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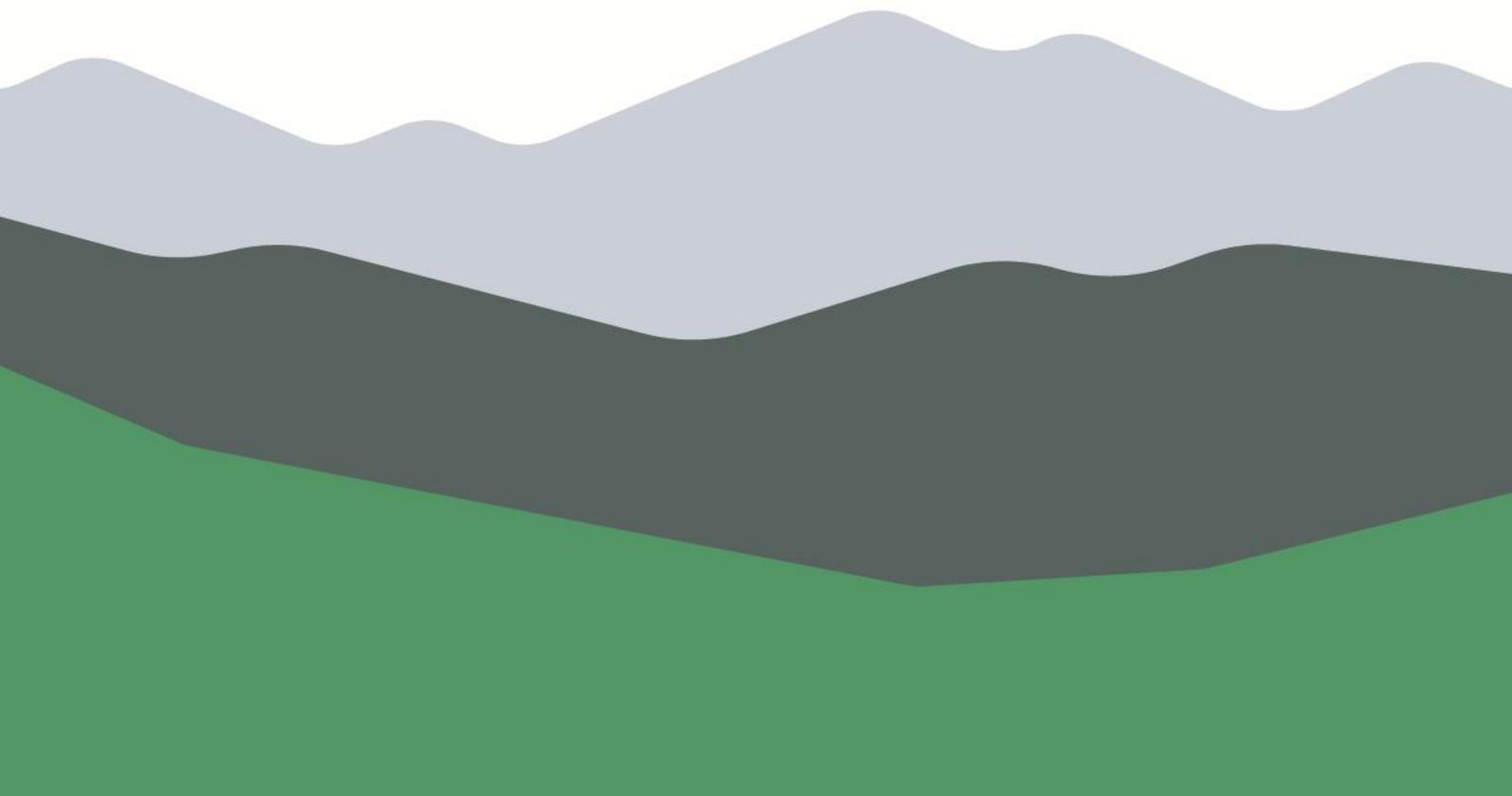
BeyondSnow

Alpine Space

Conceptual document on AS STD vulnerability and resilience assessment

D.1.2.1 – October 2023

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Who should read this report?

The intended audience of this document are:

Local and Regional Public Authorities, to increase the knowledge base and the awareness of local and regional public administrators on key concepts of vulnerability and resilience for the territories they are responsible for.

Local and Regional DMOs, to increase their understanding of the vulnerability and resilience concepts applicable to the Alpine Snow Tourism Destinations they are responsible for.

Tourism SMEs, to increase the knowledge base and the awareness on this specific aspect of climate change impacting on their activities, and to prepare them for the challenges and the necessary enhancement of climate and socioeconomic resilience through sustainable development alternatives.

Local communities of STDs, because they are also negatively impacted by increasing lack of snow and the diminishment of the attractiveness of skiing. By reading this document STDs citizens can increase their knowledge on key concepts of vulnerability and resilience applicable to their territory.

This publication is available on the project website <https://www.alpine-space.eu/project/beyondsnow/>

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Mission Statements

To provide the Consortium with a knowledge base regarding vulnerability and resilience assessment of Snow Tourism Destinations to Climate Change, indicators and guidelines for Pilot Working Areas data collection & evaluation foreseen in Action 1.3 of the project.

Disclaimer

The data and information in this document refer to and have been proposed specifically for the purposes and activities in the Pilot Areas of the BeyondSnow project. Some concepts are of course generalisable to all STDs in the Alps, but with due caution and precautions.

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Acronyms used in this report

BeyondSnow-specific acronyms are **bold**.

Acronym	Meaning
AR4	IPCC 4th Assessment Report (published in 2007)
AR5	IPCC 5th Assessment Report (published in 2014)
AS	Alpine Space
CC	Climate Change
CCA	Climate Change Adaptation
DMO	Destination Management Organisation
EbA	Ecosystem-based Adaptation
EbS	Ecosystem-based Solutions
EC	European Commission
ECO-DRR	Ecosystem-based Disaster Risk Reduction
EEA	European Environment Agency
ES	Ecosystem Services
EU	European Union
EUSALP	EU-Strategy for the Alpine Region
GIS	Geographic Information System
IPCC	Intergovernmental Panel on Climate Change
OECD	Organisation for Economic Co-operation and Development
PA	Pilot Action
PWA	Pilot Working Areas
RAM	Resilience Adaptation Model
RCP	Representative Concentration Pathways
RDMDT	Resilience Decision-Making Digital Tool
SME	Small and Medium-sized Enterprises
STD	Snow Tourism Destination
SWT	Snow & Winter Tourism
UN	United Nations
UNESCO	United Nations Educational, Scientific and Cultural Organization.
UNFCCC	United Framework Convention on Climate Change
UNWTO	United Nations World Tourism Organization



Contents

1	Introduction and background.....	6
1.1	Key definitions.....	6
2	Systemic perspective of (Snow) Tourism Destinations and Disruptions.....	10
3	Vulnerability.....	12
3.1	Vulnerability in tourism.....	15
3.2	STDs Vulnerability.....	16
4	Resilience.....	19
4.1	Resilience in tourism.....	21
4.2	STDs Resilience.....	23
5	The role of ecosystem-based approaches.....	25
6	Conclusion.....	28
7	References.....	30
8	Annexes.....	36
8.1	Vulnerability & Resilience: Lessons learned adopting the Sensitive Diagnosis in 9 mountain areas in French massifs ..	36
8.2	Guidelines for Pilot Working Areas data collection & evaluation.....	36

1 Introduction and background

The present report, part of the activity A1.2, aims at providing the partnership with a solid knowledge base regarding vulnerability and resilience in the context of tourism destinations. The report encompasses key vulnerability indicators of STDs used in the BeyondSnow project, theoretical definitions, and approaches of resilience of tourism destinations.

1.1 Key definitions

Vulnerability

The propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements, including sensitivity or susceptibility to harm and lack of capacity to cope and adapt (IPCC, 2022).

Resilience

Resilience is the ability of individuals, households, communities, cities, institutions, systems and societies to prevent, resist, absorb, adapt, respond and recover positively, efficiently and effectively when faced with a wide range of risks, while maintaining an acceptable level of functioning without compromising long-term prospects for sustainable development, peace and security, human rights and well-being for all (United Nations, 2020).

Adaptation

Adaptation is understood as actions that help communities or their ecosystems cope with a changing climate, in particular, steps that reduce any losses or harm inflicted. The IPCC defines adaptation as an adjustment in natural or human systems to reduce the harm or exploit the benefits of actual or expected climatic stimuli or their effects (IPCC, 2022). Although there is variation from indicator to indicator, the BeyondSnow project does assume STDs and their communities have a baseline capacity to adapt and that a degree of forced adaptation is already occurring.

Maladaptive actions (Maladaptation)

Maladaptive actions are referred to as those activities that may lead to increased risk of adverse climate-related outcomes, including via increased greenhouse gas (GHG) emissions, increased or shifted vulnerability to climate change, more inequitable outcomes, or diminished welfare, now or in the future (IPCC, 2022). Most often, maladaptation is an unintended consequence.

Mitigation

Mitigation is broadly understood as action that stems global warming, i.e. that mitigates the warming effect. The IPCC defines mitigation as human intervention to reduce the sources or enhance the sinks of greenhouse gases (IPCC, 2022). Mitigation policies could be programmed to minimize the negative (and positive) impacts measured.

Disruption

A disruption is a break or an interruption in the normal course or continuation of some activity or process. Climate change represents a disruption as it alters the macro-environmental equilibrium that allows for the right conditions for human life and human activities on Earth (Woodward, 2019) and whose impacts are being felt sooner and more intensely as the concentration of greenhouse gases in the atmosphere leads to higher average temperatures (Dreyfus et al., 2022). Disruptions expose the affected system(s) to a greater vulnerability and can be differentiated between **shocks** and **stressors** (Lew, 2014; Walker et al., 2012), which may or may not be climate-related:

- **Shocks** are sudden and often violent events that exert pressure on a system, especially when they are unexpected and/or they occur abruptly. Examples of shocks can be natural disasters or health issues like a pandemic.
- **Stressors** are events or trends that have a gradual effect on a system by emerging with varying intensity during a specific time frame (IPCC, 2022). Climate change itself is considered a stressor as its effects are not sudden but rather the result of an ongoing process.

Climate change adaptation

Climate change adaptation refers to the adjustments societies or ecosystems make to limit the negative effects of climate change or to take advantage of opportunities provided by a changing climate. Adaptation can range from farmers planting more drought-resistant crops to coastal communities evaluating how best to protect themselves from sea level.

Ecosystem services

Ecosystem services are the benefits or “services” of an ecosystem to human life, such as clean water and the decomposition of organic matter.

Absorption (absorptive coping capacity)

It is the ability of the system, or tourism destination to “bounce back” to its original state or equilibrium (Alvarez et al., 2022). It involves anticipating, planning, coping and recovering from specific, mostly known shocks and short-term stresses. Absorptive capacity is about ensuring stability by moderating or buffering the impacts of shocks on livelihoods and basic needs (Béné et al., 2012; Jeans et al., 2017).

Adaptative capacity

It is the ability to make adjustments for managing different conditions in order to continue functioning without major changes in function or structural identity (Alvarez et al., 2022; Béné et al., 2012). Often more generally referred to as capacity of response, it is the system's ability to adjust to a disturbance, moderate potential damage, take advantage of opportunities, and cope with the consequences of a transformation that occurs (Gallopín, 2006).

Transformative capacity

it is the ability to make essential changes that address the underlying failures or weakness of the system (Alvarez et al., 2022). In other words, it is the capacity of individuals and organisations to be able to both transform themselves and their society, tackling the deep structures that cause or increase vulnerability and risk (Ziervogel et al., 2016).

Transition vs Transformation:

Transition is especially used within sustainability research to denote fundamental social, technological, institutional and economic change from one societal regime or dynamic equilibrium to another. Research approaches concerned with global environmental change, such as resilience and transformative adaptation, adopted *transformation* to refer to fundamental shifts in human and environmental interactions and feedbacks. *Transformation* is often defined by scholars as more radical, large-scale and long-term societal changes (including values and worldviews), different from politically top-down and technocratic *transitions* (Hölscher et al., 2018; IPCC, 2022)

Path dependence

Path-dependent processes are those that develop inertial resistance to large-scale systematic shifts, with resistance to change driven by favourable initial social and economic conditions and the momentum of increasing returns to scale (Seto et al., 2016). This term is usually used to explain the economic specialization of a region as a result of long-term processes, influenced by lock-in effects that push a technology, an industry, or a regional market along one path rather than another (Strambach, 2008). This state can be altered by either major intervention, some external shock, or through structural change in the long-term (Brouder & Eriksson, 2013)

Lock-in

Lock-in is a way of conceptualizing the outcomes of path-dependent processes and describes how particular technologies—through their co-evolution with social, institutional, cultural, and political systems—may become resistant to change, ‘closing down’ or constraining possibilities for the development of alternative socio-technical configurations. The potentially negative impacts of technological lock-in—

also sometimes referred to as entrapment, or entrenchment—include a host of environmental and social problems such as climate change, ecological degradation, resource depletion, pollution, health and social problems (Cairns, 2014). Specifically, the term *carbon lock-in* refers to innovation and competitiveness of low-carbon alternatives that are inhibited by initial conditions, increasing economic returns to scale, and social and individual dynamics. Lock-in can be technological, but also institutional and behavioural (Seto et al., 2016)

Forward and Backward loop

The cycle of adaptive change proceeds through (1) forward-loop stages of innovation, growth, exploitation, consolidation, predictability, and conservation, followed by (2) back-loop phases of instability, release, collapse, experimentation, novel recombination, and reorganization. This cycle, theorized by Holling (2001), usually characterizes processes of adaptive change in both ecological and social systems (Karkkainen, 2005).

Community model vs Corporate model

In tourism destinations, a *community model* involves a local destination management organization (DMO) that, for political and structural reasons, is concerned with promoting cooperation and the widest possible harmonisation of objectives within a destination. This framework consists in service providers that are individual independent business units, operating in a decentralised way and where no unit has any dominant administrative power or dominant ownership within the destination. Hence, decisions are based on stakeholder collaboration and compromises. European destinations are usually in this category. The *corporate model*, typical of North America, involves a business corporation as representing or dominating the destination management. Corporations, which are usually centred on the 'ski product', tend to have a significant weight on how the destination is operated as well as strong political influence in the community related development of the destination (Flagestad & Hope, 2001).

Tourism destination:

A tourism destination is a physical space with or without administrative and/or analytical boundaries in which a visitor can spend an overnight. It is the cluster (co-location) of products and services, and of activities and experiences along the tourism value chain and a basic unit of analysis of tourism. A destination incorporates various stakeholders and can network to form larger destinations. It is also intangible with its image and identity which may influence its market competitiveness (UNWTO, 2023).

2 Systemic perspective of (Snow) Tourism Destinations and Disruptions

In terms of vulnerability and resilience analysis, one of the main issues to initially address is the clear definition of the research framework, which can be based on the concept of "resilience of what to what," as articulated by Carpenter et al. (2001). In the case of the project BeyondSnow, **"Resilience of what"** encompasses the (Snow) Tourism Destination.

Tourism destinations are not merely geographic locations but comprise complex socio-ecological systems. Within these systems, numerous different actors and stakeholders intentionally or inadvertently contribute to the creation of the intangible product of the tourism experience (Berkes & Folke, 2002; Fabry & Zeghni, 2019; Sainaghi & De Carlo, 2016). The geographical scope of tourism destinations can vary depending on the analyst's but also guest's objectives, possibly encompassing a municipality, region, country, or even a transnational area (Sainaghi, 2006). The organizational structures of these destinations are contingent on both their internal arrangement and the connections among its various actors and stakeholders.

Drawing from the framework proposed by Flagestad & Hope (2001), a tourism destination can be positioned on a continuum between two models: the community model and the corporate model (see the figure below).

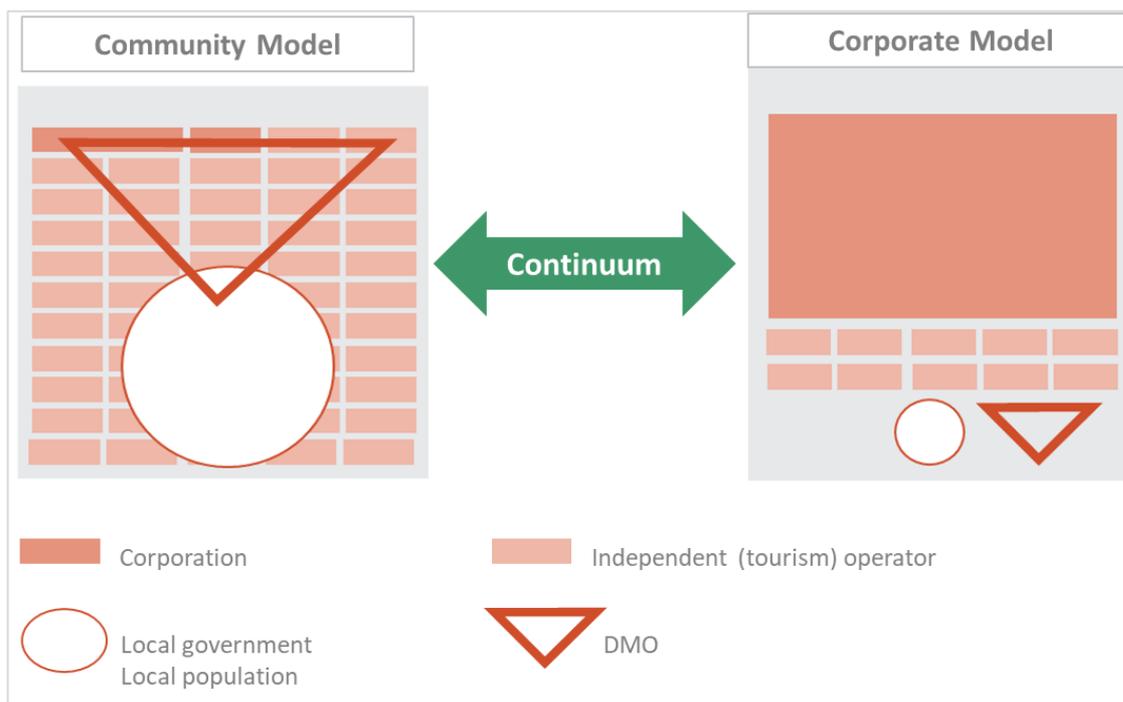


Figure 1: Continuum of tourism destination structures (Flagestad & Hope, 2001)

The community model represents a network of diverse independent stakeholders and actors, each exerting varying degrees of influence on the tourism system based on their social and economic standing. In terms of tourism management and governance, these networks often rely on a Destination Management Organization (DMO) to professionally unite the actors, foster cooperation, formulate strategic directions, and serve as a liaison between tourism actors, local government and ideally also the host community. Conversely, the corporate model is best exemplified by a typical tourism resort, featuring a dominant corporation that guides the development of the overall destination while leading the other actors.

Given the significant differences in decision-making processes between these two models, the implications for the vulnerability and resilience of different types of tourism destinations are considerable.

Fragmented, community-oriented destinations must ensure cohesive participatory approaches by involving stakeholders, relying heavily on the presence and actions of autonomous stakeholders and actors. These actions contribute to the pre-disruption reduction and readiness phases, influencing the vulnerability of the tourism destination, shaped also through the overall consensus-building capacity within the system. On the other they are connected to the resilience of the system by influencing the post-disruption response and recovery phases (Hystad & Keller, 2008; Laws & Prideaux, 2006). In contrast, hierarchical corporate-oriented destinations can adopt a more top-down-oriented approach to decision-making concerning the vulnerability and resilience-oriented actions of their tourism destination system.

In addressing the question "**Resilience to what**", the overarching terms of internal and external "disruptive events" and "disruptions" can be employed. This terminology provides a comprehensive basis for discussing a spectrum of impactful occurrences. Delving into the nature of each disruption, a nuanced differentiation emerges, classifying them into two broad categories: **sudden shocks** and **gradual stressors**. For instance, a terrorist attack exemplifies a sudden shock, while climate change represents a gradual stressor, although this stressor can also indirectly encompass sudden shocks, such as fire and flooding (Cioccio & Michael, 2007; Lew, 2014; Walker et al., 2012). It is noteworthy that both these categories, despite their disparate temporal characteristics, serve as strong drivers of change. The disruptions oblige affected systems to act, ideally based on distinct reactive and proactive strategies. The essential commonality lies in their adaptive/transformational influence, prompting an activation of the resilience mechanisms in place. Whether responding to the immediacy of a sudden shock or navigating the persistent challenges posed by gradual emerging stressors, the strategies employed by systems emphasize the dynamic nature of resilience. This realization underscores the imperative for tailored actions aligned with the unique issues connected to each disruption, ultimately contributing to a more comprehensive understanding of resilience in the face of diverse challenges.

3 Vulnerability

The ability to “measure” (or more correctly, to assess) the vulnerability is a fundamental pre-requisite for disaster risk reduction and for the application of the necessary adaptation strategies (Birkmann et al., 2023).

Although vulnerability has gained a high importance in scientific debates, there is still no unified understanding of the concept regarding what it describes, what factors constitute it, or how it can be measured. As of now, the Intergovernmental Panel on Climate Change (IPCC) offers the most comprehensive framework for understanding vulnerability in the context of climate change, recognizing the intricate interplay between environmental shifts and societal dynamics. Therefore, this chapter delves into the multifaceted nature of vulnerability to climate change, drawing upon the IPCC definition as a primary guideline.

The IPCC defines vulnerability as “**the propensity or predisposition to be adversely affected, a quality shaped by diverse factors, including exposure, sensitivity, and adaptive capacity**” (IPCC, 2022).

Exposure refers to the extent to which a system is exposed to climate stressors, sensitivity reflects the degree to which a system is affected when exposed, and adaptive capacity represents the ability of a system to adjust, moderate harm, or exploit new opportunities.

This definition captures the essence of vulnerability as a dynamic and context-specific concept, acknowledging that vulnerabilities are not uniform across regions, communities, or sectors. In fact, this general framework for assessing vulnerability has to be tailored more specifically in order to be applied to a specific area and/or circumstance.

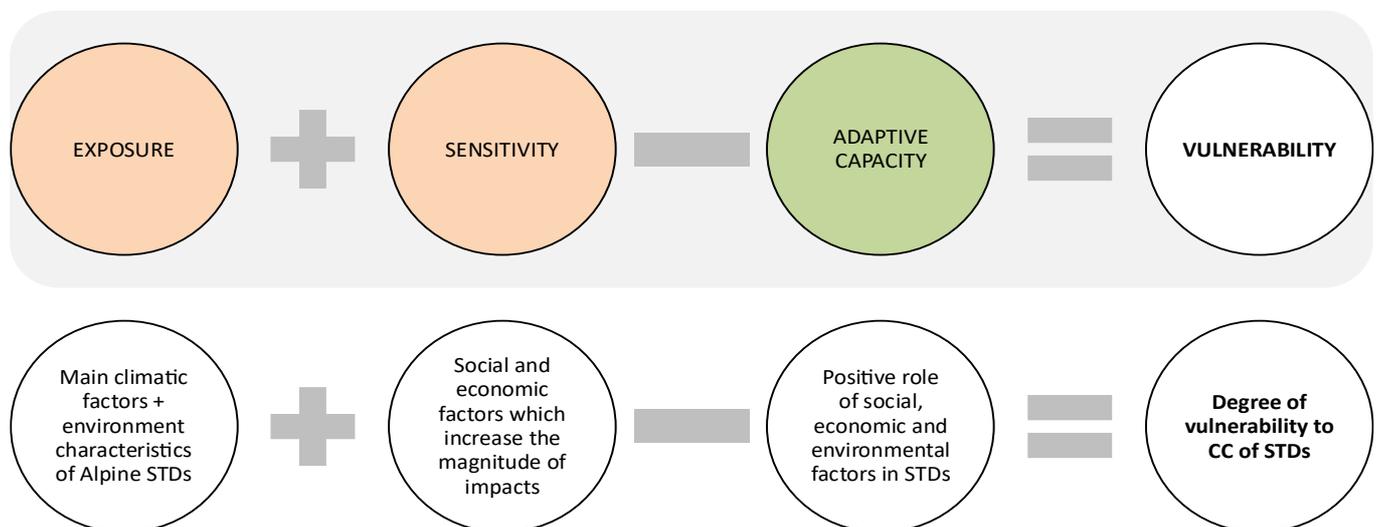


Figure 2: General framework for assessing vulnerability to climate change for BeyondSnow STDs (Based on IPCC, 2022).

In the context of the BeyondSnow project, [Section 3.2](#) proposes an application of the vulnerability framework for STDs.

At its core, vulnerability manifests a complex interplay between environmental, social, and economic factors (Alber et al., 2011). Climate-induced disruptions can vary greatly, ranging from extreme weather events (shocks) to water availability, from rising temperature to changing precipitation patterns (stressors). There pose distinct challenges to different regions and communities.

Regions with a high exposure to climate risks, such as mountain settlements and areas with key infrastructures (IPCC, 2023), tourist ones included, often face increased susceptibility to climate-induced changes. In these areas the risk of overloading the Residual Risk of Natural Hazards should also be taken into account (Schneiderbauer et al., 2018).

However, vulnerability is not solely determined by the physical exposure to climate hazards, but it is equally shaped by societal structures, economic systems, and governance frameworks. Social aspects, including demographic ageing, inequality, and governance structures, can either diminish or amplify vulnerability. For instance, areas that are marginal or with significant depopulation trends may lack the resources and capacities to cope with the impacts of climate change, exacerbating their vulnerability. Furthermore, economic aspects can also influence vulnerability, and can include GDP composition and growth rate, labour factors, workforce, and economic dependence on specific sectors. Therefore, understanding vulnerability in its complexity requires a holistic examination of the biophysical, social, and economic dimensions.

As for the BeyondSnow project, the first component of vulnerability is **Exposure**, which encompasses the character, magnitude, rate of change and variation of the climate (Fritzsche et al., 2014). In other terms, it is the foundational aspect representing the degree, duration, and/or extent in which the system is in contact with, or subject to, the (climatic) perturbation (Gallopín, 2006).

Sensitivity, the second component of vulnerability, highlights the differential impacts of climate change on various systems. Biological diversity, agricultural productivity, and water resources are examples of systems that exhibit varying degrees of sensitivity. Understanding sensitivity is essential for designing targeted adaptation strategies, as it reveals the specific weaknesses inherent in different sectors. Moreover, together with exposure factors, it can determine the **potential impacts**, which can be either direct or indirect, encompassing a variety of consequences across different systemic domains (Fritzsche et al., 2014).

Finally, **adaptive capacity** represents the ability of a system to adjust and respond to changing conditions. Societal factors such as education, infrastructure, technology, and governance play key roles in determining

adaptive capacity. Communities equipped with solid institutions and effective governance, which are also able to draw on technological innovations are better positioned to mitigate and adapt to the impacts of CC (OECD, 2014). Consequently, adaptive capacity acts as a crucial buffer, reducing the overall vulnerability of a system.

It is important to clarify that vulnerability cannot be treated as a measurable concept. Rather, it embodies the intricate interaction of different factors shaping a system's susceptibility to the impacts of CC. No fixed rule exists to dictate which factors to consider or the methods to quantify them. Therefore, vulnerability can only be "assessed" and not "measured". This acknowledgment underscores the complex, context-dependent nature of vulnerability, necessitating a holistic approach to its evaluation (Fritzsche et al., 2014).

Even the IPCC's vulnerability concept – the basis of the Vulnerability Sourcebook (Fritzsche et al., 2014) – is continually undergoing modifications, adding to the complexity of the term. The IPCC assessment report (AR5), published in 2014, introduced a new concept which aims to identify and evaluate the risk of impacts from climate change. In this concept, risk is a result of the interaction of vulnerability, exposure, and hazard. Consequently, the utilization of vulnerability in AR5 (2014) differs from that in AR4 (IPCC, 2007), with AR5 emphasizing exposure and vulnerability as the two main foundations of risk. Thus, as Williams & Baláz (2015) argue, it seems that the AR5 concept has been developed for vulnerability assessments specifically in the context of risk, whereas the AR4 vulnerability concept is mainly adopted for stand-alone vulnerability assessments, and thus is taken as primary guideline in the present report.

Overall, the concept of vulnerability to climate change, as delineated by the IPCC (2007), encapsulates a comprehensive understanding of the intricate relationships between environmental shifts and societal dynamics. **By acknowledging the multifaceted nature of vulnerability, researchers, policymakers, and practitioners can formulate targeted interventions addressing the specific challenges faced by diverse communities and regions**. Therefore, this first overview serves as foundation for a deeper inquiry into vulnerability, to be precisely defined and locally elaborated at the scale of STDs (municipal or sub-municipal) particularly within the context of tourism in mountain destinations.



Figure 3: Vulnerability key aspects (Own elaboration)

3.1 Vulnerability in tourism

In general, the tourism industry seems to be more susceptible to various disruptions than other sectors of the global and regional economies, of which the recent COVID-19 pandemic is a clear example. Furthermore, it has been demonstrated that natural disasters like earthquakes, tsunamis, and tropical cyclones induce sudden decreases in visitor numbers, which results in significant economic losses for the destinations (Alvarez et al., 2022).

Being composed of a multitude of different elements, risks and uncertainties are an integral part of tourism. Risk and uncertainty are essentially about the limits of knowledge that are characteristic of tourism among other economic sectors (Williams & Baláž, 2015). Given that disruptions can vary widely in tourism and mitigation as well as adaptation options do not follow a one-size-fits-all pattern, it is essential to address the persistent weak points, in order to cope with increasing uncertainty. It is probably these enduring susceptibilities that increase the sensitivity of tourism destinations to the lasting impacts of external shocks and stressors, as opposed to temporary and sporadic events (Alvarez et al., 2022). As previously mentioned, sensitivity, which is the degree to which a destination is affected by exposure to CC, is influenced by the pre-existing economic, social, political and environmental conditions that characterize the anticipatory and immediate response capabilities (Calgaro, Lloyd, et al., 2014).

Therefore, in navigating this complex terrain, frameworks such as the **Destination Sustainability Framework** (Calgaro, Dominey-Howes, et al., 2014) can provide a valuable tool for unravelling the intricacies that determine the destination's tendency towards either vulnerability or resilience. The framework highlights critical factors, offering approaches for impactful adjustments. Its focus on local populations is grounded in two primary considerations: the localized manifestation of vulnerability and resilience, and the key role of the destination as the overarching context shaping the entirety of the tourist experience. Including six fundamental components, the framework encompasses (1) the shock(s) or stressor(s); (2) the interconnected facets of vulnerability—exposure, sensitivity, and adaptive capacity; (3) the dynamic loops illustrating the consequences following actions (or lack thereof) in response to shocks or stressors; (4) the root causes and drivers shaping the distinctive attributes of places; (5) the scale; and (6) the varied timeframes dictating the evolution of conditions over time (Calgaro, Lloyd, et al., 2014). Nevertheless, this is simply an example of a useful approach that can be employed to better understand how destination vulnerability emerges and is influenced by a combination of multiple factors.

Furthermore, the outcomes arising from actions, inactions, or missteps regarding CC can also significantly exacerbate existing vulnerabilities. These implications inevitably establish new levels of exposure and sensitivity to future events. However, despite the critical significance of this process, there is still a

tendency to overlook the necessity for monitoring the diverse impacts of human actions over time and across varied locations, as emphasized by Calgaro et al. (2014). Hence, greater attention to the factors constituting destination vulnerability is crucial for informed decision-making and development strategies, ensuring a more resilient and responsive approach to the evolving challenges faced by tourism destinations.

3.2 STDs Vulnerability

The examination of vulnerability in Snow Tourism Destinations (STDs), a focal point within the AS Project BeyondSnow, requires a focused analysis tailored to the specific challenges faced by Alpine regions. A key point in mapping vulnerability lies in determining suitable information and indicators that effectively capture both biophysical and socio-ecological dimensions, and the way in which this information should be integrated (Preston & Stafford-Smith, 2009).

Moreover, vulnerability assessment in the context of STDs should also pay particular attention to tourism factors. These can include accommodation structures and capacities, arrivals and overnight stays within the different months, seasonality and intensity of winter/snow tourism, gross occupancy, guest source markets, transports accessibility, lift usage and pass sales, main tourism products (skiing, hiking, etc.) and their seasonality, and unique tourist attractions (UNESCO, etc.) (Alber et al., 2011).

Taking all these aspects into consideration, the elaboration of a Vulnerability Map of STDs in the context of the BeyondSnow project has followed primarily the aforementioned IPCC vulnerability concept (2007) – composed of exposure, sensitivity, potential impacts, and adaptive capacity – and the methodological guidelines provided in the Vulnerability Sourcebook by Fritzsche et al. (2014).

Moreover, the selection of indicators was motivated by and built upon previous AS projects such as AlpES (Alpine Ecosystem Services – mapping, maintenance and management), ClimAlpTour (Climate Change and its Impact on Tourism in the Alpine Space), and GreenRisk4ALPs, with which the BeyondSnow project shares a focus on ecosystem-based approaches as effective adaptation solutions (see [Section 5](#)). Hence, the indicators in Table 1 represent the selection used to elaborate the first Vulnerability Map of Alpine STDs.

Area	Indicator	Description
Exposure Current and future climate variability and change	Snowfall	Projected changes of Total Snowfall from November to April (%) between scenario RCP 4.5 data and historical data (1986-2005)
	Rainfall	Projected changes of Total Rainfall from November to April (%) between scenario RCP 4.5 data and historical data (1986-2005)
	Temperature	Projected changes of Winter Mean Temperature from November to April, between scenario RCP 4.5 data and historical data (1986-2005)
	Snow Season	Projected changes of Snow Season duration (based on natural snow on the ground) between scenario RCP 4.5 data and historical data (1986-2005)
	Ski Season	Projected changes of Days with normal height of snow of the ground (>= 30cm) between scenario RCP 4.5 data and historical data (1986-2005)
Sensitivity Natural/physical and societal environments	Population Density	People per sq. km of municipal area
	Old Age Dependency Ratio	Residents aged > 65 to residents aged 15-64 (%)
	Infrastructure at Risk	Infrastructure in hazard zone
	Outdoor Recreation Visitation Rate	Outdoor recreational Visitation rate
Adaptive Capacity Natural/physical and societal environments	Natura 2000 Areas	Total Natura 2000 areas per Municipal Area
	Site-protecting Forests	Site-protecting forests areas against avalanches, mudslides and rockfalls
	Outdoor Recreational Offer	Outdoor recreational availability

Table 1. Selection of relevant indicator for the STDs' Vulnerability (V. 0.92). (Own elaboration after BeyondSnow project, Deliverable 1.1.2)

Firstly, within mountain destinations, exposure factors play a key role in understanding vulnerability. Parameters such as “Total Snowfall from November to April”, “Total Rainfall from November to April”, “Snow Season duration” based on natural snow cover, “Ski Season duration” with a minimum snow height (>= 30cm), and “Winter Mean Temperature from November to April” were carefully selected to establish the climatic foundation for the vulnerability map in the Alpine Space.

Sensitivity in STDs exhibits significant variation in its components, with indicators such as “Population density”, “Old age dependency ratio” (Residents aged > 65 to residents aged 15-64 (%)), “Infrastructure at risk or within hazard zones”, and “Outdoor recreation visitation rate” serving as pertinent examples. The selection of these elements, however, depends on the identified potential impacts, which may involve alterations in winter tourism flows and attractiveness or, on a broader scale, the decline of the local economy.

Concluding the vulnerability assessment, factors contributing to adaptive capacity in STDs are multifaceted. Notably, ecosystem-based services emerge as a valuable solution (see [Section 5](#)). The essential role played by protected areas, forests, and outdoor recreation sites is of utmost importance in enhancing a system’s ability to adapt to climate change and mitigate vulnerability. Recognizing and employing these elements becomes fundamental in developing effective strategies to strengthen the resilience of snow tourism destinations in the face of evolving climate conditions. This holistic approach aims to provide a comprehensive understanding of vulnerability, paving the way for informed decision-making and sustainable management practices in STDs, increasing the adaptive capacity, decreasing in vulnerability to increase the total resilience of the system.

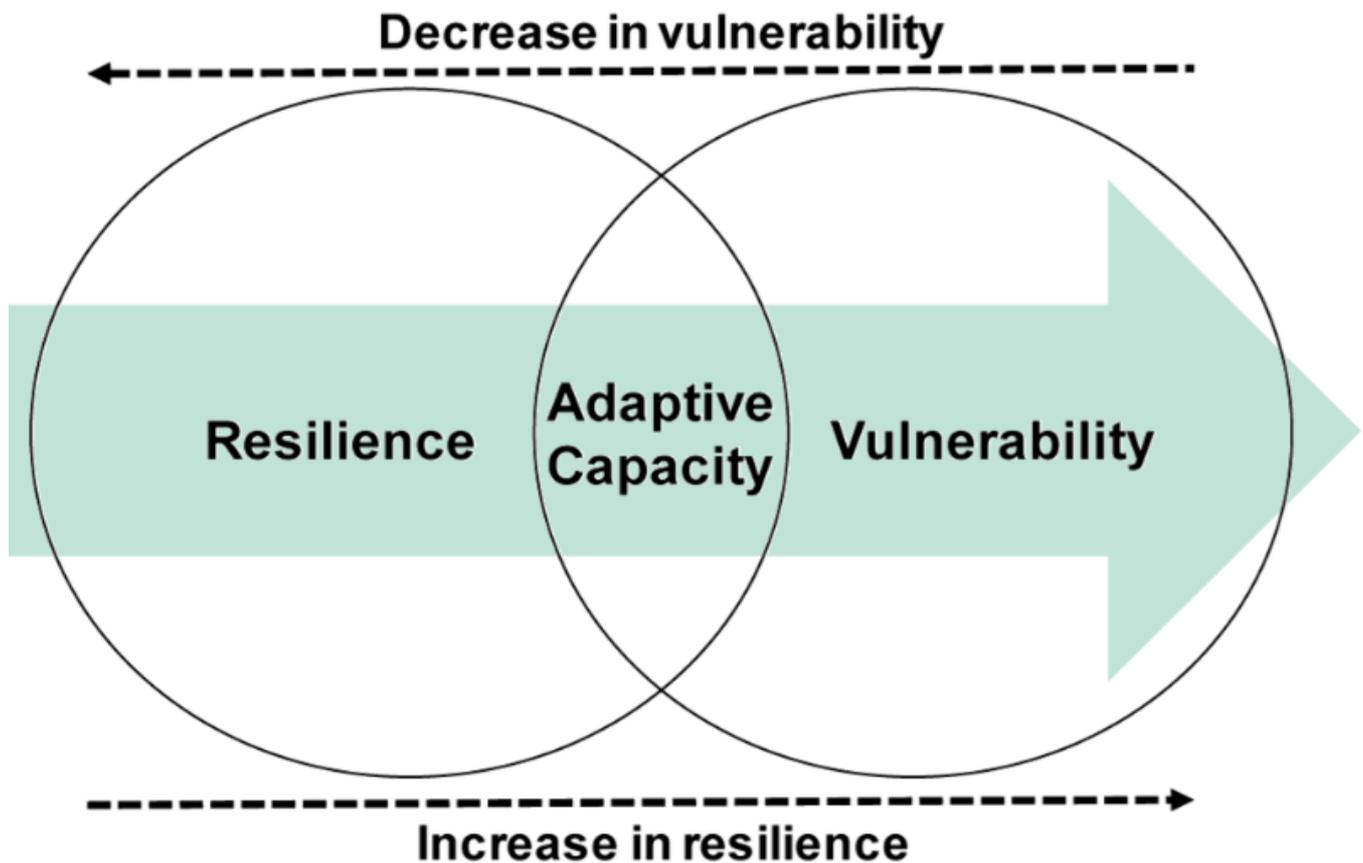


Figure 4. Vulnerability and resilience linked through the concept of adaptive capacity (Adapted from Engle, 2011)

4 Resilience

Referring to the definition by the United Nations (2017), resilience is “the ability of individuals, households, communities, cities, institutions, systems and societies to prevent, resist, absorb, adapt, respond and recover positively, efficiently and effectively when faced with a wide range of risks, while maintaining an acceptable level of functioning without compromising long-term prospects for sustainable development, peace and security, human rights and well-being for all”.

This definition represents a starting point to provide of an overview of the concept of resilience. In fact, it has gained prominence in recent decades due to the increasing recognition of the need to address, mitigate and adapt to the impacts of various stressors, including environmental changes, and unforeseen shocks on systems ranging from ecosystems to infrastructure. It is a multifaceted and evolving concept that has found application in a wide array of disciplines, from engineering and ecology to psychology, disaster management, economics, and governance. However, its diverse usage can sometimes lead to confusion, to the point that Davoudi et al. (2013) argue that it has become a contested concept, which risks acting as a buzzword mainly due to its overuse and ambiguity.

Within the field of ecology, Holling (1973) defined resilience as the capacity of a system to absorb disturbances, adapt to change, and recover while maintaining essential functions, structures, and identities. Holling’s work distinguished between engineering and ecological resilience, in order to emphasize two different aspects of stability (Holling, 1996) This distinction has gained wide recognition as it is helpful in approaching a topic as broad as resilience. From that, it has also evolved in relation to the dynamic development of complex adaptive systems, which considers also the systemic interactions across temporal and spatial scales.

Holling (1996) defined **engineering resilience** as the maintenance of stability near an equilibrium state, where resistance to disturbance and the speed of returning to the previous equilibrium are key measures of resilience, emphasizing efficiency and predictability. In particular, engineering resilience puts the emphasis on return time, i.e. “efficiency, constancy and predictability”, all of which are considered essential for optimal mathematics and engineering design (Davoudi et al., 2013). In other words, engineering resilience is measured on how fast a variable that has been displaced from equilibrium returns to the latter (Folke, 2006).

Ecological resilience is defined as “the magnitude of disturbance that can be absorbed before the system changes its structure by changing the variables and processes that control behaviour” (Holling, 1996, p. 33). According to this approach, there are several systemic equilibria since instabilities can cause a system to

shift into a different stability zone, rejecting the idea that there is one single equilibrium (Davoudi et al., 2013). As a result, contrary to engineering resilience, it emphasises traits such as persistence, change, and unpredictability, which contribute to the capacity for adaptation (Davoudi et al., 2012). Despite this difference, however, and also the fact that they originate from different disciplinary fields, what essentially characterizes both perspectives is the belief in the existence of equilibrium in systems, whether it is a pre-existing one to which a resilient system bounces back (engineering resilience) or a new one to which it bounces forth (ecological resilience) (Davoudi et al., 2012).

A third perspective of resilience was also introduced and theorised as **evolutionary resilience**. It challenges the whole idea of equilibrium and advocates that the very nature of systems change over time with or without an external disturbance (Davoudi et al., 2012). The evolutionary perspective views resilience as the capacity of complex social-ecological systems to change, adapt, or transform in response to disruptions and behaves in the form of an adaptive cycle rather than as a return to normality/equilibrium. Hence, what separates evolutionary resilience from engineering and ecological resilience is the notion of a perpetual transformation of the system. According to its adaptive cycle, systems go through a phase of creative destruction before entering a phase of regeneration and reorganisation that results in unanticipated systemic trajectories. This system transforms into something altogether new, which may be both desirable and undesired (Davoudi et al., 2013). This is a dynamic and uncertain process of continuous metamorphosis.

These concepts of resilience can be enhanced by consolidating: absorptive-coping, adaptive and transformative capacities (Béné et al., 2012; OECD, 2014). The **absorptive-coping capacity** denotes the system's aptitude to prepare for, mitigate, or prevent harmful impacts by deploying predetermined coping mechanisms. These mechanisms serve to safeguard and reinstate fundamental structural and functional attributes in the face of external disruptions. **Adaptive capacity** encompasses the system's ability to recalibrate, amend, or modify its inherent characteristics and structures, thereby diminishing potential future harm and capitalizing on emerging opportunities. This capacity ensures the system's continuity without undergoing substantial qualitative alterations in its functional essence or structural identity. **Transformative capacity** entails the system's capability to create an entirely novel systemic paradigm, also based on the impact of external disruptions. Such transformation becomes imperative when existing ecological, economic, and/or social structures make the prevailing system untenable (OECD, 2014).

In the context of this project, however, the primary emphasis resides within the domain of **adaptive capacity** as a property of ecological resilience. While acknowledging the significance of absorptive coping and transformative capacities as integral components of resilience, the specific focus lies on the augmentation of adaptive capacity. In this context, the ability to incrementally adjust existing attributes and actions is essential in navigating the complexities of the dynamic and ever-changing environment. By

fortifying adaptive capacity, the aim is to provide socio-ecological systems with the tools and strategies necessary for moderating potential harm and taking advantage of emerging opportunities, while maintaining a fundamental continuity in function and structural identity.

In general, resilience has emerged as a multifaceted concept with profound implications for engineering, ecology, and numerous other contexts. Thus, this overview of the various notions of resilience provides comprehensive support to address disruptions that can negatively affect socio-ecological systems like tourism destinations. In this regard, as Folke (2006) argues, resilience should not only be about being persistent or robust to disturbance. It should also be regarded as opportunities that arise through disturbances and disruptions in terms of recombination of evolved structures and processes, emergence of new trajectories as well as liberation of underutilized resources. It should involve an adaptive interplay between sustaining and developing with change for resilience to provide adaptive capacity that allows for continuous development.

4.1 Resilience in tourism

After building on a general overview of the concept of resilience, particular attention is now given to the application of the concept in the context of tourism destinations. The delineation of the project framework, based on the “resilience of what to what” (Carpenter et al., 2001), is necessary to ensure a more appropriately targeted working approach. This is because, as previously mentioned, resilience is used in various contexts (history, culture, economic development), in different timings (before, during, after the disruptions), in numerous locations and scales, thus often leading to confusion and even misuse (Fabry & Zeghni, 2019).

Tourism systems seen as interrelated socio-ecological systems, include a variety of actors who cooperate to reach the provision of positive tourism experiences. Starting within the ecological domain, the application of resilience concepts within tourism has grown in recent decades. In the 1970s, resilience was mainly explored in relation to the preservation and protection of natural parks. In the 1980s, it was oriented towards the examination of the environmental impacts of tourism on ecological systems. Afterwards, the concept progressively shifted from a strictly ecological point of view to climate and environmental changes as well as sustainability (Fabry & Zeghni, 2019). In fact, a variety of disruptions, including natural disasters, economic downturns, political unrest, internal strife, and others are increasingly causing severe disturbances for tourism destinations. Therefore, tourism resilience is currently more generally defined as “the capacity of these systems to deal with stresses by maintaining the stability of the tourism-related

regional economy while ensuring the flexibility and diversity necessary for innovation and further development” (Luthe & Wyss, 2014).

However, few studies specifically address the resilience of tourism-oriented communities (Lew, 2014), which place a crucial focus on the ability to adapt pro-actively to significant internal and external events. In fact, such events may cause a destination’s attractiveness (measured, for e.g., through the number of overnight stays, income, competitiveness, etc.) to decline over the short and long term (Sheppard & Williams, 2016). In this regard, the local population is often excluded from decision-making and politically marginalised, even though the ability of the tourism community to proactively respond to critical events is dependent upon the wellbeing of the tourism community members in the first place. Therefore, a careful and more thorough management of disruptions may be enhanced not only through a focus on infrastructure and tourism offer recovery, but also on local population wellbeing within the tourism community (Sheppard & Williams, 2016). Furthermore, if strong resilience is supplemented by capabilities for adaptation and innovation, a successful recovery does not only imply the re-establishment of the previous rate of growth, but it can also eventually lead to an improved development path (Gaki & Koufodontis, 2022)

Examples of established frameworks regarding tourism destination resilience are introduced below as they can serve as guidelines and provide indicators for the resilience assessment of the tourism sector.

The **resilience, adaptation and transformation assessment framework** is an example of comprehensive overview on the different aspects that need to be considered for a resilience framework analysis. Although not developed specifically for the tourism sector, this framework is oriented towards both systemic pre-disruption reduction and readiness, and post-disruption response and recovery (O’Connell et al., 2015). The first element, resilience, evaluates an entity’s ability to withstand shocks, continue operating, and recover from disturbances or crises. The second component, adaptation, is concerned with an entity’s capacity to alter its course strategically in response to changing conditions or anticipated future challenges. When resilience and adaptation are not sufficient, the third element, transformation, assesses the possibility for fundamental and sustainable changes in systems or practises.

Becken (2013) developed a conceptual model that focuses on enhancing the resilience of various components or subsystems within the broader tourism industry. The framework recognizes that tourism is a complex system comprising multiple interdependent parts and aims to address the vulnerability of these subsystems to various disruptions, such as economic crises, natural disasters, or environmental changes. Focusing primarily on socio-economic aspects, the **resilience of tourism subsystems** framework divides the subsystems based on the activities offered. It emphasizes the need for proactive strategies and policies to

increase the resilience of each subsystem. This involves strategies like sustainable resource management, disaster preparedness, community engagement, and economic diversification.

Fabry & Zeghni (2019) approach destination resilience from a more wholistic perspective on the tourism destination level, emphasizing the role of its **resilience-based governance** through the inherent complexities happening at different cross-scale interactions. According to this framework, the challenge for a destination is to set up its governance for resilience in a context of constant change and learning. That means becoming resilience-oriented by thinking, preparing, acting, governing, as well as performing and defining resilience as a continuous and adaptive process. The resilience-based governance must continually involve all the stakeholders of the destination. This involvement should comprise a process based on two pillars: coordination and adaptation. Hence, it is based on collaborative, flexible and learning-based approaches, or adaptive destination co-management. Finally, the framework differentiates between reactive and proactive capabilities, both necessary to address disruptions (Fabry & Zeghni, 2019).

4.2 STDs Resilience

Within the tourism sector, STDs are facing unprecedented challenges due to climate change, which poses a significant threat to the sustainability of the ski industry. To navigate these challenges and build resilience, STD stakeholders must base their actions on a thorough analysis of their tourism destination, adopt adaptive strategies, collaborate with various actors, and consider the broader impacts on the community and the environment.

Polderman et al. (2020) emphasize that STDs can enhance their resilience through a combination of technological and business practices. So far, technological adaptations seem to be the main types of strategies adopted by tourism stakeholders in the Alps (OECD, 2007). Among these, technical snowmaking is often considered the primary strategy. However, while it addresses positively the immediate need for reliable snow cover, in certain cases it can represent a meaningful example of potential unintended contribution to **maladaptation**.

This phenomenon refers to actions that are taken ostensibly to reduce vulnerability but can unintentionally reinforce existing unfavourable development pathways and create lock-in situations (Scott et al., 2022). Infrastructure lock-in, in particular, is a situation where significant investments are made in certain technologies or practices, which then become difficult to change or abandon, even when they are no longer suitable or sustainable. The risk with such a dependency is that it locks STDs and their resources into a gradual process of 'rigidification' and growing inflexibility, which can oftentimes lead to a narrower and unsustainable development path. In fact, as mentioned by

Stotten et al. (2021), overreliance on a single domain within the system, such as ski tourism, can make a community more vulnerable to disturbances. In the case of technical snowmaking, STDs may find themselves trapped in a cycle of ever-increasing investment in snowmaking technology, even as the environmental and economic costs rise, or as the environmental conditions do not even permit to follow this path anymore (for ex., due to rising temperatures).

Therefore, for STDs to be truly resilient in the face of climate change and other challenges, it is crucial to widen the scope of options and alternatives. This implies, among other actions, diversifying the tourism offerings beyond snow-related activities. While technical snowmaking can play a role in maintaining snow reliability, it should be used cautiously to avoid maladaptation. Relying solely on a single domain can lead to infrastructure lock-ins and hinder the long-term resilience of these destinations. The OECD (2007) underlines the need for winter tourism operators to approach the changing climate by integrating technological adaptation practices with behavioural ones. Moreover, to ensure their sustainability, STDs must embrace a broader range of tourism options and year-round activities, considering the environmental and economic consequences of their adaptation strategies.

While non-snow-related offerings can support the winter business, they cannot replace snow-related activities altogether (OECD, 2007). Nonetheless, engaging in year-round tourism, exploring climate-independent offerings, or even considering to slightly alter the overall tourism system to reduce the snow-dependency, can represent relevant and desirable strategies. From this perspective, climate change can even act as a catalyst for resilience within the winter tourism industry, emphasizing the importance of adaptive capacity in determining the future of STDs under changing climate conditions.

5 The role of ecosystem-based approaches

Ecosystem-based approaches (EbA) focus on ecosystem restoration and enhancement of ecosystem services to protect society against negative impacts of climate change. As climate change makes itself increasingly felt through, e.g., droughts, extreme weather events and flooding, the urgency of adaptation measures increases (Climate-ADAPT, 2023).

EbAs are nature-based solutions for addressing climate change impacts (FEBA (Friends of Ecosystem-based Adaptation), 2017).

The Ecosystem based Solutions, hereinafter EbS, and their role in enhancing sustainability and resilience of systems have gained significant attention in recent years. These solutions recognize the importance that ecosystems play in supporting human well-being, fostering climate adaptation, reducing disaster risks, and promoting ecological connectivity and social cohesion. They are defined by Cohen-Shacham et al. (2016) as “actions to protect, sustainably manage and restore natural or modified ecosystems that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits.”

At the core of the EbS framework is the concept of ecosystem services. As already discussed in D.1.1.1, these services are defined as the goods and services provided by ecosystems to humans, and are categorized into **life-supporting, provisioning, regulation, and cultural services**, encompassing vital functions such as the provision of food and water, the regulation of environmental conditions, and the provision of aesthetic landscapes and recreational activities (Haines-Young & Potschin, 2018).

Moreover, EbS can be implemented alone or be integrated with other solutions to societal challenges (e.g. with technological and engineering solutions) and are determined by site-specific natural and cultural contexts that include traditional, local and scientific knowledge (Cohen-Shacham et al., 2016).

Furthermore, EbS include issue-specific approaches such as **Ecosystem-based Adaptation (EbA)** and **Ecosystem-based Disaster Risk Reduction (Eco-DRR)**, which can both enable communities and ecosystems to adapt to the impacts of climate change and/or disasters through the sustainable management, conservation and restoration of ecosystems to provide goods and services (McVittie et al., 2018). In particular, EbA, if integrated into broader adaptation and development strategies, has multiple effects (Sudmeier-Rieux et al., 2019) and in particular the potential to reduce the vulnerability and increase the resilience of ecosystems and communities, while being a flexible, cost-effective and broadly applicable approach to tackle the impacts of climate change (Lo, 2016).

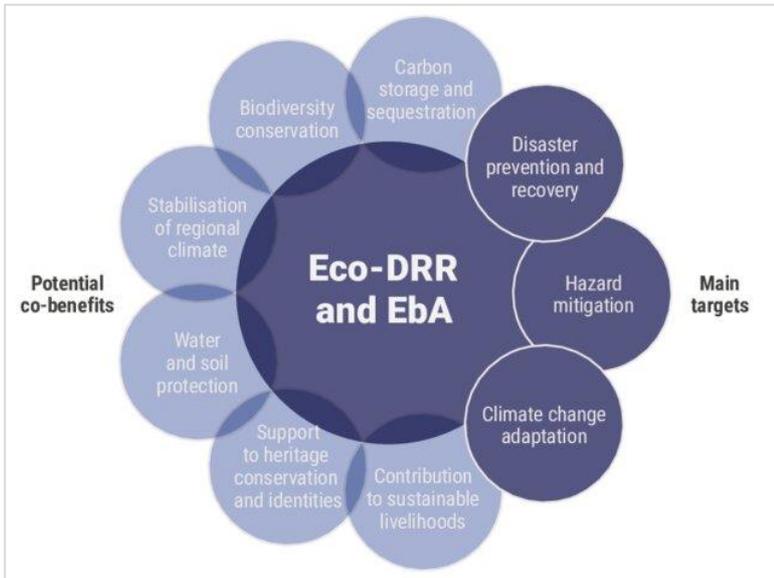


Figure 5. Multiple benefits of Eco-DRR/EbA. (Sudmeier et al, 2019, based on Nehren, 2014 as modified from Estrella & Saalisamaa 2013)

Depending on how the world’s ecosystems are managed, they can either amplify the negative effects of climate change or provide effective **Nature-based Solutions** for climate change mitigation and adaptation.

With regard of the former, **ecosystem-based mitigation** has the potential to be a significant contribution by preventing the degradation and loss of natural ecosystems. In other words, improved conservation and land management practices have the capacity to avert additional CO2 emissions, playing a substantial role in global mitigation efforts.

Ecosystems can also contribute to the fight against climate change by acting as “natural carbon sinks” as they absorb and store CO2 emissions effectively. Consequently, the conservation, restoration, and sustainable management of forests, wetlands, and oceans are vital for maintaining a healthy carbon cycle and regulating the planet’s climate. On top of this, ecosystems can benefit vulnerable communities, particularly those reliant on natural resources, in adapting and building resilience to the adverse disruptions connected to climate change, including extreme weather events and climate-related disasters (Cohen-Shacham et al., 2016).

Restoring and managing forests can be taken as an example among the most tangible ecosystem-based solutions in the face of multiple environmental challenges. The sustainable management and preservation of forests exemplifies how EbS can simultaneously contribute to climate change mitigation, disaster risk reduction, and human well-being. These vital ecosystems, when properly conserved, act as potent natural carbon sinks, sequestering carbon emissions and mitigating climate change (Cohen-Shacham et al., 2016).

Moreover, they play a crucial role in safeguarding against natural hazards, as seen in mountainous regions where well-managed forests can prevent landslides and avalanches (EEA, 2015; Poratelli et al., 2020). Beyond environmental benefits, forests offer a wide array of ecosystem services, such as timber, clean water, and **recreational opportunities**, supporting local livelihoods and fostering a deeper connection between communities and their natural surroundings (Lo, 2016).

Finally, in the context of tourism, the role of EbS takes on added significance. The sustainability and resilience of tourism destinations heavily rely on the maintenance and responsible utilization of ecosystems. As demonstrated by Loehr et al. (2022), the integration of EbS into tourism practices offers a multifaceted approach to strengthening the sector's resilience, ensuring the long-term well-being of both ecosystems and visitors.

Natural settings, particularly in Alpine regions, constitute the very essence of tourism destinations and one of the main resources of tourism attractiveness. They are widely acknowledged to be beneficial for boosting social connections, expanding local economies, fostering local and indigenous identity, connecting people with their cultural and natural heritage, and raising conservation awareness (Winter et al., 2020). Moreover, these ecosystems contribute significantly to the leisure-related services that underpin the tourism industry, including recreation, spiritual, and cultural experiences. Thus, tourism destinations that prioritize the conservation and sustainable management of these ecosystems are better positioned to provide an authentic and attractive array of leisure-related services. Overall, this mutually beneficial relationship underlines the vital role of EbS in enhancing tourism resilience and sustaining the sector's central leisure-related services.

Note:

Concrete examples of EbA and EbS can be found at the interactive searchable database of tools and methods relevant to EbA "Ecosystem-based Adaptation Tools Navigator" accessible at the website of the Friends of Ecosystem-based Adaptation (FEBA): <https://toolsnavigator.friendsofeba.com>

6 Conclusion

In the dynamic landscape of STDs, the intertwining concepts of vulnerability and resilience offer a helpful roadmap for addressing the challenges posed by climate change. The comprehensive vulnerability assessments, as outlined by the present report and the project BeyondSnow, aim to delve deep into the intricate web of climatic, socio-ecological, and tourism-specific factors that shape the fate of Alpine regions.

The vulnerability mapping process underlines the multifaceted nature of exposure, sensitivity, potential impacts, and adaptive capacity within STDs. Climatic elements, such as snowfall and temperature, lay the foundation, while sensitivity indicators, including population density and infrastructure risks, provide further socio-economic elements of analysis. The acknowledgment of the pivotal role played by ecosystem-based services underscores the importance of nature in fortifying adaptive capacities and resilience.

In the face of unprecedented disruptions, and based on vulnerability assessments as groundwork, the narrative seamlessly transitions to the imperative of resilience. The ski industry, a cornerstone of STDs in the Alps, is experiencing an increase of the quantity and intensity of challenges connected to climate change. Adopting a resilience-oriented vision presupposes the collaborative efforts of stakeholders, a meticulous analysis of destinations, the consideration of adaptive strategies, and the examination of broader impacts on communities and the environment.

Technological adaptations, notably technical snowmaking, emerge as a double-edged sword in the pursuit of resilience. While addressing the immediate need for reliable snow cover, the risk of maladaptation and infrastructure lock-in looms large. The cautionary tale emphasizes the importance of widening the scope of options and alternatives. Overreliance on a single domain, such as skiing, leaves destinations vulnerable to disruptions, necessitating a shift toward diversified offerings.

Within this ever-changing landscape, Ecosystem-based Services (EbS) seem to become a more significant role in the context of tourism. The sustainability and resilience of tourism destinations heavily rely on the maintenance and responsible utilization of ecosystems. The responsible integration of EbS into tourism practices offers a multifaceted approach to strengthening the sector's resilience, ensuring the long-term well-being of both ecosystems and humans (local inhabitants and guests alike). Natural settings, particularly in Alpine regions, constitute the very essence of tourism destinations and one of the main resources of tourism attractiveness. They are widely acknowledged to be beneficial for boosting social connections, expanding local economies, fostering local and indigenous identity, connecting people with their cultural and natural heritage, and raising conservation awareness. Furthermore, these ecosystems can contribute significantly to year-round tourism offers, including recreation, spiritual, and cultural experiences.

Therefore, tourism destinations that prioritize the conservation and sustainable management of their ecosystems can be positioned, due to the provision of authentic and attractive leisure-related services. This mutually beneficial relationship underlines the vital role of EbS in enhancing tourism resilience and sustaining the sector's central leisure-related services.

In essence, the future of STDs hinges on informed decision-making, adaptive strategies, and a commitment to sustainability. Vulnerability assessments, resilience-building efforts, and the integration of EbS can provide a blueprint for a thriving coexistence with the changing climate. As the snow tourism industry navigates uncharted territories, the integration of diverse insights and proactive measures can ensure not only survival but the flourishing of STDs in the face of evolving climates.

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8 Annexes

8.1 Vulnerability & Resilience: Lessons learned adopting the Sensitive Diagnosis in 9 mountain areas in French massifs

8.2 Guidelines for Pilot Working Areas data collection & evaluation

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BeyondSnow is an Interreg - Alpine Space project co-funded by the European Union. It aims at decreasing the snow-dependency of Alpine Space snow tourism destinations, strengthen their resilience to climate change and retain/increase the viability for residents and their attractiveness for tourists.