discussing, and further developing initial hypotheses and interim findings on transformative adaptation with knowledgeable regional actors. The workshop hence consisted of two parts: In a first session, regional CCA measures, challenges and opportunities deriving from the previous analysis were presented and subsequently debated in smaller groups as well as in the plenum. In the second session, regional transformative capacities that were identified as relevant by the research team were introduced and put up for discussion. This gave participants the opportunity to share feedback, give concrete examples stemming from their own experience or bring in new ideas for effective CCA governance.

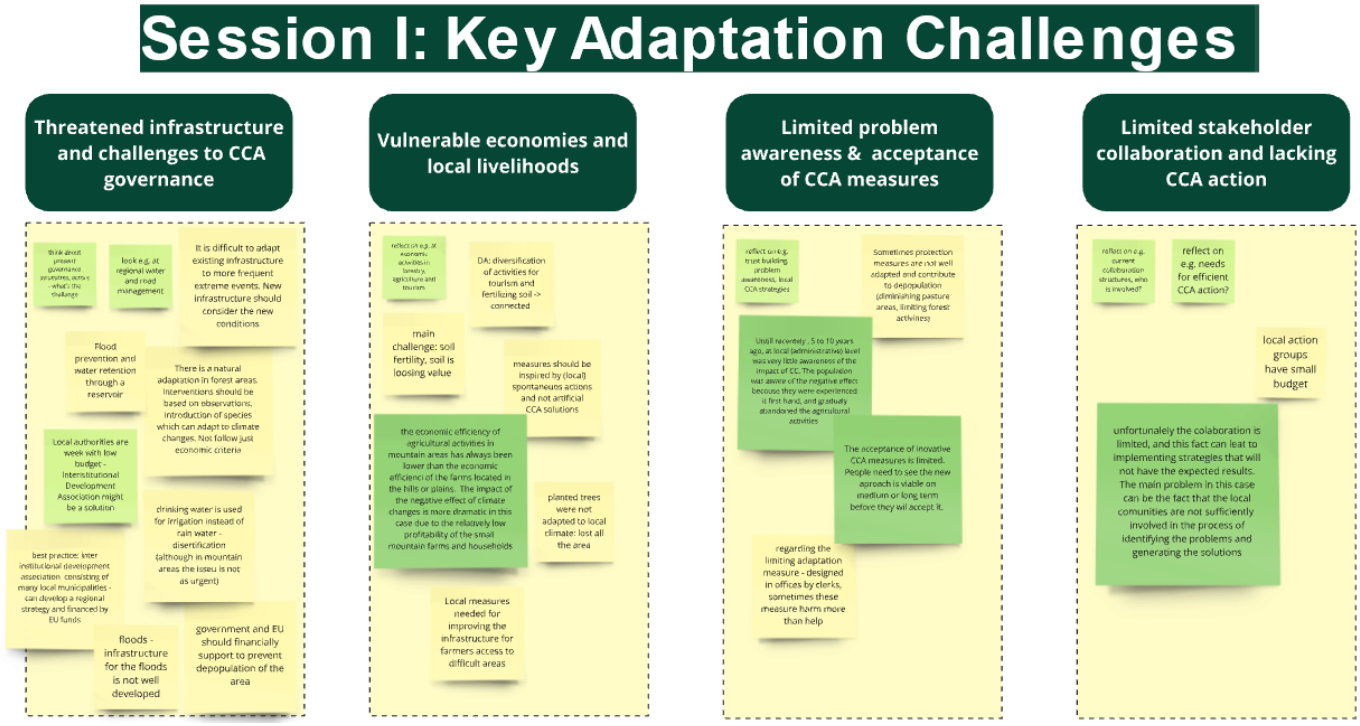

Figure 25. Accompanying Miro Board from VDWS in Râu Sadului

Main topics discussed centred around infrastructure provision and governance, funding aspects and the involvement of local actors to better reflect local realities. It was stressed out that "*some EU regulations have negative impacts on local communities or the opposite effect of what was expected*" (RVDWS), for example leading to issues such as a growing bear population in the region. These factors should be taken better into account, together with the need for provision of accessible funding mechanisms, as "*implementing innovative solutions and technologies for CCA can be expensive and the small farmers do not have the budget for this*" (RVDWS). Also, the participants discussed the need to increase local and regional awareness and reduce resentments against CCA measures. It was emphasised, that a better dissemination of research results, active cooperations between regional, private and civic

actors is needed to support local acceptance and CCA implementation. Overall, addressing issues of inclusive governance, community empowerment, mutual understanding and awareness building as well as enhanced outreach and collaboration, the discussions then evolved along the proposed transformative capacities, introduced in the following chapter.

The workshop was conducted in an online format on June 25, 2024, from 09:00 to 11:00 (EEST) with an audience of 16 participants. The online tool Miro was used to facilitate visualization of discussion points.

4.5.3. Regional transformative capacities

Overcoming a focus on mere adaptation responses towards more long-term transformative change, the concept of transformative regional capacities offers a perspective on the wider interplay, forming a more systemic perspective. The last step of the regional CCA analysis aimed at the identification of regional strengths and transformative capacities by assessing regional/local implementation barriers and existing regional capacities. Building on the analysis results and workshop responses (conducted in June 2024), transformative regional capacities were determined. The framework proposed by Wolfram's (2016) of ten adaptive capacities addresses organisational visions, work culture, structures, skills, human and material resources, but also community participation, relations, networks and institutions, and the understanding of existing systems. For the regional climate change analysis, the most relevant transformative capacities were identified, based on the barriers and windows of opportunity for CCA, to guide adaptation action, particularly with regards to the regional Demo Activities (DAs). Based on our findings, successful CCA approaches should reflect the following transformative capacities: *Inclusive Governance; Community Empowerment; Mutual Understanding / Problem awareness; Outreach and Collaboration*. These reflect actual regional potentials while mirroring present regional needs for improvement for CCA action (for the full list of TCs, see Annex).

Table 14. Transformative capacities for effective CCA in Râu Sadului

Inclusive Governance	There are already various regional actors involved in CCA measures. However, there is a need for a **comprehensive, multi-stakeholder approach to infrastructure governance and CCA** in the region (e.g. broader stakeholder involvement, more bottom-up initiatives and coordination between different roles/responsibilities). With many regional actors involved in CCA measures, the participants in the RVDWS pointed out the need to sufficiently involve local farmers, as the main stakeholders, into local governance actions. This would also support the better reflection on local challenges and realities for implementation. Furthermore, limits in access to relevant information and in (personal/financial) capacities need to be better addressed to overcome the lacking CCA support (e.g. increase participation in workshops and in CCA activities).
Community Empowerment	**The region has strong local communities and a diversity of economic activities**. Still, there is a necessity to find new solutions for maintaining traditional small-scale farming and adapting to climate change. In addition, it is necessary to find viable economic solutions to support the rural population and preserve the region's environmental and cultural heritage (e.g. capacity building, training on Nature-based-, technological solutions etc).

	The RVDWS participants stressed out the need to better target the depopulation of mountainous areas by more actively pursuing community empowerment. Also, in order to overcome essential funding shortages for local CCA measures, access to funding instruments for innovative CCA solutions and technologies should be ensured for to support local action.
Mutual Understanding / Problem Awareness	**There is a growing problem awareness when it comes to climate hazards in the region**. However, stronger balance of interests of different sectors/ actors/communities and development a mutual problem awareness together with active trust building measures should be targeted (e.g. local action plans, shared visions, public involvement in activities; advisory services etc.). With regional actors actively involved in CCA research and environmental protection, still, the RVDWS participants emphasised the need for better dissemination of research results to the general public to raise problem awareness. Especially local opinions should be taken stronger into account, to ensure a balance of interests and support acceptance of new solutions.
Outreach and Collaboration	**There are already positive regional collaborations on CCA in the region**. Still, more efforts should be put into establishing networks that work efficiently across agency levels (cross-sectoral) and have wider outreach to different CCA target groups and the general public to support trust building and engagement in CCA activities. In the RVDWS participants stressed out that a better and balanced collaboration of Local Action Groups, Local Councils and professional associations is needed, also taking into account private stakeholders. Furthermore, the stronger involvement of research and educational institutions could enhance local CCA decision making.

4.5.4. Concrete advice for the DA and beyond

Identifying systemic climate risks, challenges but also transformative capacities, takeaways and major issues that should be put under further consideration for the implementation of the DAs and for successful regional CCA are seen in the following needs.

Provide inclusive governance structures and secure essential CCA funding instruments. Effective CCA in rural and mountainous areas requires inclusive, context-sensitive governance that actively involves local actors (e.g. farmers) and addresses the specific problems of local inhabitants. The impact of some EU regulations on local communities needs reassessment to ensure that measures meet intended goals without adverse effects. A more inclusive governance structure further helps to empower local communities and secure commitment with protective and adaptive measures. It is also imperative to also secure access to critical information and target budgetary constraints faced by regional authorities and local actors. Government and EU intervention could help to actively support the technological and financial needs of small farmers, as they often lack resources to implement innovative CCA solutions and struggle with financial limitations.

Improve knowledge exchange and local problem awareness. Active, and audience centred dissemination of research results helps to overcome CCA knowledge gaps and raise problem awareness of the general public. This helps to enhance local innovations (e.g. regarding nature-based solutions), but also the overall implementation and solution acceptance of CCA measures. Also, central authorities need to show greater interest in CCA measures. An

improved knowledge exchange between academic, public, private and civic actors helps to raise local and regional awareness based on research institutes' findings and local realities. Furthermore, nature protection policies need to better balance local interests and protective measures to secure acceptance and ensure commitment of local population. Intensifying knowledge exchange at local levels and providing space for dialogue can empower local communities to manage their resources more effectively.

Target active outreach and CCA collaboration. Local councils and professional associations should have the ability to influence local regulations, with frameworks like Local Action Groups (LAGs) promoting collaboration despite their limited budgets. Research and educational institutions must be involved in local decision-making processes regarding CCA policies, and private stakeholders should be encouraged to collaborate more effectively with municipalities and meadow owners. Enhancing these partnerships can drive more coordinated and impactful climate adaptation efforts at the local level.

Further suggestions

Given the identified regional challenges but also transformative potentials, the region needs to find stronger context-sensitive governance measures for CCA implementation. Thereby, the establishment of **new network building and collaboration supporting platforms or formats** are indispensable. They need to bring together the various interests and actors in the region involved in CCA research, governance and implementation to support knowledge building, personal exchange and local acceptance and thereby helot to enhance local action. Furthermore, given the challenges identified in the systemic risk analysis for the agricultural sector, leading to potential lower agricultural yields and dangers to livestock, loss of biodiversity, but also depopulation and the abandonment of agricultural land, the need for active **knowledge and financial support for local innovation-oriented activities** (e.g nature-based solutions) is essential for developing new solutions to pending challenges and develop best practices to learn from.

5. Baseline – Tyrol

5.1. Regional profile

Regional structures, political competencies and development objectives profoundly influence the potential pathways for regional CCA. This chapter introduces the topographic, functional, environmental, and socio-economic characteristics that shape the region structurally, briefly introduces the territorial governance framework to illustrate the region's formal competencies for implementing CCA autonomously and outlines the dominant self-image to sketch the normative starting point for regional CCA.

Since the late 19th century, the mean temperature in Austria has increased by 2°C, which is above the global average of 1.15°C (Bundesministerium für Klimaschutz, Umwelt, Energie, Mobilität, Innovation und Technologie (BMK), 2024a). Due to its geographical location in the Alps, Tyrol is particularly vulnerable to the effects of climate change. The consequences that are already observed and that are predicted to intensify depending on the mitigation scenario, include, among others, the retreat of glaciers, a (substantial) increase in the frequency of hot days, a lengthening of the vegetation period, and a reduction in frost days (Chimani et al., 2016).

5.1.1. Structural characteristics

Overview to topographic and functional characteristics

Tyrol is one of the nine federal states of Austria, situated in the western part of the country, bordering Germany, Italy and Switzerland. It is constituted of two parts, North and East Tyrol, spatially separated by the federal state of Salzburg and South Tyrol in Italy. Tyrol is administratively divided into nine political districts and a total of 277 municipalities. Its provincial capital and largest city in terms of population is Innsbruck (Tirol Werbung, 2024). With a total area of 12,648km^2 it is the third largest federal state of Austria, well known for its alpine landscape with high peaks, deep valleys and numerous glaciers. Almost two thirds of Tyrol's area consist of forests (37%) and mountain landscapes (27%), followed by unproductive (25%) and arable land (11%). Only one-eighth of the total area (12,4%) is designated for permanent settlement. Tyrol is home to the country's two highest mountains, Großglockner (3,798m) and Wildspitze (3,768m), and its second largest glacier, Gepatschferner, covering an area of 17.6km^2. The Inn River, which flows through Tyrol for 212.5km, is Tyrol's longest river (ibid. 2024). Its central location makes Tyrol an important transit region between Austria and Italy. The Brenner Pass, an ancient trade route, is one of the most important Alpine transit routes, especially for freight transport (Rathkolb, 2016).

Overview of ecosystem and environmental characteristics

Tyrol is characterised by a great diversity of species and habitats. The ecological richness of the province is reflected in its 81 protected areas, which account for more than a quarter of the Tyrolean territory. These protected areas are home to rare animals and plant species and serve as nature reserves and as recreational areas for the population. The best-known of these protected areas is the national park Hohe Tauern, which covers a total of approximately 1,800km^2 across Tyrol, Carinthia and Salzburg. Of these, 611km^2 are located in East Tyrol (Amt der Tiroler Landesregierung, n.d.). The climate in northern and central Tyrol is mainly influenced by the Atlantic whereas the southern part is more influenced by the Mediterranean Sea with the main Alpine divide as a clear climatic borderline (Steiger & Stötter, 2013).

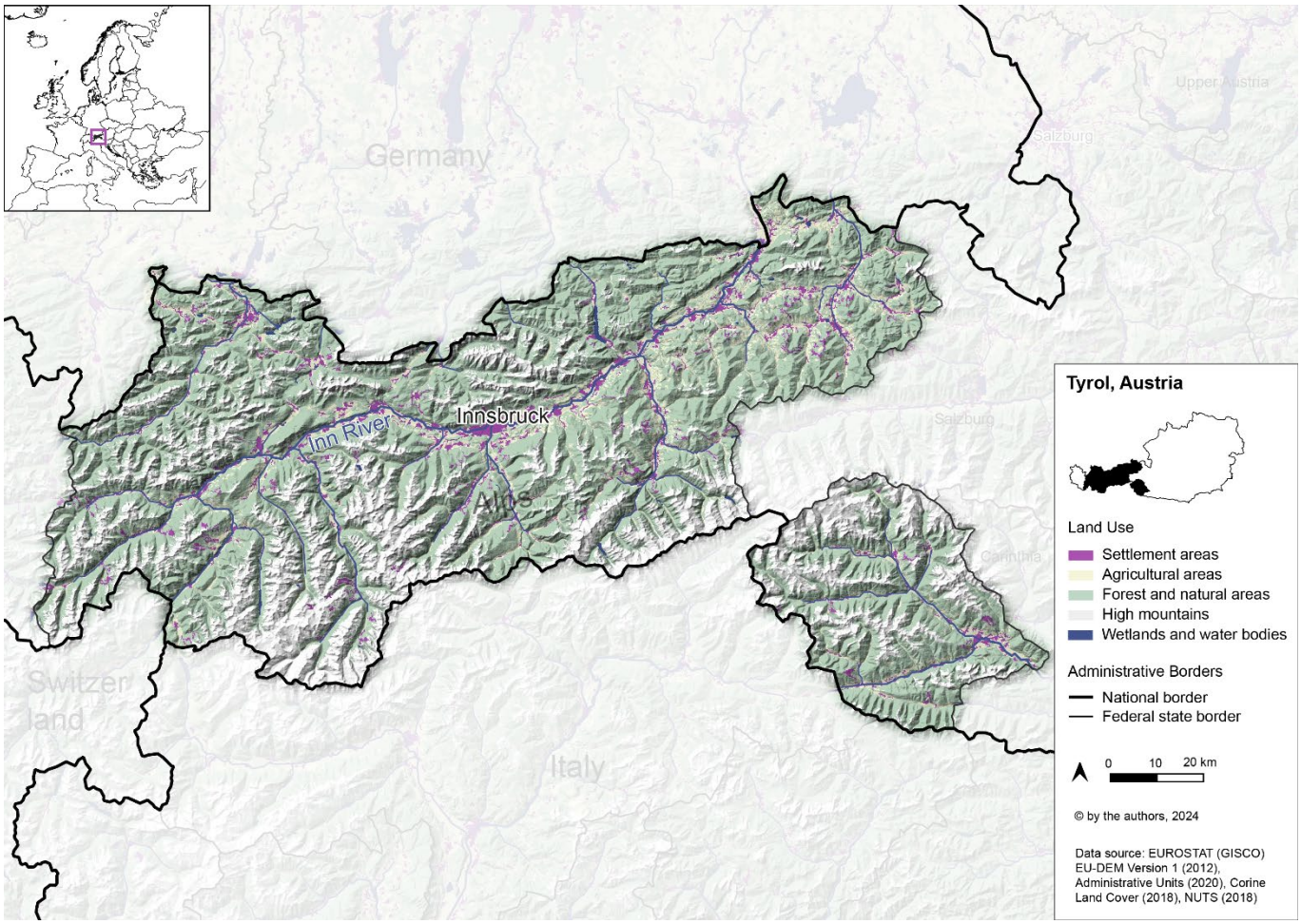

Figure 26. Map of Tyrol (TU Wien, 2024)

Description and key indicators for socio-economic profile

The population of Tyrol amounts to 764,102 inhabitants in 2022 (Eurostat, 2022) with a total population change of +9.4 per year (crude rate of total population change per 1,000 inhabitants) (Eurostat, 2022) and a relatively low population density of 61.4 persons per km² (Eurostat, 2022) comparably to the project region Valais with a population density of 68.4 persons per km2, which shares comparable geographical characteristics. The median age of Tyrol's population was estimated to 43.1 years in 2022 (Eurostat, 2022). Of those aged 15-64, the overall employment rate was estimated 77.8% (male: 82.5%; female: 73.1%) which is close to the EU-average (Eurostat, 2022). The risk of poverty or social exclusion was estimated to be 19.2% (Eurostat, 2022). The regional Purchasing Power Standard (PPS) numbers € 45,600 PPS per inhabitant (Eurostat, 2022), making it the second highest PPS in comparison with the other project regions, just behind Valais. Around 37% of Tyrol's gross regional product (GRP) is concentrated in Innsbruck and its immediate surroundings (Amt der Tiroler Landesregierung, 2023, p. 10).

Tyrol's economy is strongly based on the industrial and the tourism sector: The highest gross values in the year 2020 were generated by manufacturing (€ 4.77 billion); trade, maintenance and repair of motor vehicles (€ 2.58 billion) and accommodation and catering (€ 2.29 billion). The importance of the service sector and subsequently of tourism becomes evident when looking at the employees of Tyrol: 63% of employees work in the service sector, whereas only 37% work in the manufacturing sector. (Amt der Tiroler Landesregierung, 2023, p. 6ff).

Tourism is an important source of income for the whole region, especially winter tourism, accounting for almost half of annual stays. Considering the whole year, 32% of all overnight stays of Austria were booked in Tyrol (Statistik Austria, 2024). The economic dependency on tourism generally increases with increasing distance from the economic centres, meaning that in remote areas tourism is often the main, if not the only source, of income (Steiger & Stötter, 2013).

Table 15. Socio-economic data for Tyrol, compared to EU average (Source: Eurostat, 2022)

	Population density *(per km$^{2)}$*	**Median age** *(in years)*	**Population change** *(in % from 2021 to 2022)*	**PPS per capita** *(in €)*	**Employment rate** *(in %)*	**Risk of poverty** *(in %)*
Tyrol (2022)	61.4	43.1	+9.4	45,600	77.8	19.2
EU-average (2022)	109.1	44.5	+4.0	35,400	74.4	21.6

5.1.2. Governance framework

In Austria, legislation and enforcement competencies are shared among the national government and the federal states. As one of the nine federal states, Tyrol can therefore enact and enforce laws within its areas of responsibility, which include, among others, building law and housing subsidies, spatial planning, nature and landscape protection, and tourism (Parlament Österreich, n.d.).

Currently, there is no binding legal framework for climate change mitigation and adaptation in Austria, as the "Austrian Climate Change Act", which set out emission ceilings for different sectors and defined corresponding mitigation measures, has not been updated for the years after 20208/27/2024 2:21:00 PM.

5.1.3. Identity and self-image

"*Seen from above, Tyrol resembles a sea of mountain peaks. They spread out in all shapes and facets, some rugged and rocky, others snow-covered or gentle and wooded right to the top. With their versatility, they give Tirol a striking face and at the same time make the country a radiant whole*." (Tirol Werbung, n.d.-b, translation by the authors)

Tyrol's diverse alpine landscape and image of unspoilt nature is central to the region's identity and self-image, as well as for tourism, as emphasised in the interviews: "i*n Tyrol everything revolves around the mountains. The economy is based on them, the people are characterized by them*" (TI7, translation by the authors). Tourism is referred to be the main livelihood for the region (TI2). Although the regional population is described as inward-oriented, tourism is perceived to be strongly outward-oriented (TI1a; TI6).

In general, the economy plays a central role for Tyrol's self-image, positioning itself as a major "*business location*" and a "*region with high innovative strength*" (Amt der Tiroler Landesregierung, 2021, p. 12, translation by the authors). In this context, the climate crisis is seen as an opportunity to "*strengthen Tyrol as a place to live and to do business in the long-term*" and to "*develop it into the most sustainable and climate-friendly tourism region in the Alps*" (ibid. 2021, p. 46, translation by the authors).

5.2. Systemic climate risks

The most important factors determining the directionality and design of CCA are concrete regional climate hazards and consequent systemic risks. This chapter overviews the main climate risks and relevant climate impact chains, pointing to the challenges for regional adaptation.

5.2.1. Main climate hazards and intermediate impacts

Temperature increase

Since 1900, the temperature in the European Alps has risen by up to 2°C, particularly in high elevations, which is roughly three times higher than the global average. In the Austrian Alps, average temperature change predictions are 0.8–1.2°C (low/high emission scenarios) in the 2030s, 1.6–2.6°C in the 2050s, and 2.8–4.2°C in the 2080s (Steiger & Stötter, 2013). This warming causes a shift in the zero-degree line and the snow line, along with changes in the timing and duration of seasons, collectively affecting the distribution of adapted plant and animal species in mountain ecosystems (Hock et al., 2022). Albedo lowering (i.e. the reduction of bright surfaces reflecting the sunlight) has led to a decrease in snow depth and a significant increase in the melting of snow and ice. There is an expected reduction of 20-40% in seasonal snow amount and an increase in sunshine duration throughout the year (Schneider, 2014).

Changes in species distribution are also occurring as temperatures rise, prompting some species to move to higher altitudes to find cooler climates. This migration leads to changes in the composition of plant and animal communities at different altitude levels within the Alps. Alpine plant species, adapted to cold and harsh conditions, face threats from changing temperatures and precipitation patterns, which may lead to their decline or disappearance from the Alps. Additionally, the warming climate increases the risk of invasive species, as non-native animals and plants that were once restricted to lower latitudes can now thrive in the Alps, outcompeting native species and reducing biodiversity.

Mountain animals, such as hares, mountain goats, and ibex, are also at risk due to changes in temperature and snow cover, which can affect the availability of food and habitat. These changes can also impact migration and hibernation times, with cascading effects on ecosystems. Freshwater ecosystems, crucial for many species' survival in the Alps, are also affected by rising water temperatures, which reduce oxygen levels available to fish and other aquatic organisms. Changes in snowmelt patterns alter the timing and amount of water available to these ecosystems (Corradini et al., n.d.; Kotlarski et al., 2023).

Forests, especially those with a high population of spruce — a common tree used for economic purposes — are highly affected by heat and tend to become more vulnerable to storm damage or destruction and to the bark beetle. This vulnerability may cause cascading effects, as many forests have a protective value (Corradini et al., n.d.).

These changes are not solely due to rising temperatures but also include alterations in precipitation patterns, global radiation, humidity, and extremes in temperature and precipitation. Such shifts are expected to result in drastic reductions in snow cover, particularly below 1500–2000 meters, melting of glaciers and permafrost, and an increase in the frequency of natural hazards like floods, droughts, debris flows, landslides, and rockfalls (Oedl-Wieser, 2017).

Precipitation

By the end of the 21st century, climate change under the high emission scenario A1B is projected to significantly impact the Austrian Alps, with winter precipitation increasing by 10% and summer precipitation decreasing by over 20% compared to 1970–2000 levels. This shift will lead to more intense and irregular rainfall, increased rain-on-snow events, and a higher frequency of rapid snowmelt, exacerbating the risks of floods and landslides. Rising

temperatures, causing the snowline to ascend by approximately 150 meters per degree Celsius, will diminish snow cover that is crucial for winter sports tourism. Consequently, the increased reliance on artificial snowmaking, which demands substantial water and electricity, will further strain water resources and potentially ignite conflicts over water and energy use (Fuchs et al., 2022; Kotlarski et al., 2023; Schneider, 2014).

Melting of glaciers and permafrost

Between 65% and 95% of the European glaciers will be lost by the end of the 21. century. Most of Austria's glaciers are below 3200m, which is the category experiencing the main ice loss until 2050. Some glaciers have already lost 85% of their volume since the 1960s (Oedl-Wieser, 2017). The retreat of glaciers and permafrost is causing an increase in natural processes like rock falls, landslides, icefalls, and mudslides, which pose a danger to people and infrastructure. Protective measures and securing infrastructure in areas like settlements, traffic routes, and ski slopes are becoming more costly. Those who venture outside secured areas face an increased safety risk.

In the case of permafrost, predicting natural hazards is more complex as it is not directly visible. Thawing of permafrost causes the terrain to sink, making slopes and ridges unstable, which can lead to more frequent rockfalls and rockslides. The increase in loose rock also increases the sediment load in streams and rivers, which can trigger mudslides during heavy rainfall. Additionally, glacier melt can exacerbate flooding, especially during summer thunderstorms when precipitation quickly reaches the runoff.

Climate change has significant effects on tourism, especially in Alpine regions. The retreat of glaciers poses challenges for glacier ski resorts, with shrinking glaciers narrowing or interrupting existing ski slopes. The maintenance of ski operations requires ongoing technical adaptation to protect the infrastructure on the glaciers. The reduction of snowfall in winters has led to an increase in demand for glacier ski areas and high-altitude resorts. The tourism industry in valleys dependent on glaciers is threatened, while the attractiveness of alpine glaciers for tourism is diminished. Other activities like hiking and mountain biking, as well as associated infrastructure such as climbing routes and mountain huts, are negatively impacted by glacier retreat. Additionally, the navigability of alpine rivers with kayaks and rafts is affected by low water levels during summer (Stangl et al., 2022).

Extreme weather events

As a result of precipitation and temperature changes, as well as changing wind, and humidity, extreme weather events will accumulate and intensify, resulting in increasing danger to life but also to infrastructure, businesses, systems, transport infrastructure and buildings. Floods, debris flows, avalanches etc. can lead to enormous costs for reconstruction and damage (TransAlp, 2022).

Urban heat islands

Urban heat islands refer to the phenomenon where the city is warmer on average over the year and at night than the surrounding area. Periods of heat lead to an impairment of human health and rising mortality. Vulnerable population groups, especially children, elderly and people with pre-existing health conditions are particularly affected. Negative effects also directly correlate with insecurities in the housing sector and the distribution of resources and access to blue and green infrastructure. Indirect effects on health result from the increase in indigenous and new disease vectors (mosquitoes, bugs, ticks) and new plants with high allergenicity such as ragweed (Hohenwallner-Ries et al., 2020).

5.2.2. Climate Impact Chains

We developed two Climate Impact Chains. Given that extreme weather events and winter tourism are directly interrelated and primarily rural in nature, they were addressed separately from the heat aspect, which is predominantly urban and building focused. While these aspects are not entirely separable and must be considered together, separating them into two distinct graphics enhances comprehension and facilitates a better understanding of the risks involved.

For tourism, the relevant climate hazards and, therefore, the focus in this systemic risk assessment are the increase in temperature, the change in precipitation patterns, extreme weather events such as storms, and natural hazards/disasters. The latter present direct risks, endangering people and buildings with potentially severe consequences for the region. The increase in rain-on-snow events and the thawing of permafrost and glaciers consequently lead to more natural hazards of gravitational and hydrological processes, such as floods, rockfalls, landslides, and debris flows, further endangering people and structures and leading to immense financial and emotional loss. This risk is exacerbated by inadequate hazard zone planning and planning mistakes made in the past (Corradini et al., n.d.; Kotlarski et al., 2023; TI9).

The changes in precipitation patterns, coupled with rising temperatures, result in an upward shift of the snow and zero-degree lines and earlier snowmelt. This, in turn, increases water and electricity demand for snowmaking, as the tourism sector in Tyrol heavily relies on skiing and winter sports. Ski resorts at lower altitudes will particularly struggle with snow reliability, threatening their viability.

Heat waves, increased solar radiation, rising temperatures, decreased precipitation and seasonal shifts will create more urban heat islands, significantly affecting the population and infrastructure. In Innsbruck and the Inn Valley (Inntal), the frequency of hot days exceeding 30 degrees and nights above 20 degrees will increase, leading to severe health consequences due to heat stress. Urban infrastructures and electricity as well as water demand will rise and potentially lead to high (maintenance) costs. Vulnerable populations living or working in dense inner-city areas lacking green and blue infrastructure and living in poorly insulated housing will be particularly affected (Gau, 2024; Hohenwallner-Ries et al., 2020).

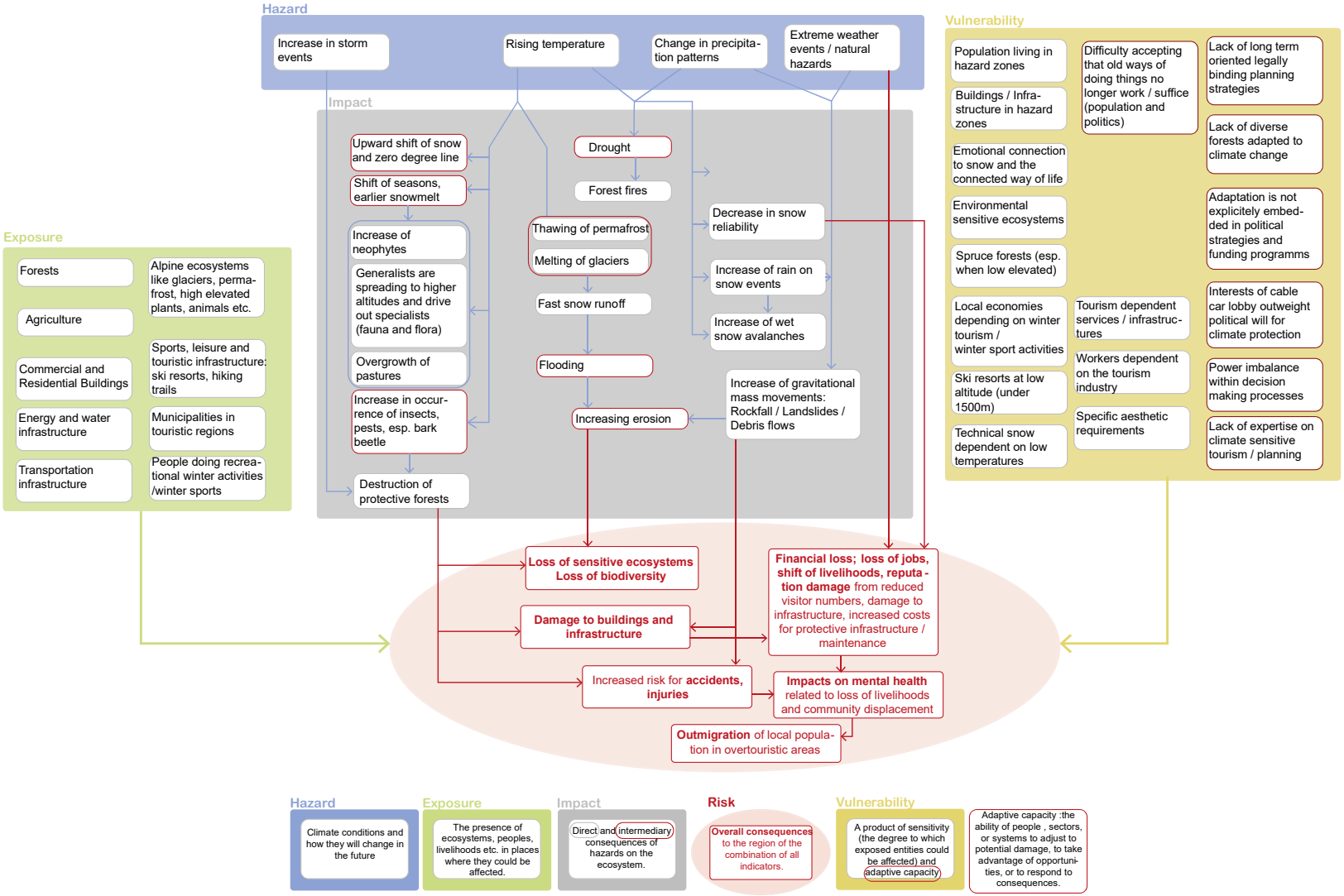

Figure 27. Tyrol IC for tourism (ZSI, 2024) | *cf. chapter 11.2 for IC methodology*

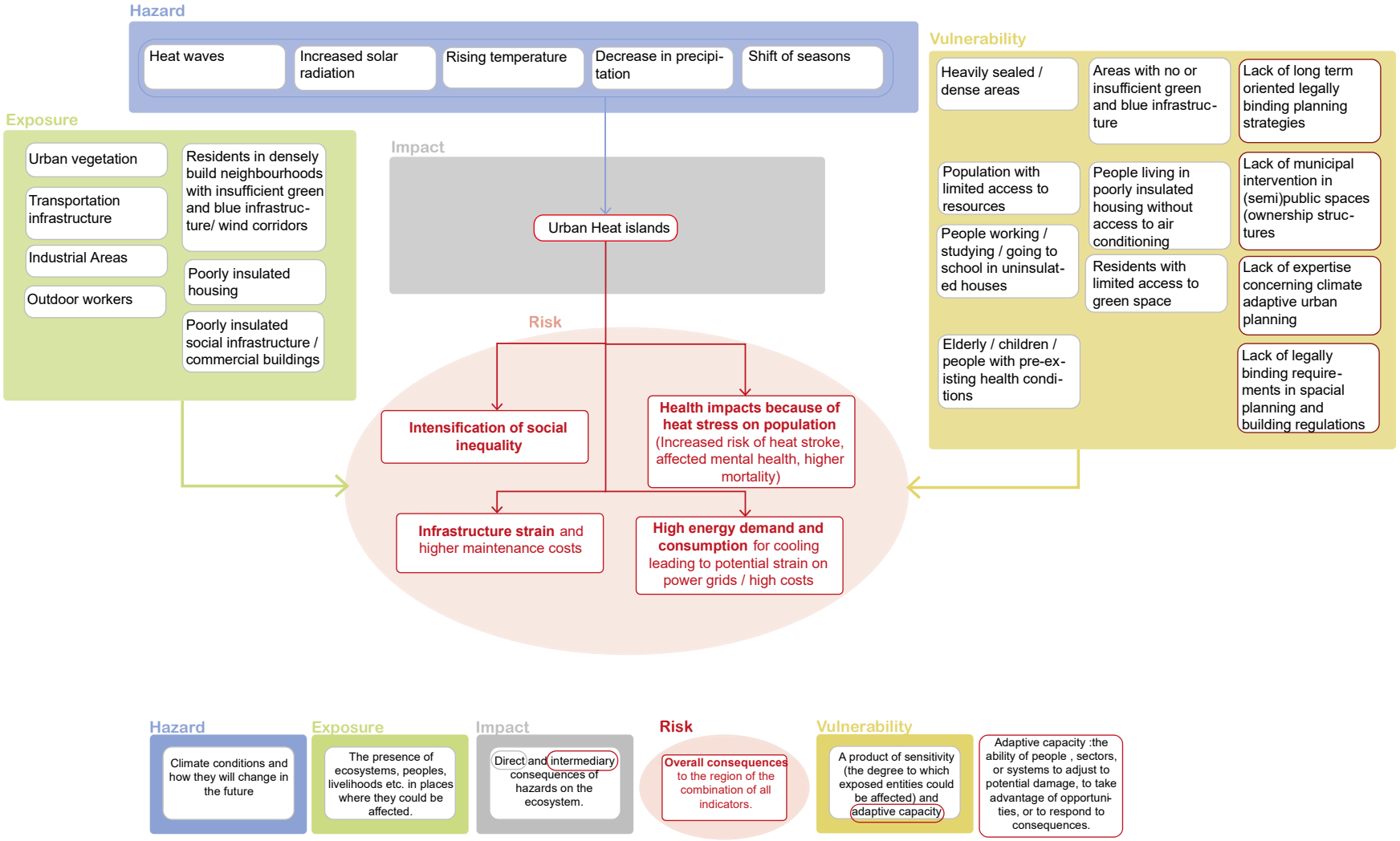

Figure 28. Tyrol IC for heat (ZSI, 2024) | *cf. chapter 11.2 for IC methodology*

5.3. Regional CCA governance

CCA activities should be well-embedded in the strategic objectives of a region and strike a balance between stakeholder inclusion and leadership. Accordingly, understanding the strategy framework and stakeholder landscape of regional CCA governance is important. This chapter identifies key regional CCA-related strategies, how CC and its consequences are problematized therein and how certain adaptation challenges are prioritized. It highlights the prevailing understanding of CCA and the emphasized approaches for tackling it, as well as the most important regional stakeholder groups, which is important for the design and implementation of concrete adaptation activities.

5.3.1. Strategy framework

Austria issued its first **"Strategy for Adaptation to Climate Change"** in 2012, which was updated in 2017 and 2024. The newest version serves as the current strategic framework for climate change adaptation, in line with international and strategic frameworks such as the Paris Agreement (2015), the United Nations Agenda 2030 (2015), the European Strategy for Adaptation to Climate Change (2013[2021]) and the EUs Green Deal (2019) but is legally not binding. It is comprised of two documents, the first one providing the context of climate change adaptation and introducing its strategic considerations and the action plan including recommendations for action for different sectors (BMK, 2024a, 2024b).

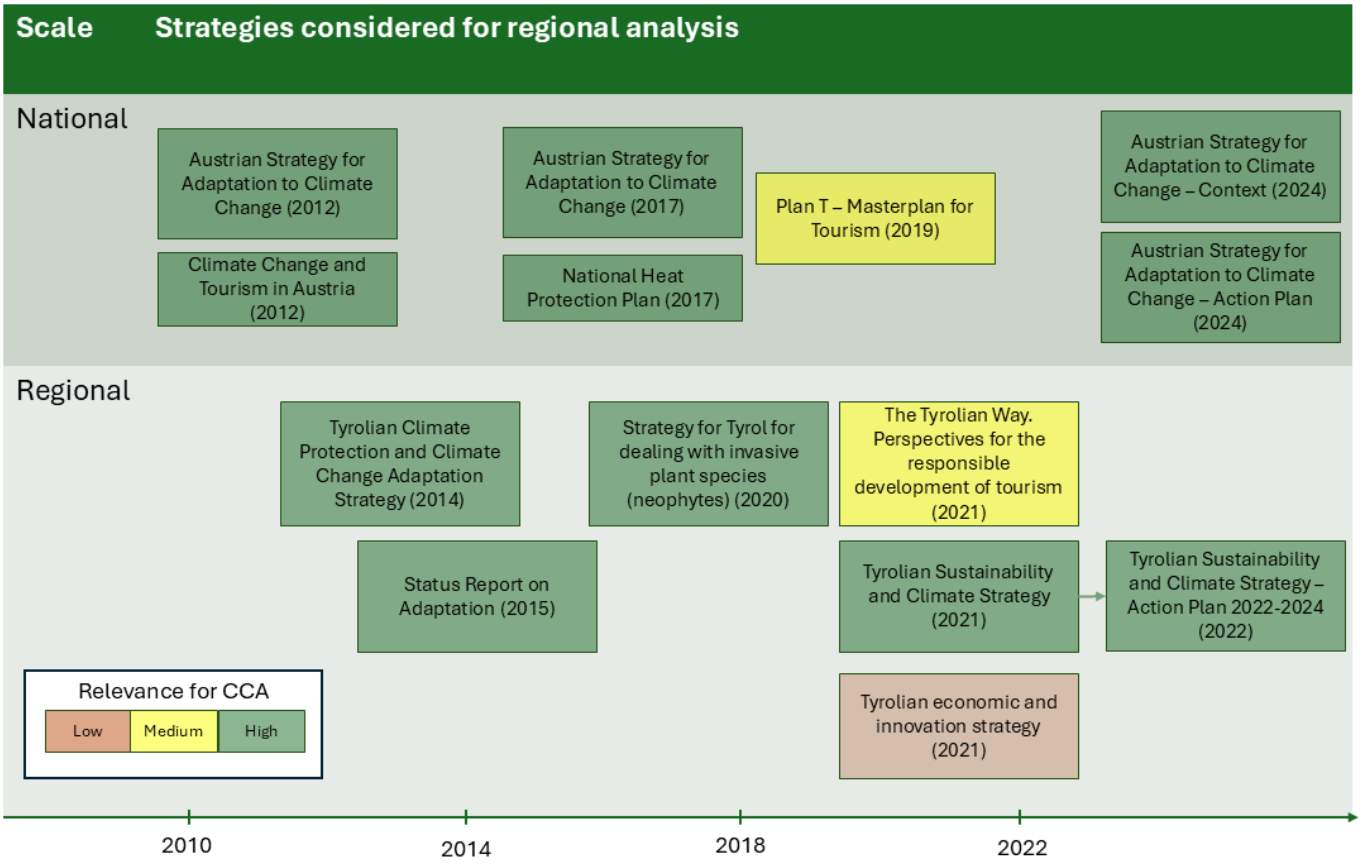

Figure 29. Overview of CCA-relevant strategies for Tyrol (TU Wien, 2024)

In response to the national impetus of the first climate change adaptation strategy, Tyrol published its first "Climate Protection and Climate Change Adaptation Strategy" in 2014, bringing these two topics together for the first time. Its main objective was to enhance awareness of the multifaceted nature of climate change adaptation and to underscore the conceptual distinction between climate protection and climate change adaptation (TI1b). The follow-up **"Sustainability and Climate Strategy",** adopted by the Tyrolian government in 2021, is no longer specifically

dedicated to climate change adaptation, but instead approaches sustainable development, climate change mitigation and adaptation as interlinked. It is accompanied by an action plan for a three-year period, breaking the strategic objectives down into implementation measures. The current action plan, focusing on the years 2022-2024, was adopted by the provincial government in 2022 (Amt der Tiroler Landesregierung, 2021, 2022).

The attempt to integrate sustainability, climate protection and adaptation efforts into a single document has resulted in a loss in depth and quality (TI1b). The current strategic framework is described as an "*absolute minimum*" (TI3) and as "*negligent*" (TI1b) as it is not based on a prior vulnerability analysis: "*Adaptation to climate change is not mandatory in Tyrol. It's so rudimentary that you can't really call it adaptation*" (TI4, translation by the authors). However, the "Sustainability and Climate Strategy" provides guidance and funding opportunities for regional adaptation actions (ibid.).

Additionally, the nine KLAR! Regions (cf. chapter 5.4) have been or are currently developing regional adaptation concepts (TVDWS). Also, the city of Innsbruck has developed a local adaptation strategy (2020).

5.3.2. Problem background and prioritized challenges

The key challenges addressed in Tyrol throughout the regional strategic documents are strongly focused on the economic damage due to climate change on the one hand, and the economic potential of adaptation measures on the other hand. In the expert interviews and the VDWS, however, social and cultural challenges of climate change adaptation were also raised.

Table 16. Main CCA challenges for Tyrol

Climate change as a threat to nature and the Alpine identity	Tyrol's self-image and identity is strongly based on its mountainous landscapes. These are increasingly endangered by the effects of climate change, such as increasing natural disasters, the thawing of permafrost and glaciers: "*People feel the glacier retreat, it moves people, they identify with it, it's part of the Alpine identity*" (TI5, translation by the authors).
Economic damage & vulnerable local economies	Tyrol is facing increasing damage and adaptation costs due to climate change. These economic impacts of climate change are an important aspect of regional climate change adaptation (Amt der Tiroler Landesregierung, 2021; TI6; TI8). As the regional "*cash cow*" (TI2), winter tourism is particularly economically vulnerable to climate change (Amt der Tiroler Landesregierung, 2021; TI8). As the risk assessment has shown, due to the upward shift of the snow and zero-degree lines and earlier snowmelt, ski resorts struggle with snow reliability and are confronted with increasing water and electricity demand for artificial snowmaking – especially at lower to medium altitudes up to 1.500m (TI6). It is therefore becoming increasingly expensive to uphold winter tourism in the face of changing climatic conditions. Additionally, tourism in Tyrol is much centred on the idea of unspoilt nature, which is increasingly threatened by the lack of snow: "*just a band of snow and green all around (…) that's not how Tyrol can be advertised*" (TI8, translation by the authors). Winter tourism contributes significantly to regional value creation and is an important

	source of employment for the population (TI6). Accordingly, the regional economic dependence on tourism was emphasized (TI2).
Lack of awareness	Natural hazards have always been an issue in Tyrol due to its alpine location. However, the frequency and intensity of floods, droughts, debris flows, landslides and rockfalls are increasing as an effect of climate change (Amt der Tiroler Landesregierung, 2021). The local population and government are thus used to adapting to traditional natural hazards, but there is a lack of awareness that "*the way we have always done it is no longer enough"* (TI1b, translation by the authors; TI7). Additionally, there is a lack of awareness and sensibilisation, not only among the local population but also among the local governments and economic actors, regarding other domains of adaptation, such as heat (TI3; TI4; TI7): "*People are not yet aware of heat as a concern for adaptation. They tend to say, 'it may be hot now, but we've had that in the past too'"* (TI7, translation by the authors)
Lack of commitment and ambitions	Regional political and touristic actors are aware of the need for climate change adaptation but lack commitment to action (TI1b; TI3; TI4). When implementing measures, a wide range of interests are involved, which are weighed up politically and "*in the end, the result may be something that takes adaptation into account, but perhaps to a much lesser extent than would have been necessary from a scientific point of view*" (TI4, translation by the authors). The agenda-setting of climate change adaptation is very sector specific. While it is a relatively uncontroversial topic in the fields of forestry, agriculture and nature conservation, it is subject to a wide range of interests in the context of tourism (TI1b). Also, among civil society and economic actors, the ambitions to proactively engage in climate change adaptation are said to remain relatively low (TI3).

5.3.3. Prevailing understanding

Climate change adaptation action in the region is strongly:

- **Reactive to climate induced risks:** personal affectedness of climate change effects is driving adaptation actions in Tyrol (TI2; TI4; TI6; TI7) (TVDWS): "*as long as it doesn't happen, people don't believe in it*" (TI8). Therefore, measures with an immediate effect, such as for shading or flood protection, are way easier to implement in comparison to mid- or long-term measures. This understanding makes it easier to implement adaptation actions as a direct response to an effect or problem (heat wave, flooding, rockfalls etc.) – "*Following a winter like this, it will not be difficult to find people in tourism who are willing to work on reducing the dependence on snow-based tourism."* (TI4, translation by the authors) – but bears the risk that solutions with a short-term effect are adopted instead of structural changes as in anticipatory approaches to adaptation (TI4).

- **Preservative towards regional economies:** winter tourism plays a major role for the regional economy and identity but is increasingly threatened by climate change, especially at lower altitudes. Measures are being taken to uphold the touristic offers and switching to renewable resources, e.g. for "*arrival and departure of tourists and on-site mobility*" (Amt der Tiroler Landesregierung, 2021, p. 55, translation by the authors) or for snow groomers and snowmaking equipment (TI2). Additionally, economic incentives are provided: "*the price of the annual ski pass is not increased in order to encourage more people to use the little snow that remains*"

(TI3, translation by the authors). At the same time, the expansion of all year-round and summer tourism is being promoted to compensate for the expected failure of winter tourism (TI2; TI3; TI4; TI8). The Tyrolian Alps are increasingly regarded as a popular destination for tourists seeking cooler climates in the future, as more southerly holiday destinations become uncomfortably hot in the summer months (TI8).

- **Incremental, especially with regard to adaptation in the building sector:** current adaptation measures are generally considered to be insufficient (TI3; TI4; TI7). With regard to heat, a major climate risk both for the population and urban infrastructure (cf. chapter 5.2), some measures are being implemented, but there is no fundamental change in building culture towards denser housing or unsealing of land (TI3; TI4; TI7): "Yet new land is being zoned for commercial and residential development, with little though given to densification for example (…) it is going in the right direction, but too slowly" (TI3, translation by the authors). In comparison to other adaptation domains, awareness remains relatively low in adapting the building sector to climate change (TI4).

5.3.4. Emphasized approaches

In Tyrol, the main approaches to climate change adaptation are governance, knowledge transfer and behavioural change. In contrast, nature-based solutions, physical/technological, and economic/financial approaches play a rather subordinate role in Tyrol.

Individual behavioural change: the prevailing political approach to climate change adaptation is to focus on the "*power of the market economy*" (TI3) as a means for achieving the desired outcomes, rather than on regulatory approaches (Amt der Tiroler Landesregierung, 2021). In that sense, politics shall provide the key framework conditions, but civil society is seen as the key agent of change (TI6). However, individual behavioural change is hindered for reasons of convenience: "*a paved driveway is much easier to maintain (..) and it only happens twice a year that the water does not seep away. Snow needs to be cleared much more often*" (TI3, translation by the authors).

Increased public awareness: raising public awareness and acceptance for adaptation requirements is seen as crucial for driving adaptation actions (Amt der Tiroler Landesregierung, 2021). This includes training and knowledge transfer to municipal authorities, as well as more general communication strategies as a means for raising awareness, such as:

- *The use of illustrative examples, e.g. poles that mark the water level during floods (TI1b)*
- *The emphasis of the individual, preferably economic, vulnerability to climate risks, for example "your cellar will also be flooded during heavy rainfall" (TI7, translation by the authors)*
- *The use of a hands-on approaches, e.g. combining information and action-based events (TI4)*
- *The stimulation of new narratives, e.g. turning away from large houses as status symbols towards 'I can afford to live in a small space" (TI3, translation by the authors)*

Local-specific but integrated adaptation governance: climate change adaptation measures should be coordinated across administrative levels and sectors and alongside climate change mitigation efforts to make use of synergy effects and reduce conflicting goals (Amt der Tiroler Landesregierung, 2021; TI3; TI4). However, it is considered especially important that adaptation efforts are implemented at the local or regional level, as the requirements might be very different, embedded in local conditions and supported by local key stakeholders (Amt der Tiroler Landesregierung, 2021; TI1; TI4; TI6; TI7). For successful adaptation, the focus should rather be placed on a few, very important measures than on "*a diverse bouquet of minor measures*" (TI6, translation by the authors).

Participatory approaches to tourism development: In the context of tourism development, there is a preference to approaches based on local participation (TI1b; TI2; TI6). In the past, tourism development has been very outward-oriented and has "*left the local population behind*" (TI6, translation by the authors).

5.3.5. Important stakeholder groups

Community: Following the political emphasis of individual behavioural change as an approach to climate change adaptation (cf. chapter 5.3.4), civil society is considered as the main agent of change.

Government: In the interviews, however, politics is recognized as having the power to drive adaptation action, but political decisionmakers are not making use of their capacity to act (TI1b; TI2; TI3; TI6): "*the politicians prefer to leave everything as it is*" (TI2, translation by the authors). The question is not a lack of awareness of the problem among high-level politicians – "*they know exactly what is at stake*" (TI1b, translation by the authors) – but rather a lack of foresight in terms of adaptation action in the face of many diverging interests (TI6) (cf. chapter 5.3.2). In this context, civil society should build up political pressure and demonstrate the support of the population (TI3; TI6).

As the consequences of climate change are particularly noticeable at the local level, the local level is regarded as the key actor in terms of climate change adaptation (Amt der Tiroler Landesregierung, 2021; TI1b; TI4; TI7; TI8). Local authorities are generally considered to be generally very open and committed to climate change adaptation but as lacking the financial resources to act: "*The municipalities are open to adaptation, but it shouldn't cost anything*" (TI7, translation by the authors). Interestingly, the municipalities have not been mentioned as key stakeholders in the regional stakeholder mapping in D.1.3.

Regional (CCA) management(s): Nine sub-regions in Tyrol are part of the national initiative "Climate Change Adaptation Model Regions for Austria – KLAR!". As part of this program, the participating regions are funded to raise awareness and implement concrete actions to adapt to climate change (cf. chapter 5.4). The major strengths of this approach are seen in the opportunity to set regional-specific adaptation priorities, according to the regional vulnerabilities, in contributing to knowledge transfer and skill development among the regional population and other regional stakeholders and to have a regional contact person in the form of dedicated "adaptation" managers, who can reveal central levers for climate change adaptation, e.g. when redesigning the central square: "*as managers we can point out that there are other ways of providing shade than putting up umbrellas afterwards*" (TI4). Repeatedly addressing climate change adaptation issues ultimately leads to these issues being automatically considered "*without me having to sit at the table*" (ibid.). However, the regional managers are very much dependent on the good-will of the regional stakeholders when it comes to implementing adaptation actions as they have "*no formal power nor financial resources for concrete actions*" (TI4).

Multipliers: In general, teaming up with economic actors and different interest groups (e.g. Chamber of Commerce, Chamber of Labour, Industrial Association, Chamber of Agriculture), as well as local associations and institutions is considered crucial for successful climate change adaptation. These actors can serve as important multipliers because of both, their standing and their networks (TI1a; TI4; TI5; TI6).

In regard to tourism, tourism associations are considered as important regional partners "*with a large sphere of influence*" (TI7; TI4). Stakeholders from the cable car industry, on the other hand, are described as difficult to reach: "*they have economic power that we cannot reach*" (ibid.). Additionally, the media is perceived as a key player in the discourse on tourism development (TI2; TI4; TI6).

Additionally, academic institutions have been identified as key stakeholders as part of the stakeholder mapping in D.1.3 but were not given a prominent role in the interviews or in the regional documents.

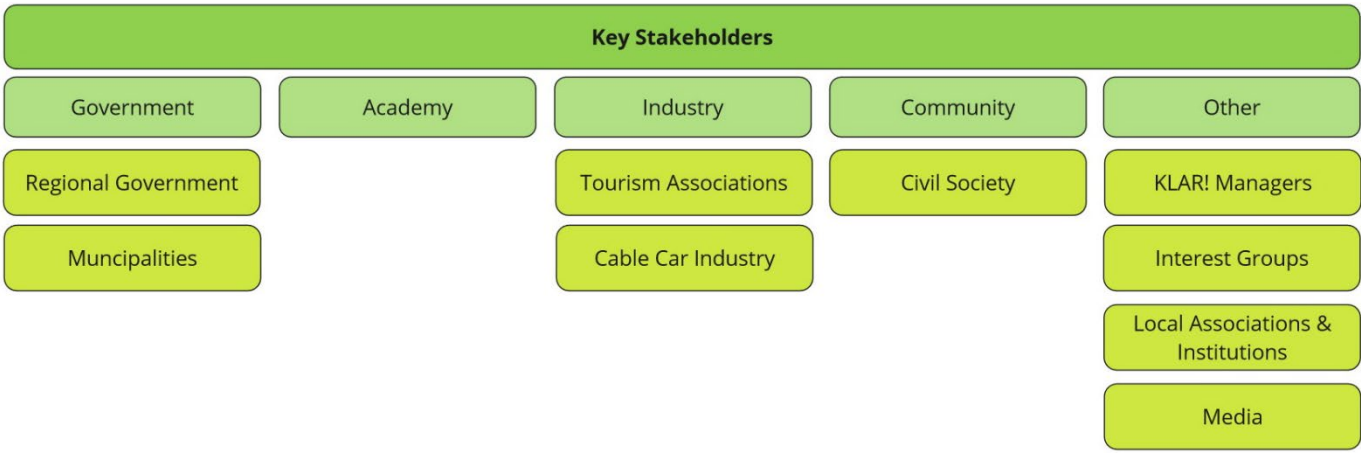

Figure 30. Key stakeholders in CCA in Tyrol (TU Wien, 2024)

5.3.6. Assessment

The national climate change adaptation strategy has served as a significant catalyst for agenda-setting of climate change adaptation in Tyrol. However, the current regional strategy only touches upon the topic of adaptation and does not provide extensive guidance for adaptation actions.

As observed in other project regions, climate change is regarded as a significant threat to regional economies, especially tourism, which are to be preserved through adaptation measures. This predominantly preservative and reactive approach is a major challenge for transformative and forward-looking adaptation. Regional managements, such as the KLAR! managers, play a crucial intermediary role for climate change adaptation in Tyrol, following a multi-level governance approach with the local level seen as a key driver. Major obstacles to adaptation action, however, are the lack of awareness and ambition. While tourism development is subject to many diverging interests and ambition to transformative change seems to be lacking, discussions on adapting to (urban) heat appear to be in an early stage. Consequently, climate change adaptation ambitions in Tyrol may be characterized as actor- and sector-specific.

5.4. Key adaptation actions

This chapter introduces good practices that have already demonstrated how CCA can be approached in the region. These actions are not representing the full scale of approaches in the region but give a relevant overview of the priorities given to adaptation while pointing out different innovative solutions to address the specific challenges and risks that were induced by climate change.

KLAR! - Climate Change Adaptation Model Regions for Austria: In 2016, the Austrian “Climate and Energyfonds” (“Klima und Energiefonds”) and the Federal Ministry for Climate Action, Environment, Energy, Mobility, Innovation and Technology initiated the funding program “KLAR!” to push climate change adaptation on a regional and a local level. Within this program, regions can apply for funding to first develop a regional adaptation concept including a minimum of 10 concrete measures, then implement these measures and finally, monitor the results and develop and implement further actions. In 2017, the first “KLAR!” region in Tyrol started to receive funding to push regional adaptation action. Since then, another 8 “KLAR!” regions have followed (Klima- und Energiefonds, n.d.). In this context, several projects have been carried out, many of which focused on raising awareness for climate change adaptation matters (TI4; TI6; TI7).

Regional Climate Council(s): From February to April 2023, climate councils developed regional recommendations for policymakers for the three Tyrolean regions (Wattens and Volders, Leutasch and Reith bei Seefeld and the "KLAR!" Region Kaunergrat). Around 20 randomly selected citizens from each region took part in a 3-day workshop, discussing pre-defined regional challenges and questions and presented them to political decision-makers and the public. The councils were initiated by the Tyrolean provincial government, coordinated by "Climate Alliance Tyrol" ("Klimaallianz") and carried out by independent process managers (Klocker, 2023), and are viewed as an „*innovative instrument to involve citizens into decision-making and allow them to shape them*" (TI6, authors' translation).

CLAR - Clean Alpine Region: "CLAR" supported tourism regions in Tyrol in adopting measures in climate protection, sustainability and energy in order to "*position Tyrol as the most climate-friendly region in the Alps*" (Standortagentur Tirol, n.d., translation by the authors). After a call for projects in the frame of an EU funding programme, four pilot regions were selected ("CLAR" Kaunergrat, Kufsteinerland, Pitztal and St. Johann) and supported with €150.000 each to strengthen their already existing initiatives and test new innovative technologies, supported by the "Business Promotion Agency" in Tyrol ("Standortagentur Tirol") and a regional "CLAR" Manager (Tirol Werbung, n.d.-a). The project was initiated by "Lebensraum Tirol Holding" and the provincial government and pathed the way for cooperation with tourism associations and organization of the "KLAR!"-Regions today (TI4).

TranStat – Transitions to Sustainable Ski Tourism in the Alps of Tomorrow: The Interreg project TranStat is developing transition pathways for mountain resorts in the face of the climate crisis. The project pursues a stakeholder-driven approach, involving not only politicians and economic actors, but also local residents. While the pilot areas are not located in Tyrol, the regional project partner "AlpS", is responsible for the involvement of stakeholders (Interreg Alpine Space, 2021)

CLIMA-MAP: Within the "CLIMA-MAP" framework, climate impact maps were developed with representatives of several Austrian municipalities to increase the awareness for climate change impacts and further integrate them into local decision-making processes. The project was carried out by "AlpS" in collaboration with several national research units from 2016 to 2018 (alpS GmbH, n.d.)

5.4.1. Learnings

The projects demonstrate Tyrol's experiences in building regional and local capacities for climate change adaptation. With the introduction of "KLAR!" Regions in Tyrol, intermediary actors have been introduced with the goal of raising awareness and building networks for CCA. These adaptation managers have now become key contact person regarding climate change adaptation on a local scale. Additionally, experiences have been made in engaging civil society in adaptation planning, using maps as a tool for awareness-raising and testing new ways of working together on tourism management.

5.5. Transformative pathways

The overview of regional structure, systemic climate risks and existing CCA governance, coupled with knowledge on the planned DA, allow a final assessment of the most relevant barriers and opportunities for transformative CCA in the region, as well as pointing to the key transformative capacities that need to be utilized or developed further. To this end, a validation workshop was held in the region to discuss barriers, opportunities and key transformative capacities with knowledgeable actors. This chapter elaborates on these aspects and concludes by providing concrete advice for transformative CCA in conjunction with the fields of action of the respective DA and beyond to facilitate transformative regional CCA.

5.5.1. Barriers and windows of opportunity for CCA

Following the strategic framework for CCA, Tyrol should "*make use of synergy effects and promote win-win approaches*" (Amt der Tiroler Landesregierung, 2021, p. 6, translation by the authors) when addressing climate

change in a broader sense. In this regard, climate change adaptation offers the opportunity for "*new impulses for the development of products and services*" (ibid., 2021, p. 46, translation by the authors) or "*develop and strengthen regional business cycles*" (ibid. 2021, p. 47, translation by the authors) in tourism. According to the interviewees, however, the provision of an effective strategic framework for CCA, the financing and the acceptance and ambitions regarding adaptation actions are major challenges:

- **Strategic framework*:*** adaptation, as a cross-sectoral issue, is embedded within different sectoral strategies (TI6) and is sometimes not explicitly labelled as adaptation: "*there are no subsidies explicitly designated for unsealing, but there is a subsidy within the urban water management programme going into this direction, but it does not directly relate to adaptation*" (TI4, translation by the authors). Additionally, adaptation requirements may be very different across different municipalities or regions, which is why the development of general indicators for adaptation funding is considered challenging (TI4).
- **Financing*:*** as far as the financing of adaptation measures is concerned, the pre-financing by the municipalities is considered challenging given the tight municipal budgets (TI8).
- **Acceptance and ambitions:** resistance to climate change mitigation and adaptation measures is growing among the population: "*The local population does not want this kind of paternalism*" (TI8, translation by the authors). Additionally, regional political and touristic actors lack ambition and commitment to transformative climate change adaptation (TI1b; TI3; TI4).

5.5.2. Regional validation workshop

The regional validation workshop aimed at presenting, critically discussing, and further developing initial hypotheses and interim findings on transformative adaptation with knowledgeable regional actors. The workshop hence consisted of two parts: In a first session, regional CCA measures, challenges and opportunities deriving from the previous analysis were presented and subsequently debated in smaller groups as well as in the plenum. In the second session, regional transformative capacities that were identified as relevant by the research team were introduced and put up for discussion. This gave participants the opportunity to share feedback, give concrete examples stemming from their own experience or bring in new ideas for effective CCA governance.

The key discussion points included the awareness of CCA requirements, a shared vision of CCA and the upscaling of transformative practices and projects. It was noted by the participants that a shared understanding and awareness of adaptation needs, followed by a vision that drives adaptation action, is a prerequisite for effective CCA action. However, this understanding and awareness was said to be currently lacking. In particular, the participants of the workshop identified a lack of "*systemic thinking*" (TVDWS). It was emphasised that politicians at the state and federal level must take on a leading role here: "*politicians and interest groups must lead the way*" (TVWDS). The participants pointed out that CCA in Tyrol predominantly takes place on a voluntary basis, with the exception of traditional natural risk management as for flooding, or in direct response to already felt climate impacts. At the local level, funding was said to be a significant barrier to the implementation of adaptation measures. With regard to tourism, the participants emphasised that although there had been great progress towards sustainability in recent years, fundamental changes have not been made. The discussion on tourism development in Tyrol is regarded as particularly sensitive. However, the participants agreed that a "*paradigm shift*" (TVDWS) is required, which could be started informally by the MountResilience project.

The workshop was conducted in an online format on June 20, 2024, from 08:30 to 10:30 (EEST) with an audience of 16 participants. The online tool Miro was used to facilitate visualization of discussion points.

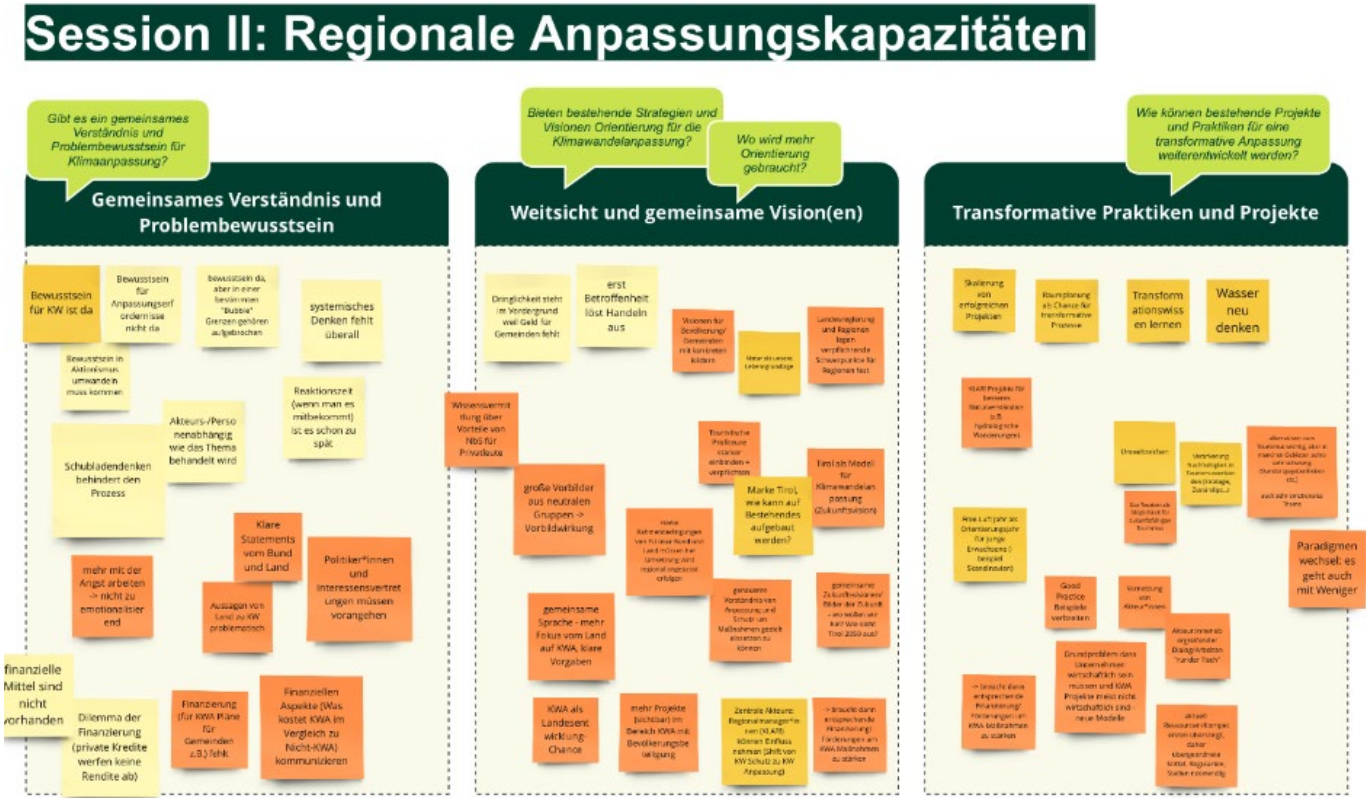

Figure 31. Accompanying Miro Board from VDWS in Tyrol

5.5.3. Regional transformative capacities

Overcoming a focus on mere adaptation responses towards more long-term transformative change, the concept of transformative regional capacities offers a perspective on the wider interplay, forming a more systemic perspective. The last step of the regional CCA analysis aimed at the identification of regional strengths and transformative capacities by assessing regional/local implementation barriers and existing regional capacities. Building on the analysis results and workshop responses (conducted in June 2024), transformative regional capacities were determined. The framework proposed by Wolfram's (2016) of ten adaptive capacities addresses organisational visions, work culture, structures, skills, human and material resources, but also community participation, relations, networks and institutions, and the understanding of existing systems. For the regional climate change analysis, the most relevant transformative capacities were identified to guide adaptation action, particularly with regards to the regional Demo Activities (DAs).

Table 17. Transformative capacities for effective CCA in Tyrol

System awareness & memory	High-level political actors are aware of the necessity of adaptation, but there is a lack of ambitions adaptation policies and action. Ambitions to adapt to climate change are described as sector- and person-specific and as lacking systemic thinking (TVDWS). A clear political commitment is called for, especially among the federal and state governments: "*Politicians and interest groups must take the lead"* (ibid.). Politicians, however, are relying on the local level and civil society to become active through

	awareness-raising measures. Awareness of traditional natural climate hazards as rockfall or flooding is high, but is lagging in other adaptation domains, such as heat. Here, having a regional contact person to push for adaptation action as well as knowledge transfer and skill development among local actors, like the "KLAR!"-managers, is a major capacity that should be expanded.
Foresight	The "Sustainability and Climate Strategy" serves as the regional informal strategic framework for climate change adaptation. However, climate change adaptation is only discussed superficially. The approach to adaptation remains predominantly reactive; adaptation measures are primarily driven by concern and thus hinder future-oriented structural change. In this respect, a clear and effectively communicated vision of climate change adaptation for Tyrol is needed, in order to be able to drive adaptation action on a local and regional scale. Forward-looking adaptation should thereby be seen as an opportunity to pro-actively shape transformation processes and to position Tyrol as a model region for foresighted adaptation (TVDWS).
Practical Implementation	Tyrol is experienced with implementing innovative projects and practices, but there is no fundamental structural change. The main barrier to practical implementation is seen in the financing of adaptation actions (TVDWS). To increase Tyrol's capacity in this regard, financial resources should be provided to the communities for more low-threshold experimentation, scaling-up of successful adaptation actions should be encouraged and key actors should be connected (TVDWS).

5.5.4. Concrete advice for the DA and beyond

Initiate a holistic and inclusive discussion on alternative development paths: in the past, tourism development has tended to be rather outwards-oriented. A holistic and inclusive discussion of potential future development paths that go beyond the preservation of the status-quo and considers decreasing the economic dependence on tourism is needed and should be taken into account when participatorily developing transformation pathways for tourism. In this respect, the Demonstration Activity can help to initiate these discussions.

Increase awareness for adaptation requirements of building(s): the increase in heat waves, solar radiation, rising temperatures, decreasing precipitation and shifts in seasonality leads to urban heat islands, increasing the vulnerability of the local population and challenging the built infrastructure. However, both civil society and decision-makers are less aware of the need and suitable approaches for adapting to increased heat exposure. Simulating buildings' vulnerability to heat, as envisioned by the DA, may therefore serve as a tool to increase awareness. Other proven means of communication should also be considered. Additionally, more profound changes in building culture should be sought within Tyrol's formal competencies in spatial planning, such as the radical reduction of soil sealing, increased unsealing of land and expansion of green and blue infrastructure.

Strengthen the local level and regional strategic framework: municipalities have a key role to play in adapting to climate change in Tyrol. The provision of the necessary resources, both financially and in the form of expertise, should therefore be encouraged. It is further advised that adaptation actions are developed and implemented in close cooperation with local stakeholders who may act as multipliers and intermediaries. At the same time, a more comprehensive and potentially binding common strategic framework for adaptation to climate change needs to be established at the regional level to ensure a coherent and coordinated approach. As a very first step, a vulnerability analysis should be conducted.

Prioritise key adaptation measures: it is recommended that, both on a regional and on a local level, priority should be given to a few key adaptation measures, rather than a multitude of approaches. When further expanding the “Platform for Climate, Energy and Circularity”, this approach should be considered.

6. Baseline – Valais

6.1. Regional profile

Regional structures, political competencies and development objectives profoundly influence the potential pathways for regional CCA. This chapter introduces the topographic, functional, environmental, and socio-economic characteristics that shape the region structurally, briefly introduces the territorial governance framework to illustrate the region's formal competencies for implementing CCA autonomously and outlines the dominant self-image to sketch the normative starting point for regional CCA.

In Switzerland, the average temperature has increased by 2 degrees Celsius in the last 150 years and a very similar trend was observed in the Canton of Valais. Consequently, Valais is already confronted with more dry summers, more intense precipitation, more hot days and more winters with less snow. These trends are projected to continue in the next few decades (National Centre for Climate Services, 2021). Until 2060, temperatures are projected to increase by another 2 to 3°C (compared to 1980-2010) and precipitation is projected to decrease by 5 to 25% in summer. Further, glaciers will continue to retreat, and risks of natural disasters will continue to increase (Canton du Valais, 2016).

6.1.1. Structural characteristics

Overview of topographic and functional characteristics

Valais is the third largest canton of Switzerland, located in the Southwest, bordering both Italy and France. It is situated in the high alpine western Alps and is traversed by the Rhone Valley, which extends from the Rhone Glacier to Lake Geneva. Valais is characterized by its great spatial diversity, encompassing touristic mountain landscapes, the multifunctional Rhone valley much used for agriculture, urban centres such as the agglomerations Sion-Sierre, Brig-Visp-Naters, Monthey-Aigle and Martigny and subcentres such as Leuk, Saint-Maurice and Gampel-Steg, as well as natural and cultural landscapes (Canton du Valais, 2014; Kanton Wallis, 2022a). The elevation within the Canton ranges from less than 400m above sea level to its highest point at 4,600m (Canton du Valais, 2023).

The Canton of Valais covers an area of 5,225km^2. Most of its land is unproductive land, constituting for 53% of the total area, followed by forested area at 24% and agricultural land at 19%. Settlement and urban areas only account for 3,5% of its total area (Bundesamt für Statistik (BFS), 2019). Most of the arable land are natural pastures, followed by vineyards and orchards (Kanton Wallis, 2022a).

Overview of ecosystem and environmental characteristics

The region is often described as the water tower of Europe. However, surrounded by the Valais Alps in the South and Bernese Alps in the North, which catch a lot of the precipitation, it is also one of the driest regions in Switzerland, as measured by mean annual precipitation. Some of the driest valleys receive less than 600mm of precipitation a year, while the surrounding mountains may receive up to 3,700mm of precipitation (Paulsson & Liechti, 2013). Contrary to other regions in Switzerland, precipitation is lower in the summer than in winter. Dry periods are common, as variability of precipitation over the years is high. In the Val de Bagnes, composed of two communes, Bagnes and Vollèges, river flow of the Dranse river is greatly influenced by the Mauvoisin dam in the upper valley, which has greatly reduced the flow. Despite high availability of water, the supply of drinking water has been a source of concern (Aubin, 2011). To cope with the historic lack of precipitation and water shortage in the summer, inhabitants of the region have developed an irrigation system that has been in use for hundreds of years. A network of small water channels, sometimes guided by wooden plates (called ‘Suonen’, or ‘bisses’ in French). Water is channeled from

higher altitudes, via meadows and fields, to lower altitudes, also for the irrigation of fruit trees or vineyards. The water is rerouted from streams that are fed by glacier and melt water, which means they can provide water throughout summer and autumn, the seasons with the lowest precipitation. This system is also a part of what makes the cultural landscape of Valais so unique. The water use through these traditional channels is regulated through cooperatives, where members have the right of using the water but also the obligation to contribute to their maintenance. There has been a decline in this traditional way of conducting agriculture, which has often been conducted next to a main income. This leads to a loss in traditional handicrafts and knowledge, as well as cultural landscape of the region (Achermann & Liechti, 2012). In addition, they contribute to a historical culture of collaboratively managing the commons in the region (VI1).

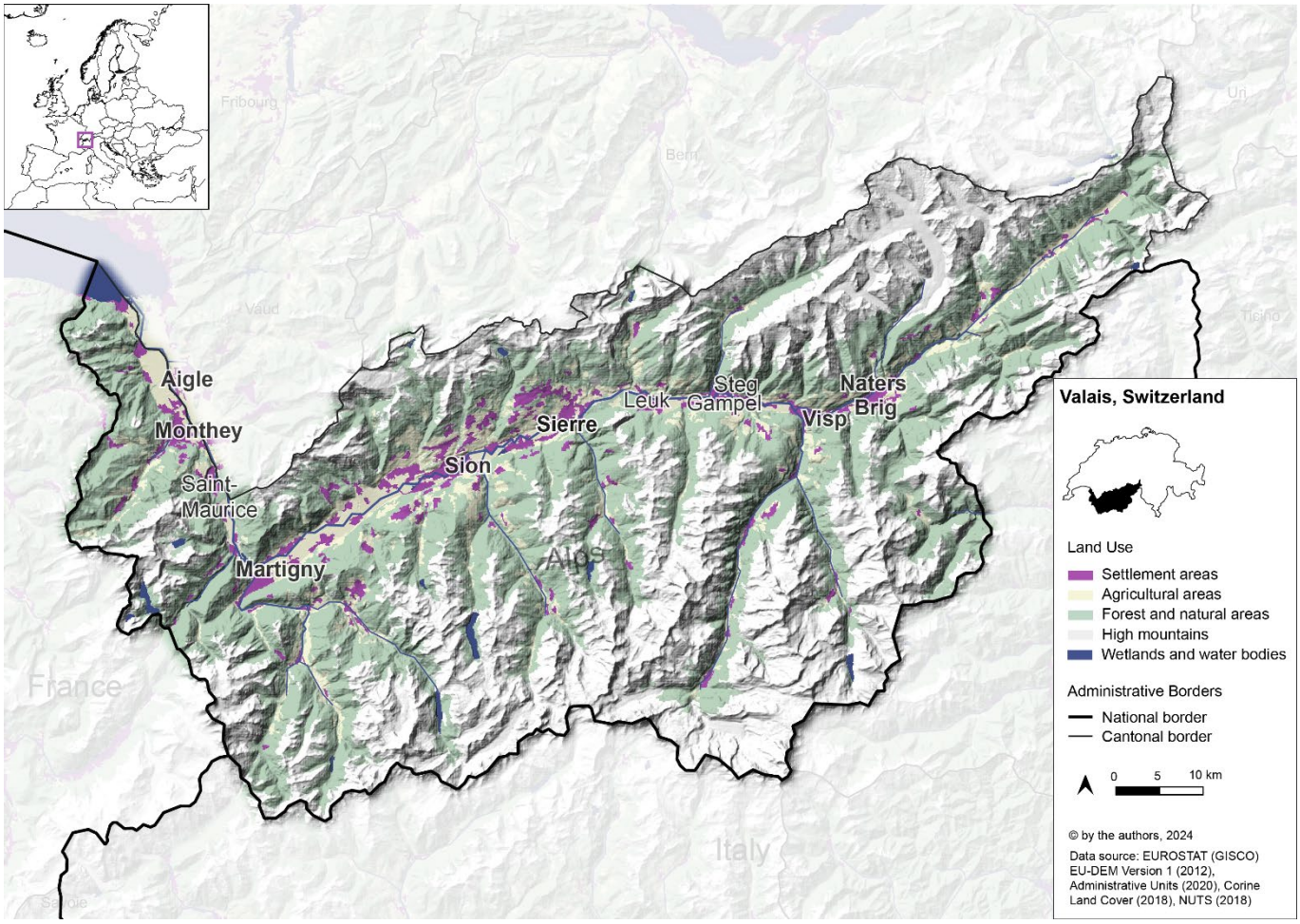

Figure 32. Map of Valais (TU Wien, 2024)

Socio-economic profile

Valais is a multi-lingual region. French is the main language in two thirds of the Canton, followed by German (25%), Italian (5%) and English (4%) (Bundesamt für Statistik, 2019). Valais' population amounts to 353,209 inhabitants (Eurostat, 2022), of which 80% live in urban areas (Bundesamt für Statistik (BFS), 2019). Annual population growth is comparatively high with +11.5 per 1,000 inhabitants (Eurostat, 2022). Population density lies at 68.4 persons per km^2 (Eurostat, 2022). The average age of permanent residents was estimated at 43.5 years (Bundesamt für Statistik, 2022), whereas the estimated rate for inhabitants in the Lake Geneva region in risk of poverty or social exclusion was estimated at 18.8% (Eurostat, 2022) – a slightly lower number in comparison with other regions. In the Lake Geneva

region (NUTS 2), where Valais is located, the employment rate for 15- to 64-year-olds was estimated at 78.8%, composed by a male employment rate of 82.4% and a female employment rate of 74.7% (Eurostat, 2022). In 2021, the regional GDP of Valais was € 18,711.57 million which amounts to 2.41% of the national GDP (Eurostat, 2022). Valais' Purchasing Power per capital is the highest of all MountResilience regions with € 46,300 per inhabitant (in 2019).

Table 18. Socio-economic data for Valais, compared to EU average (Source: Eurostat, 2022)

	Population density *(per km²)*	**Median age** *(in years)*	**Population change** *(in % from 2021 to 2022)*	**PPS per capita** *(in €)*	**Employment rate** *(in %)*	**Risk of poverty** *(in %)*
Valais (2022)	68.4	43.5	+11.5	46,300 (2019)	78.8*	18.8*
EU-average (2022)	109.1	44.5	+4.0	35,400	74.4	21.6

**ref. Région lémanique*

The most important sector of the economy in terms of gross value added in Valais is the industrial sector with the following business segments (in descending order): mining (and quarrying); real estate and housing and "trade, maintenance and repair of motor vehicles" (Bundesamt für Statistik, 2024). Industry amounts to a total of 25% of the cantonal gross value added and 20,000 jobs depend on this sector. However, in terms of employment, the tourism sector represents the largest employer with 24,100 jobs and accounts for 15% of total value added (Regions- und Wirtschaftszentrum Oberwallis, n.d.).

Water is a key resource for numerous sectors, such as (winter-)tourism, industry, agriculture and private households. As tourism is concerned, the use of artificial snow has become common to cope with decreasing snowfall, or just to always ensure high quality slopes. To supply the water, artificial reservoirs and an underground piping system had to be dug up, which has come with different environmental costs (Crémel & de Laage, 2023). Peaks in water use in the ski-resort of Verbier could be observed especially towards the end of the year and in February, but also between mid-July and mid-August (presumably high season for summer tourism). With the decline of traditional agriculture and an increase in commercial irrigation, agriculture has also been taking up more water resources (Paulsson & Liechti, 2013).

Hydropower plays a big role in the region's economy, as Valais produces nearly 30% of Switzerland's hydropower. Dams are often situated near irrigated areas, villages and towns, and some are also used for multiple purposes, such as supplying water to irrigation (Flaminio & Reynard, 2023).

6.1.2. Governance framework

The Canton of Valais is embedded in a multi-level governance framework characterized by federalism and direct democracy. The legislative and executive power is distributed between the Swiss confederation, the 26 cantons and more than 2,000 communes, while judicial power remains with the confederation and the cantons. The cantons have their own constitutions, parliaments, governments and courts, but the communes are conceded the highest possible degree of autonomy (Schweizer Eidgenossenschaft, 2024).

There are different responsibilities and competences depending on the policy area. This can be seen very clearly in the example of dealing with water as a resource and infrastructure. The constitution stipulates that the cantons are competent in this area, although the communes have sovereignty over water supply and disposal. This will be elaborated in chapter 6.3.

6.1.3. Identity and self-image

Valais positions itself as a major tourist destination characterized by its diverse landscape (Valais/Wallis Promotion, 2024). This self-image was also emphasized in the interviews, in which Valais was described as "*well-known as a touristic destination*" (VI6) and as "*offering both, winter sports in its mountainous parts and spring-like climate in its vineyards in the Rhone valley*" (VI3). Valais' diverse landscape not only plays an important role for tourism and therefore for the regional economy but is also central to the region's identity (VI4; VI5; VI6). However, its touristic character with "*famous resorts*" (VI1) has created the image of Valais as a canton that "*is not very well known to takes care of its resources*" (VI6). This image is aimed to be reversed (VI6). Another characteristic of the Canton is seen in its bilingualism (VI3; VI6). Its population is described as traditional and sometimes skeptical of change (VI3).

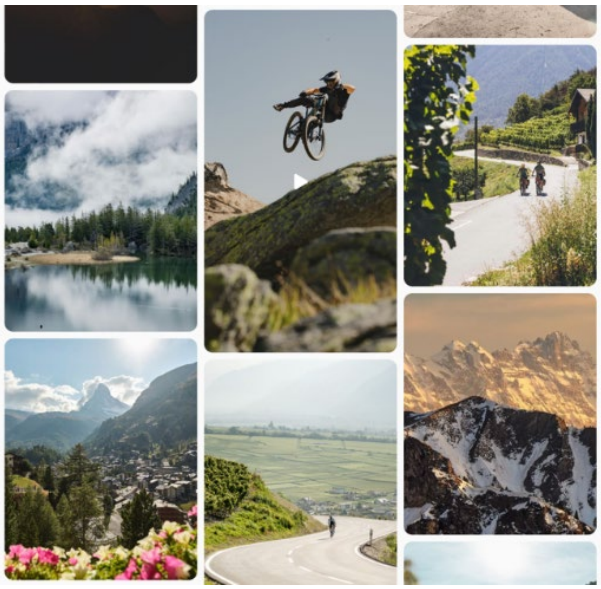

Figure 33. Touristic advertisement of Valais (Source: Valais/Wallis Promotion, 2024)

6.2. Systemic climate risks

The most important factors determining the directionality and design of CCA are concrete regional climate hazards and consequent systemic risks. This chapter overviews the main climate risks and relevant climate impact chains, pointing to the challenges for regional adaptation.

6.2.1. Main climate hazards and intermediate impacts

Temperature

In summer, in a low-emissions scenario (RCP2.6) temperatures will increase by 2°C by mid-century and then remain stable towards the end of the century (2°C by 2085). However, in a high emissions scenario (RCP8.5) temperatures would rise 4°C by 2060 and 6°C by 2085. In winter, temperatures will increase by less than 1°C by mid-century and then remain stable towards the end of the century (1°C by 2085) in a low-emissions scenario (RCP2.6). In a high

emissions-scenario (RCP8.5), temperatures are set to rise by up to around 2°C by 2060 and up to 4°C by 2085. The heat stress on the population, however, remains very low until the end of the century, even under the worst-case scenario, due to existing sensitivity and adaptive capacity (Navarro et al., 2022). While the risk of wildfire is currently considered very low, it would remain so under a low emissions scenario (RCP2.6) but rise to a medium risk under a worst-case scenario (RCP8.5) by the end of the century.

Precipitation and glaciers

Precipitation is likely to decrease in summer under the worst-case scenario and stay the same under a low emissions scenario (National Centre for Climate Services, 2021). This adds to summers that are already drier than in the rest of the country. Even if precipitation should not significantly decrease, due to the higher temperatures, the risk of drought or dry periods will increase due to higher evapotranspiration (Canton du Valais, 2016). Yet the overall drought risk (considering vulnerabilities, exposure, and adaptive capacity) remains very low in all emission scenarios (Navarro et al., 2022).

Especially in regions of medium altitude (ca. 1000-2000m a.s.l.) precipitation will increasingly fall in form of rain rather than snow. Even in high altitudes (above 2000m a.s.l.), which represent a large part of the Canton's surface area (VI2), rain will increase by 10-20% to snow. Per degree of warming, the snow line will move up by 150-200m, which means that by the end of the century it might rise by 500m. Precipitation will become more intense in spring and autumn, with dry periods in summer (Canton du Valais, 2016). With the earlier onset of snowmelt and glacier melting each year, the peak of discharge in the river will come earlier in the summer (May/June), which means there will be less water available later in the year, when agricultural irrigation still requires a substantial amount of water (VI2).

In the Swiss Alps, snow cover duration has shortened in the period from 1970 to 2015, with the snow season being on average 12 days shorter than in 1970. This decrease is more substantial in lower altitudes and less at high altitudes (Mourey et al., 2022). With 80% of the total ice volume, the majority of Swiss glaciers can be found in Valais (Canton du Valais, 2016). Giétro, Breney and Otemma glaciers have lost respectively 43%, 61% and 63% of their mass between 1850 and 2009 (Mourey et al., 2022). It is likely that by the end of the century, more than two thirds of the glaciers in Valais will have melted. Some glaciers will have completely vanished, others will remain but very small. For example, for Aletsch glacier, the surface will likely reduce by 70% and the volume by 90% by the end of the century (Paulsson & Liechti, 2013).

Due to the glaciers melting, water availability will not follow a linear path throughout the 21st century. Until 2040 a slight increase in discharge in general is expected due to melt water from the accelerated melting of glaciers. In addition, the seasonal distribution will also change. In winter, a slight increase is expected due to increased rain instead of snow. The peak in discharge in rivers will be in May instead of in June. In the second part of the century, the total amount of available water will decrease as summer precipitation will decrease even more and glaciers will have almost vanished, thus reducing the flow of melt water (Schneider et al., 2016). The risk of river floods on population and on infrastructure therefore will decrease by the end of the century in all emissions scenarios (Navarro et al., 2022)

Implications for the availability of water and societal development

Despite their projected decline, water volumes are sufficient for today's and for future demand, at least until 2050 (or as long as there is still meltwater from the glaciers). However, the challenge will be the seasonal variability and seasonal shortages. They key will be a successful water management strategy to prevent conflict or shortages in dry periods (Schneider et al., 2016).

6.2.2. Climate Impact Chain

This climate impact chain deals with the risk of water scarcity and conflicts around water use. The three relevant climate hazards are the increase in temperature, the decrease in precipitation in summer and the change in snowmelt and precipitation patterns. Together, these hazards lead to an upward moving snowline, glaciers melting and higher evapotranspiration. This will lead to impacts such as temporary water scarcity, as described above, as well as natural disasters, such as landslides, rockfall or floods. Due to the strong glacier-melting projected for the first half of the century, there is higher likelihood of floods. In addition, it might lead to temporary higher water availability, especially in spring and early summer, however, this will only be seasonal and in the later part of the century water will become scarce again.

Water needs are projected to rise in a business-as-usual scenario, especially in urban areas and in the keeping of livestock (Milano & Reynard, 2022). There are several elements of the regional system that are exposed to these changes. Hydropower production requires the largest amount of water. Agriculture requires water especially when precipitation is lowest and water most scarce in the region, during summer and autumn. This includes both, commercial agriculture and small scale and traditional farming. The situation will be exacerbated by the fact that an earlier onset of the snowmelt will lead to an earlier peak in water availability in rivers, removed from the peak of water needs in agriculture later in the summer. Residential areas require water, too. Depending on the commune, some have separate systems for drinking water and water for irrigation, while in others drinking water is used for all purposes (Schneider et al., 2016). Finally, tourism also requires large amounts of water, especially for snowmaking for winter sports.

Economic vulnerabilities stem from the fact that the two most important industries in the region, hydropower and tourism, strongly depend on the availability of water. The economic importance of skiing and winter tourism makes the region vulnerable as this income is highly dependent on the right weather conditions and on the availability and quality of snow.

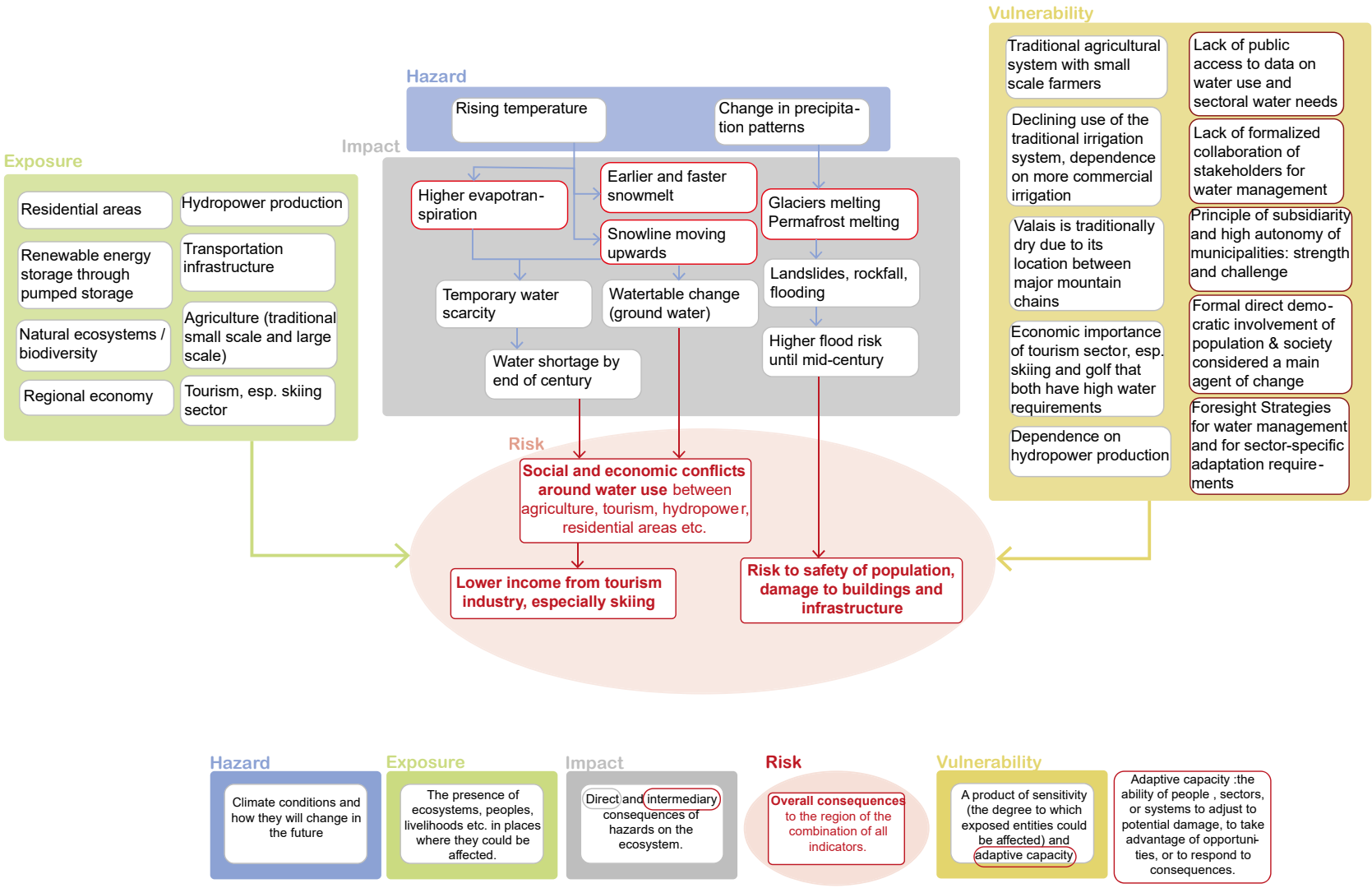

Figure 34. Valais IC for water (ZSI, 2024) | *cf. chapter 11.2 for IC methodology*

6.3. Regional CCA governance

CCA activities should be well-embedded in the strategic objectives of a region and strike a balance between stakeholder inclusion and leadership. Accordingly, understanding the strategy framework and stakeholder landscape of regional CCA governance is important. This chapter identifies key regional CCA-related strategies, how CC and its consequences are problematized therein and how certain adaptation challenges are prioritized. It highlights the prevailing understanding of CCA and the emphasized approaches for tackling it, as well as the most important regional stakeholder groups, which is important for the design and implementation of concrete adaptation activities.

6.3.1. Strategy framework

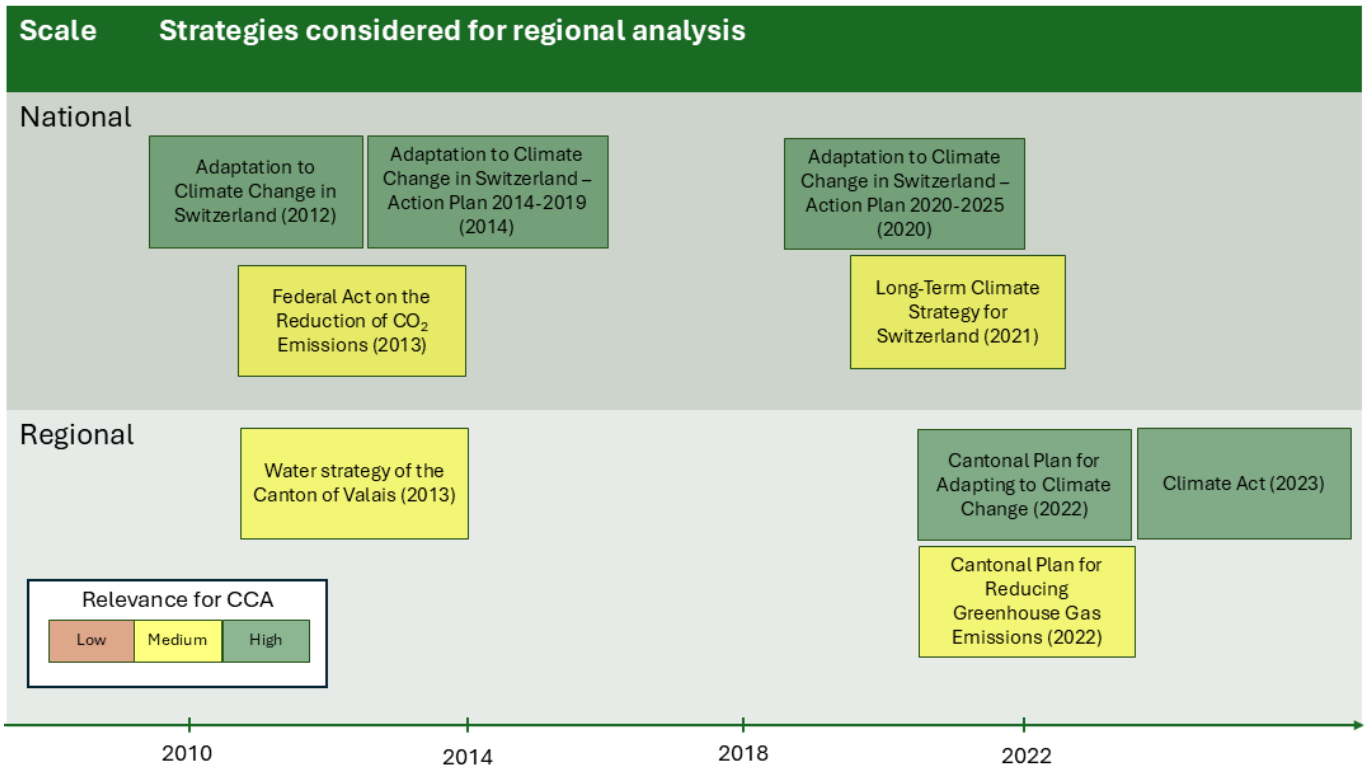

Figure 35. Overview of CCA-relevant strategies for Valais (TU Wien, 2024)

In line with international and European strategic frameworks, such as the Paris Agreement (2015), the United Nations Agenda 2030 (2015), the European Strategy for Adaptation to Climate Change (2013[2021]) or the EU's Green Deal (2019), there are national as well as cantonal strategies to combat and adapt to climate change in Valais.

On the national level, the "**Federal Act on the Reduction of CO_2 Emissions" ("CO_2 Act"**) and the corresponding ordinance, which have been in force since 2013, provide the legal framework for climate mitigation. Climate change adaptation is referred to in Article 8, which sets out the federal government's responsibility for the coordination of measures to prevent or manage damage of significant value and for the development and procurement of the necessary basic knowledge (Federal Act on the Reduction of CO_2 Emissions, 2013). A revision of the "CO_2 Act" was brought forward by the Federal Council and Parliament in 2020 to comply with the goals set out in the Paris Agreement, but it was rejected by the population in the 2021 referendum (UVEK, n.d.). The "Long-Term Climate Strategy for Switzerland" was adopted in 2021, fulfilling the obligation under the Paris Agreement to submit a long-term climate strategy (Schweizerische Eidgenossenschaft, 2021). To guide national adaptation action, the federal government has developed an **adaptation strategy** in 2012 (BAFU, 2012) including the goals, challenges and fields

of action of climate change adaptation. Following the first action plan for 2014-2019 (BAFU, 2014), the second action plan provides orientation for the implantation of adaptation actions for the years 2020-2025. (BAFU, 2020).

On the cantonal level**,** the **cantonal climate strategy** consisting of a plan for reducing greenhouse gas emissions (Kanton Wallis, 2022b) as well as a plan for adapting to climate change (Kanton Wallis, 2022a) provides the strategic framework for climate change mitigation and adaptation. Based on the climate scenarios of the "National Centre for Climate Services" (NCCS), the cantonal plan for adapting to climate change identifies adaptation measures for 10 different sectors. The State Council has also drafted a "**Climate Act"** (Klimagesetz, 2023) in 2023, which will be voted upon at the end of 2024 (Walliser Zeitung, 2024).

In 2013, the Canton Valais has published a **cantonal water strategy** that sets out the challenges, a vision and corresponding measures to coordinate water use within the Canton (Kanton Wallis, 2013). This strategy, however, has only recently started to be put into practice as reflected in the creation of a new position of a water delegate for the Canton, as envisioned as a key measure of the water strategy. The delegate is expected to take over a coordinative role and "*to advocate a holistic and coordinated approach to water as a resource*" (Kanton Wallis, 2013, p. 26, translation by the authors). In the interviews, the expectations towards this position were emphasized: "*we really expect a lot from this new cantonal figure*" (VI5).

6.3.2. Problem background and prioritized challenges

The key challenges associated with climate change adaptation, as addressed in the regional documents and emphasized by the expert interviews and the VVWDS, are not only environmental, but also include economic, social and governance aspects.

Table 19. Main CCA challenges for Valais

Increased periods of water shortage	As discussed in the systemic climate risks, the melting of glaciers, reduced precipitation and increased evaporation in summer, the increase in winter precipitation in the form of rain instead of snowfall and the increase in the frequency of heavy rainfall and dry periods lead to changed water availability throughout the year with more frequent periods of seasonal water shortage (Kanton Wallis, 2013). This could increasingly be experienced in the past years (VI2; VI3; VI4; VI5). Due to the heterogeneity of the Canton in terms of natural, climatic and geological conditions and available water resources, the vulnerability to increased periods of water shortage varies greatly within the region (VI2; VI4).
Vulnerable regional economies	Climate change and the changing water availability in particular have broad implications not only for individual households, but also for the main regional economies. As previously discussed, water availability is key for the region's main industries, hydroelectricity and tourism, as well as for agriculture and domestic use (VI2; VI3; VI4; Kanton Wallis, 2022a). The economic risk of climate change and "*the costs of inaction"* (Kanton Wallis, 2022a, p. 19), as noted for each sector within the cantonal adaptation plan, are seen as major drivers for adaptation actions (VI3).

Fragmented water governance	Valais has always had and still has plenty of water resources and has only recently been confronted with temporal challenges of water availability (VI2, 2024; Kanton Wallis, 2022a). Additionally, water demand is expected to increase in the future, as discussed in the systemic climate risks. These changes in availability are challenging the governance structures that have worked well in the past. In terms of water management, the Swiss constitution foresees that the cantons have control over the water resources on their territory. In the Canton Valais, however, the communes exercise strong autonomy over water management as the rivers, torrents and channels, apart from Lake Geneva and the Rhone, are managed by the communes. The provision of drinking water and wastewater is also largely their responsibility. In this regard, the Canton is only responsible for approving drinking water protection zones, monitoring the requirements for drinking water supply and quality, coordinating and subsidizing the construction of wastewater treatment. Additionally, the Canton monitors the overall water quality and manages usage rights and regulations regarding hydropower production (Kanton Wallis, 2013). In times of water shortage, communes have so far acted on the spot, lacking coordinated, proactive and foresighted management of water usage on cantonal level that considers the different and potentially conflicting water needs (VI1; VI2; VI3; VI5). Divided water property rights and competencies between Canton and communes, and the fact that economic actors hold the data on water consumption that they "*might not be very eager to share*" (VI1) are key concerns for integrated water management (VI2).
Lack of awareness and resources	Awareness for the need for integrated adaptation measures appears to be lacking, particularly among the local administration (VI2; VI3): "*they are just reflecting in a business-as-usual scenario"* (VI2). Instead of integrated planning and management of water, a strongly sectoral policy continues to prevail (VI3). As noted in the cantonal water strategy, the communes lack the necessary resources to ensure coherent and forward-looking planning and management of their water resources (Kanton Wallis, 2013).

6.3.3. Prevailing Understanding

Climate change adaptation action in the region is strongly…

- **preservative towards regional economies, especially tourism:** as previously discussed, the rise in temperature causes a rise in the snow line, posing a threat to tourism, particularly at low and medium altitudes. The demand for water for artificial snowmaking is increasing to secure enough snow and ensure high quality winter tourism (Kanton Wallis, 2022a). As tourism is of great regional importance for the regional economy and identity, water reservoirs are being built to have enough water for artificial snowmaking even in times of water shortage (VI4). In addition, summer tourism is increasingly being promoted to make up for the climate-related economic losses in winter tourism, especially in lower areas (VI4; VI6).

- **reactive to climate induced risks:** urgency and (personal) affectedness are driving adaptation actions in general and in terms of water management. Adaptation therefore happens in direct response to an effect or

to a problem: „*The last few years we had problems with water availability. Then people said, ‚Now we really need to do something!'*“ (VI1). This reactive understanding goes hand in hand with a lack of foresight in terms of adaptation action, thereby impeding a pro-active approach to adaptation: “*if it is something that does not help today or tomorrow, some people don't want to do it*” (VI4).

6.3.4. Emphasized Approaches

In Valais, the main approaches to climate change adaptation, es highlighted in the regional documents and the interviews, are governance, knowledge transfer and behavioural change. The cantonal adaptation strategy also emphasises technological and physical approaches to adaptation, such as modelling and monitoring of water flows (Kanton Wallis, 2022a), but does not have a focus on nature-based solutions. Interestingly, although the economic risk of climate change is an important argument for adaptation actions, economic and financial approaches to adaptation play a minor role in Valais.

Effective coordination and (water) governance: new ways of organizing and working together are envisioned to ensure a coordinated approach to water management, counteract limited resources in small communes, avoid infrastructure duplication and make use of synergy effects (VI2; Kanton Wallis, 2013). These include:

- *inter-municipal planning and use of infrastructure within water catchment areas (VI2; Kanton Wallis, 2013).*
- *financial support for the communes by the Canton (Kanton Wallis, 2013)*
- *introduction of an online platform, comprising relevant data and information on water to allow for ongoing monitoring (Kanton Wallis, 2013)*
- *adoption of a framework law on water to formalise the cooperation between different actors (Kanton Wallis, 2013)*
- *creation of a cantonal operating company, particularly for the provision of drinking water supply and wastewater disposal (Kanton Wallis, 2013)*

Water management is thereby seen as a part of a broader conscious change in terms of governance, meaning that it is hoped to pave the way for new ways of working together in other domains and sectors (VI1)

Transparent and prioritised use of water resources: for times of water scarcity, priorities must be set in advance (VI1; VI2; VI5, 2024). This first requires a comprehensive overview of the various needs and available resources to be able to prioritise these different water needs (Kanton Wallis, 2022a). In this context, questions arise such as: *“do we give the water to the owners of the swimming pools or to the farmer*s” (VI2, 2024). The decision-making process should ensure transparency (VI5) and could also involve the local population (VI1; VI2).

Increased local sensibilisation and awareness: awareness-raising among the various actors regarding the sustainable use of water and working on a common understanding of adaptation requirements are seen as prerequisites to drive adaptation action (VI1; VI3; VI4; Kanton Wallis, 2022a): “*we have to work on a common understanding of what is going on, what is happening*” (VI1) In this respect, emphasis is placed on strengthening research and development as well as knowledge transfer among different stakeholders within the Canton (Kanton Wallis, 2022a).

Enhanced behavioural change: to promote behavioural change and to “*make the people go into the right direction*” (VI4) are seen as key approaches to adaptation: “*I believe we as human beings always try to find what is the easiest way*” (VI1). These habits are seen as especially hard to change (VI5). Playful approaches to environmental education are considered conducive to bringing about a change in peoples' values and in mindset (VI3; VI4).

6.3.5. Important stakeholder groups

Community: following the general regional understanding that the responsibility for initiating change to adapt to climate change lies with each and every individual, society is seen as the main agent of change (VI1) helping to drive political action: "*a vision that is backed by the local population gives me much more power to act*" (VI6). One the one hand, society may act as a major enabler and driver of change, as seen in the efforts of NGOs advocating for a climate legislation (VI6). On the other hand, society may also act as a major barrier as reflected in the climate sceptic movement, which initiated a referendum on the climate law (VI1).

Government: political actors are regarded as responsible for creating the framework conditions for change, with a clear commitment to climate mitigation and adaptation (VI3; VI4). Within the direct democratic governance framework, however, society has a decisive role in shaping political decision-making.

In terms of water management, both the communes and the Canton itself are key stakeholders: the communes as they are owning and managing large parts of the regional water resources (VI5), and the Canton for managing the large water bodies and because of its judicial power. Within the Canton, the water delegate is now responsible for increasing the coordination between the different stakeholders and for working on the strategic framework for water management and therefore plays a crucial role (VI2; VI3; VI5; Kanton Wallis, 2013).

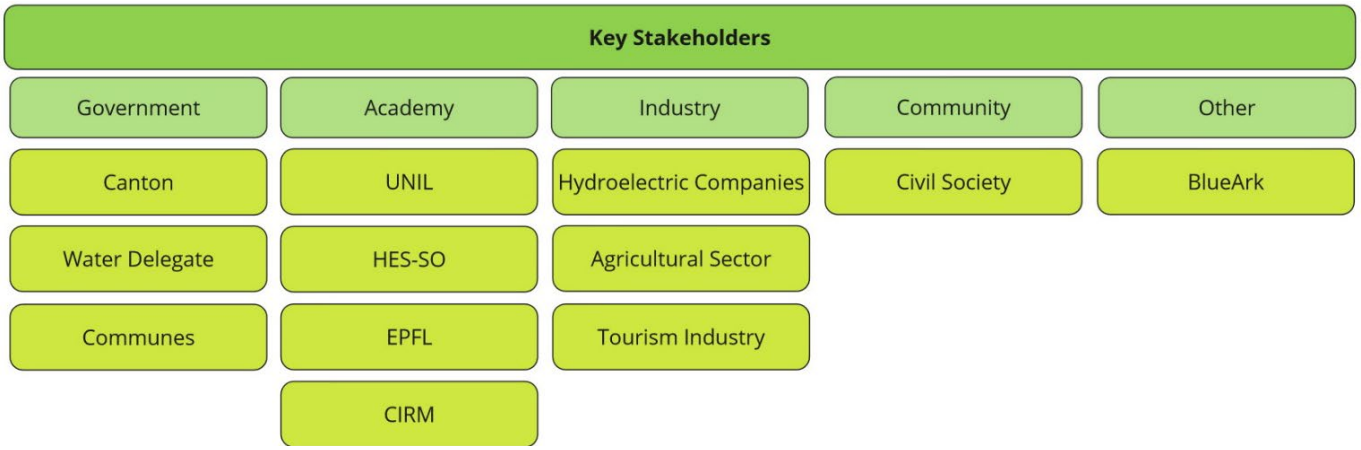

Figure 36. Key stakeholders in CCA in Valais (TU Wien, 2024)

Industry: hydroelectric companies are not only a key economic actor in Valais, but also play a major role for water management as they are relying on the availability of water resources as their factor of production (VI5) and are the only ones holding key data on water consumption (VI1).

Both, the touristic and the agricultural sector are largely dependent on the availability of water resources and infrastructure and will face increasing demand of water in the future, especially for irrigation and snowmaking (VI2). Sensitivity and willingness to make changes in their practices are said to be especially high among agricultural actors (VI5).

Academy: as academic institutions, University of Lausanne ("UNIL"), University of Applied Sciences and Arts of Western Switzerland ("HES-SO"), École Polytechnique Fédérale de Lausanne ("EPFL") and the associated Centre interdisciplinaire de recherche sur la montagne ("CIRM"), are also engaged with research on climate change adaptation and/or water management. Additionally, on a national level, the National Centre for Climate services (NCCS) has been mentioned as an important coordinative body as part of the stakeholder mapping in D.1.3.

"BlueArk", an innovation hub focusing on water and natural resource management is engaging as an intermediary actor between academic institutions and start-ups (VI6).

6.3.6. Assessment

Compared to other MountResilience regions, Valais is embedded in an extensive strategic framework for climate change adaptation, with informal strategies at both the national and regional level. Legally binding climate acts, on the other hand, have encountered significant opposition from civil society. Nevertheless, civil society is seen as the major agent of change in driving climate change adaptation.

Emphasis is put on new ways of working together and governance approaches to adaptation, especially regarding water management, although a predominantly reactive understanding of adaptation persists. The increasing frequency of water scarcity have exposed the limitations of existing governance structures, where formal competencies are split between the communes and, to a lesser extent, the Canton. This reactive stance impedes the development of a proactive and forward-looking approach to adaptation, which is essential for effectively tackling the long-term challenges posed by climate change. Additionally, a major barrier to proactive and foresighted water management is the untransparent monitoring of water uses and needs, which remains with economic actors.

6.4. Key adaptation actions

This chapter introduces good practices that have already demonstrated how CCA can be approached in the region. These actions are not representing the full scale of approaches in the region but give a relevant overview of the priorities given to adaptation while pointing out different innovative solutions to address the specific challenges and risks that were induced by climate change.

LAB2030 – Factory for social entrepreneurship: As part of the national initiative "engagement-local" ("engagement-lokal") within the Agenda 2030, the communes Sierre and Sion were committed to connecting civil society and socio-economic actors in order to promote cooperation, coordination, knowledge transfer and therefore local engagement (Engagement-Lokal, n.d.). Civil society initiatives were connected to local authorities aiming to establish a dialogue based on trust and mutual understanding of needs and objectives. As part of the project, concrete projects were developed by the initiatives, which were presented during a final event in 2023 (FDDM, n.d.).

BlueArk Challenge: The "BlueArk challenge" was first initiated in 2018 as a call for innovative ideas and technologies addressing water management challenges. Individuals, companies or institutions can participate by submitting a solution concept tackling one or more pre-defined challenges, such as mechanical snow removal or rainwater infiltration on sloping land among others. Selected projects receive 10,000CHF to further develop their ideas and realize them in collaboration with the challenge leader and with support from "BlueArk". Selected projects will also be featured at the "BlueArk conference" on water management (BlueArk Challenge - Call for Projects, 2021).

Funding for rainwater recovery: The commune of Salgesch is offering subsidies for the use of rainwater for its households. Since 2023, homeowners can apply for a subsidy of 10% of the costs for additional and new systems for rainwater recovery with a volume of more than 500 liters (Gemeinde Salgesch, 2023).

Smart meter device for measuring water and energy consumption: ETH Zurich as well as its spin-off company "Amphiro" have developed a device, measuring and displaying the water energy consumption while showering in real time. The display shows a polar bear on an ice floe, which gradually melts the more hot water is used for showering. A study conducted by the ETH Zurich and the University of Lausanne, supported by the Swiss Federal Office of Energy, showed that hot water consumption could be reduced by an average of 20 to 25% when using this device (Naegeli, 2013).

6.4.1. Learnings

These projects demonstrate Valais' experience in engaging with civil society actors, promoting private initiatives and, consequently, strengthening civic engagement and inclusive governance of climate change adaptation at the local level. Further, the use of playful, technological awareness-raising approaches for enacting individual behavioural change regarding resource-use (as also envisioned by the Demonstration Activity) has been tested for driving adaptation action. Additionally, Valais is experienced in fostering and promoting innovative approaches and therefore practical implementation of projects that address water management challenges.

6.5. Transformative pathways

The overview of regional structure, systemic climate risks and existing CCA governance, coupled with knowledge on the planned DA, allow a final assessment of the most relevant barriers and opportunities for transformative CCA in the region, as well as pointing to the key transformative capacities that need to be utilized or developed further. To this end, a validation workshop was held in the region to discuss barriers, opportunities and key transformative capacities with knowledgeable actors. This chapter elaborates on these aspects and concludes by providing concrete advice for transformative CCA in conjunction with the fields of action of the respective DA and beyond to facilitate transformative regional CCA.

6.5.1. Barriers and windows of opportunity for CCA

The main barriers to climate change adaptation are seen in changing habits: "*there are still people, who have difficulty changing their habits because they have always done it this way*." (VI5) This is regarded as particularly challenging for adaptation action because the effects of climate change are not always immediately visible, but changes occur gradually (VI3).

In this regard, changes in communication may be an important lever for driving adaptation action. First, the use of playful approaches as for the smart meter device for measuring water and energy consumption have proven to be successful for raising awareness and sensibilization among the population (VI3). Second, in line with the emphasis on the economic risks of climate change in both the cantonal documents and the interviews, stressing the economic costs of inaction can be a major driver for adaptation action (VI1; VI3). Third, emphasizing the benefits and opportunities of adapting over non-adaption (as in the regional strategy, where the costs of inaction are addressed) and planning for quick wins and direct rewards to counter the lacking foresight associated with adaptation actions has the potential to be an impactful strategy (VI6).

6.5.2. Regional validation workshop

The regional validation workshop aimed at presenting, critically discussing, and further developing initial hypotheses and interim findings on transformative adaptation with knowledgeable regional actors. The workshop hence consisted of two parts: In a first session, regional CCA measures, challenges and opportunities deriving from the previous analysis were presented and subsequently debated in smaller groups as well as in the plenum. In the second session, regional transformative capacities that were identified as relevant by the research team were introduced and put up for discussion. This gave participants the opportunity to share feedback, give concrete examples stemming from their own experience or bring in new ideas for effective CCA governance.

The workshop focused on the topics of governance, leadership and climate change adaptation strategies in Valais. In terms of governance, participants highlighted the advantages and disadvantages inherent to a highly democratic society. On the one hand, public engagement and debate is encouraged. On the other hand, reaching consensus is a time-consuming process that is further slowed down by climate skeptics. Therefore, a key level for effective CCA was seen in understanding the "*factors to reach engagement and consensus among significant actors*" (VVDWS).

The Canton was mentioned as having a particular responsibility to provide the necessary framework conditions. However, it was also emphasised that the national, cantonal and local level must collaborate "*driven by a common purpose*" (VVDWS) in a manner that avoids an increase in administrative workload. In this context, reference was made to the coordinating function that leadership must fulfil. It was emphasised that positive images and visions of the future are needed to promote adaptation to climate change.

Figure 37. Accompanying Miro Board from VDWS in Valais

The workshop was conducted in an online format on June 13, 2024, from 14:00 to 16:00 (EEST) with an audience of 14 participants. The online tool Miro was used to facilitate visualization of discussion points.

6.5.3. Regional transformative capacities

Overcoming a focus on mere adaptation responses towards more long-term transformative change, the concept of transformative regional capacities offers a perspective on the wider interplay, forming a more systemic perspective. The last step of the regional CCA analysis aimed at the identification of regional strengths and transformative capacities by assessing regional/local implementation barriers and existing regional capacities. Building on the analysis results and workshop responses (conducted in June 2024), transformative regional capacities were determined. The framework proposed by Wolfram's (2016) of ten adaptive capacities addresses organisational visions, work culture, structures, skills, human and material resources, but also community participation, relations, networks and institutions, and the understanding of existing systems. For the regional climate change analysis, the most relevant transformative capacities were identified to guide adaptation action, particularly with regards to the regional Demo Activities (DAs).

Table 20. Transformative capacities for effective CCA in Valais

Inclusive and multiform governance	The governance structures are founded on the principles of subsidiarity and direct democracy. Within this formal framework, communes are granted significant autonomy, which makes them key actors in various domains, including CCA. When it comes to ensuring a coordinated approach to adaptation and water management, the autonomy of the communes is hence a major challenge. Similarly, due to direct democracy, population plays a crucial role. The formal direct involvement of the population in decision-making processes ensures broad approval and inclusion. However, it also entails prolonged democratic processes as exemplified by the revision of the climate legislation, both on national and cantonal level. While these legal processes contribute to governance stability, they are inherently lengthy and consequently less agile (VVDWS). Regarding integrated water management, the lack of public access to data on water use and sectoral water needs presents a major challenge (VVWDS). The introduction of a new intermediary position for the Canton, the water delegate, is expected to enhance coordination, although largely based on voluntary efforts. As far as governance models are concerned, Valais has a long tradition in the communal governance of common resources (VI1). This traditional management of resources may also open new perspectives for future governance (VVWDS).
CCA Leadership Distribution	Formally, there is (political) commitment to adapt to climate change with strategies implemented both on a national and on a cantonal level. However, society is considered the main agent of change. Changing the populations attitude and behaviour through awareness-raising and nudging is seen as the major lever for advancing adaptation action given the legal framework of direct democracy (VVWDS).
Foresight	The Climate Strategy serves as a cantonal document that, although not legally binding, formulates sector-specific adaptation requirements based on national climate scenarios. Similarly, there has long been a strategy for water management that formulates objectives and corresponding measures. However, there is a discrepancy between the strategically formulated adaptation goals and the actions undertaken. The approach to adaptation remains predominantly reactive; adaptation measures are primarily driven by concern, as evidenced in the water management sector where actions are now increasingly being taken in response to increasing water scarcity.

6.5.4. Concrete advice for the DA and beyond

Utilize the services of intermediaries for inclusive water governance: with the recent appointment of a cantonal water delegate, there seems to be renewed interest in improving water governance in Valais. In this regard, the demonstration activity can benefit from this momentum.

Experiment with new water governance approaches: as envisioned by the DA, novel approaches to governance are to be tested in the field of water management. The DA has the potential to explore new opportunities for inter-communal cooperation beyond the strong legal autonomy of the communes with the objective of enhancing effective water governance and purposefully bringing different actors together.

Address existing knowledge and power imbalances: in terms of leadership, it appears especially important to proceed with sensitivity and to facilitate mediation between different players, given that key data on water consumption are gathered by economic actors, which is a major challenge for integrated water management. Regarding communication within the DA, it is advised to emphasize the (economic) benefits of cooperatively adapting water management to climate change.

Engage a critical mass of citizens in water governance: as mentioned in the interviews, involving the local population in decisions regarding the prioritization of water-use appears crucial. Within this highly democratic governance framework, civil society plays a key role in driving adaptation and should therefore be actively engaged.

Reduce water demand in general: Although Valais' water resources are projected to be sufficient for meeting the increasing water demands, Valais is facing challenges in ensuring year-round availability. Reducing water consumption in various sectors, including agriculture, industry, tourism, but also for private use, would also contribute to the protection of the region's ecosystem.

7. Factsheet Catalonia

Regional structures, political competencies and development objectives profoundly influence the potential pathways for regional CCA. This factsheet hence introduces the topographic, functional, environmental, and socio-economic characteristics that shape the region structurally, briefly introduces the territorial governance framework to illustrate the region's formal competencies for implementing CCA autonomously and gives and overview to key strategies that frame current regional CCA efforts.

Spain is one of the most vulnerable countries in Europe to change climate, where increases in temperature and a variation of extreme rainfall and droughts critically affect future water availability, with increasingly important implications in sectors such as agriculture, livestock, forestry and tourism (UN DESA, 2021). Being subject to overexploitation, also 61% of the country's surface water bodies and 45% of the underground water bodies are strongly affected by changing precipitation and pollution. Challenging climatic trends are also increasingly observable in Catalonia, one of the project's replicator regions, which is particularly affected by a mixture of hazards such as floods, droughts heatwaves and wildfires. According to the Third Report on Climatic Change in Catalonia (TICCC, 2017), Catalonia will experience a temperature increase of 0.8°C this decade and an increase of 1.4°C by 2050, as well as an increase in extreme temperatures and precipitation, heat waves, tropical nights (especially in coastal and pre-coastal areas), and the duration of dry spells. Threatening local ecosystems and local resilience, these events are posing a specific need for efficient CCA measures in the region.

7.1. Structural characteristics

Overview of topographic and functional characteristics

The autonomous region of Catalonia is located in the northeastern corner of Spain, bordering with France and Andorra in the north, Aragon to the west, the Valencia region to the southwest and the Balearic Sea to the east. Most of its territory lies in the northeast of the Iberian Peninsula. The region consists of the provinces Girona, Barcelona, Tarragona, and Lleida (Rodriguez, 2024). The mountainous plateau of the Pyrenees separates Catalonia from France, to the west, the pre-Pyrenees and the Ebro River basin mark the border with Aragon. To the southwest the Ebro basin gives way to coastal hills separating the Catalonian province of Tarragona from the Valencian province of Castellón. The city of Barcelona, the regional capital, has a free economic zone near the port, where distribution centres are concentrated, and is an important center for the region's tourism and events (offering conferences, exhibitions, and trade fairs).

Commercially, the Catalan emphasis is on small firms (few have more than 200 employees), yet the region has increasingly adopted policies to attract major international investors to the region. Catalan economy is based on a strong services sector, tourism, but also manufacturing (automotive), industry (cork sector) and life sciences (Chemical, Pharmaceutical), however food production is its leading industry, accounting to 20% of its GDP (ICEX, 2024). The total regional, area covers about 32,091km^2 and is home to 7,6 million people. Administratively, it is divided into four provinces of Tarragona, Barcelona, and Girona and Lleida, which (except of Lleida) have a Mediterranean shoreline. The low-lying Catalanides range separates the coastal plain from the Ebro River basin and the coastal industrial towns from the higher tableland, with agricultural settlements. The main rivers are the Ter, Llobregat, and Ebro River, all flowing into the Mediterranean Sea.

Ecosystem and environmental characteristics

Mediterranean climate prevails throughout most of the region, with hot and dry summers with rather mild, relatively rainy winters (Rodriguez, 2024). The area differs between the coastline, the hinterlands and along the Ebro Delta. The Ebro, the longest river (987km) in Spain, originates in Fontibre, flows through the gorges of Burgos, the limestones of central Ebro valley, and discharges in the Ebro Delta to the Mediterranean Sea. It is characteristic for providing the largest wetlands (320km²) in the region (JRC, n.d.). Intensive agriculture exerts severe pressure on freshwater resources of the Ebro River Basin, especially in terms of nutrient and pesticides fluxes from agricultural fields, while a combination of intense irrigation and excessive and inefficient fertilization (e.g. in maize) has led to significant water pollution in the region (JRC, n.d.). The Ebro Delta is one of the most threatened ecosystems to climate change in whole Spain with climate-induced threats to livelihoods as well as directly to the living conditions, mostly through the sea level rise water (expected 0.6-1m by the end of the century) resulting in salinization and loss of the surface with its possibilities for economic activities (Zografos, 2017, p.52f; Lomelí-Quintero, 2023).

Regarding its precipitation, the mean annual rainfall varies between low 320mm per year in the semi-arid central Ebro valley, and relatively high amounts of 2000mm per year in the Pyrenees and Cantabrian mountains. Due to the surrounding mountain range, the river basin is characterised by both, a continental and semi-arid tendency (Loidi, 2017). The vegetation is made up by forests and woodlands, garrigue on limestone or on gypsum substrates, and large grasslands. However, the forests in the northern Mediterranean basin having a history of land-use fragmentation, deforestation, a general negligent forest management and, most recently, afforestation of abandoned farmland, face a particularly high risk from large fires (Selkimäki et al., 2012).

Table 21. Socioeconomic data for Catalonia, compared to EU average (Source: Eurostat 2022)

	Population density *(in km²)*	**Median age** *(in years)*	**Population change** *(in % from 2021 to 2022)*	**PPS per capita** *(in €)*	**Employment rate** *(in %)*	**Risk of poverty** *(in %)*
Catalonia (2022)	243.7	44.2	+28.6	35,000	69.9	20.4
EU-average (2022)	109.1	44.5	+4.0	35,400	74.4	21.6

Regional socio-economic profile

Catalonia's population in 2022 amounts to 7,679,192 inhabitants (Eurostat, 2022), leading to the highest population density of 243.7 persons per km² in comparison the other project regions. The population change lies at +28.6 persons in the year 2022 (crude rate of total population change per 1,000 per inhabitant) (Eurostat, 2022) which is by far the highest increase compared to the other regions. The median age of the population was estimated at 44.2 years (Eurostat, 2022), of those aged 15 to 64, the overall employment rate was estimated 69.9%, whereby the rate is made up by an employment rate of 72.5% of men and 65.0% of women (Eurostat, 2022). Catalonia is renowned as Spain's industrial driving force, with accounting for around 20% of Spain's GDP (Eurostat, 2022). Catalonia's economy is highly diversified with the main industry branches being in chemicals and plastics, food and beverages, motor vehicles and life science (Catalonia Trade&Investment, n. d.). Catalonia's Purchasing Power Standard (PPS) per inhabitant lies at € 35,000 PPS per inhabitant (Eurostat, 2022) An estimated rate of 20.4% of Catalonia's population are facing risk of poverty or social exclusion (Eurostat, 2022).

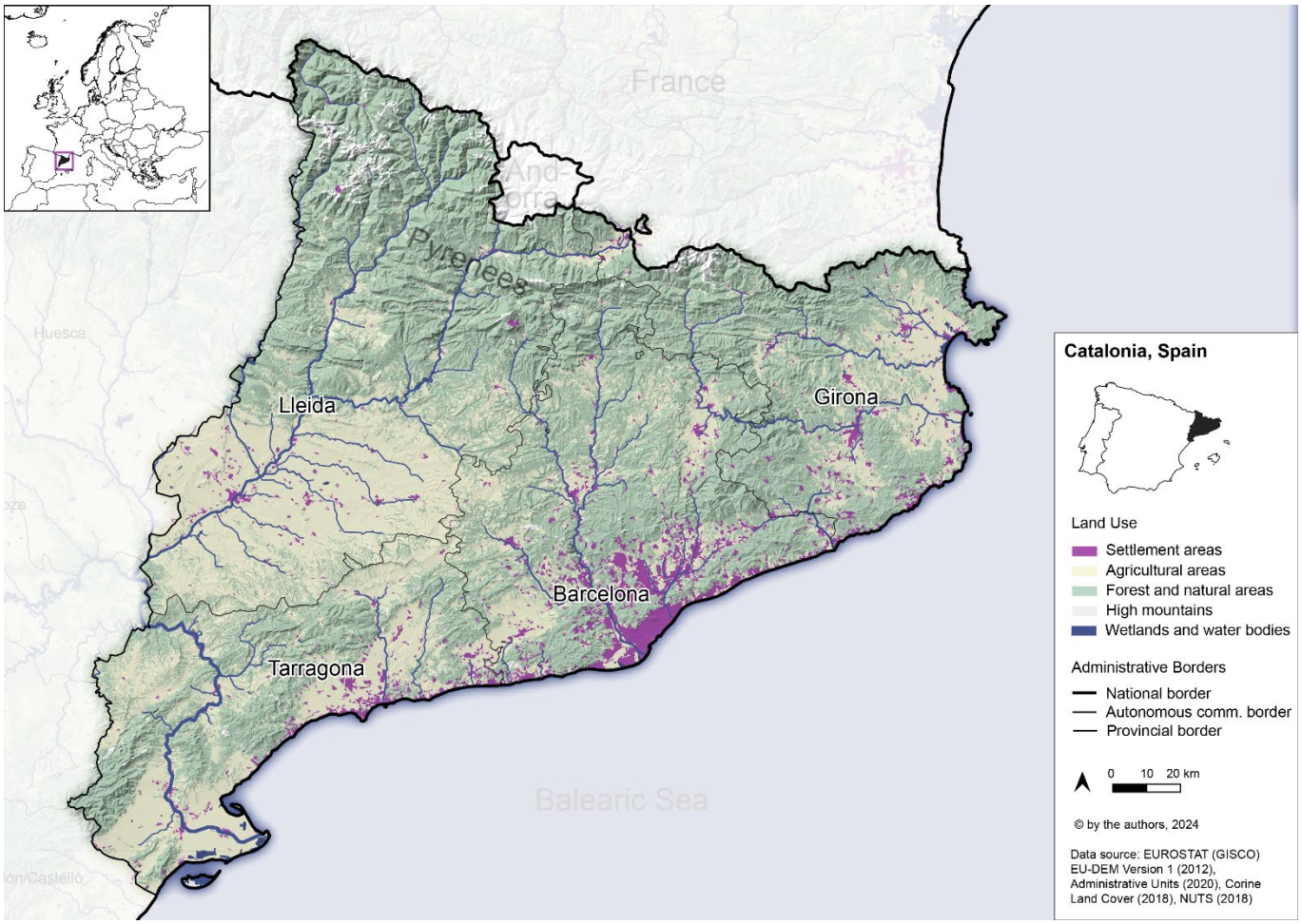

Figure 38. Map of Catalonia (TU Wien, 2024)

7.2. Governance framework

The Generalitat de Catalunya (Government of Catalonia), is the institutional system by which Catalonia is self-governed as an autonomous community of Spain. The government consists of the Generalitat (executive council headed by a president) and a unicameral parliament (Rodriguez, 2024). The Parliament represents the Catalan people, consists of a single chamber, is independent and passes the laws governing the community, as well as controlling the executive. It also approves the annual budget and new taxes (SOIR, 2024). At national level, the region coordinates its efforts with the Ministerio para la Transición ecológica y el reto demográfico (MITECO) (The Ministry for Ecological Transition and Demographic Challenge). Regional bodies for CCA policy advising, drafting and implementation are Catalan Climate Change Office and the Advisory Council for Sustainable Development of Catalonia (CADS), while also several universities (12 public/private universities) are active in research and policy recommendations.

7.3. Strategy framework for regional CCA

At national level, one of the main CCA policy guiding document of Spain is the “National Climate Change Adaptation Plan 2021-2030 (MITECO, 2020)”, aiming to promote coordinated and coherent adaptation action.

In accordance with its competences in matters of environmental protection and definition of public climate policies, the Government of Catalonia approved the “Catalan Strategy for Adapting to Climate Change 2013-2020 (ESCACC20, 2012)”, as the first strategic document on climate change adaptation policies in Catalonia. This strategy was lately followed by the “Catalan Strategy for Adapting to Climate Change 2021-2030 (ESCACC30, 2023)”. The strategy analyses the vulnerability of 17 areas to the risks of climate change and aims for the reduction of the vulnerability of these 17 areas is articulated through 76 operational objectives that are developed through a total of 312 measures. It also highlights actions corresponding to natural systems (forests and forestry), socioeconomic areas (agriculture and livestock) and the general territory (mountains).

Further relevant strategies are **“**The 2030 Agenda: Transform Catalonia, improve the world (CADS, 2016)”, discussing the main challenges that need to be tackled within each of the 16 SDGs in order to successfully meet the common goals and the “Strategy of the Pyrenees Areas of action and main transformative projects (OPCC2, 2023)”, characterizing the Pyrenees regions to develop a vision for the Pyrenees that is based on transformative projects.

8. Factsheet Friuli-Venezia-Giulia

Regional structures, political competencies and development objectives profoundly influence the potential pathways for regional CCA. This factsheet hence introduces the topographic, functional, environmental, and socio-economic characteristics that shape the region structurally, briefly introduces the territorial governance framework to illustrate the region's formal competencies for implementing CCA autonomously and gives and overview to key strategies that frame current regional CCA efforts.

Italy faces significant climate change related challenges, including the increase of natural risks due to drought, hydrogeological instability, floods, forest fires or coastal erosion (CMCC, 2020). In the last twenty years the higher-than-average temperatures and the intensification of extreme weather events have increased the probability of being affected by climate hazards by 9%. This trend is also observable in Friuli–Venezia Giulia, one of the project's replicator regions, bordering Friulian Dolomites and the Upper Adriatic Sea. The region has a temperature increase of about 1°C in the last thirty years, while also changes in precipitation are increasingly affecting local livelihoods and natural environments (AcegasApsAmga & DMG-UNITS, 2014).

8.1. Structural characteristics

Overview of topographic and functional characteristics

Friuli–Venezia Giulia (FVG) is an autonomous Italian region of northeastern Italy, with strong devolved legislative and fiscal powers, bordering Austria to the North, Slovenia to the East, the Adriatic Sea to the South, and the Veneto region to the West. It has an area of 7,847 km^2, comprising the provinces of Udine, Pordenone, Gorizia, and Trieste encompasses a population of 1.19 million people (OECD, 2023; Tikkanen, 2024). Situated in the western part of Italy, with the major towns Udine and Pordenone, the region is consisting of alpine area and a southern plain. After the Second World War, the boundaries of the region expanded to include the city of Trieste (approximately 200,000 residents), the regional capital, along with its immediate surroundings on the Adriatic Sea and the Karst plateau. The rainfall in the North, the highest in Italy, favours the development of natural meadows for livestock, providing ham and dairy products, while also the wine of Friuli is well known. Maize and other cereals are grown in the valley of the Tagliamento. However, the region is economically also specialised in various sectors such as textile, furniture and food industry and tourism (Interreg Mediterranean, 2017). The larger cities—Udine, Pordenone, Gorizia, Monfalcone, and Trieste—have all experienced considerable industrial development, and Trieste is one of Italy's great ports (before 1914 it served most of Central Europe). The region is connected by rail and road with Austria, Slovenia, and Venice and thence the rest of Italy.

Ecosystem and environmental characteristics

The area belongs to the climate type Cfa, characterized by a warm temperature, humid (humid mesothermal) climate with rainfall throughout the year, but also experiences very hot summer season (AcegasApsAmga & DMG-UNITS, 2014, p. 4). The region has a great variety of climates and landscapes, with 42.5% of its surface consisting of mountains, 19.3% of hills (Friulian Dolomites, Carnic Alps, Julian Alps), and the remaining 38.2% of the plains located in the central areas and along the coast (Bajtalan, 2017; Tikkanen, 2024). In the North, the region is therefore characterised by e. g. Monte Croce Pass, the low Tarvisio saddle, and the Tagliamento River valley, considered one of the last morphologically intact rivers in the Alps. The South, it is characterised mostly by its low coastal plain, some of which is occupied by the shallow lagoons of Grado and Caorle. The Southeast extends as a narrow corridor, between the Carso limestone plateau and the Adriatic Sea to the city of Trieste. The region is also one of Italy's most seismically active regions. While the alpine system protects the region from the direct impact of the rigid northerly winds, the opening towards the Po Valley influences the general circulation of air masses from the west to the east.

With that, the region is affected by thunder- and hailstorms, especially in summer times, as well as, being open to the Adriatic Sea, sirocco winds bringing heavy rainfalls (AcegasApsAmga & DMG-UNITS, 2014). The FVG region is one of the rainiest places in Italy, with the city of Udine contending about 1450mm of rain per year. Especially in the Julian Pre-Alps, about 25km in the northeast of Udine (Mt. Canin area), the average annual rainfall exceeds 3m, which is among the highest amount registered in Europe (ibid.).

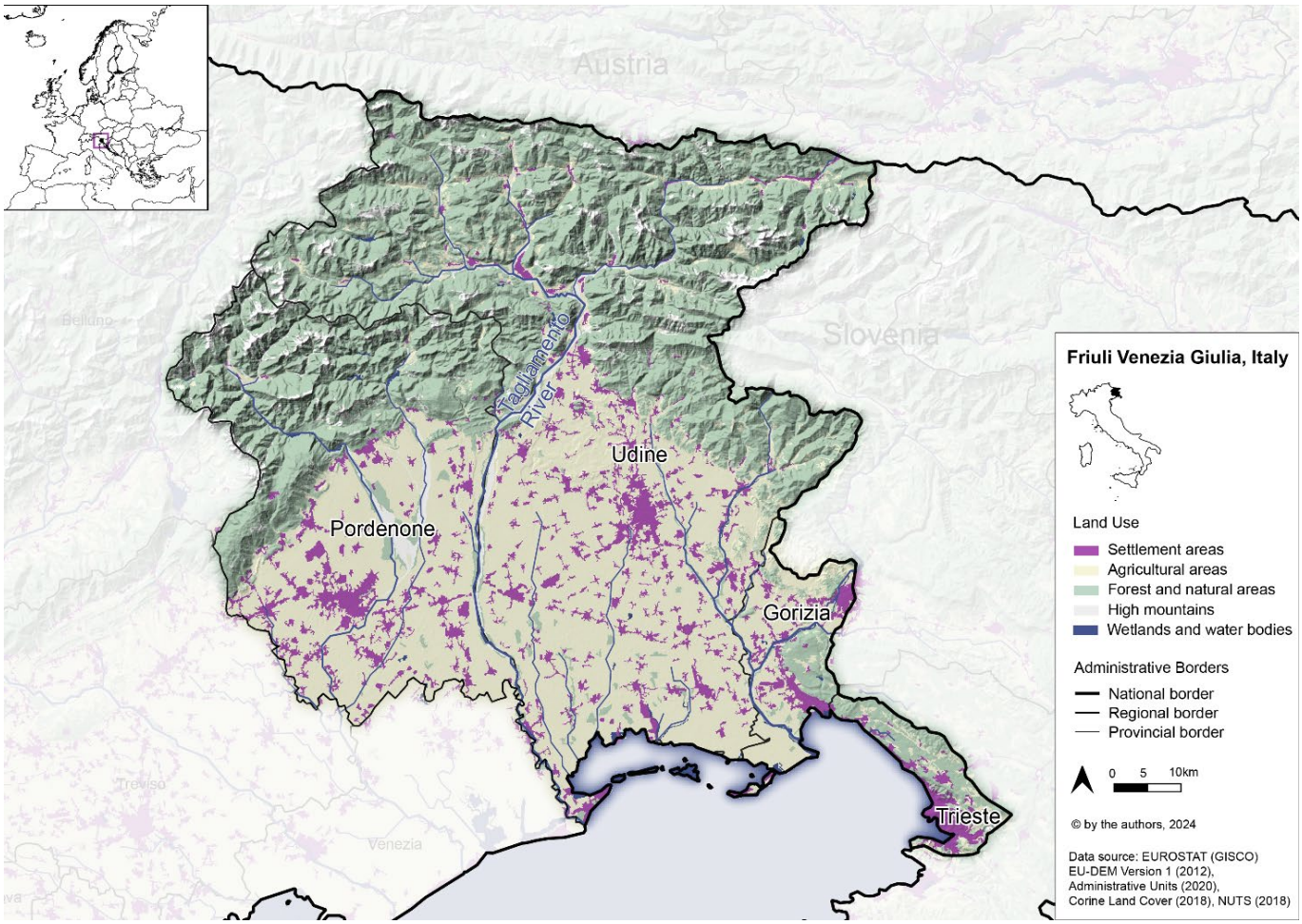

Figure 39. Map of Friuli-Venezia Giulia (TU Wien, 2024)

Climate change in FVG, as in the entire western Mediterranean region, is leading to a decrease in annual precipitation, with mountain and coastal areas being more severely affected (Caloiero et al., 2023). At the same time, in urban and densely populated areas, such as the cities of Trieste, Udine, Pordenone, but also in the tourist areas of Lignano Sabbiadoro and Grado, few green spaces and a high degree of impermeability lead to a high vulnerability to heat (Pagani et al., 2022).

Regional socio-economic profile

FVG is ranked fourth among Italian regions in terms of disposable income while taking the first place among Italian regions when it comes to regional well-being indicators (OECD, 2023). The region demonstrates relatively high-income equality and strong employment rates. The population in Friuli-Venezia Giulia in the year 2022 amounts to 1,194,647 inhabitants (Eurostat, 2022), following a population density of 157.8 inhabitants per km^2, close to the EU average of 109.1 persons per km^2 (Eurostat, 2022) and a total annual change of population of -0.3 persons per year

(crude rate of total population change per 1,000 inhabitants.). The median age of the population was estimated at 50.3 years (Eurostat, 2022). This is the highest median age in comparison to the other MountResilience regions. The employment rate amounts 68.5% in total, whereby the rate is made up by an employment rate of 72.5% of men and 65.0% of women (Eurostat, 2022). The risk of poverty and social exclusion was estimated for 15.5% of the population in FVG (Eurostat, 2022), the lowest rate compared to the other project regions. The regional GDP of FVG in the year 2022 was estimated at € 43,048.67 million (Eurostat, 2022) following a PPS of € 37,600 per inhabitant. The main sectors of FVG are agriculture (with coffee among the most representative products) with 7,800 employees (in 2015) and the engineering industry including metallurgy with 57,000 employees (in 2015) (Regione Autonoma Friuli Venezia Giulia, n.d.).

Table 22. Socio-economic data for FVG, compared to EU average (Source: Eurostat 2022)

	Population density *(per km²)*	**Median age** *(in years)*	**Population change** *(in %)*	**PPS per capita** *(in €)*	**Employment rate** *(in %)*	**Risk of poverty** *(in %)*
Friuli-Venezia Giulia (2022)	157.8	50.3	-0.3	37,600	68.5	15.5
EU-average (2022)	109.1	44.5	+4.0	35,400	74.4	21.6

8.2. Governance framework

The territory of Italy is divided into 20 regions and further into provinces and municipalities, with five of the regions, including FVG, having an autonomous status. Following an own Special Statute (CoR, 2024), the FVG Regional Assembly holds primary legislative power in areas such as agriculture, hunting and fishing, industry and trade, roadways, tourism and culture, and concurrent legislative power in relation to fields such as health, local police, cooperation and taxes. Further, it has supplementary-implementation powers in areas such as education, employment, social welfare, protection of the landscape and cultural assets. In these domains, the region can implement and supplement state law (but cannot repeal it). As a result of the 2001 constitutional reform, which extended the areas in which the Italian regions hold concurrent legislative competencies and which gave the regions greater legislative autonomy, the state holds legislative powers only in expressly defined areas. The Italian ministry concerned with overall CCA provisions is the Italian Ministry of the Environment and Energy Security. It is collaborating with designated regional authorities for strategy implementation, such as the ARPA FVG- Regional agency for environmental protection.

8.3. Strategy framework for regional CCA

At national level, in particular the “National Climate Change Adaptation Strategy” (SNAC, 2015) serves as an important guiding strategy for adaptation measures. Also, in 2022 the implementation plan was released, titled the “National Plan for Adaptation to Climate Change” (PNACC, 2022), to complement the SNAC and support its enforcement. Additional relevant guiding strategies, though not explicitly targeting CCA, are also the “National Strategy for Sustainable Development” (SNSvS, 2017; SNSvS, 2022), the “National Integrated Energy and Climate Plan 2030” (PNIEC, 2019), the “Transition 4.0 Plan (2021)”, the “National Recovery and Resilience Plan” (PNRR,

2021), the “National Strategic Plan for the Common Agriculture 2023-2027” (PAC, 2022), the “National Waste Management Program (2022)”, and the “National Strategy for Circular Economy (2021)”.

At regional level, one of the main actors implementing CCA policies is the ARPA FVG. It publishes strategic reports such as “The report on the state of the environment in FVG” (ARPA FVG, 2018) or “The strategy for the sustainable development of the autonomous region of FVG” (ARPA FVG, 2023). Also, the Universities of Udine and Trieste are involved in the development of new strategies and in CCA research. Further, with a special dedication to the general public, publications such as “Climate Signs in FVG” (ARPA FVG, 2024a) or “Signals from the Climate in FVG” (ARPA FVG, 2024b) are being released. The region proposed an own technical-scientific working group on climate (Universities, ARPA and regional administration) in 2022, to raise awareness towards climate change in the region.

9. Factsheet Primorje-Gorski Kotar

Regional structures, political competencies and development objectives profoundly influence the potential pathways for regional CCA. This factsheet hence introduces the topographic, functional, environmental, and socio-economic characteristics that shape the region structurally, briefly introduces the territorial governance framework to illustrate the region's formal competencies for implementing CCA autonomously and gives and overview to key strategies that frame current regional CCA efforts.

Virtually all sub-regions of the Mediterranean Basin, both on land and in the sea, face great climate change impacts including increasing temperature, changed precipitation and atmospheric circulation, extreme weather events, sea-level and sea water temperature rise, changed salinity and acidification (MedECC, 2020). In the county Primorje-Gorski Kotar, located in the northern part of the Adriatic Sea, Croatia, climate change impacts are already clearly observable. Over the past two decades, rising air temperatures have led to noticeable changes in weather patterns, such as the decrease in the regular alternation of sunny and rainy days and usual changes in wind directions. Instead, longer dry spells followed by sudden and intense rainfalls are causing flash floods, often accompanied by strong winds, particularly during summer storms (Vahtar-Jurković et al., 2024, p. 11). It is projected that while average annual water flows will decrease, dry periods will increase, both in length and in intensity. The availability of drinking water and the water quality is therefore expected to decrease, particularly in the summer months, when climatic factors are most pronounced, and water demand is at its highest. Additionally, the rise in temperature of the Adriatic Sea of 1.4-2.2°C by 2070 is expected to have a significant impact on aquaculture, leading to a reduction or even disappearance of native fish species and an increase in invasive species. The most harmful negative impact is regarded to be the increase of the sea level with an expected rise of 32-65cm by the end of this century, which will particularly endanger coastal and urban areas (Višnja, 2019, p. 17ff).

9.1. Structural characteristics

Overview of topographic and functional characteristics

The Primorje-Gorski Kotar County is one of seven counties along the Adriatic coast in the Republic of Croatia. It shares a northern border with the Republic of Slovenia, a western border with Istria County, an eastern border with Karlovac County, and a southeastern border with Lika-Senj and Zadar Counties. The county encompasses a section of coastal waters, extending to the state border 22km southwest of the island of Susak. Its location makes it a key traffic hub, connecting central and southeastern Europe, as well as parts of western Europe, to the Mediterranean Sea. The land area of the county is 3,587km², while the marine area covers 4,344km².

The port of Rijeka holds a special economic significance in the maritime traffic for the Republic of Croatia. Additionally, there are 27 ports open to public traffic of county-level importance, 74 ports open to public traffic of local-level importance, and 4 ferry lines that function as extensions of state roads (Prigoda, n.d.). Unlike neighbouring counties, it encompasses a larger number of permanently inhabited islands, including Krk, Cres, Rab, Lošinj, and the islands of the Lošinj archipelago: Unije, Ilovik, Susak, and Srakane (Prigoda, n.d.). The county is divided into three functionally distinct units based on various natural, social, and economic parameters. These units — the highland, the islands, and the coastal region — differ significantly in terms of population density and development, each serving as a key development center within the county (Prigoda, n.d.).

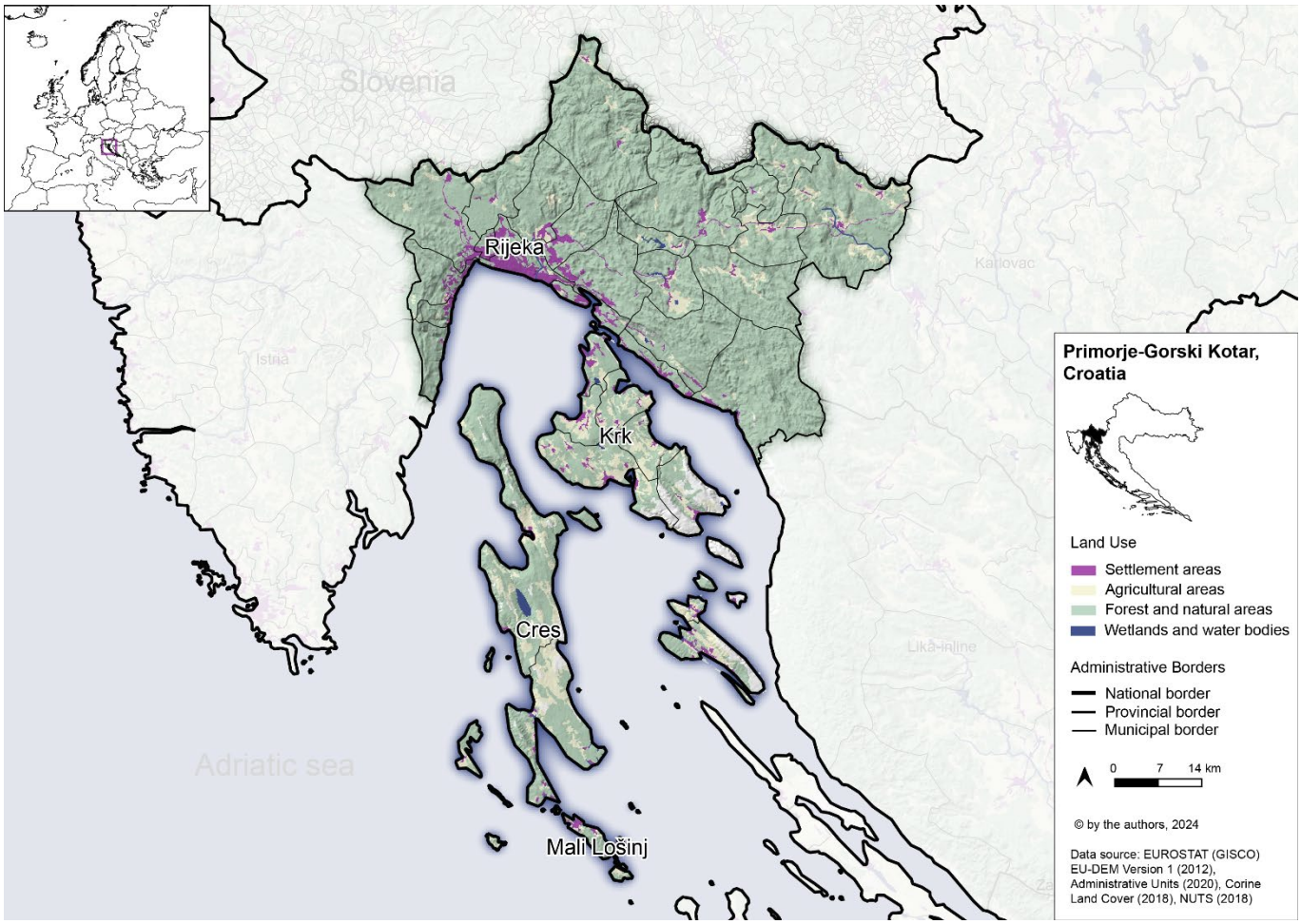

Figure 40. Map of Primorje-Gorski Kotar (TU Wien, 2024)

Ecosystem and environmental characteristics

The three units differ along their relief and climate characteristics. The coastal area is primarily composed of Mesozoic limestone with some dolomite zones, particularly along the northern coast of Rijeka Bay near Kastav and on the island of Cres. Numerous springs emerge from the underground watercourses in the mountainous hinterland, supplying water to the coastline from Opatija to Rijeka and further to Vinodol. These springs provide water for the coastal towns and villages, but their capacity is insufficient to meet today's water-supply demands, especially for tourism. The coastal area experiences a predominantly mediterranean climate. Due to its growing population density and its key location for tourism, transportation, and industry, the coastal area faces significant threats to habitat protection and biodiversity conservation.

The highland area of Gorski Kotar includes plateaus, fields, valleys, high mountain regions, as well as the Dobra and the Kupa River valley. Risnjak National Park, the only national park in the PGK county, is located in Gorski Kotar (Kozlica, Radunovi & Kovaÿiÿ, 2022, p. 6). The highest mountain peaks are Mt. Risnjak (1,529 meters) and Mt. Snježnik (1,506 meters), in the western part of Gorski Kotar, and Mt. Bjelolasica (1,534 meters) and Mt. Viševica (1,428 meters), in the southeastern part. The mountains of Gorski Kotar block the warm influence of the Adriatic Sea from reaching the inland, and their high altitudes lead to increased precipitation levels, resulting in a climate between moderately continental and mountain climate. In Gorski-Kotar, climate change is expected to cause a reduction in

underground water supplies, lowering of the groundwater level and damaging of forest ecosystems (Kozlica, Radunovi & Kovaÿiÿ, 2022, p. 9f).

The island area is characterized by a distinctly mediterranean climate and comprises two groups: the western group with Cres, Lošinj, and several smaller islands, and the eastern group with Krk, Rab, and some uninhabited islets. Kvarner Bay's islands are the largest in the Adriatic Sea by both size and population (Priroda, 2016, p. 19ff).

Regional socio-economic profile

The population in Primorje-Gorski Kotar amounts to 246,560 inhabitants in 2022 (Eurostat, 2022) leading to a population density of 74.1 persons per km^2 (Eurostat, 2022). The total change of population in the same year was estimated at a decline of -2.4 inhabitants per 1,000 inhabitants (crude rate of total population change per 1,000 inhabitants), whereby the change of population as well as the population density differs within the three territorial units (Eurostat, 2022). The population and its density are growing in the coastal area and rather decreasing on the islands and in highlands (Priroda, 2016). The median age of Adriatic Croatia (NUTS 2) is 46.3 years and can be transferred to PGK (Eurostat, 2022), as well as the total employment rate of 64.6% in the age group of 15 to 64 years which differs from 68.5 % for men's employment rate and 60.7% for female's employment rate (Eurostat, 2022). The risk of poverty and social exclusion is 20.5% in Adria Croatia (Eurostat, 2022). The GDP of PGK amounts to € 5,304.55 million, which figures 7.76% of the national GDP (Eurostat, 2022) and a slightly higher Purchasing Power Standard (PPS) of €24,900 PPS per inhabitant compared to the national average (€22,800 per inhabitant for Croatia) (Eurostat, 2022).

Compared to other counties of Croatia, PGK is distinguished by its concentration of economic infrastructure, including international seaport, refinery, shipyards and oil terminals. The manufacturing sector represents 23% of the economy. However, the county is one of the most developed tourist regions in Croatia and in the EU (Prigoda, n.d.). The entire Adriatic-Croatia region recorded the highest number of foreign tourists in Europe (61 million) (Eurostat, 2022). PGK is also characterized by being the largest business and trade zone in Croatia, after the City of Zagreb, it is the most developed county in Croatia (Prigoda, n.d.).

Table 23. Socio-economic data for PGK, compared to EU average (Source: Eurostat, 2022)

	Population density *(per km^2)*	**Median age** *(in years)*	**Population change** *(in % from 2021 to 2022)*	**PPS per capita** *(in €)*	**Employment rate** *(in %)*	**Risk of poverty** *(in %)*
Primorje-Gorski Kotar (2022)	74.1	46.3*	-2.4	24,900	64.6*	20.5*
EU-average (2022)	109.1	44.5	+4.0	35,400	74.4	21.6

**ref. Adriatic Croatia*

9.2. Governance framework

Croatia is a unitary State with three levels of governance: the central level, the regional level with the counties and the local level with the municipalities. While the central level is responsible for overall legislation and execution, the counties have a relatively large share of autonomy regarding matters of interest at their respective levels, which

includes, among others, regional and urban planning (European Committee of the Regions., n.d.). For adopting and implementing county development plans, the counties rely on their respective Regional Development Agencies which function as “regional co-ordinators” and are responsible for guiding strategic planning in order to implement national policies as well identify relevant EU and national funding calls. These responsibilities emphasize the leading role of the Regional Development Agencies, such as Prigoda for Primorje-Gorski Kotar, in Croatia in comparison to other countries (OECD, 2024, p. 79). The local level is self-managing, among others, the organisation of settlement and housing, and protection and improvement of the environment (European Committee of the Regions., n.d.).

9.3. Strategy framework for regional CCA

In line with international and strategic frameworks such as the Paris Agreement (2015), the United Nations Agenda 2030 (2015), the European Strategy for Adaptation to Climate Change (2013[2021]) or the EU’s Green Deal (2019), the “**Climate Change Adaptation Strategy in the Republic of Croatia for the period until 2040 with a view to 2070”** serves as the strategic framework for climate change adaptation on a national level. Climate change adaptation is therein defined as “*a process that implies an assessment of adverse impacts of climate change and taking appropriate measures to prevent or reduce the potential damage they may cause*” (Ministry of Environment and Energy, 2017, p. 6). As part of the development of the very first adaptation strategy, climate models were developed and a vulnerability analysis was conducted. Following the goals of reducing the vulnerability of natural and social systems, increasing their abilities to recover and exploiting their potential positive effects, the adaptation strategy defines priority measures for adaptation action in 10 different sectors, including: water resources, agriculture, forestry, fisheries and aquaculture, biodiversity, energy, tourism, health, spatial planning, and risk management. The adaptation measures are specified in five-year action plans.

The “**Climate Change and Finnish Prime Minister’s Office Action Act”** forms the legal basis for climate change adaptation in Croatia. The legislation stipulates the development and 5-yearly update of a national adaptation strategy as well as the adoption of action plans (Narodne Novine, 2019). Furthermore, it serves as a basis for the regional “**Air Protection, Ozone Layer, Climate Change Mitigation and Climate Change Adaptation Program in Primorje-Gorski Kotar County”.** In this document, conducting a vulnerability analysis and developing an adaptation plan for the coastal area is recommended (Višnja, 2019).

10. Factsheet Subcarpathian Region

Regional structures, political competencies and development objectives profoundly influence the potential pathways for regional CCA. This factsheet hence introduces the topographic, functional, environmental, and socio-economic characteristics that shape the region structurally, briefly introduces the territorial governance framework to illustrate the region's formal competencies for implementing CCA autonomously and gives and overview to key strategies that frame current regional CCA efforts.

Poland is affected by climate change through rising temperatures and occurrences of extreme precipitation leading to various challenges such as river flooding, heat waves and weather extremes affecting agriculture. Since agriculture employs the largest number of skilled workers in Poland (in absolute and relative terms), this sector is particularly important and particularly vulnerable to climate change (Kundzewicz et al., 2018, p. 1516f). Climate change is also affecting he Subcarpathian Region, located in the southeastern Poland on the foot of the Carpathian Mountains. The Carpathians are the second-largest mountain range in Europe and function as one of the most important forests in terms of biodiversity. The temperature in the Carpathians is projected to increase between 3.0°C and 4.5°C by 2100 (UN Environment Programme, n.d.,) and is in need of adaptation policies to build resilience to extreme climate events (Czekaj, 2020). In the city of Rzeszów for instance, the climate change related increase of heat waves, average annual temperature and extreme precipitation (resulting in sudden urban floods), negatively impact the public health and specifically vulnerable groups, the water management, the transport system and the tourism sector (Rzeszów City Council, 2019).

10.1. Structural characteristics

Overview of topographic and functional characteristics

The Subcarpathian Region (Podkarpackie Voivodship) is located in the southeastern part of Poland. It shares borders to the north and west with the Małopolskie, Świętokrzyskie, and Lubelskie Voivodships, to the south with Slovakia, and to the east with Ukraine. The Voivodship encompasses three distinct physiographic regions: the Sandomierz Basin in the north, the Carpathian Foothills in the central area, and the Beskids in the south, which are further divided into the Beskid Niski and the Bieszczady Mountains. Additionally, the northeastern part of the Voivodship extends into the Roztocze range. The total area of Podkarpackie Voivodship amounts to 17,845km^2, representing 5.7% of Poland's total land area. Of this, 54.0% is agricultural land, 39.0% is forested or covered by wooded and shrub areas, 5.0% is developed or urbanized land, and the remaining 2% consists of other types of land. The largest city and simultaneously the capital is Rzeszóv, which is surrounded by various medium and small towns. The size structure of the cities is characterized by many small towns with less than 5,000 inhabitants (amounting to 40% of all cities) (Center for Statistical Research and Education of the Central Statistic Office, n.d., p. 15ff). The province is divided into 21 powiats (equivalent to a county/district), 4 cities with powiat rights and 160 municipalities. (Czekaj, 2020, p. 21).

Ecosystem and environmental characteristics

The Subcarpathian Region is situated in a region with a moderate climate that exhibits transitional characteristics between maritime and continental climates. Within the region, three primary climate zones can be identified: the mountainous area, which includes the Bieszczady, Beskid Niski, and Sanocko-Turczańskie Mountains; the submontane region, encompassing the Carpathian Foothills; and the sub mountainous basins, such as the Sandomierz Basin. Additionally, certain areas in the Low Beskids, like Rymanów-Zdrój, experience a climate typical of mountain resorts (Center for Statistical Research and Education of the Central Statistic Office, n.d., p. 15ff).

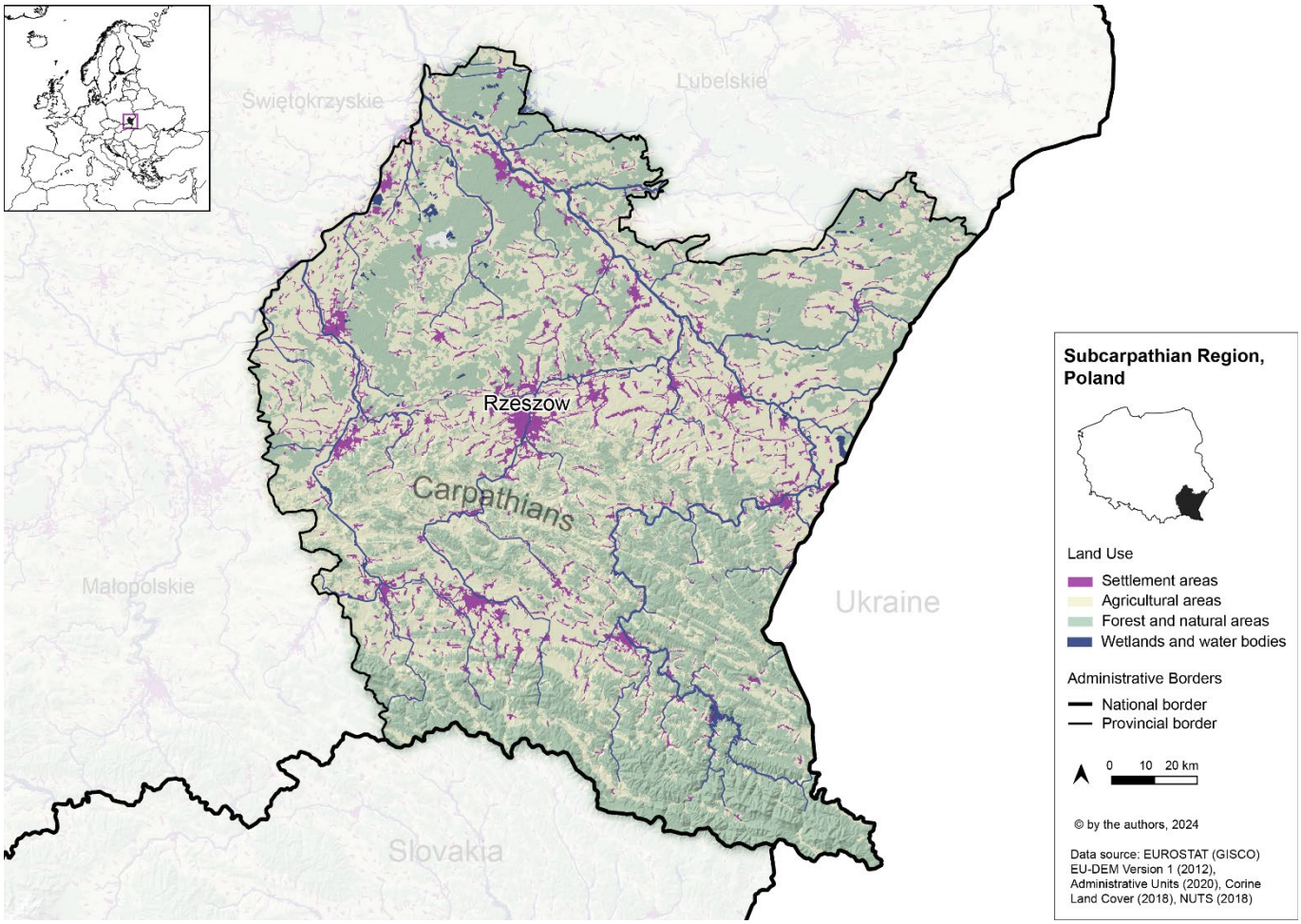

Figure 41. Map of Subcarpathian Region (TU Wien, 2024)

Regional socio-economic profile

In the Subcarpathian Region, the total population amounts to 1,968,616 inhabitants in 2022 (Eurostat, 2022). The total population decline amounts to -3.2 inhabitants per 1,000 inhabitants annually (crude rate of total population change per 1,000 inhabitants) (Eurostat, 2022) following a population density of 117.6 persons per km^2 in the year 2021 (Eurostat, 2022). As in all of Poland recently, the region is facing an increased risk of an ageing population. The median age of the population was estimated at 41.8 years (Eurostat, 2022). Withing the age group of 15 to 64 years the employment rate was estimated to be 63.4% in 2022, the second lowest in comparison to the other project regions and characterised by a comparatively high gender gap (70.5% employment rate of men, 56.1% employment rate of women) (Eurostat, 2022). In 2022, the GDP in the Subcarpathian Region amounted to € 24,486,83 million (3.7% of the national GDP) (Eurostat, 2022). The Purchasing Power Standard (PPS) of the inhabitants in the Subcarpathian Region in 2022 numbers € 19,100 PPS per inhabitant (Eurostat, 2022). 19.0% of the population living in the region were estimated to be at risk of poverty or social exclusion (Eurostat, 2022). A unique selling point of the Subcarpathian region is the high concentration of aerospace companies as well as various science and research centres and IT companies, the latter also being one of the fastest growing industries in the region, as well as the automotive sector (Podkarpackiego, n.d.). In terms of employment, the main business activities were conducted in the sector trade and repair of motor vehicles, construction and industrial processing (Center for Statistical Research and Education of the Central Statistic Office, n.d., p. 25).

Table 24. Socio-economic data for Subcarpathians, compared to EU average (Source: Eurostat, 2022)

	Population density *(per km²)*	**Median age** *(in years)*	**Population change** *(in % from 2021 to 2022)*	**PPS per capita** *(in €)*	**Employment rate** *(in %)*	**Risk of poverty** *(in %)*
Subcarpathian Region (2022)	117.6 *(2021)*	41.8	-3.2	19,100	63.4	19.0
EU-average (2022)	109.1	44.5	+4.0	35,400	74.4	21.6

10.2. Governance framework

Poland as a unitary state is organised at three levels: voivodships or regions, counties and municipalities. The governance of Poland and its administrative units is subject to the principle of decentralization. The voivodships therefore have executive power, bundled and executed in the voivodship executive board as well as legislative power, represented through the respective regional assemblies in matters of regional interest. They are authorized to assigning various sectors, including spatial planning and environmental protection. However, according to the Constitution, the basic unit of local self-government is the municipality, which also holds authority over multiple sectors of local interest, among others environment and nature protection (European Committee of the Regions, n.d.).

10.3. Strategy framework for CCA

The current strategic framework for climate change adaptation in Poland is the “Polish National Strategy for Adaptation to Climate Change by 2020 with the perspective by 2030” from the year 2013 (SPA2020)”, with the aim “*to ensure conditions for stable socio-economic development in the face of the risks posed by climate change, but also with a view to using the positive impact that adaptation activities can have not only on the condition of the Polish environment, but also on economic growth*.” (Ministry of the Environment, 2013, p. 5) This plan is part of a broader research project called KLIMADA, (c.f. KLIMADA), which functions as an official platform for national adaptation information. The “SPA2020” has not been updated since its publication and although the strategy was in line with international and EU regulations with regards to CCA, Poland’s previous government had brought lawsuits against four EU climate policies. However, the new government under the Polish Prime Minister Donald Tusk is going to withdraw these lawsuits (Abnett & Strzelecki, 2024).

The project "Development of Urban Adaptation Plans for cities with more than 100,000 inhabitants in Poland” (2015-2018 (cf. 44mpa) has been implemented by the Ministry of Environment/Climate and has assessed the sensitivity and vulnerability to climate change in 44 Polish Cities. The project resulted in the development of adaptation measures for the identified risks for each city which are bundled in adaptation plans (Republic of Poland, n.d.). The plan for the city of Rzeszów “Climate Change Adaptation Plan for the City of Rzeszów until 2030” has already been published.

11. Annex

11.1. Conceptual understanding

The concept of climate change risks and their impacts, as highlighted in the AR5 (IPCC, 2014), is embedded in two major domains of natural and anthropogenic climate variabilities and overall socioeconomic process (Figure 42). Building on this understanding and our research framework (Deliverable D1.1), a concept for the study of regional CCA governance was developed (D1.2). Risk of climate-related impacts result from the complex interaction between climate-related hazards and the place-specific vulnerability and exposure of human and natural systems. We therefore first apply a systemic risk assessment. This initial assessment of immediate climate risks for each Demonstrator Region is based on the respective climate impact chains (IC). While primarily addressing ecological and biophysical risks, socio-economic vulnerabilities are also included to reflect on the socioeconomic processes of the region.

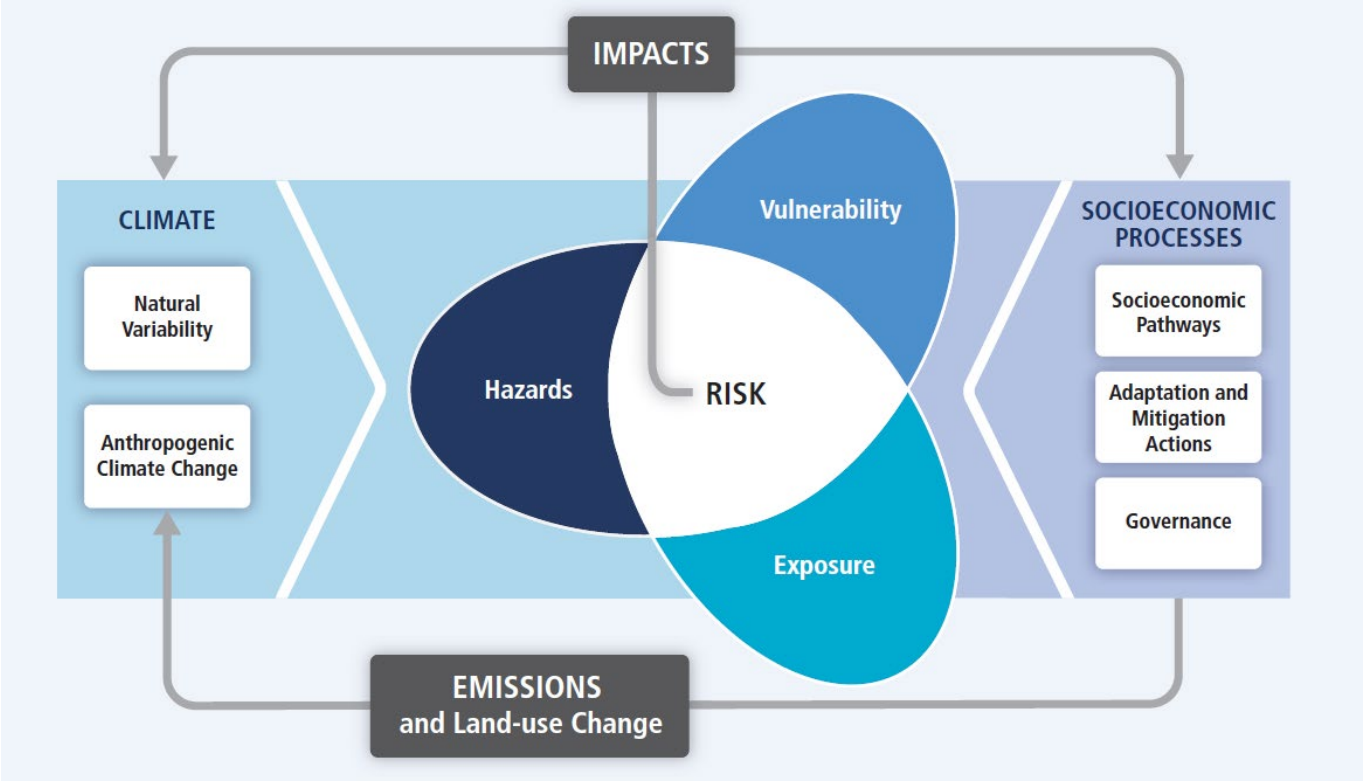

Figure 42. Conceptualisation of systemic risk (Source: IPCC, 2014, p. 3).

Socioeconomic processes are path-dependent, they are deeply entrenched in historically established structural and institutional conditions, cultural value systems, preferences or well-proven governance arrangements. They shape the social and economic trajectory of a region. Together, these factors heavily influence the future pathways for regional development, particularly in terms of transformative CCA. Accordingly, the regional baseline differentiates three fundamental aspects of the socioeconomic process for analysis:

- ***Socioeconomic pathways:*** *based on a structural overview of the region's physical and functional geography, basic statistical data on its socio-economic structure, and its identity and self-image.*
- ***Regional CCA governance:*** *based on the prevailing political approaches to and interpretations of CCA in the respective region, the associated objectives, policies, and stakeholders, as well as the modes of engagement to successfully address CCA locally.*
- ***Adaptation actions:*** *based on concrete regional measures and projects tackling specific CCA challenges and relevant for transformative change.*

Using an interpretive approach, the different layers of analysis allow for carving out the key spheres of a regional **'Adaptation activity space'** (2015) and how these translate into concrete **transformative capacities** for transformative adaptation in the respective MountResilience region (Figure 43).

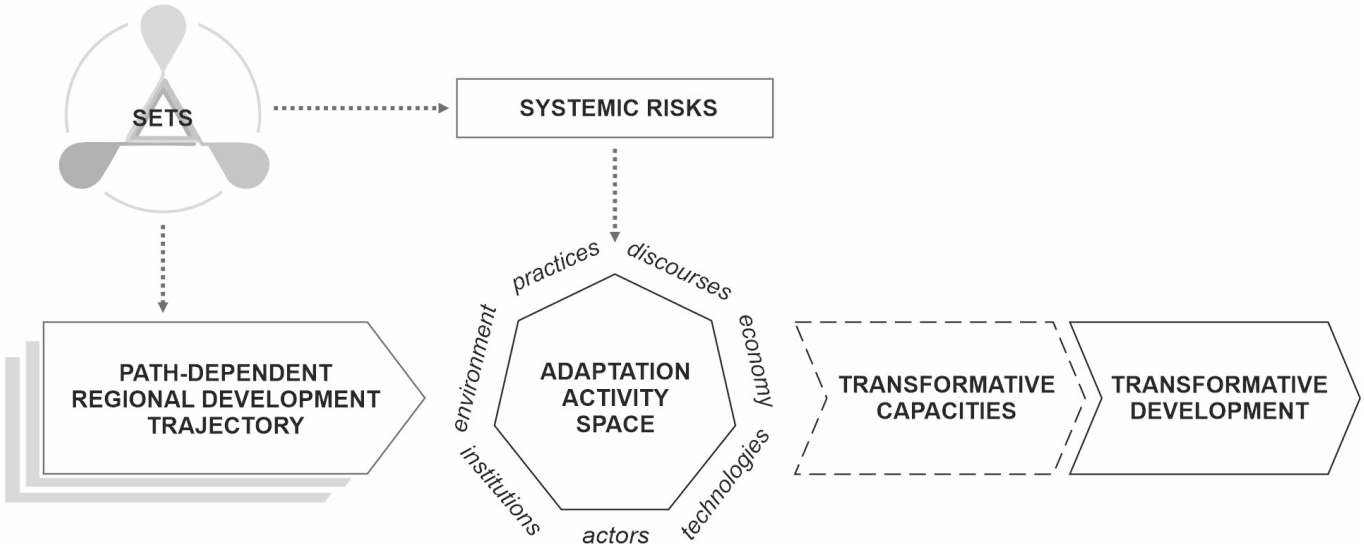

Figure 43. Conceptual understanding of transformative regional development (TU Wien, 2024)

The concept highlights the interactions between actors and spheres, pointing towards the ability of actors to influence local structures, while also allowing to address the negotiation processes within the various spheres of the activity space (ibid. p. 119). The concept is rooted in **Social-Ecological-Technological Systems** (SETS) as the holistic foundation of determinants of local transformative development (McPhearson et al., 2022). Following this understanding, SETS shape not only the **path-dependent regional development** trajectory, but also the **systemic risks** associated with a region. Together, the regional trajectory and the systemic risks thus determine the scope and constraints for 'doing' regional CCA in the adaptation activity space. The comprehensive combination of regional governance factors results in the depiction of concrete **transformative capacities,** important for transformative adaptation to come to fruition. The introduced approach forms the basis for the formulation of consolidated **conclusions** regarding regional adaptation challenges and opportunities. It also provides takeaways for the implementation of the respective DA and other regional CCA activities, thereby contributing to the enhanced understanding and effective application of CCA for transformative development in European mountainous regions.

A conceptual embedding in Social-Ecological-Technological Systems thinking & systemic risks

The most prominent systemic approaches to transformation guiding our understanding are the Socio-Ecological Systems (SES), the Socio-Technical Systems (STS) and, further extending both, the **Social-Ecological-Technological Systems (SETS)** approach. While the SES and STS approach recognise helping to better

understand human-nature and human-technology relations (Cote & Nightingale, 2012; Smith & Stirling, 2010), the SETS Framework (McPhearson et al., 2022) develops this understanding further. It points towards the explicit systemic interactions and interdependencies by focusing on linkages among broadly defined social, ecological, and technological dimensions of complex systems. In particular, it allows a detailed perspective on nature-based solutions, best understood within their social, ecological, and technical-infrastructural dimensions, providing viable solutions to present climate change challenges inspired and supported by nature (Frantzeskaki, 2019).

Risks, in the context of climate change, are being determined by exposure and vulnerability to impacts of extreme and non-extreme weather and climate events (Cardona et al., 2012). They are also understood as the potential for adverse consequences for human and ecological systems. With vulnerability and exposure posing non-static processes, that vary across spatial and temporal scales, they are dependent on economic, geographic, cultural, institutional, governance as well as environmental factors (ibid p. 67). Therefore, the actual exposure to risks emerges as a result from dynamic interactions between climate-related hazards with affected human or ecological systems and their ability to cope and adapt to the impacts. Overall, together with the need to engage stakeholders in discussions on climate-related impacts, the planning of adaptations to climate change requires a deep understanding of how climate-related impacts cascade across sectors of society (Estoque et al., 2022).

The **Impact Chain (IC) Approach** further helps to map the potential climate risks and vulnerabilities and describe climate impacts as cause-effect relationships within a socio-ecological system along three steps: (1) **climate stimuli** (e.g. droughts, floods, and shifts in climatic regimes); (2**) direct climate impact** (consequences of changing climate stimuli, which can be both biophysical and social); and (3) **indirect climate impacts** (secondary effects that result from direct climate impacts).

Transformative adaptation

According to Fedele et al. (2019), there are **numerous barriers for the implementation** of transformative adaptation measures, leading to a preference for choosing rather simpler coping or incremental adaptation responses (Figure 44). These barriers range from a lack of social or political support, a tendency to adapt through business-as-usual strategies, and lacking familiarity with alternative strategies, to the uncertainty about outcomes, power imbalances, and rigid governance structures (ibid. p. 117). Looking at examples from agricultural land use, Fedele et al. (2019) identify the main stages towards transformative adaptation in the inaction of systems suffering from climate impacts, moving towards coping strategies out of necessity. With growing pressure for alternative solutions, these may lead towards incremental adaptation, and in combination with a more holistic approach, builds the basis for actual transformative adaptation that is replacing prevailing status-quo approaches to development.

The potential to link transformation with CCA was early pointed out in the IPCC's AR5 report (IPCC, 2014, 513 ff.), **raising awareness towards the need for moving from incremental adaptations to systemic, transformational approaches**. Still, the recent IPCC synthesis report (IPCC, 2023, p. 27) highlights that most approaches to adaptation remain fragmented, small in scale, incremental, sector-specific and more focused on strategies and plans than on actual implementation, while many funding, knowledge and practice gaps remain present. Building on the understanding of transformative adaptation as changing "*the fundamental attributes of systems in response to actual or expected climate and its effects*" (IPCC, 2023, p. 839), this approach helps to overcome soft adaptation limits and generate adaptation of broader aspects of development through more holistic adaptation activities (Few, Morchain, Spear, Mensah, & Bendapudi, 2017, p. 6). Pelling et al. (2015) note that transformative adaptation goes beyond the preservation of status-quo adjustments for functional persistence, it challenges the doings and functioning of regional systems and their broader networks to respond with novel solutions to actual challenges.

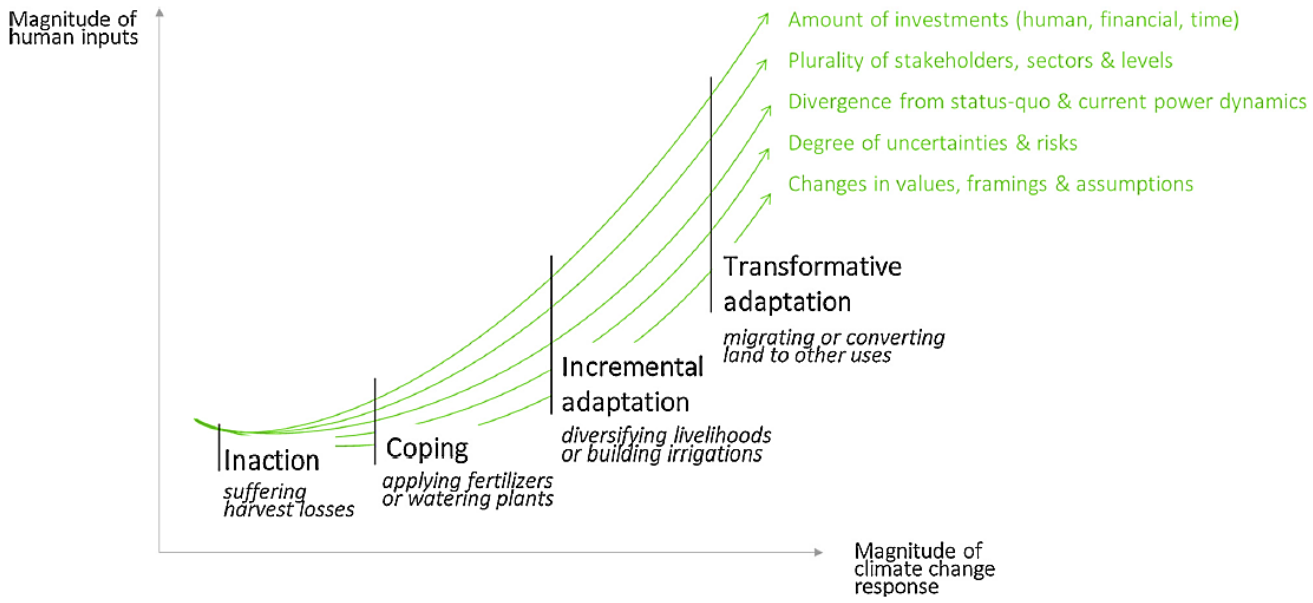

Figure 44. Strategies towards transformative adaptation (Source: Fedele et al., 2019, p. 117)

On place and paths: Path-dependency, regional trajectories, and adaptation pathways

Understanding path dependence as "*a process or effect that is locally contingent and locally emergent, and hence to a large extend 'place dependent'*" (Martin & Sunley, 2006, p. 3), the concept helped to provide answers for the continuity of place dependent economic activities, shaping regional development responses (Martin, 2010). Path dependence and path creation as well as new path development (Grillitsch & Sotarauta, 2020) are key concepts of evolutionary economic geography helping to understand regional economic development trajectories and reginal processes, "*in which previous events affect the probability of future events to occur*" (Boschma & Frenken, 2006, p. 281). Calling for a more comprehensive understanding of new regional economic activities, new multi-actor and multi-scalar approaches to regional economic development have been proposed (Grillitsch & Sotarauta, 2020; Hassink, Isaksen, & Trippl, 2019). Though the discussion on path dependence and path development mostly focussed on economic development at its core, it emphasised the place-dependency of regional development processes and the need for a comprehensive understanding of the regional actor, governance and socio-economic landscapes. Therefore, Hassink et al. (2019) emphasise the need for (1) an application of a multi-actor framework, together with (2) a multi-scalar approach that includes extra-regional factors, while (3) exploring regional development visions and expectations and (4) considering inter-path relations and local interdependencies.

Adapting to climate change poses an enormous challenge for society, with decision making being constrained by societal norms, knowledge forms and values as well as preferences guiding future goalsetting (Colloff et al., 2016). As sustainable development and CCA measures are facing significant complexity and are at the same time co-shaped by uncertain eco-social challenges, planning approaches promoting adaptability increasingly need to accommodate changing conditions over time (Werners, Wise, Butler, Totin, & Vincent, 2021). The notion of **adaptation pathways** addresses decisions and measures sequenced in time to achieve future goals with adaptation responses, considering path dependency, decision sequencing, and timeframes (Colloff et al., 2016; Werners et al., 2021; Wise et al., 2014). As such, this allows for the identification of different adaptation options, but also for understanding how changes in pathways have occurred (Fazey et al., 2018).

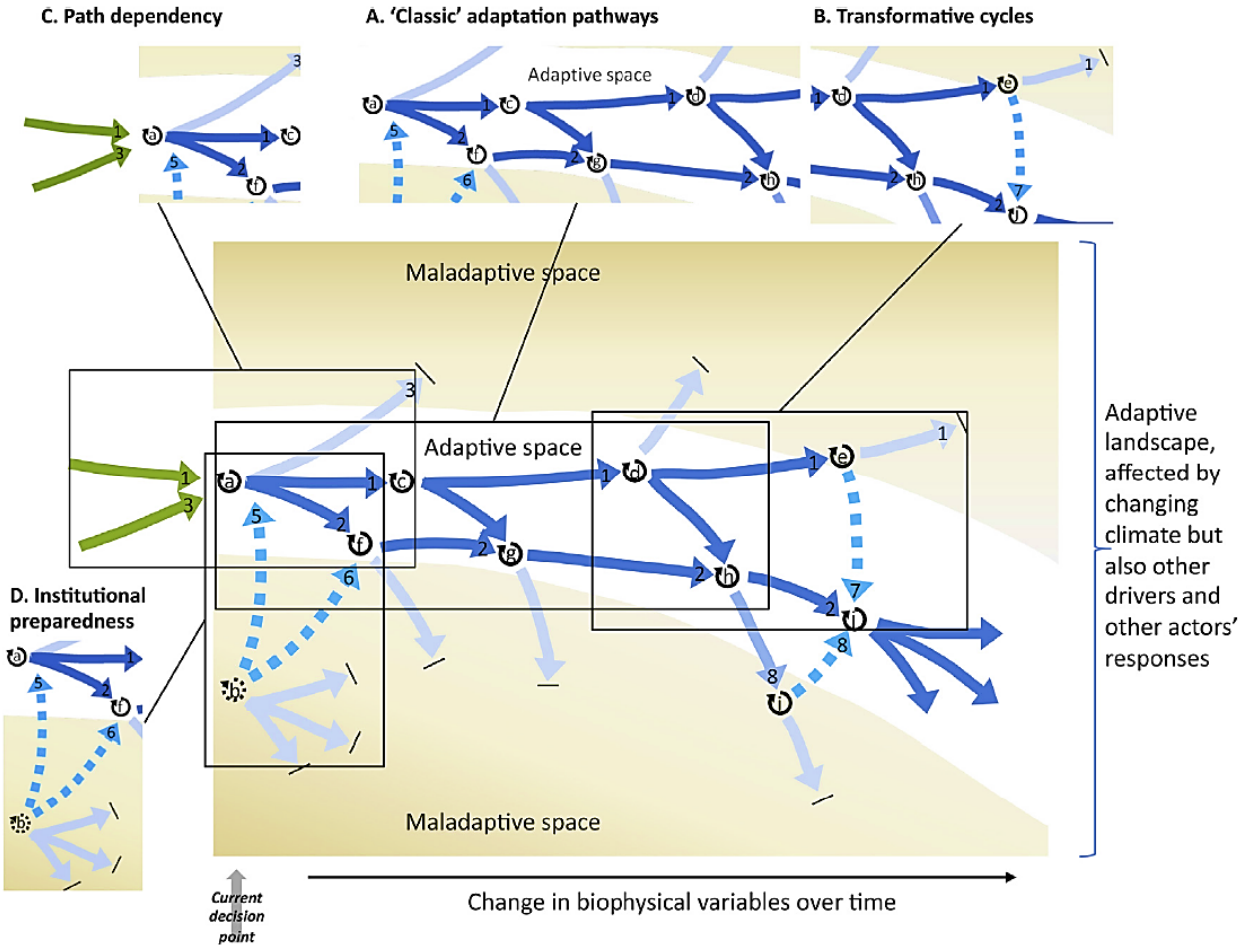

Figure 45. Adaptation pathways (Source: Wise et al., 2014, p. 333)

Wise et al. (2014, p. 325) consider the implications of path dependency as interactions between adaptation plans, vested interests, global change, and situations where values, interests, or institutions constrain societal responses to change. Therefore, they differentiate between 'classic' adaptation pathways, path dependency and transformative cycles to assess the actual 'adaptive space', institutional preparedness and change over time (Figure 45). With the 'classic' view on CCA often ignoring the embeddedness of adaptation in social processes (Câmpeanu & Fazey, 2014), the concept of adaptation pathways helps to steer attention towards the decision-making process and its cultural, political, economic, environmental and developmental context that crosses spatial scales, sectors and jurisdictional boundaries.

"Doing" regional CCA: Introducing the adaptation activity space

Pelling et al. (2015) formulate the adaptation activity space as a conceptual lens, aiming to identify spaces in which transformation (and other adaptive actions) can be observed. The seven interrelated activity spheres are essentially co-evolving with time, with each bearing a transformative potential. The concept allows unpacking the systemic components where transformation is already taking place or could be induced (Pelling et al., 2015). We apply this concept to systematically analyse different spheres of relevance regarding CCA governance and actions on the regional level. The spheres, co-evolving though history, are interrelated and "*each activity sphere itself is capable of transformation as a result of internal processes of change, as well as in response to changes in surrounding spheres*" (Pelling et al., 2015, p. 120). Asking about the relative significance, phasing and direction as well as interaction of

individual activity spheres in specific cases of transformation, the authors address power relations that shape the content and interactions of spheres, opening or closing spaces for transformation, incremental adjustment and future resistance.

Table 25. Spheres of the adaptation activity space (cf. Pelling et al., 2015, p. 119)

Spheres as in Pelling et al., 2015	MountResilience Spheres	Description
Individuals *(values and identity)*	Actors	Actors and stakeholders with active roles in regional CCA (both factually and envisioned), their significance for transformative change, and their interactions (if any).
Technology *(material or orgnaizational)*	Technologies	Material interventions, such as engineered structures, new seed varieties, watershed-management tools, early warning systems, and innovation in organization structure and function.
Livelihood *(production & labour)*	Economy	Economic trajectory of a region (e.g., dominant, identity-forming sectors), and how this trajectory and a regional workforce are affected by climate change and CCA actions (both positively and negatively).
Discourse *(popular and policy)*	Discourse	Concepts, strategies and visions that provide system and normative knowledge, aspirations, future visions and scenarios for CCA and suggest place-specific strategies for (transformative) adaptation.
Behaviour *(practices and routines)*	Practices	”Ways of doing things” (traditional or established) in the everyday lifeworlds of regional individuals that are either endangered by climate change or serve as levers of adaptation and transformation.
Environment *(biotic and abiotic)*	Environment	Actual physical structures and environmental system conditions as analysed in the systemic risk assessment.
Institutions *(regulatory and cultural)*	Institutions	Rules and regulations that play a significant role on framing regional CCA actions.

Towards climate action: Adaptation can be understood as key types of adaptation actions

Adaptation as “*the process of adjustment to climate effects to moderate the negative impacts and/or enhance the positive impacts of climate change*” (Fankhauser, 2017, p. 210), is an essential response to climate change. The Paris Agreement set the agenda for global political action towards adaptation, placing adaptation along with the urgency for mitigation efforts. However, adaptation to climate change continues to pose numerous challenges in practice (Fankhauser, 2017). While social and ecosystems have always adapted to changing climatic conditions, adaptation is by no means automatic. It requires knowledge, planning, coordination, and foresight (ibid.). With prevailing knowledge gaps, behavioural barriers, and market failures blocking effective adaptation, effective and holistic interventions are needed To ensure comparability, we are relying on the common framework and reporting approach developed by the ‘European Topic Centre on Climate Change Impacts, Vulnerability and Adaptation’ (ETC/CCA), distinguishing five key type measures, proposed as: (1) governance and institutional, (2) economic and

finance, (3) physical and technological, (4) nature based solutions and ecosystem- based approaches, as well as (5) knowledge and behavioural change targeting measures (Leitner et al., 2020).

Moving from adaptive to transformative capacity

Adaptive capacity is the "*ability of systems, institutions, humans and other organisms to adjust to potential damage, to take advantage of opportunities or to respond to consequences*" (IPCC, 2022, p. 2899). However, the determinants for adaptive capacity differ greatly based on their scale and interdependencies (Smit & Pilifosova, 2003). Whereas a high adaptive capacity does not automatically lead to actual adaptation or transformation on an individual or household scale, (multi-level) governance of adaptation in particular poses an important enabling condition for planning, implementing, monitoring and evaluating adaptation action (Mortreux, O'Neill, & Barnett, 2020).

The adaptive capacity discourse, however, has been criticized for not properly considering the comprehensiveness of the transformation issue. A number of authors have thus contributed to the development of a thorough understanding of transformative capacity as an advancement of adaptation discourse (Shahani, Pineda-Pinto, & Frantzeskaki, 2022; Wolfram, 2016; Ziervogel, Cowen, & Ziniades, 2016), better serving as a practical guide for regional policy- and decisionmakers, communities and practitioners on how to engage in transformative change. Overcoming a focus on mere adaptation responses towards more long-term transformative change, the concept of transformative capacities offers a perspective on the wider interplay, forming a systemic perspective. In particular, the framework proposed by Wolfram's (2016) of ten adaptive capacities addresses organizational visions, work culture, structures, skills, human and material resources, but also community participation, relations, networks and institutions, and the understanding of existing systems (Table 26).

Building on these observations, Wolfram proposes the following 10 TCs, with first three referring to forms of agency and interaction, 4-8 reflecting the core development processes, while 9 and 10 addressing relational dimensions affecting all other capacities (ibid. p. 126). Following Wolfram's (2016) understanding we aimed at embedding the approach in the guiding questions for our regional assessments to better address power imbalances, changes and opportunities for transformative change.

Table 26. Transformative capacities (authors' elaboration following Wolfram, 2016)

Transformative Capacities	Guiding Questions
Inclusive & multiform governance *… with wide stakeholder participation and cross-sectoral diversity*	• Are actors broadly involved in CCA actions and what does cooperation look like – (in)formal, contractual, hierarchical? • Are there intermediary actors engaged in regional CCA? • What does CCA governance look like – cooperation, funding, regulations, strategies, …?
Leadership *… polycentric, socially embedded, allowing for the articulation of new visions*	• Who are initiators of CCA action or key agents of change? • Is there political commitment and action to adapt to climate change?
Empowered & autonomous communities *… with access to resources and able to form coalitions*	• Are there independent or interdependent regional interest groups addressing CCA and how are they dealt with?

System awareness & memory *… with shared understanding of relevant systems dynamics, path dependencies and opportunities*	• What is the level of awareness regarding CCA, its consequences and systemic interdependencies? • Are CCA actions monitored and accessible to interested actors?
Foresight *… targeting transformational knowledge, transdisciplinarity, collective visions and alternative scenarios*	• Is there a shared vision for regional CCA and does it provide orientation for regional activities? • What is the foundation for a shared vision? • Do regional (CCA) scenarios or prognoses exist?
Practical experimentation *… enabling path-deviant projects/practices*	• Is the region experienced with innovation, experimentation, unconventional projects and practices or novel solutions?
Innovation embedding *… access resources, remove innovation barriers, add innovations to local routines, organisations and (legal) frameworks*	• Are financial or other resources for CCA accessible? • Are CCA innovations embedded into regional legal and/or organisational structures?
Reflexivity & social learning *… support the development of assessment skills while critically engaging and managing transformational knowledge production*	• Is there an active monitoring, evaluation and learning connected to CCA activities? • Are assessment, reflection and learning institutionalised in programs or governance processes?
Working across agency levels *… supporting outreach to different groups and society at large*	• Are multiple societal spheres, stakeholders and actor groups addressed with CCA activities?
Working across political-administrative levels and geographical scales *… considering multi-scalar interactions and interdependencies of systems*	• (How) are interactions across sectors, scales and competencies addressed?

11.2. Methodology

Given the complexity and heterogeneity of the regional dynamics shaping CCA responses, we followed a **mixed-methods research design** (Poth, 2023). We therefore combine regional structural data analysis and systemic risk analysis (SRA) with policy-document analysis, expert interviews and regional online-workshops that discussed and further improved our findings with local communities in all six involved Demonstrator Regions.

Following our conceptual understanding for transformative regional development (cf. chapter 6.3), we firstly **conducted a systemic risk assessment (SRA)**. An SRA identifies and analyses the multiple levels of interdependencies and cascading effects of CC. It determines the main climate risk(s) the region faces and their impact on other aspects of the regional socio-ecological system, providing an informed foundation for the development and implementation of effective transformative adaptation activities.

To perform this SRA, we employed the method of climate impact chains (IC). This method links climate stimuli with subsequent impacts in the regional system. ICs are conceptual models used to describe climate impact as cause-effect relationships within a socio-ecological system. It can be leveraged as a tool to facilitate understanding, systemization, and prioritization of risk drivers in a system of interest. The concept was first developed in 2013 to assess climate vulnerability in the alps (Schneiderbauer et al., 2013) and has since been used in a variety of vulnerability assessments and adaptation planning (Buth et al., 2015; Fritschze et al., 2014; Menk et al., 2022). IC

framework conceptualizes climate risk in line with the IPCC Risk Assessment concept (GIZ and EURAC, 2017). The ICs should support the identification of root causes of climate risks in the region-specific context. This serves as the basis for transformative climate change adaptation, by identifying the root causes of the climate risks, and highlighting at which points adaptation activities can be most effective. This way, maladaptation can be prevented. The following will explain important concepts that together comprise the climate impact chains used in this project.

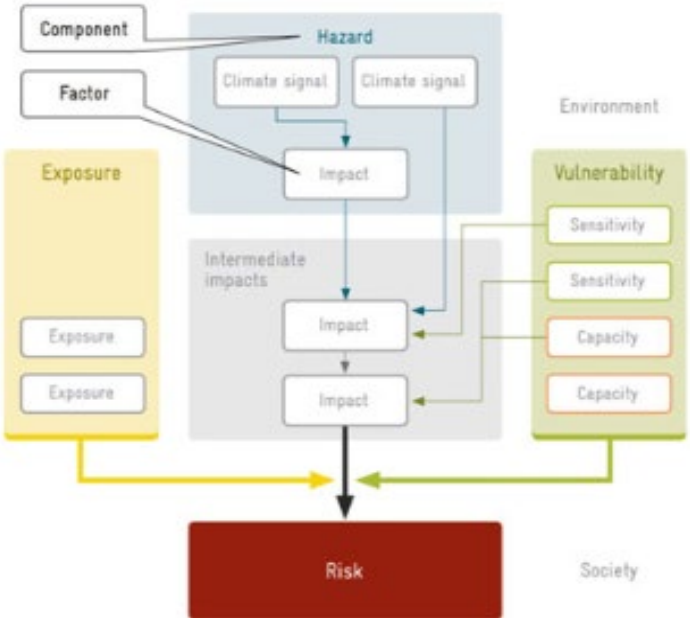

Figure 46. Model for Climate Impact Chain (Source: Zebisch et al., 2022)

Risk, in the context of climate change impacts, is a composite indicator comprised from climate-related hazards, exposure, and vulnerability of the system of interest (IPCC 2014). The different terms are defined as follows:

- ***Climate-related hazards*** *- The current climate conditions and how they will change in the future. These conditions will determine the likelihood of an area being affected by either extreme events, such as heatwaves, or slow onset events such as sea-level rise.*
- ***Direct and intermediary impacts****: These are the direct consequences of the climate hazard, e.g. flooding from extreme rain or drought from lack of precipitation. These may have other consequences (such as flood damage), which are the intermediary impacts.*
- ***Vulnerability*** *- The tendency of the exposed system and its components to be adversely affected. Vulnerability is a product of:*
  - ***Sensitivity*** *- The degree to which a system or species is affected, either adversely or beneficially, by climate variability or change. The effect may be direct (e.g., a change in crop yield in response to a change in the mean, range, or variability of temperature) or indirect (e.g., damages caused by an increase in the frequency of coastal flooding due to sea level rise).*
  - ***Adaptive Capacity*** *- the ability of people, sectors, or systems to adjust to potential damage, to take advantage of opportunities, or to respond to consequences. Adaptive capacity will differ between risks and sectors, for example, a region that is well prepared to cope with floods may be taken aback by a heat wave.*
- ***Exposure*** *– The presence of people; livelihoods; infrastructure; and assets; or species and ecosystems in places and settings that could be adversely affected. For example, the exposure of vulnerable populations to heat or expansion of residential and economic areas in floodplains.*

To distinguish between exposure and vulnerability, it can be helpful to think of an example. In the case of the climate impact of flooding, all the houses that are in the area that could be touched by flooding are exposed. However, only those house that are built in a way that they will be severely damaged by the flooding are vulnerable to it.

The SRAs are based on available data from strategic documents and regional and national reports, as well as scientific sources. Data gaps were filled through regional workshops and interviews with regional experts. It is important to keep in mind that SRAs are based on data, but also normative decisions about priorities, targets and settings. To avoid too much bias, a participatory approach is recommended and has been employed in the development of the SRAs for the MountResilience Demonstrator Regions.

Regarding CCA governance, then, **an initial screening** in the MountResilience Demonstrator Regions was conducted to gain basic insights into the state-of-play regarding regional climate change and regional development policy. To gain additional information on regional CCA we set up an **online survey** (using SurveyMonkey) for the MountResilience regional partners, to help us identify regional (i) key strategic CCA documents, (ii) pioneering CCA implementations, and (iii) key stakeholders. Analysing the strategic documents for regional CCA, we applied **qualitative content analysis** (Mayring, 2021). Thereby we coded key information on regional climate change governance, central visions associated with regional transformation, and priorities set for local adaptation in the respective regions (for the coding analysis we used MAXQDA). For those documents that were not available either in English or German, we used DeepL to translate the documents in order to be able to include them in the analysis.

Desk research and the online survey enabled us to develop a longlist of potentially relevant stakeholders for transformative climate adaptation in each region, which was in further rounds of exchange with the MountResilience regional partners boiled down to shortlists of potential interviewees. The **interviewees** were invited to share (tacit and place-based) knowledge on regional CCA and (transformative) regional development. Based on comprehensive interview guidelines, we conducted **semi-structured interviews** with different stakeholders – from local authorities to non-governmental organizations and regional experts (Bogner, Littig, & Menz, 2010). Analysing the expert interviews along our research focus, applying Wolfram's (2016) 10 transformative capacities, we also did additional desk research, to close remaining knowledge gaps and/or dig deeper into aspects that were indicated during interviews by regional stakeholders (e.g. because of tacit/local knowledge).

In combination with the prior steps of analysis, the interview results enabled the development of initial hypotheses regarding existing or expandable transformative capacities and transformative pathways for each region. These served for the preparation of regional **online validation workshops** (Tippin, 2018). The validation workshops were held in the regions to share our findings with a wider local audience, present our ensuing hypotheses and discuss and develop these further towards the formulation of concrete advice for the DAs and beyond. We chose an online format to open workshop participation to all interested regional actors, notwithstanding their (remote) location.

Through the workshops, we addressed the identified CCA measures, challenges and opportunities in the region, but also – using the Miro tool for visualization and collaboration – traced further needs related to resources and capacities to successfully govern regional CCA actions. Table 27 illustrates our data sources, pointing out the number of analysed documents, conducted interviews as well as the share of workshop participants in the DAs.

Based on that, we summarised our diagnosis in the present document(s), pointing to key barriers and opportunities for regional CCA and key transformative capacities for the DAs and transformative CCA more generally.

Table 27. No. of analysed documents, conducted interviews, and workshop participants

Demonstrator region	Analysed documents	Conducted interviews	Workshop participants
Gabrovo	9	5	35
Lapland	18	9	21
Piedmont	17	8	26
Râu Sadului	7	5	16
Tyrol	17	9	16
Valais	14	6	14
Total	**82**	**42**	**128**

Replicator region	Analysed documents	---	---
Catalonia	9	---	---
Friuli-Venezia-Giulia	14	---	---
Primorje-Gorski Kotar	9	---	---
Subcarpathian Region	4	---	---
Total	**36**	**---**	**---**

11.3. Guideline for CCA analysis in replicator regions

This chapter provides a guideline for assessing regional climate change adaptation challenges and the ensuing potentials for regional transformation. It is meant as a "cooking recipe" for conducting the same regional CCA analysis as for the six Demo Regions of MountResilience, herewith enabling the Replicator Regions to go beyond the above presented factsheets. Each of the following sections explains one step of the three-step CCA analysis by introducing the objective, methods, and data sources for conducting the respective step. While each region has its context-specific particularities that need to be considered individually, our regional diagnoses show that this general approach enables assessing a regionally specific status quo and developing respective steps for adaptation. By looking into (i) structural climate risks, (ii) key adaptation practices and challenges, and (iii) transformative capacities, successful regional adaptation responses to climate change can be derived, helping to build a solid basis for future transformative visions.

11.3.1. Identify systemic risks

There is no one-size-fits-all solution to CCA. It is a question of how a region with its specific characteristics can integrate an extant path-dependent socio-economic development trajectory with transformative actions that properly address specific climate risks. Hence, in a first step, two components must be studied: (1) the regional structural profile, and (2) regional climate induced hazards and ensuing systemic risks.

Goal	**Understand regional pathway, analyse climate induced hazards, and identify ensuing systemic risks**
Analysis	(1) Regional structural analysis. (2) Strategic risk assessment.
Data	(1) Regional Structural Analysis: Academic literature, ESPON Mapfinder; CORINE Land Cover Data https://land.copernicus.eu/en/products/corine-land-cover (2) Productivity, trade and innovation: e.g., OECD Statistics https://www.oecd-ilibrary.org/statistics (3) Economy, environment, industries and social conditions, e.g., Eurostat's regional statistics. https://ec.europa.eu/eurostat/web/main/data/statistical-themes#general-regional-statistics (4) Regional & local statistics *(5) Climate data, e.g., ESPON Climate Update* https://archive.espon.eu/projects/espon-2020/monitoring-and-tools/climate-data-and-maps-update

Regional structural analysis: Firstly, regional mapping und desk research on regional characteristics was conducted, to gain an overview on underlying functional and structural conditions, relevant for regional CCA implementation. Therefore, reginal topography, land cover, environmental characteristics, population and socio-economic indicators, as well as the regional self-image and the governance framework were analysed.

***Method**: The method of choice is desk research or secondary research (cf. Largan and Morris 2019) and involves existing data from the internet, (EU/national/regional) databases, reports, assessments, scientific literature or regional information platforms that provide information concerning climate change on the regional level. This can be combined with a snowballing technique, where one analysed document or data source gives reference to another useful source of information. This analysis is complete, once saturation appears, thus new sources don't deliver significant additional information. The mapping of the region followed also desk research, focussing on environmental and topographic characteristics, analysing existing academic literature, project reports and studies.*

Strategic risk assessment: Consists of two consecutive steps: First, the analysis of climate hazards to be derived from European sources such as ESPON Climate Update, or, depending on availability, national or regional climate change assessments and reports providing information on climate hazards on subnational level. And second, an analysis of systemic risks based on the integration of hazards with the above regional structural analysis and further socio-economic data from resources such as OECD Statistics, Eurostat, national or regional reports and statistics (to the extent that it is necessary/available).

***Method**: Here as well, the method chosen was desk research in combination with a snowballing technique. Data was derived from resources such as OECD Statistics on productivity, trade and innovation; Eurostat data on economy, environment, industries and social conditions; National/regional reports and (if available) regional & local statistics.*

11.3.2. Analyse adaptation challenges and approaches

On the regional level, the implementation of CCA strategies and measures builds on region-specific governance frameworks. In other words, the way CCA is problematized, envisioned and put into practice strongly depends on the specifics of regional governance – factual competencies, strategic framings, and stakeholder constellation. Hence, in a second step, it is instrumental to look into these governance frameworks at different scales and identify the most important documents and how they interpret the challenges and opportunities that come with CCA.

Goal	**Identify CCA governance framework, emphasized challenges and approaches, and main stakeholder constellation.**
Analysis	(1) CCA policy analysis. (2) Expert interviews.
Data	Regional CCA strategies, expert interviews

CCA policy analysis: This step of analysis should begin with a general overview of the distribution of competencies for CCA-related matters between national, regional and municipal level to clarify the relevance and potential impact of CCA-related strategies. It then collects the 3-5 most relevant strategic documents (e.g., sustainable development concept, CCA strategy, or similar) and systematically analyses their content regarding how CCA is being addressed and how it should be approached from the authorities' perspective.

***Method**: The method to analyse the policy documents and regional strategies is Qualitative Content Analysis (cf. Silverman 2021). Through thematic analysis, goals, motifs, understandings and identified solutions can be assessed. Relevant questions for assessment are: How is CCA being framed and interpreted? What is considered the biggest regional challenge? What is already being done to address CCA and how are these measures legitimised? Who is involved and who should take future action – which actors, sectors, and how?*

Expert interviews: Oftentimes, regional actors have tacit knowledge that cannot be derived from public documents but can be key for understanding regional pathways vis-à-vis the regional challenges of CCA. Interviewing such experts can help further determine (more or less useful) approaches. Depending on the complexity of the issue, the depth of information from prior desk research and document analysis and the consequent knowledge gaps, at least 5-8 such interviews should be conducted.

***Method**: Semi-structured expert interviews (cf. Bogner et al. 2009) are a data collection method that uses a thematic framework or questionnaire for the interview, though questions are not set in a specific order nor follow a predetermined phrasing. Experts should be identified based on their potential knowledge on a specific issue related to regional CCA. Overall, the interviews should ideally represent views from different societal spheres, e.g., academia, the public and private sector, and/or people involved in relevant CCA implementation actions. Interviews can be analysed using the same Qualitative Content Analysis approach as above and, for traceability, audio recordings and transcripts should be stored.*

11.3.3. Reflect on transformative capacities

Understanding regional risks and current policy responses to climate change are two important steps for developing effective climate actions that are both visionary in their transformative perspective but realistic in their starting point. In a third step, the regional CCA analysis thus reflects regional development threats (i.e., systemic climate risks) and opportunities (i.e., development potentials and visions, windows of opportunity) vis-à-vis elaborated strengths (i.e., existing regional capacities) and weaknesses (i.e., implementation barriers) for governing CCA "from within". The concept of Transformative Capacities (TCs) (cf. Wolfram 2016) serves as framework for reflecting different strengths and weaknesses and pointing out the most relevant ones for implementing successful CCA activities (e.g., transformative CCA demonstration projects and their replication).

Goal	**Identification of strengths & weaknesses and ensuing transformative capacities.**
Analysis	Focus group reflection on TCs for regional CCA.
Data	Interviews, stakeholder workshops

Focus group reflection on TCs for regional CCA: The information derived from the prior steps of analysis allows for an assessment of TCs for effectively governing CCA and implementing impactful CCA activities. This assessment can be a starting point for further discussing regional transformation perspectives with a focused group of regional experts (potentially beyond the interviews) and retrieve feedback on governance capacities that need to be either honed or developed to spur transformative regional climate governance. In a regional stakeholder workshop, the 2-4 most relevant TCs should be discussed in terms of their relevance and what needs to be done to improve them. Results should then be incorporated into the strategy for regional CCA actions.

***Method**: In a focus group or stakeholder workshop (cf. Tippin et al. 2018), 10-25 regional experts with relevant knowledge should be invited to discuss the findings of the regional CCA analysis and how to hone or develop the key TCs.*

TCs help to set a more specific focus on regional factors supporting CCA approaches and must be understood as the main regional components, where actual progress has already been made but should be enhanced to set the stage for actual transformative action. Wolfram's (2016) 10 transformative capacities were summarised as follows:

- TC 1 Inclusive & Multiform Governance
- TC 2 Polycentric and Embedded Leadership
- TC 3 Empowered Communities
- TC 4 Shared (Mutual) Understanding, Memory and System Awareness
- TC 5 Foresight and Shared Vision
- TC 6 Transformative Projects and Practices
- TC 7 Openness for Innovations

- TC 8 Reflexivity and Learning
- TC 9 Outreach and Collaboration with Different Groups
- TC 10 Working Across Political and Administrative Levels

11.4. Data sources for analysis

11.4.1. List of analysed documents

Catalonia

- *National Climate Change Adaptation Plan 2021-2030*
- *Work Program 2021-2025 National Plan for Adaptation to Climate*
- *2016 The 2030 Agenda: Transform Catalonia, Improve the World*
- *2015 Boost to the green economy and the circular economy*
- *2023 Catalan Strategy for Adapting to Climate Change 2021-2030. Executive summary*
- *2012 Catalan Strategy for Adapting to Climate Change (ESCACC) Horizon 2013-2020. Executive Summary*
- *2020 Executive summary regionalized climate projections Catalonia 2030-2050*
- *2017 Monitoring and Assessment of the Catalan Strategy for Adapting to Climate Change 2013-2020*
- *2023 Strategy of the Pyrenees Action points and main transformative projects*

Friuli-Venezia Giulia

- *2018 Report on the state of the environment in Friuli Venezia Giulia*
- *2018 Cognitive study of climate changes and some of their impacts in Friuli Venezia Giulia*
- *2023 Climate in FVG*
- *2023 Climate signals in FVG*
- *2013 National Strategy for Adaptation to Climate Change*
- *2022 National plan for Adaptation to Climate Change*
- *2023 The strategy for the sustainable development of the autonomous region of Friuli Venezia Giulia*
- *2023 FVGreen - Provisions for sustainable development and ecological transition of Friuli Venezia Giulia*
- *2022 Accession of FVG to the mission for CCA promoted by the EU within Europe Horizon*
- *2023 Establishment of the steering committee for the regional sustainable development strategy*
- *2021 Regional Strategy for Sustainable Development of FVG*
- *2017 National Sustainable Development Strategy (NSDS)*
- *2019 Integrated National Energy and Climate Plan*
- *2021 Plan for the Ecological Transition (PTE)*

Gabrovo

- *Action Plan for Sustainable Energy and Climate of Gabrovo until 2030*
- *Environmental Protection Program of the Municipality of Gabrovo 2023 – 2027*
- *First Adaptation Report – National Climate Change Adaptation Planning and Strategies*
- *National Communication on Climate Change*
- *National Strategy for Adaptation to Climate Change and Action Plan*
- *Plan for sustainable urban mobility of Gabrovo Municipality 2021-2030*
- *Report for Implementation of the Third National Action Plan on Climate Change 2013 – 2020*
- *Strategy for intelligent specialization of Gabrovo Municipality 2021-2030*
- *Strategy for the development of the green infrastructure of Gabrovo 2017-2023*

Lapland

- *2011 Lapland's Climate Strategy 2030*
- *2022/432 Climate Act*
- *Adaptation to climate change in Finland. Current state and future prospects*
- *Carbon neutral Finland 2035 – National Climate and Energy Strategy*
- *Climate Change Adaptation Action Plan 2022 from the Environment Agency*
- *Enonteki Municipal Strategy 2022-2025*
- *Finland's National Climate Change Adaptation Plan 2022*
- *Finland's National Climate Change Adaptation Plan 2030*
- *Government Report on Medium-term Climate Change Policy Plan for 2030*
- *Government Report on the Climate Plan for the Land Use Sector*
- *Green Deal Roadmap*
- *Lapland's Tourism Strategy 2020-2030*
- *Lapland's Tourism Strategy. Update on the Corona Situation 2021*
- *Medium-Term Climate Change Policy Plan- Towards a carbon-neutral society in 2035*
- *National Strategy for Adaptation to Climate Change*
- *Regional characteristics and vulnerabilites related to climate change in Finland*
- *Rovaniemi Action Plan*
- *Strategy of the National Commission Sustainable Development 2022-2030*

Piedmont

- *2020 Guidance Document. Towards the regional strategy on CC_SRF*
- *Charta of Budoia*
- *Climate Resilience Plan Turin*
- *ESPON Regional strategies for sustainable and inclusive territorial development*
- *Monitoring of SDGs Piedmont*
- *PNACC National plan for Adaptation to Climate Change*
- *Regional Climate Scenario Analysis 2020*
- *RSDS-Regional Strategy Sustainable Development Piedmont*
- *SNAC National Climate Change Adaptation Strategy (2015)*
- *SNSvS National Strategy for Sustainable Development (2017)*
- *SNSvS National Strategy for Sustainable Development (2022)*
- *SRCC Regional CC Strategy Piedmont*
- *SRCC Regional Strategy on Climate Change Piedmont*

Primorje-Gorksi Kotar

- *2020 Climate change adaptation strategy in the republic of Croatia for the period until 2040 with a view to 2070*
- *2017 Draft Action Plan for the period 2019-2023*
- *2019 Integrated National Energy and Climate Plan for the Republic of Croatia for the Period 2021-2030*
- *2017 Spatial Development Strategy of the Republic of Croatia*
- *2019 Air protection program, ozone layer, climate mitigation and adjustments to climate changes in Primorje Gorski Counties 2019-2022*
- *Development plan of the mountain district for the period of 2022-2027*
- *2022 Gorski Development Plan District 2022-2027 – state analysis*
- *2022 Vulnerability analysis of the coastal area of the Primorje-Gorski Kotar County due to sea level rise*

- *2021 Croatia National Development Strategy 2030*

Râu Sadului

- *2023 Report on limiting climate change and its impact: an integrated approach for Romania*
- *Best practice and awareness raising guide on climate change mitigation and adaptation for the Sibiu County Council*
- *National action plan for the implementation of the National Strategy on adaptation to climate change for the period 2023-2030*
- *Romania's 8th National Communication on Climate Change*
- *SNACS National Strategy on Adaptation to Climate Change 2022-2030*
- *SNDDR Romania's Sustainable Development Strategy 2030*
- *SPAASC Strategy and Plan for mitigating and adapting to climate change in the Municipality of Sibiu*

Subcarpathian Region

- *2013 Strategic adaptation plan for sectors and areas sensitive to climate change until 2020*
- *2019 Draft of National Energy and Climate Plan for the years 2021-2030*
- *Climate change adaptation plan for the city of Rzeszów until 2030*
- *2017 Strategy for Responsible Development for the period up to 2020 (including the perspective up to 2030) (SRD)*

Tyrol

- *Austrian Strategy for Adaptation to Climate Change*
- *Climate change adaptation in Innsbruck – Action plan*
- *Climate change and tourism in Austria*
- *Climate scenarios for Tyrol until 2100*
- *Implementation of the Tyrolean climate protection and climate change adaptation strategy*
- *National climate resilience check on health for municipalities and regions*
- *National heat protection plan*
- *Plan T – Masterplan for tourism*
- *Progress report 2023 according to §6 Climate Law*
- *Second progress report on the Austrian strategy for adapting to climate change*
- *Status report on adaptation*
- *Strategy for climate change adaptation in Innsbruck*
- *Strategy for Tyrol in dealing with invasive plant species (neophytes)*
- *The Tyrolian Way. Perspectives for the responsible development of tourism*
- *Tyrolian economic and innovation strategy*
- *Tyrolian sustainability and climate strategy*
- *Tyrolian sustainability and climate strategy. Action plan 2022-2024*

Valais

- *2023 Climate Act*
- *Adaptation to climate change in Switzerland*
- *Adaptation to climate change in Switzerland – Action Plan 2014-2019*
- *Adaptation to climate change in Switzerland – Action Plan 2020-2025*

- *Agenda 2030 of sustainable development in the Canton Valais*
- *Bundesgesetz über die Ziele im Klimaschutz, die Innovation und die Stärkung der Energiesicherheit*
- *Cantonal plan for adapting to climate change*
- *Cantonal plan for reducing greenhouse gas emissions*
- *Cantonal water strategy*
- *Climate-related risks and opportunities for Switzerland*
- *Energieland Wallis: Gemeinsam zu 100% erneuerbarer und einheimischer Versorgung*
- *Environment Switzerland report*
- *Federal Act on the Reduction of CO2 Emissions*
- *Klimawandel im Kanton Wallis*
- *Long-term climate strategy for Switzerland*
- *Valais in the face of Climate change*

11.4.2. List of interviews

Gabrovo

No.	Role (pseudonymized)	Date of interview
GI1	Researcher at TU Gabrovo	March, 22, 2024, Duration: 51 min
GI2	Representative of Gabrovo's Regional Administration	March, 26, 2024, Duration: 29 min
GI3	Expert at "Public Works" Gabrovo	April, 03, 2024, Duration: 57 min
GI4	Representatives of Central Balkan National Park	March, 28, 2024, Duration: 55 min
GI5	Expert at RAM Central Stara Planina	April, 02, 2024, Duration: 25 min

Lapland

No.	Role (pseudonymized)	Date of interview
LI1	Expert in land-use planning at Metsähallitus	March, 23, 2024, Duration: 47 min
LI2	Expert at Finnish Lapland Tourism Board	March, 20, 2024, Duration: 41 min
LI3	Expert of Finish Association for Nature Conservation	March, 21, 2024, Duration: 50 min

LI4	Climate Specialist at ELY	March, 21, 2024, Duration: 28 min
LI5	Researcher at the University of Lapland	March, 28 2024, Duration: 54 min
LI6	Researcher at TYRSKY Consulting	April, 10, 2024, Duration: 45 min
LI7	Representative of Municipality of Enontekiö	May, 03, 2024, Duration: 41 min
LI8	Representative of Sámi Reindeer Herders Association	May, 10, 2024, Duration: 1 hour 7 min
LI9	Sámi Climate Council	Written response. May, 23, 2024

Piedmont

No.	Role (pseudonymized)	Date of interview
PI1	Scientific Expert at CREA - Consiglio per la ricerca in agricoltura e l'analisi dell'economia agraria (Council for the study of agriculture and the analysis of agricultural economics)	April, 19, 2024, 53 min
PI2	Expert at Coldiretti - Confederazione Nazionale Coltivatori Diretti (National Confederation of Direct Farmers)	April, 19, 2024, Duration: 55 min
PI3	Expert at Est Sesia – L'Associazione Irrigazione Est Sesia (Association Irrigation East Sesia) Expert at Associazione d'Irrigazione Ovest Sesia (West Sesia Irrigation Association)	April, 23, 2024, Duration: 45 min
PI4	Expert at Regione Piedmont (Region of Piedmont)	April, 24, 2024, Duration: 1 hour 20 min
PI5	Scientific Expert at ARPA Piedmont - Agenzia Regionale per la Protezione Ambientale (Regional Environmental Protection Agency)	May, 05, 2024 Duration: 1 hour 03 min
PI6	Expert at Legambiente Piedmont e Valle d'Aosta (Piedmont and Aosta Valley Environment Agency)	June, 6, 2024 Duration: 1 hour 30 min
PI7	Independent expert for nature conservation and Natura 2000	Written response. May, 21, 2024
PI8	Expert at ADBPO - Autorità di Bacino Distrettuale del Fiume Po (Po River District Basin Authority)	Written response. Duration: July, 1, 2024

Râu Sadului

No.	Role (pseudonymized)	Date of interview
RI1	Scientific Expert at ICDM -	March, 22, 2024 Duration: 1 hour 34 min

	Institutul De Cercetare-Dezvoltare PT. Montanologie (Research/Development Institute for Mountainology Christian-Sibiu)	
RI2	Scientific Expert at Babeş – Bolyai University	March, 27, 2024, Duration: 1 hour 2 min
RI3	Expert at ADRCentru - Agentia pentru Dezvoltare Regionala Centru (Regional Development Agency Centru)	April, 10, 2024, Duration: 51 min
RI4	Expert at Sibiu County Council	April, 23, 2024, Duration: 47 min
RI5	Expert at FUNDATIA ADEPT	May, 10, 2024, Duration: 40 min

Tyrol

No.	Role (pseudonymized)	Date of interview
TI1a TI1b	Researchers at University of Innsbruck	March, 22, 2024, Duration: 45 min
TI2	Director of a company engaging in winter tourism	March, 27, 2024, Duration: 52 min
TI3	Researcher at FH Kufstein	April, 09, 2024, Duration: 45 min
TI4	Regional manager of one of the KLAR! regions	April, 09, 2024, Duration: 64min
TI5	Representative of a civil society initiative	April, 11, 2024, Duration: 64min
TI6	Representative of the provincial government	April, 15, 2024, Duration: 43min
TI7	Regional manager of one of the KLAR! regions	April, 18, 2024, Duration: 45min
TI8	Mayor of one Tyrolian municipality	May, 07, 2024, Duration: 70min
TI9	Researcher at University of Innsbruck (Interview was conducted by Standortagentur Tirol)	Duration: 63min

Valais

No.	Role (pseudonymized)	Date of interview
VI1	Expert at regional development in Valais	April, 03, 2024, Duration: 1 hour, 3 min

VI2	Researcher at UNIL	April, 11, 2024, Duration: 59 min
VI3	Director of regional management agency	April, 12, 2024, Duration: 46 min
VI4	Director of tourism management agency	April, 12, 2024, Duration: 49 min
VI5	Representative at Energy production company	April, 23, 2024, Duration: 44 min
VI6	Representative at Regional marketing agency	April, 24, 2024, Duration: 53 min

11.5. Overview of regional indicators

Table 28. Socio-economic data for MountResilience regions (Source: Eurostat, 2022)

	Statistical unit	**Population**	**Population density** *(per km²)*	**Median age of population** *(in years)*	**Population change** *(in % from 2021 to 2022)*	**PPS per capita** *(in €)*	**Employment rate** *(in % 15-64 years)*	**Risk of poverty or social exclusion** *(in %)*
EU-average *(27 countries)*	-	446,055,933	109.1	44.5	+4.0	35,400	74.4	21.6
Piedmonte	NUTS 2	4,256,350	169.1	49.8	-1.2	35,700	66.3	16.5
Tirol	NUTS 2	764,102	61.4	43.1	+9.4	45,600	77.8	19.2
Valais	NUTS 3 **ref. Région lémanique*	353,209	68.4	43.5	+11.5	46,300* *(2019)*	78,8*	18.8*
Sibiu	NUTS 3 **ref. Centru*	388,898	72.2	43.1*	+6.4	25,200*	61.9 *	31.7
Gabrovo province	NUTS 3 **ref. Northern Central*	103,404	49.4	47.5*	-74.7	14,800*	68.0*	37.5*
Lapland	NUTS 3 **ref. North & East Finland*	176,494	1.9	45.2*	-4.0	33,500*	71.5*	17.3

	Statistical unit	**Population**	**Population density** *(per km²)*	**Median age of population** *(in years)*	**Population change** *(in % from 2021 to 2022)*	**PPS per capita** *(in €)*	**Employment rate** *(in % 15-64 years)*	**Risk of poverty or social exclusion (in %)**
EU-average *(27 countries)*	-	446,055,933	109.1	44.5	+4.0	35,400	74.4	21.6
Catalonia	NUTS 2	7,679,192	243.7	44.2	+28.6	35,000	69.9	20.4
Friuli Venezia Giulia	NUTS 2	1,194,647	157.8	50.3	-0.3	37,600	68.5	15.5
Primorje-Gorski Kotar	NUTS 3 **ref. Adriatic Croatia*	246,560	74.1	46.3*	-2.4	24,900	64.6*	20.5*
Subcarpathian region	NUTS 2	1,968,616	117.6 *(2021)*	41.8	-3.2	19,100	63.4	19.0

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