D1.3

Climate resilient regional transformation strategies

Validation processes and implementation procedures

MOUNT RESILIENCE

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or CINEA. Neither the European Union nor CINEA can be held responsible for them.

Swiss partners have received funding from the Swiss State Secretariat for Education, Research and Innovation (SERI).

Deliverable Information Sheet

Version	v.1
Grant Agreement Number	01112876
Project Acronym	MountResilience
Project Title:	Accelerating transformative climate adaptation for higher resilience in European mountain regions
Project Call	HORIZON-MISS-2022-CLIMA-01-06
Project Duration	54 months
Deliverable Number	D1.3
Deliverable Title	Climate resilient regional transformation strategies
Deliverable Type	R – Document, report
Deliverable Dissemination Level	PU - Public
Work Package	WP1
Lead Partner	UMIL
Authors	Dario Pezzotti, Stefano Sala, Matteo Vizzarri, Gloria Coatti, Francesco Moreschi, Luca Giupponi, Arthur Berchet, Ziona Rose, Annamaria Giorgi
Contributing Partners	ZSI, TU Wien, FEBEA
Reviewers	ZSI, TU Wien, Advisory Board, INOVA+
Official Due Date	31.10.2024
Delivery Date	29.10.2024

History of changes

Version	Date	Author/Reviewer	Changes/notes
v.1	02/09/2024	Dario Pezzotti	First structured draft
v.2	13/09/2024	Dario Pezzotti	Factsheet adding started
v.3	10/10/2024	Dario Pezzotti	Shared draft

v.4	29/10/2024	Dario Pezzotti	Final draft

List of Acronyms

NbS	Nature-based Solutions
NCS	Natural Climate Solutions
DRR	Disaster Risk Reduction
CC	Climate Change
CCA	Climate change adaptations
STES	Socio-Technical-Ecological Systems
SRA	System Risk Assessment
RD	Regional Demonstrators
PPGIS	Participation Geographic Information Systems
EWS	Early Warning Systems
IC	Impact Chain
ES	Ecosystem Services

List of Tables

Table 1. Creation and distribution timeline for Factsheets (UMIL, 2024) 167

Table 2. List of participant's leaders from each regional demonstrator project who was in charge to distribute, collect and validate processes through Local Councils (UMIL, 2024).....167

Table 3. Outputs from Exercise 1 (a) – Gabrovo Regional Demonstrator Partners Factsheet (UMIL, 2024).....169

Table 4. Outputs from Exercise 1 (b) – Gabrovo Regional Demonstrator Partners Factsheet (UMIL, 2024).....169

Table 5. Outputs from Exercise 2 – Gabrovo Regional Demonstrator Partners Factsheet (UMIL, 2024) 170

Table 6. Outputs from Exercise 3 – Gabrovo Regional Demonstrator Partners Factsheet (UMIL, 2024) 172

Table 7. Outputs from Exercise 4 (a) – Gabrovo Regional Demonstrator Partners Factsheet (UMIL, 2024).....174

Table 8. Outputs from Exercise 4 (b) – Gabrovo Regional Demonstrator Partners Factsheet (UMIL, 2024).....174

Table 9. Outputs from Exercise 2A – Gabrovo Stakeholders Factsheet (UMIL, 2024).....177

Table 10. Chosen mitigation and adaptation solution to CC by Stakeholders - Gabrovo 179

Table 11. Outputs from Exercise 1 (a) – Lapland Regional Demonstrator Partners Factsheet (UMIL, 2024) .182

Table 12. Outputs from Exercise 1 (b) – Lapland Regional Demonstrator Partners Factsheet (UMIL, 2024) .182

Table 13. Outputs from Exercise 2 – Lapland Regional Demonstrator Partners Factsheet (UMIL, 2024) 183

Table 14. Outputs from Exercise 3 – Lapland Regional Demonstrator Partners Factsheet (UMIL, 2024) 183

Table 15. Outputs from Exercise 4 (a) – Lapland Regional Demonstrator Partners Factsheet (UMIL, 2024) .185

Table 16. Outputs from Exercise 2A – Lapland Stakeholders Factsheet (UMIL, 2024).....187

Table 17. Chosen mitigation and adaptation solution to CC by Stakeholders - Lapland 189

Table 18. Outputs from Exercise 1 (a) – Piedmont Regional Demonstrator Partners Factsheet (UMIL, 2024) 191

Table 19. Outputs from Exercise 1 (b) – Piedmont Regional Demonstrator Partners Factsheet (UMIL, 2024) 191

Table 20. Outputs from Exercise 2 – Piedmont Regional Demonstrator Partners Factsheet (UMIL, 2024) 192

Table 21. Outputs from Exercise 3 – Piedmont Regional Demonstrator Partners Factsheet (UMIL, 2024) 193

Table 22. Outputs from Exercise 4 (a) – Piedmont Regional Demonstrator Partners Factsheet (UMIL, 2024) 194

Table 23. Outputs from Exercise 2A – Piedmont Stakeholders Factsheet (UMIL, 2024) 197

Table 24. Chosen mitigation and adaptation solution to CC by Stakeholders - Piedmont.....199

Table 25. Outputs from Exercise 1 (a) – Râu Sadului Regional Demonstrator Partners Factsheet (UMIL, 2024) 201

Table 26. Outputs from Exercise 1 (b) – Râu Sadului Regional Demonstrator Partners Factsheet (UMIL, 2024) 202

Table 27. Outputs from Exercise 2 – Râu Sadului Regional Demonstrator Partners Factsheet (UMIL, 2024) 202

Table 28. Outputs from Exercise 3 – Râu Sadului Regional Demonstrator Partners Factsheet (UMIL, 2024) 204

Table 29. Outputs from Exercise 4 (a) – Râu Sadului Regional Demonstrator Partners Factsheet (UMIL, 2024) 206

Table 30. Outputs from Exercise 4 (b) – Râu Sadului Regional Demonstrator Partners Factsheet (UMIL, 2024) 207

Table 31. Outputs from Exercise 2A – Râu Sadului Stakeholders Factsheet (UMIL, 2024) 209

Table 32. Chosen mitigation and adaptation solution to CC by Stakeholders - Râu Sadului 211

Table 33. Outputs from Exercise 1 (a) – Tyrol Regional Demonstrator Partners Factsheet (UMIL, 2024) 212

Table 34. Outputs from Exercise 1 (b) – Tyrol Regional Demonstrator Partners Factsheet (UMIL, 2024) 212

Table 35. Outputs from Exercise 2 – Tyrol Regional Demonstrator Partners Factsheet (UMIL, 2024) 213

Table 36. Outputs from Exercise 3 – Tyrol Regional Demonstrator Partners Factsheet (UMIL, 2024) 215

Table 37. Outputs from Exercise 4 (a) – Tyrol Regional Demonstrator Partners Factsheet (UMIL, 2024) 216

Table 38. Outputs from Exercise 4 (b) – Tyrol Regional Demonstrator Partners Factsheet (UMIL, 2024) 217

Table 39. Outputs from Exercise 2A – Tyrol Stakeholders Factsheet (UMIL, 2024) 220

Table 40. Chosen mitigation and adaptation solution to CC by Stakeholders - Tyrol 224

Table 41. Outputs from Exercise 1 (a) – Valais Regional Demonstrator Partners Factsheet (UMIL, 2024) 226

Table 42. Outputs from Exercise 1 (b) – Valais Regional Demonstrator Partners Factsheet (UMIL, 2024) 226

Table 43. Outputs from Exercise 2 – Valais Regional Demonstrator Partners Factsheet (UMIL, 2024) 227

Table 44. Outputs from Exercise 3 – Valais Regional Demonstrator Partners Factsheet (UMIL, 2024) 227

Table 45. Outputs from Exercise 4 (a) – Valais Regional Demonstrator Partners Factsheet (UMIL, 2024) 228

Table 46. Outputs from Exercise 2A – Valais Stakeholders Factsheet (UMIL, 2024) 233

Table 47. Chosen mitigation and adaptation solution to CC by Stakeholders - Valais 236

Table 48. Outputs from Exercise 2A – Catalonia Replicators Factsheet (UMIL, 2024) 238

Table 49. Outputs from Exercise 2A – Friuli-Venezia Giulia Replicators Factsheet (UMIL, 2024) 242

Table 50. Chosen mitigation and adaptation solution to CC by Stakeholders – Friuli-Venezia Giulia 244

Table 51. Outputs from Exercise 2A – Primorje-Gorski Kotar Factsheet (UMIL, 2024) 247

Table 52. Chosen mitigation and adaptation solution to CC by Stakeholders – Primorje-Gorski Kotar.....249

Table 53. Outputs from Exercise 2A – Subcarpathian Region Factsheet (UMIL, 2024) 254

Table 54. Chosen mitigation and adaptation solution to CC by Stakeholders – Subcarpathian Region.....256

List of Figures

Figure 1. Project regions (UMIL, 2024).....12

Figure 2. Procedural structure (UMIL, 2024) 13

Figure 3. Flow diagram adapted from the PRISMA model (UMIL, 2024).....15

Figure 4. Challenges divided by macro-areas – Database structure (UMIL, 2024) 16

Figure 5. Beneficial effects divided by macro-areas – Database structure (UMIL, 2024) 17

Figure 6. Database resume – Date of articles publications (UMIL, 2024).....19

Figure 7. Database resume – Project beginnings years (UMIL, 2024) 19

Figure 8. List of information sent for exercise participants – Database structure (UMIL, 2024) 20

Figure 9. List of articles and projects sent to each regional demonstrator – Database structure (UMIL, 2024) 21

Figure 10. Number of database challenges reached by projects/articles (UMIL, 2024).....23

Figure 11. Number of database beneficial impacts reached by projects/articles (UMIL, 2024) 24

Figure 12. Number of proposed solutions reached by projects/articles in the database – graph 1 of 2 (UMIL, 2024) 25

Figure 13. Number of proposed solutions reached by projects/articles in the database - graph 2 of 2 (UMIL, 2024) 26

Figure 14. Number of Funding areas reached by projects/articles (UMIL, 2024).....27

Figure 15. Online tool creation phases (UMIL, 2024) 28

Figure 16. TransformAr logo (Source: https://transformar.eu/).....30

Figure 17. RAST process (Source: https://climate-adapt.eea.europa.eu/en/mission/knowledge-and-data/regional-adaptation-support-tool) 31

Figure 18. RAST DIY MANUAL (Wehbe, M., et al. 2024) 32

Figure 19. Factsheet exercise definition based on Project tas*ks* (UMIL, 2024) 34

Figure 20. Gabrovo Impact Chain – Exercise baseline (ZSI) 37

Figure 21. Gabrovo Local Council (G-LCL material)....38

Figure 22. Lapland Impact Chain (Focus: Reindeer herding) – Exercise baseline (ZSI, 2024) 45

Figure 23. Lapland Impact Chain (Focus: Tourism sector) – Exercise baseline (ZSI, 2024) 46

Figure 24. Reindeers in Inari natural environment (Source: https://www.pexels.com/it-it/) 47

Figure 25. Piedmont Impact Chain (Focus: Irrigation) – Exercise Baseline (ZSI, 2024) 56

Figure 26. Cultivated fields in Alba, Piedmont (Source: https://www.pexels.com/it-it/) 57

Figure 27. Râu Sadului Impact Chain (Focus: Agriculture) – Exercise baseline (ZSI, 2024) 65

Figure 28. Visit at Râu Sadului project fields (Source: R-LCL material) 66

Figure 29. Tyrol Impact Chain (Focus: Heat) – Exercise baseline (ZSI, 2024) 74

Figure 30. Tyrol Impact Chain (Focus: Nature) – Exercise baseline (ZSI, 2024) 75

Figure 31. Tyrol Local Council (T-LCL material) 76

Figure 32. Valais Impact Chain (Focus: Winter) – Exercise baseline (ZSI, 2024)....84

Figure 33. The ski touristic city of Zermatt, Valais (https://www.pexels.com/it-it/) 85

Figure 34. Catalonia Simplified Impact Chain, based on Innsbruck workshop - (UMIL 2024, based on ZSI, 2024) 92

Figure 35. A mountain field in Catalonia (Source: https://www.pexels.com/it-it/) 93

Figure 36. Friuli-Venezia Giulia Simplified Impact Chain, based on Innsbruck workshop - (UMIL 2024, based on ZSI, 2024) 99

Figure 37. Monte Lussari – a mountainous village near the Montasio plateau (Source: https://www.pexels.com/it-it/) 100

Figure 38. Primorje-Gorski Kotar Simplified Impact Chain, based on Innsbruck workshop - (UMIL 2024, based on ZSI, 2024) 107

Figure 39. Primorje-Gorski Kotar County mountains, Malo Selo, Delnice (https://www.pexels.com/it-it/).....108

Figure 40. Subcarpathian Region Simplified Impact Chain, based on Innsbruck workshop - (UMIL 2024, based on ZSI, 2024) 115

Figure 41. Subcarpathian region meeting organized to work on the exercises (Source: S-EP material).....116

Figure 42. List of partners and stakeholders that participated at the factsheet's exercises (UMIL, 2024).....123

Figure 43. Key discussion areas with proposed solutions, divided by region (UMIL, 2024).....125

Figure 44. Suggested collaborations and meeting for information sharing (UMIL, 2024) 126

Figure 45. Suggested key areas on which reg. replicators should focus on for the replication process (UMIL, 2024) 126

Figure 46. Factsheet slides (9 images) - Regional Demonstrator's workshop for project partners (UMIL, 2024) 134

Figure 47. Factsheet slides (10 images) - Regional Demonstrator's workshop for stakeholders and replicators (UMIL, 2024) 144

Figure 48. Factsheet slides (7 images) - User manual for the exercitation leader (UMIL, 2024).....154

Figure 49. Factsheet slides – Suggested solutions from the database for the exercitation leader based on Gabrovo background (UMIL, 2024) 161

Figure 50. Factsheet slides – Suggested solutions from the database for the exercitation leader based on Lapland background (UMIL, 2024) 162

Figure 51. Factsheet slides – Suggested solutions from the database for the exercitation leader based on Piedmont background (UMIL, 2024).....163

Figure 52. Factsheet slides – Suggested solutions from the database for the exercitation leader based on Râu Sadului background (UMIL, 2024).....164

Figure 53. Factsheet slides – Suggested solutions from the database for the exercitation leader based on Tyrol background (UMIL, 2024) 165

Figure 54. Factsheet slides – Suggested solutions from the database for the exercitation leader based on Valais background (UMIL, 2024) 166

Figure 55. Outputs from Exercise 1 – Gabrovo Stakeholders Factsheet (UMIL, 2024) 176

Figure 56. Outputs from Exercise 2B – Gabrovo Stakeholders Factsheet (UMIL, 2024).....178

Figure 57. Outputs from Exercise 1 – Lapland Stakeholders Factsheet (UMIL, 2024) 186

Figure 58. Outputs from Exercise 2B – Lapland Stakeholders Factsheet (UMIL, 2024).....188

Figure 59. Outputs from Exercise 1 – Piedmont Stakeholders Factsheet (UMIL, 2024).....196

Figure 60. Outputs from Exercise 2B – Piedmont Stakeholders Factsheet (UMIL, 2024) 198

Figure 61. Outputs from Exercise 1 – Râu Sadului Stakeholders Factsheet (UMIL, 2024) 208

Figure 62. Outputs from Exercise 2B – Râu Sadului Stakeholders Factsheet (UMIL, 2024).....210

Figure 63. Outputs from Exercise 1 (Buildings & Heat) – Tyrol Stakeholders Factsheet (UMIL, 2024).....218

Figure 64. Outputs from Exercise 1 (Nature & Tourism) – Tyrol Stakeholders Factsheet (UMIL, 2024) 219

Figure 65. Outputs from Exercise 2B (Building & Heat) – Tyrol Stakeholders Factsheet (UMIL, 2024) 222

Figure 66. Outputs from Exercise 2B (Nature & Tourism) – Tyrol Stakeholders Factsheet (UMIL, 2024).....223

Figure 67. Outputs from Exercise 1 (Local Vision) – Valais Stakeholders Factsheet (UMIL, 2024) 230

Figure 68. Outputs from Exercise 1 (Regional vision) – Valais Stakeholders Factsheet (UMIL, 2024) 231

Figure 69. Outputs from Exercise 1 (National vision) – Valais Stakeholders Factsheet (UMIL, 2024) 232

Figure 70. Outputs from Exercise 2B – Valais Stakeholders Factsheet (UMIL, 2024).....235

Figure 71. Outputs from Exercise 1 – Catalonia Replicators Factsheet (UMIL, 2024).....237

Figure 72. Outputs from Exercise 2B – Catalonia Replicators Factsheet (UMIL, 2024) 240

Figure 73. Outputs from Exercise 1 – Friuli-Venezia Giulia Replicators Factsheet (UMIL, 2024).....241

Figure 74. Outputs from Exercise 2B – Friuli-Venezia Giulia Replicators Factsheet (UMIL, 2024) 243

Figure 75. Outputs from Exercise 1 – Primorje-Gorski Kotar Replicators Factsheet (UMIL, 2024) 246

Figure 76. Outputs from Exercise 2B – Primorje-Gorski Kotar Replicators Factsheet (UMIL, 2024).....249

Figure 77. Outputs from Exercise 1 – Subcarpathian Region Replicators Factsheet (UMIL, 2024) 253

Figure 78. Outputs from Exercise 2B – Subcarpathian Region Replicators Factsheet (UMIL, 2024).....255

Keywords list

- MountResilience;
- Horizon Europe
- Nature-based solutions
- Transformative climate adaptation
- Climate change
- Resilience
- Adaptation strategies
- Mitigation

Disclaimer

Table of content

Deliverable Information Sheet **1**

List of Acronyms **2**

List of Tables **2**

List of Figures **5**

Keywords list **8**

Disclaimer **9**

Table of content **9**

Executive summary **11**

1. Methods **12**

1.1. Deliverable background **12**

1.2. The database creation **14**

1.3. Factsheet creation **29**

2. Regional demonstrators adaptations strategies **35**

2.1. GABROVO FACTSHEET 35
2.2. LAPLAND FACTSHEET 43
2.3. PIEDMONT FACTSHEET 54
2.4. RÂU SADULUI FACTSHEET 63
2.5. TYROL FACTSHEET 71
2.6. VALAIS FACTSHEET 81
3. Regional replicators adaptations strategies 85
3.2. CATALONIA FACTSHEET 90
3.3. FRIULI-VENEZIA GIULIA FACTSHEET 97
3.4. PRIMORJE-GORSKI KOTAR FACTSHEET 105
3.5. SUBCARPATHIAN REGION FACTSHEET 113
4. Considerations on the regional Factsheets and strategies for climate adaptation 120
5. Annex 127
5.1. Conceptual understanding 127
5.2. Guideline for the Factsheets compilation 133
5.3. Factsheet timeline 167
5.4. Factsheet distribution list 167
5.5. Factsheet in detail 169
6. References 257

Executive summary

The MountResilience project was formulated to increase the adaptation capacity and climate resilience of European Mountain Regions and communities. To achieve this goal a conceptual model of a systemic approach to transformative adaptation (D1.1), and a diagnosis of climate challenges and possible adaptation solutions (D1.2) were developed. This report presents the specific regional transformation strategies suggested for the implementation of actions towards a climate resilient transformation.

As a first step the regional demonstrator challenges were identified, through the support of information provided by D1.1 and D1.2 (previous deliverables of MountResilience). By implementing a co-creation approach involving the quadruple helix, and particularly with a first group of expert and stakeholders, more scientific and technical aspects on CC challenges were covered. D1.3 was supported by a validation process activated within the Local Councils in each demo region. The group of stakeholders was asked to define the climate adaptation path to address the regional climate change challenges that were identified as at the beginning of the project. For this phase both STES and SRA (see the list of acronyms) composed in previous deliverables were considered and implemented.

Bibliographic research on a set of defined keywords (see section 1.2) linked to Nature Based Solutions (NbS) and adaptation strategies related to these specific CC challenges was performed by searching peer reviewed articles and researching projects outputs available on CORDIS (e.g., LIFE, Horizon 2020, Horizon Europe, Interreg). Afterwards, a catalogue of adaptation options and Factsheets were developed, providing a climate resilient transformation strategy for demo regions, as a base for the implementation roadmap (D2.1) and as a supporting part for future discussions performed in the capacity-building program (D2.2).

Finally, all this information will be rendered available into an open-source inventory that includes a tool. Regional demonstrators will be encouraged to use this decision-making tool, that will be available on the MountResilience project site, as a base for future deliverables on regional projects realization. Future stakeholders will also be able to access it to evaluate their own CCA strategies, and so have a base of instrument/solutions to their CC challenges, all this work will make it possible to achieve the fully operationality of all RDs.

1. Methods

1.1. Deliverable background

Deliverable 1.3 has solid links with the previous deliverables (D1.1 “Conceptual model for climate resilient transformation” and D1.2 “Regional diagnosis for CCA”) and will be the base for further deliverables on regional projects realization. In this chapter a little resume of the work context is done. The main aspects that come out from D1.1 and D1.2, that have defined the structure of D1.3, and the main definitions can be found in the Annex.

The deliverable D1.3 (Climate resilient regional transformation strategies) is one of the 55 deliverables that will be produced throughout the MountResilience project’s lifetime. The MountResilience project aims to increase the adaptation capacity of mountainous regions and their communities, and to accelerate and strengthen climate resilience of the European mountainous biogeographical regions. The project will focus on ten of the most relevant communities and regions located in the mountains from nine different European countries, and on understanding their challenges (climate hazards and related socioeconomic vulnerabilities) to define a tailored climate adaptation strategy. One of the core objectives of the MountResilience project is to support European regions and communities located in mountainous areas in increasing their CCA capacity and their transition to a climate-resilient society by developing, testing and scaling up multi-level, multidimensional and re-applicable innovative CCA solutions in their regional and local settings. It is important to define the structure and the aims of this deliverable, as defined in the MountResilience project: *“Grounded on the conceptual model elaborated in T1.1 and the regional diagnosis in T1.2, this task will focus on creating a tailored adaptation and engagement strategy outlining possible solutions, strategic assets, financial instruments and actor networks to be taken into account for each project region (both demo and replicator) to promote a coherent transformation, ensuring that the project interventions provide an impulse for accelerating a sustainable, climate-resilient transformation of structures and practices in the project regions”.* Project regions are listed in the following figure (Figure 1):

Figure 1. Project regions (UMIL, 2024)

The spectrum of solution that can be tailored for each demonstrator region is wide: among these were included not only solutions related to nature or NbS in a narrow sense, but, as aimed in the project definition and as included in regional programmes, tailored solutions that ranges from rainwater harvesting systems, new technologies, meadow restoration practices, engagement strategies, early-warning and monitoring devices. Similarly, CCA business coaching, plan models for corporations and digital platform supporting participative governance were and will be evaluated and implemented among this and further deliverables. D1.3 has a focus on NbS and CCA strategies more suitable to Regional Demonstrators, but also solutions not strictly related to nature will be included in the database creation. One of the purposes was to find solutions to locally identified multi-risks defined in D1.2, such as floods

caused by ice/snow melting (Valais), upward shift of snowline (Lapland), heatwaves (Tyrol), drought and fires (Gabrovo), water scarcity caused by precipitation regime change, with heavy rain, dry periods, etc. (Piedmont) or loss of biodiversity (Râu Sadului).

As a starting point to define suitable climate adaptation solutions and to better understand the interdependencies between Climate Change, ecosystems, and the services provided, a systematic scientific literature review was performed and that is for a component of D1.3. This is reported in the project description:
"The task oversees the development of an open-source inventory the most relevant solutions, approaches, methods and tools for the fast-track of climate-resilient regional development (e.g., CCA solutions, NbS, co-creation methods, stakeholder engagement practices, behavioural change frameworks, governance models, data, etc.)."

An open-source inventory of the most relevant solutions for addressing climate change and related challenges was developed, primarily based on the regional needs identified in D1.2 and bibliographic research. This inventory is implementable and already includes some solutions not strictly related to RD challenges. By applying these solutions sustainably, stakeholders — including end-users, funders, investors, and decision-makers — will be able to encourage public and private investments, supporting the implementation of local and regional adaptation strategies to address the impacts of climate change.

The information in the database will be presented in a more user-friendly format. As stated in D1.3, "The inventory and engagement strategies will be complemented by a decision-making toolbox, enabling the demo regions to define the transformation strategies to be implemented." This user-friendly tool, along with the creation of Factsheets for regional demonstrators and replicators, will represents the final objective of this deliverable.

To ensure the quality and timely submission of this work, the internal review process outlined in the "Internal Reviewing Process of MountResilience Deliverables" document was followed.

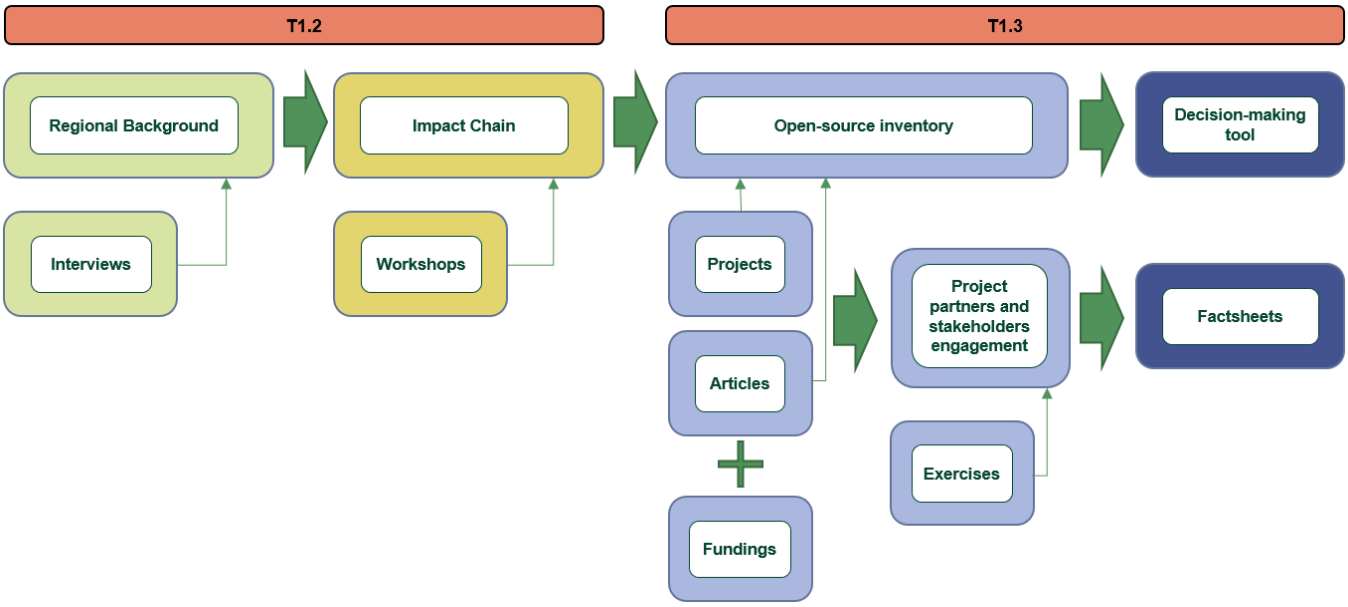


Figure 2. Procedural structure (UMIL, 2024)

1.2. The database creation

This section shows the main steps that were considered to create the database, including the scientific review process and choices taken to define the catalogue form and keywords for challenges, benefits and solution.

1.2.1. Searching process and preliminary choices

To define and begin the creation of the database, that will be the founding base for the online tool, the following steps were implemented (as indicated in T1.3 *definition "The inventory will be based on the regional needs as identified in T1.2*"):

1. Gathering adequate and relevant information related to the regional demonstrators and replicators, starting from the written project base, defining local challenges and needs through research and dedicated workshops;
2. Validation of the collected information concerning the regional demonstrators through a series of scheduled interviews with experts that are involved in the regional challenges posed by Climate Change;
3. Creation of regional backgrounds and Impact Chains (IC) based on the results of interviews and workshops.

As shown in Figure 1, the specific directions for research in each region were clearly outlined. The research began by identifying a set of keywords related to the selected topics, providing a scientific foundation for the decisions made by regional demonstrators, particularly regarding the selection of Nature-based Solutions (NbS). These NbS were broadly defined (D1.3, Annex) to include not only nature-related or nature-inspired solutions (e.g., river re-naturalization) but also practices that provide frameworks, technical tools, or methods for climate change adaptation that rely on external supports, such as Participatory Geographic Information Systems or Early Warning Systems, which go beyond traditional nature-based approaches.

The creation of a comprehensive database, including a wide range of articles and projects, required a standardized approach—a systematic review process. To achieve this, the PRISMA Flow Diagram (Page et al., 2021) was adapted to guide the information flow through the scientific review phases. For the MountResilience project, a customized version of the PRISMA diagram was developed, expanding the framework to incorporate additional elements, such as opportunities for using more funds or solutions from projects funded by the European Commission. Given the project's requirements for scientific backing, both in terms of scholarly articles and project development examples of NbS and climate change adaptation efforts, the research phase incorporated both types of information into the diagram as thoroughly as possible.

The flow diagram for the identified articles, projects and funding opportunities implemented within the MountResilience project appears as follows (Figure 3):

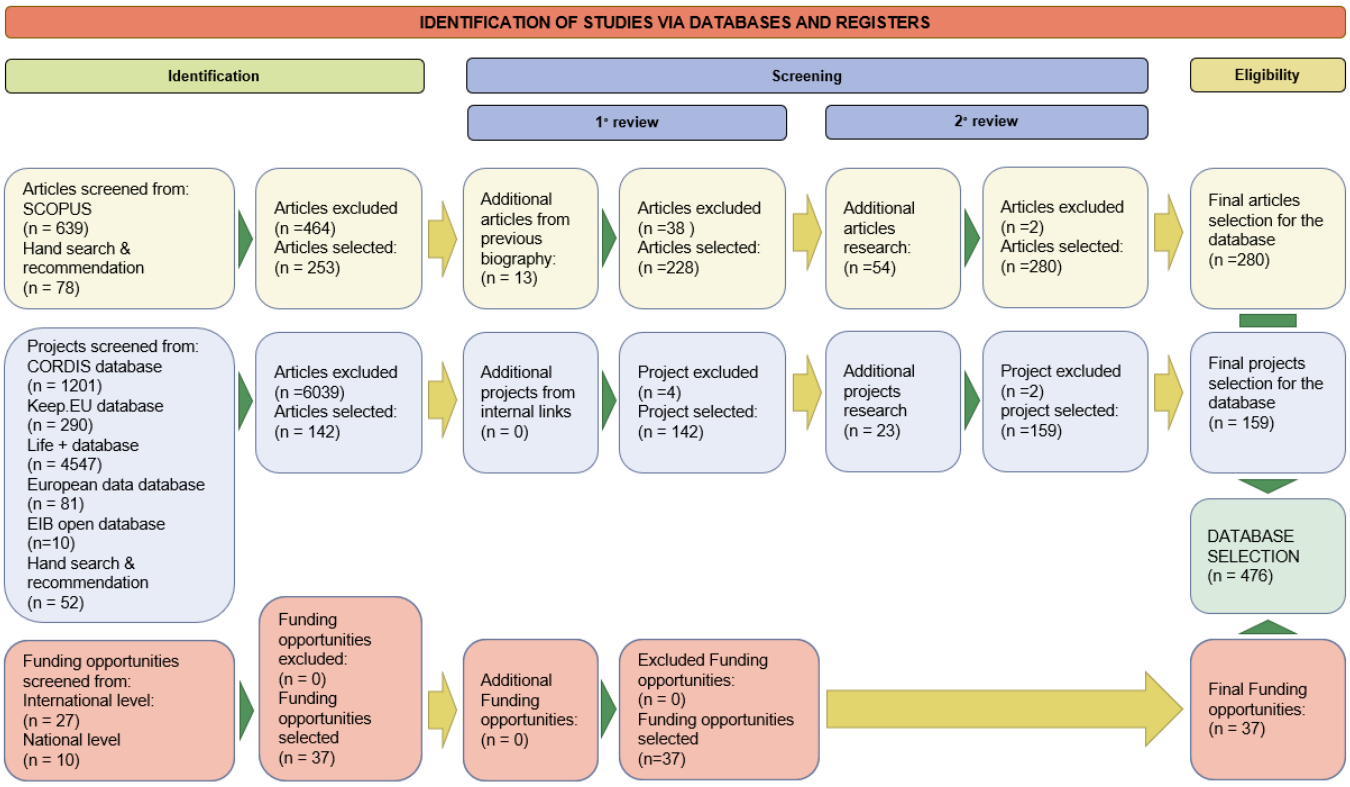


Figure 3. Flow diagram adapted from the PRISMA model (UMIL, 2024)

As illustrated in the previous diagram, Scopus was the primary platform used to search for scientific articles. For project searches, in line with T1.3 guidelines, the focus was on key initiatives such as Horizon 2020, EIT KICs, LIFE+, Structural Funds, EIB, EBRD, and other national programs. The main databases used for this process were Cordis, LIFE+, European Data, and Keep EU.

Additional searches that included these sources but followed a less structured procedure were classified under the "Hand Search & Recommendation" section. This category also included any resources or recommendations based on personal knowledge, especially those identified during the T1.2 interviews, which were incorporated before the formal screening process for both articles and projects.

This **identification phase** allowed the project consortium to gather a preliminary total of 280 articles, 159 projects and 37 funding opportunities which composed the initial database, and which will be then implemented through the project duration.

The primary goal of this task is outlined in the T1.3 guidelines: *"this task will focus on creating a tailored adaptation and engagement strategy outlining possible solutions, strategic assets, financial instruments, and actor networks to be taken into account for each project region (both demo and replicator)*", the main goal is therefore to provide dedicated examples for the six demonstrative regions and for the four replicators, to support tailored solutions based on specific regional challenges, so to face local priorities related to CC challenges.

Considering this, the research focused primarily on specific keywords and domains for these regions, ranging from reindeer management (for Lapland) to monitoring systems (for Valais). However, projects and articles not exclusively related to the primary challenges were included, considering future needs to expand the research to all NbS and Climate Change solutions that may be relevant to mountain territories. Moreover, the online tool will make it easy for the project consortium to add new challenges/solutions and manage the already existing ones. These aspects have been considered with the future perspective to make this tool not only bound to this project but useful for future works.

The identified macro-areas in terms of challenges for the MountResilience project are indicated below (Figure 4):

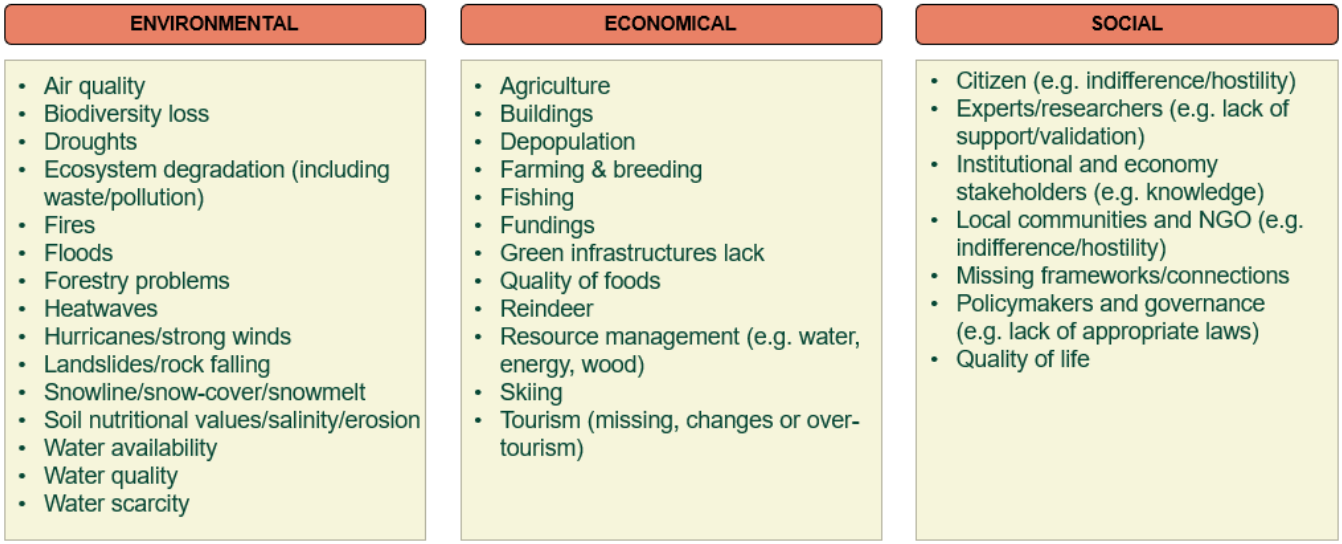


Figure 4. Challenges divided by macro-areas – Database structure (UMIL, 2024)

Positive outcomes obtainable through specific solutions have been outlined based on the data collected, to ensure a correct classification of the projects with the aim of enhancing their usability within the tool. These will be referred to as “Beneficial Effects”.

Beneficial effects have been summarized in the following table (Figure 5), organized by macro-areas (note that biodiversity appears twice, but in the online database they will be combined simply because this is a transversal theme between vegetation and animals).

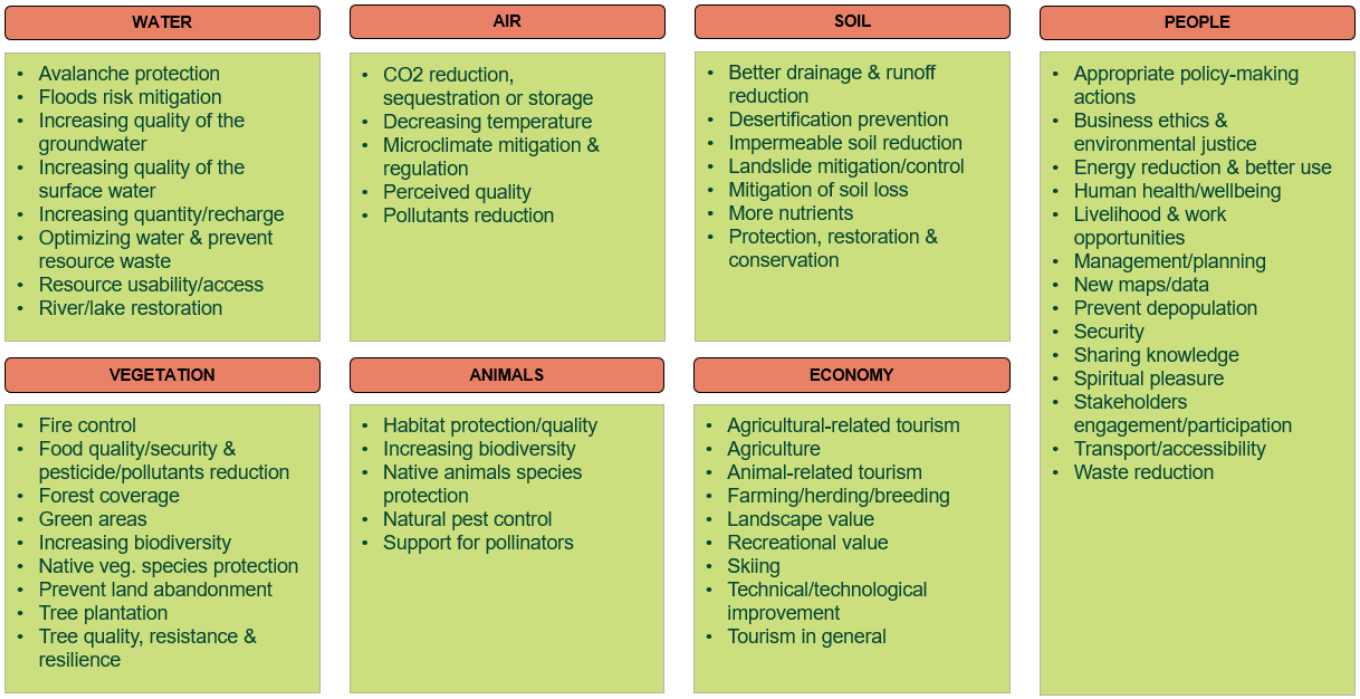


Figure 5. Beneficial effects divided by macro-areas – Database structure (UMIL, 2024)

1.2.2. Identification phase

The beginning of the identification phase is the mere acquisition of projects and articles that could be helpful for the previous written arguments, on the basis of specific keywords related to identified regional challenges. This list of keywords was used for each regional demonstrator, to scan scientific documents developed within major European projects, remembering the main purpose; that was to develop responses to issues meaningful for mountain areas and mostly related to NbS.

ARTICLES - The research process was mainly based on SCOPUS, where keywords related to the six regions were inserted searching at papers that included them in the title, abstract, or keywords. Then an early control on the found articles was done and abstract/conclusion information were synthesized to evaluate the macro-areas and determine challenges and beneficial effects.

PROJECTS - The research process in this case was deeper, due to the necessity of using different online databases. The investigation started with CORDIS and Keep.EU project databases, as they could provide the most information and relevant overviews.

FUNDING SOURCES - The research process was performed by Project Partner FEBEA, looking mainly at international and transversal areas (covering many CC challenges). This will help to have long term possibilities, still active at the end of the project, and not so specific to be a barrier for users.

After we completed the list of key search words for each regional demonstrator – pulling from the sources outlined above – we attempted to go back through our work and fill in what was lacking. Specifically, we aimed to have at least two projects addressing any environmental challenge the regional demonstrators might face. By use of graphics, we were able to identify where information still needed to be added. We also worked back through the added projects to ensure everything was clear and the information was accurate.

1.2.3. First review phase

Once this initial identification phase was completed, the first screening phase took place: the goal of this process was to perform a preliminary selection of articles to be forwarded to the regional demonstrators and replicators for the validation phase. This review involved (if not already done in the first phase) the following actions:

- *Removal of duplicates*
- *Removal of articles in languages other than English*
- *Removal of articles and projects not relevant to the project research*
- *Removal of articles where only abstracts were available*
- *Temporal verification of articles*
- *Classification and definition of each article and project*

REMOVAL - The first four listed cases were due mainly to an erroneous selection, because of the volume of work or insufficient data in the abstracts. For future works we suggest, based on this experience, to use programs that automatically check the information related to the “mechanical” article selection. Our removal process was based on information collected on an Excel document.

TEMPORAL VERIFICATION - Regarding articles and projects, a temporal evaluation was conducted, looking at the publication date of the article and the start date of the project. While this was not necessarily an exclusionary factor, it served to highlight “older” works: in these cases, a more thorough review of the respective article/project was performed, to determine if included information were no longer relevant concepts, particularly for the purposes of the research.

Below (Figure 6 and Figure 7), just for transparency, the two graphs showing the date of the final collected material are listed. These images include all articles and projects inserted in the definitive database, and not only those used for the validation process.

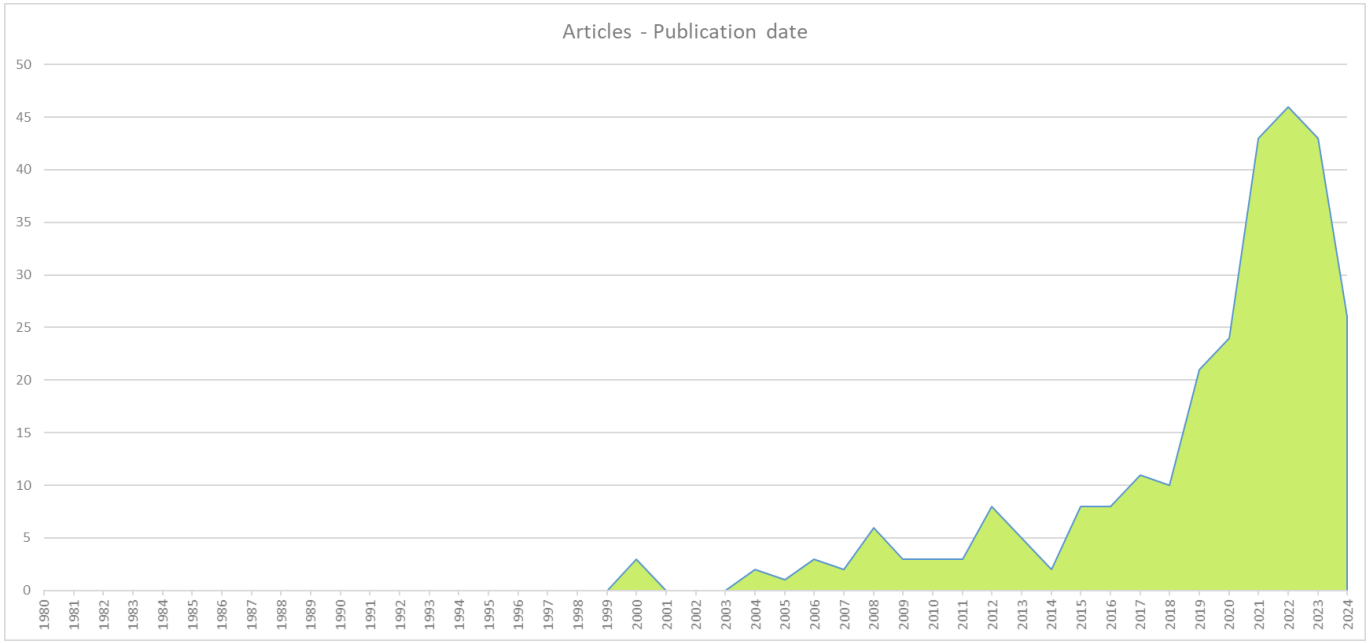


Figure 6. Database resume – Date of articles publications (UMIL, 2024)

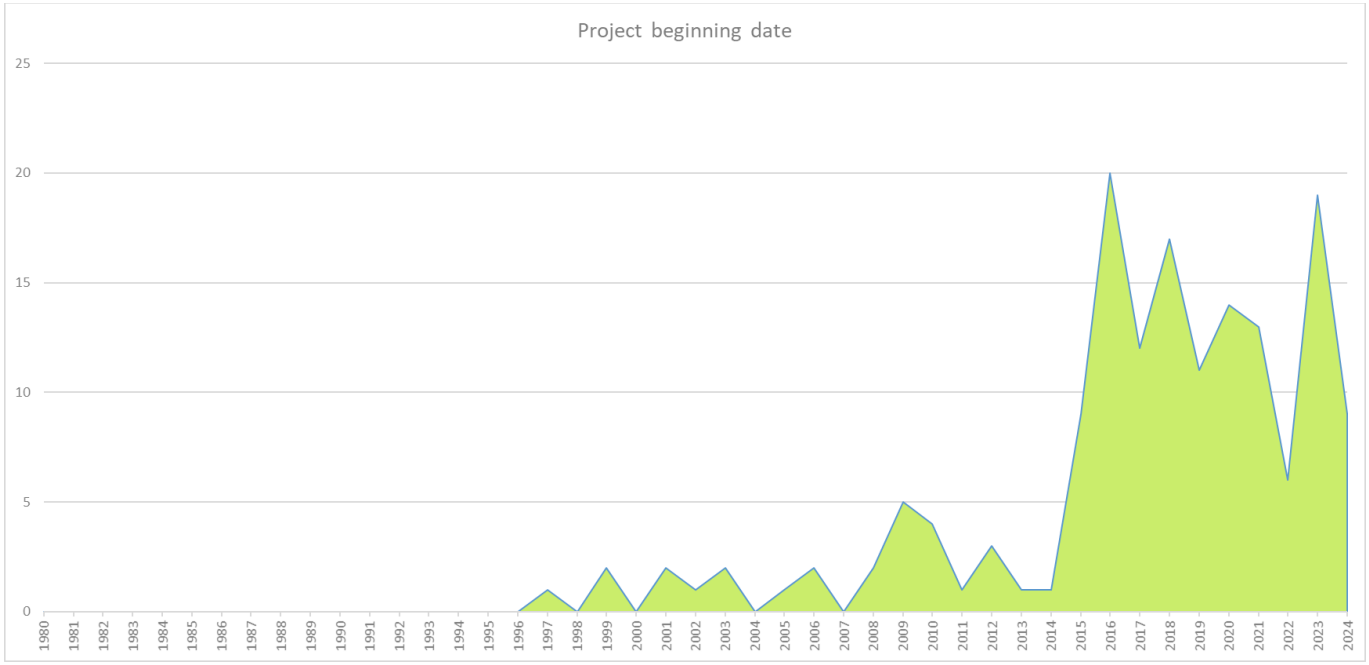


Figure 7. Database resume – Project beginnings years (UMIL, 2024)

Concerning peer-reviewed articles, unlike most scientific overview studies, the number of citations was not a factor considered in the selection of articles. This is because most of the articles had very few citations, because solutions

related to Climate Change tailored on specific regions, and particularly NbS, was a field highly active only in recent years. This is why the database is largely composed of recent publications (which generally have few citations).

CLASSIFICATION AND DEFINITION - The core section of the work conducted in the pre-validation phase was to identify, for each included project and article, not only Challenges and Beneficial Effects (not yet categorized at this stage, see the following sections), but also a preliminary indication of the solutions and NbS that the articles/project chosen could offer. With the aim of allowing everybody to understand essential concept included in the material selected in this overview, we compiled the initial database adding the following fields (Figure 8):

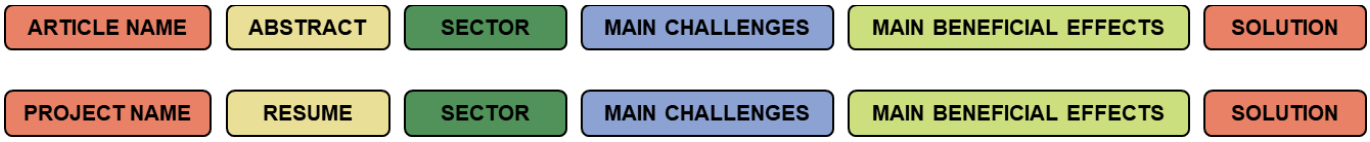


Figure 8. List of information sent for exercise participants – Database structure (UMIL, 2024)

With this structure, the database contained all the necessary information to understand articles and projects even without reading them in detail (which is unlikely impossible during the validation phase, considering the time that participants can consider to be involved in the exercise). These fields, sent to participants via an Excel document, could be more easily identified by indicating the sector of interest for their own region (e.g., skiing, reindeer, water, tourism, etc.).

1.2.4. Documents for the validation process

As stated in T1.3, one of the outputs requested by this task was the creation of “6 regional Factsheets”: these documents should resume the 6 regional demonstrators information obtained by partners and stakeholders’ engagement, considering main project phases, starting from the background validation to the suggestion of strategies for Climate Change adaptation (and decision taken to reach them).

To do that and to correctly engage regional partners/stakeholders, two additional documents were included. These documents, including the Factsheet exercises, contain all the necessary instructions and essential information to understand the work carried out so far, aimed at explaining the process of selecting solutions to CC and engaging participants in the decision-making process in an informed manner. The final documents added for the validation process were the following:

- *Background and Impact Chain (Pdf) - (Included in the Factsheet chapter)*
- *Projects and articles database (Excel) - (Not included in the deliverable)*

The "Background and Impact Chain” document includes regional information and the relative Impact Chain (with the background material derived from T1.2 and refined in T1.3 and the Impact Chain derived from Innsbruck workshops) on which is based the first part of the exercises proposed to regional demonstrator participants and stakeholders. The document is therefore structured in two different sections:

- *A section titled “Regional Background,” which includes basic information about the region, such as geography, weather conditions, critical issues, challenges, and needs. These were primarily derived from*

project data and interviews conducted during the T1.2 phase, in which also the producer of this deliverable has participated.

- *An "Impact Chain," defined following the validation of regional information carried out during the Innsbruck Workshop and based on D1.2 theoretical aspects (see Annex for main concepts resume). This section encapsulates the logical flow for understanding and defining actions for effective Climate Change adaptation, starting from hazards, exposures, and vulnerabilities, through impacts, and ultimately identifying regional risks.*

The "Project and Articles Database" is the list of projects and articles that can be useful to face or understand regional challenges.

To allow participants to correct the Factsheet during the development the list of articles and projects needed to be organized so to make the searching process easier. Thus, it was decided to make a division based on primary regional challenges and, where applicable (as in the cases of monitoring and tourism that involve multiple regions), including a secondary indication. Additionally, a set of articles and projects shared across all regions was included, covering topics such as framework creation, NbS in general, or stakeholder engagement that could be useful for all the participants. This approach made it possible to provide different database lists depending on the region, simplifying the validation process.

The result was as follows (Figure 9):

Regional database subdivision		1° choice	2° choice	for all	Total	
Lapland	Number of projects	36	2	15	53	112
	Number of articles	31	8	20	59	
Piedmont	Number of projects	27	14	15	56	163
	Number of articles	42	45	20	107	
Tyrol	Number of projects	22	18	15	55	134
	Number of articles	41	18	20	79	
Râu Sadului	Number of projects	11	17	15	43	112
	Number of articles	36	13	20	69	
Gabrovo	Number of projects	18	24	15	57	152
	Number of articles	43	32	20	95	
Valais	Number of projects	7	29	15	51	123
	Number of articles	37	15	20	72	

Figure 9. List of articles and projects sent to each regional demonstrator – Database structure (UMIL, 2024)

The full database was provided to regional replicators, to let them pick their priorities based on which to define a Climate Change adaptation project.

1.2.5. Final database review

The validation process done through Local Councils and stakeholders/partner feedback enabled a second review of the screening process, to determine articles and projects eligibility. This involved the removal of articles and projects that, based on received feedback or subsequent checks, proved to be unnecessary, and most important, the addition of a range of articles/projects researched by topic, to cover areas that sparked more interest or had not yet been adequately addressed by the research procedure.

The thematic considerations were conducted not by quantity (e.g., adding research documents to the lowest considered one) but by useful categorization for project purposes in the fields addressed. For this objective, the grouping process we conducted was beneficial: it was applied in the categorization of the online tool to simplify the user's process by organizing searches within various fields using keywords.

Below (Figure 10,11,12, 13), for informational purposes, we outline the topics covered in the first version of the tool, along with some summary charts illustrating the contents of the database.

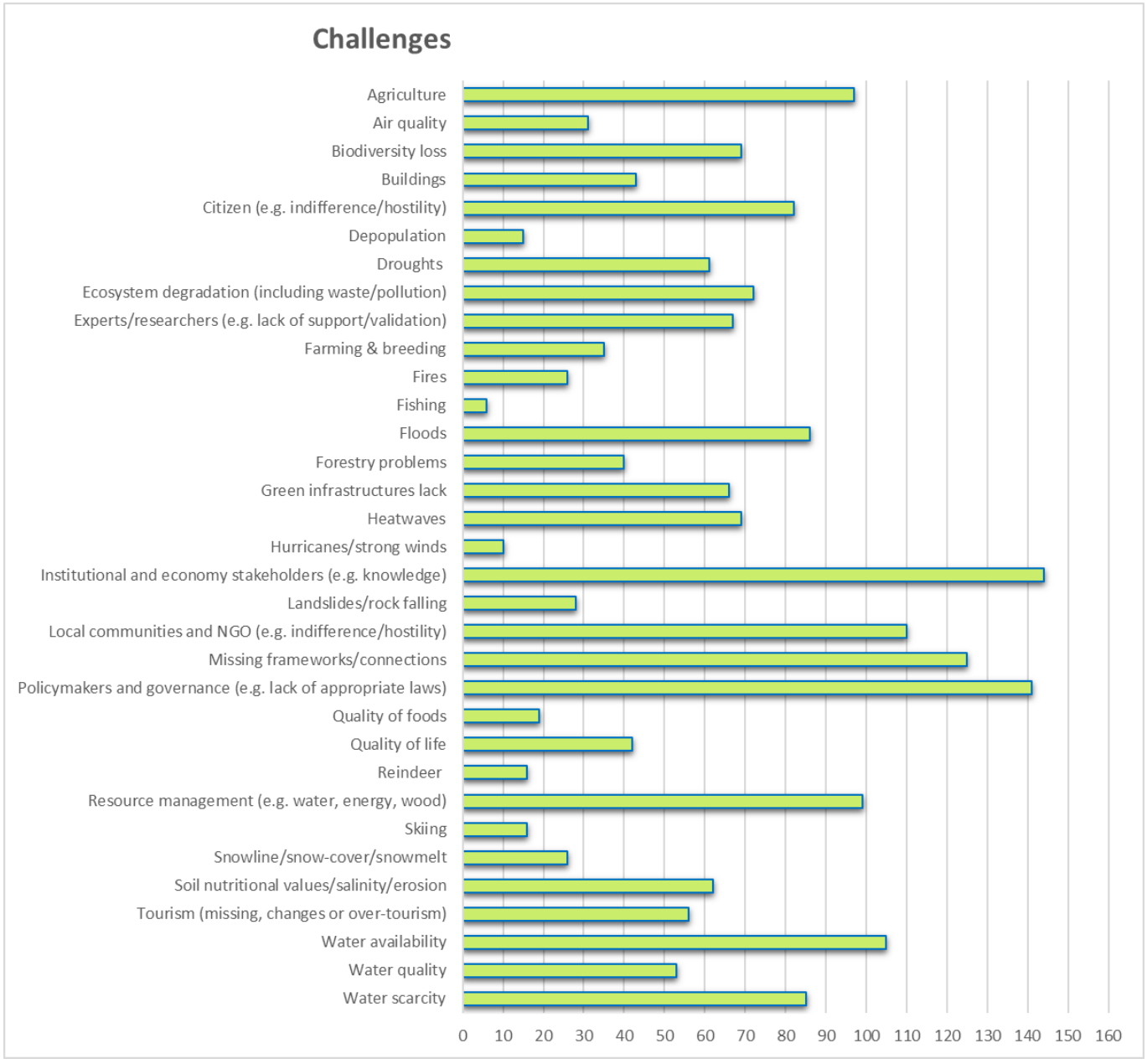


Figure 10. Number of database challenges reached by projects/articles (UMIL, 2024)

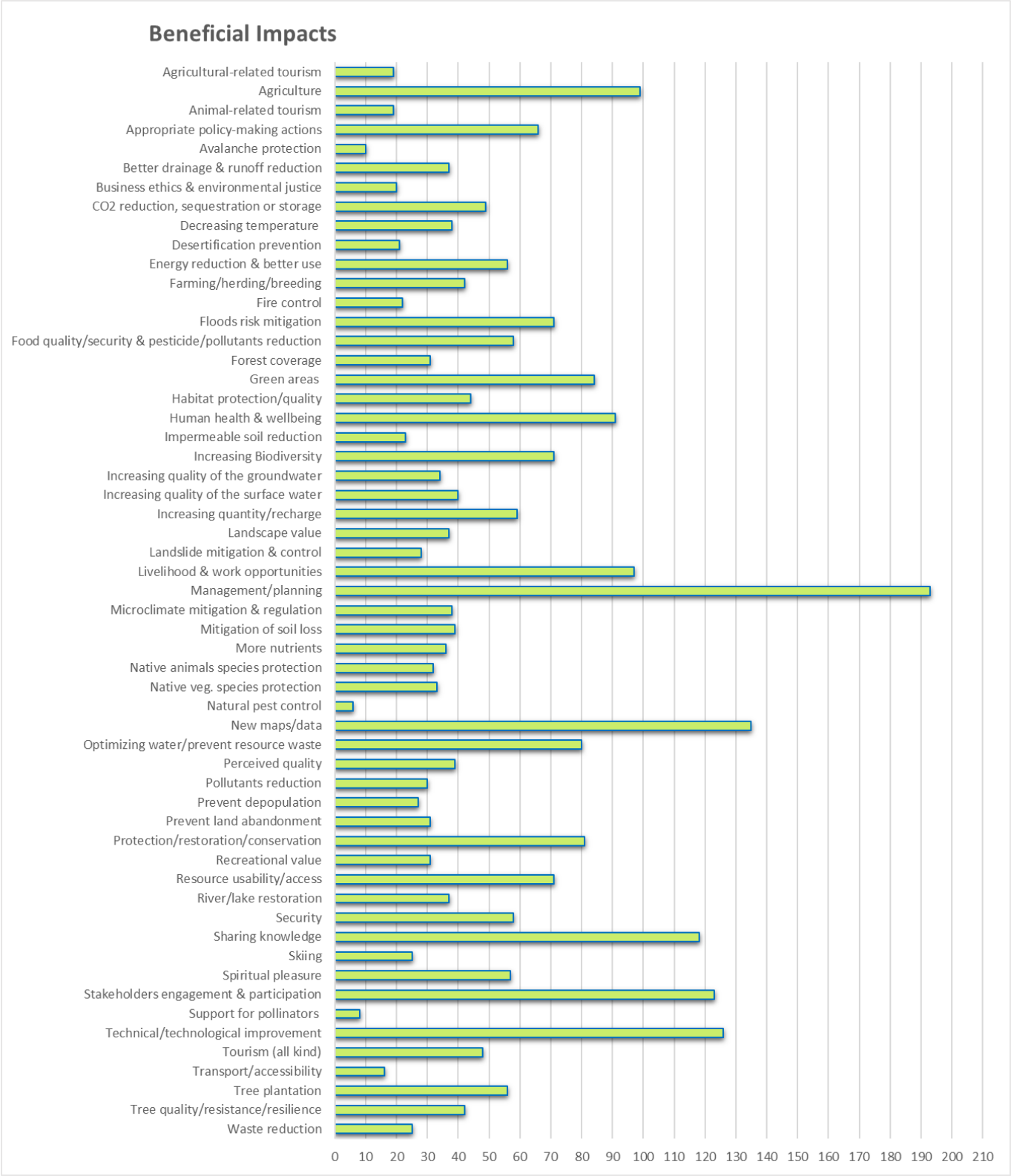


Figure 11. Number of database beneficial impacts reached by projects/articles (UMIL, 2024)

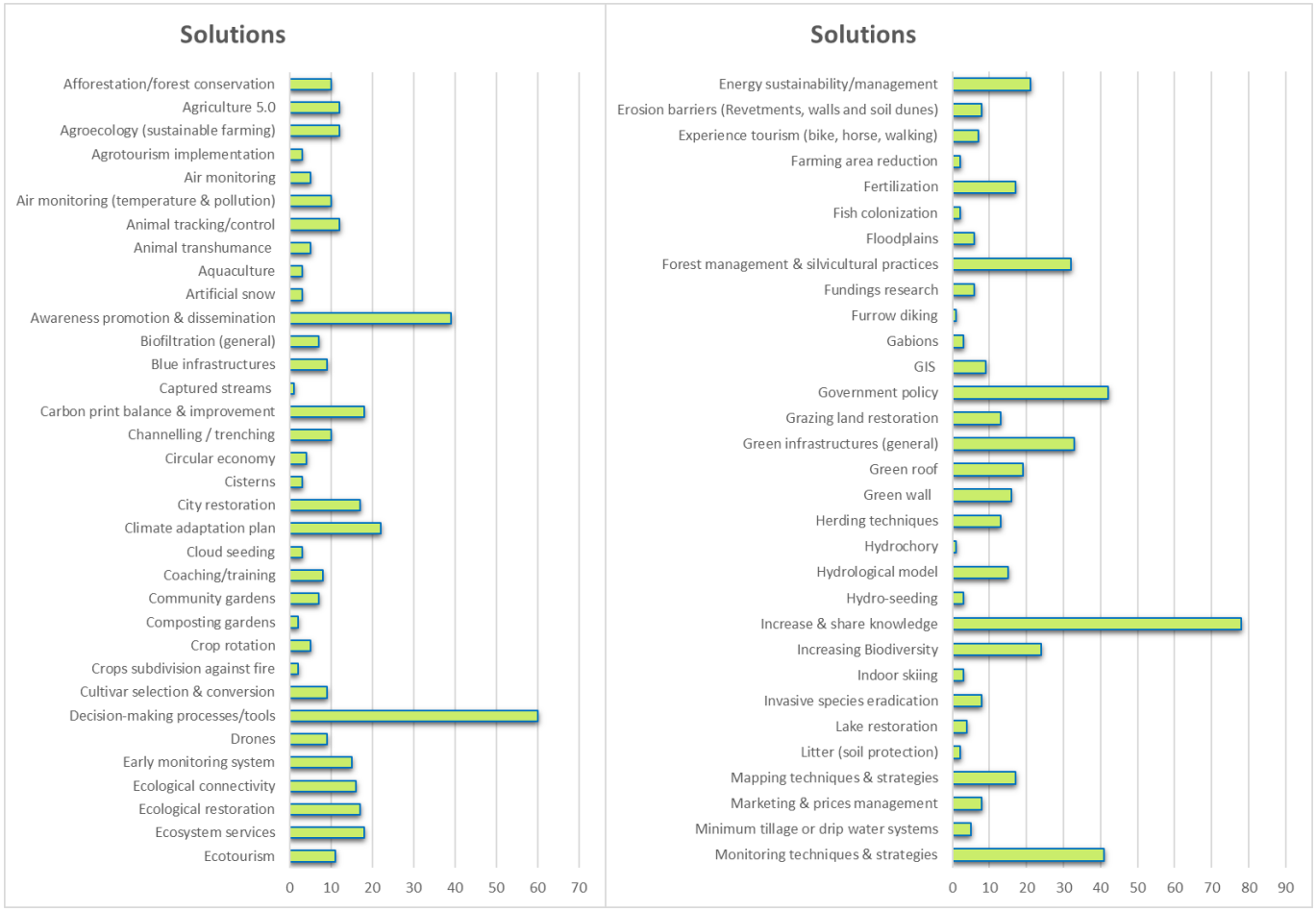


Figure 12. Number of proposed solutions reached by projects/articles in the database – graph 1 of 2 (UMIL, 2024)

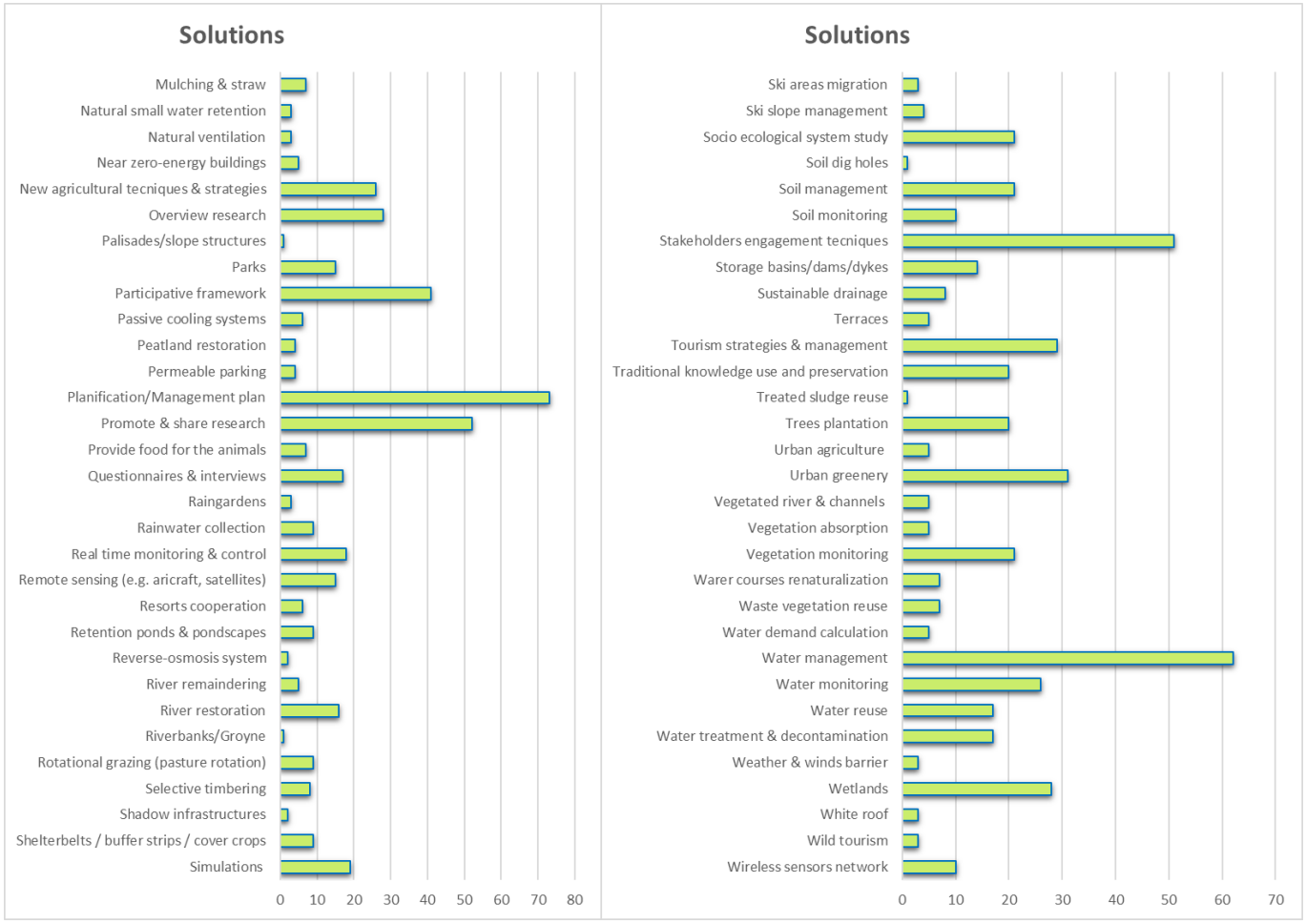


Figure 13. Number of proposed solutions reached by projects/articles in the database - graph 2 of 2 (UMIL, 2024)

Additionally, for the online tool, a section related to funding has been added, which will be integrated in the tool as a guidance to future users: for a chosen challenge a certain number of funding options related to the project area will be suggested, as reported in the following figure (Figure 15). Given that this section will be further developed in subsequent project stages, it will serve as a structural foundation for future tasks. The following graph (Figure 13) shows the fields covered by founded funding programmes.

To build the table of (EU) funding opportunities, the search was conducted at various levels:

- *the EU funding and tender portal was reviewed to identify relevant programmes and calls related to CCA*
- *The websites of several institutions (CINEA, DG CLIMA, CLIMATE ADAPT, etc.) and reports (such as those from the European Investment Bank etc.) were consulted to uncover complementary EU funding opportunities that may not have been identified through the EU portal search*
- *Euromontana was consulted, which provided further complementary information*
- *A final internet search was done, using key words through a search engine*

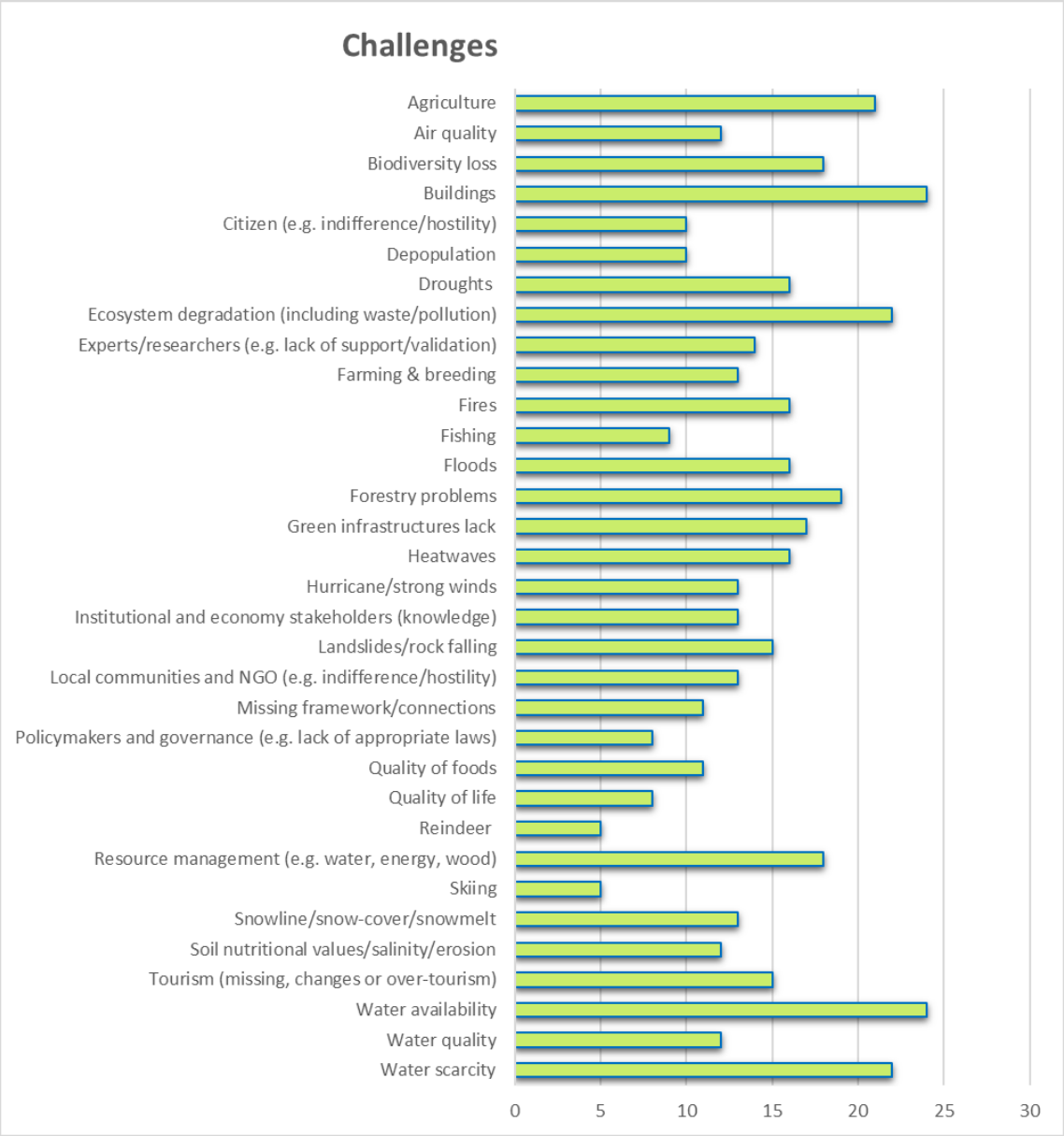


Figure 14. Number of Funding areas reached by projects/articles (UMIL, 2024)

1.2.6. The online tool

The scientific review and the subsequent database creation were the base for the creation of an online tool that can work as a user-friendly methodology for search information and, mostly important, solution, related to Climate Change challenges and their solutions. This chapter resumes the basis actions done to create the tool (Figure 15).

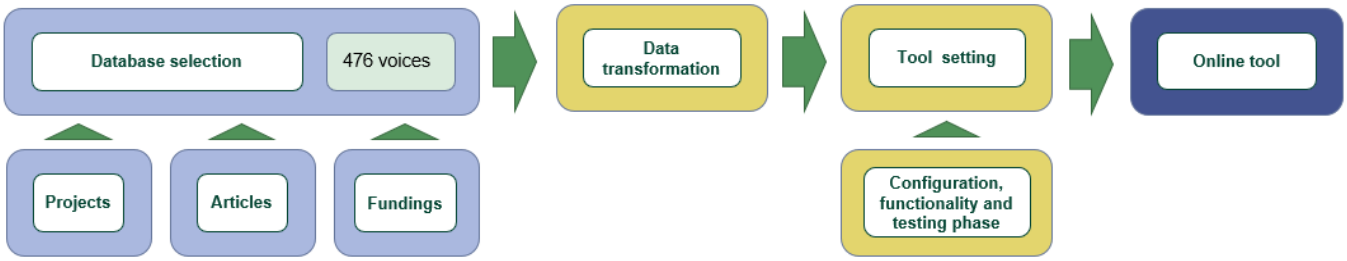


Figure 15. Online tool creation phases (UMIL, 2024)

The project involved a conversion of the Database Excel file that contains articles and projects into a structured database: this was done using Drupal 10.3. The key steps were the following:

- ***Data Transformation:*** *the Excel data was directly imported into Drupal with minimal transformation due to its compatible structure.*
- ***Drupal Configuration:*** *default Drupal settings were used with the frontend accessible via an iframe.*
- ***Search Functionality:*** *the search tool was implemented, allowing users to find content based on taxonomy terms, titles, and dates.*
- ***Testing and Deployment****: standard testing procedures were conducted to ensure its functionality.*

Technical note: Drupal 10.3 was utilized for its robust content management capabilities. The default configurations were sufficient for the project's needs. The frontend was designed to be embedded via an iframe, ensuring easy integration with external websites. The backend employed Drupal's default Claro theme, providing a user-friendly interface for administrators.

Outcome: the Excel data was successfully transformed into a searchable database accessible through a user-friendly interface. The tool can be easily integrated into existing websites, meeting the project requirements efficiently.

Essentially, after this work MountResilience regions and future stakeholders will have the possibility to use this decision-making toolbox, to better evaluate challenges and solutions on which implement adaptation strategies.

The online tool will be available on MountResilience site (https://mountresilience.eu/it/home-page/) with the structure visible at the following link: https://mountresilience.cleversoft.it/explore. The instruction to embed the tool in the site, that will be used, can be read at this link: https://mountresilience.cleversoft.it/embedding-instructions.

1.3. Factsheet creation

To create a Factsheet for regional demonstrators (and replicators) a schematic base of exercises to involve MountResilience stakeholders and partners participants and to collect fundamental information must be created, considering both the different knowledge level of participants (stakeholders are less confident with scientific concepts related to CC than regional partners) and the modality in which these answers can be obtained. This chapter explains the procedures adopted to create the exercises that will be the Factsheet base, starting from two already existing European procedures.

FACTSHEET: “A factsheet is a short, typed or hand-written document that contains the most relevant information about a particular subject in the least amount of space. The goal is to provide facts and key points about a topic in a clear, concise, and easy-to-understand way” (Cubon-Bell, V.,2019, p.1).

The purpose of a Factsheet is therefore to organize and communicate information in a clear way, creating a document with the purpose to indicate the most relevant information about a particular topic (in this case Climate Change adaptation) and that can be consulted for future works, workshops or projects.

Factsheets that are used as a report of research evidence are usually a one-page document (Valente, 2005), here they were adopted as a summary of all the information (Weiler, 1998; Zimeri, 2016) provided by the exercises done by MountResilience participants, like it was done for the deliverable D1.2.

Thus, following chapters (D1.3, Regional demonstrators adaptations strategies; D1.3, Regional replicators adaptations strategies) will include and resume the feedback received by the regional demonstrator partners and stakeholders validated through the Local Council. Raw material received, when possible, was re-elaborated considering the answers provided.

To optimize the validation process, differentiated regional Factsheets were created based on the recipients' level of involvement in the MountResilience project, in accordance with the grant agreement. A total of 12 Factsheets were produced: 6 for regional project partners, containing more technical content and detailed information, and 6 for regional stakeholders, designed to be simpler and accessible to those without specialized knowledge. Additionally, 4 Factsheets with the same structure as the stakeholder versions were produced for replicators to actively engage them in the project, even though this wasn't required at this phase (but was anticipated to be helpful for future stages).

These Factsheets can also be applied to other regions or local authorities in future projects, as their structure for gathering information is not region-specific. Only a few details, along with the background documents, are tailored to specific regions. The structure of the Factsheets is available in the Annex (D1.3, Annex).

Regarding the specific creation of the Factsheets, we finally decided to use the two different methods listed below, which permitted to have different levels of complexity for the Factsheets creation

1.3.1. TransformAr – Stakeholders and replicators' Factsheets

Figure 16. TransformAr logo (Source: https://transformar.eu/)

To define the structure for the exercises proposed for the regional stakeholder and replicator Factsheets the methodology developed in TransformAr Horizon project was used (Source: transformar.eu)

TransformAr is a project funded by the European Union's Horizon H2020 innovation action program under grant agreement 101036683, which aims to develop and demonstrate solutions and pathways to achieve rapid and far-reaching transformational adaptation (TA) across the EU. As stated on their website: "*The project will combine cross-sectoral and multi-scale innovation packages, as the combination of solutions and pathways, to support regions and communities in their societal transformation towards Climate Change resilience.*"

Launched in 2022, the project aims to design and implement a series of solutions to mitigate and adapt to Climate Change. This includes developing guidance documents to engage stakeholders, selecting and evaluating decision-making processes, and understanding preferences and acceptability of the proposed solutions.

A key component of this project is a manual titled "Playbook to discover, build and achieve Transformational Adaptation and boost your Climate Change Resilience". This playbook is based on the project's experience and is designed to outline the exercises and procedures necessary to bring stakeholders together in a well-organized working group.

The Playbook is modular, and it consists of relatively independent modules tailored on specifics arguments. These modules can guide working groups in exploring Climate Change adaptation solutions through co-innovation processes, with the goal of creating adaptation pathways informed by stakeholder inputs, as well as scientific and socio-economic indicators. The Playbook provides an overview of the essential tools needed to engage local communities and stakeholders, guide them, and co-develop adaptation pathways that will be both supported and accepted by participants (and so, ideally, by local authorities and population). Thus, the workshops, facilitated by the Playbook, are designed to offer various solutions, assess their feasibility, and identify decision nodes or tipping points where a particular pathway can be implemented or activated, simplifying the stakeholder's involvement in decisional processes.

The Playbook includes, after the introduction, chapters regarding "Engaging Stakeholders", "Planning a Workshop", "Driving Transformation Adaptation", "Inspiring content" and a final part where the inspiration for the exercise used as a base for the regional replicators and stakeholders' Factsheets can be found; this session is named "Annex: Tips and Canvases".

MAIN ADVANTAGES: the main advantages of the Playbook included in this project are its adaptability and simplicity in addressing complex topics, allowing exercises to be conducted individually or in working groups. “Intuitive” exercises structured in this way can be understood, with some tailored information, also by participants that do not have a professional knowledge on Climate Change and adaptation practices. Secondly, these types of exercise can be adopted in a physical workshop, but with correct instructions they can be also compiled by single people, allowing participants to compile them by e-mail.

MAIN DISADVANTAGES: a potential drawback is the risk of receiving inadequate or irrelevant responses, particularly due to the breadth of topics covered in some exercises. This can be challenging for participants who are not adequately prepared/involved in the project activities and/or lack a sufficient general understanding of Climate Change, including its technical and scientific aspects.

1.3.2. RAST – Demonstrators’ Factsheets

Figure 17. RAST process (Source: https://climate-adapt.eea.europa.eu/en/mission/knowledge-and-data/regional-adaptation-support-tool)

To define the structure of the exercises proposed to the regional demonstrator partners it was decided to follow the RAST tool. (Source: Climate-Adapt, n.d.)

As stated on the Climate Adapt website “*The Regional Adaptation Support Tool (RAST) is designed to help local and regional authorities with Climate Change adaptation strategies and plans, from development and implementation to monitoring, evaluating and updating them. RAST provides practical guidance in 6 steps aligned with the key features of climate adaptation policy processes*”.

The Regional Adaptation Support Tool (RAST) (Climate-Adapt, n.d.) is included in the EU Mission on Adaptation to Climate Change Portal, from the European Climate Adaptation Platform Climate-ADAPT, which is a partnership between the European Commission and the European Environment Agency. This tool aims to provide guidelines for mobilizing and planning with stakeholders – from experts to citizens – to ensure the selection of coherent and effective long-term adaptation measures. Its main goal is to achieve successful adaptation through the planning and implementation of chosen solutions.
This tool offers relevant aspects: firstly, this regional tool helps projects to effectively engage stakeholders in the planning process, fostering trust, avoiding conflicts, and providing both decision-making support and a concrete

understanding of Climate Change-related issues. Secondly, the steps proposed in the adaptation planning cycle offer to the participants the opportunity to contribute with their input and validate the process, utilizing their cross-sectoral knowledge on specific key points proposed. Thirdly, by using this tool, not only can Climate Change adaptation solutions be implemented but, at the same time, stakeholders can also increase their awareness and knowledge, through the activation of a co-design process.

The RAST includes the following steps: “Preparing the ground for adaptation”, “Assessing climate risks and vulnerabilities”, “Assessing and selecting adaptation options”, “Implementing adaptation policies and actions”, and “Monitoring, Evaluation and Learning (MEL)”

MAIN ADVANTAGES: the main advantages of this tool are related to its comprehensive coverage of quite all relevant topics that can be included in a project dedicated to adaptations options to CC, exploring all the necessary aspects for developing an informed approach to select NbS, including those aspects often considered secondary. In addition to this, the steps given by the RAST try to correctly guide the user to follow fundamental adaptation and implementation stages, helping to not lose the way.

MAIN DISADVANTAGES: the RAST also presents some challenges, mainly due to the complexity of the topic. Firstly, there is a lack of exhaustive graphical examples or exercises, making some steps less intuitive and difficult to use for people unfamiliar with similar projects. This issue affects both participants and organizers, as organizers had to create the exercises on complex topics to gather the necessary information. Secondly, trying to adapt these concepts in exercises or workshops is challenging due to a lack of coherence between the available and required information, with some data grouped differently from the usual approach commonly used when engaging stakeholders. For example, concepts that theoretically can be obtained in the early stages of a project, can be defined only after many of the stages listed in the tool.

After these considerations, we opted to use this tool exclusively for the more in-depth exercises, specifically targeting regional demonstrator partners.

These problems were noticed also after the first publication, in the EU Mission Implementation Platform for Adaptation to Climate Change (MIP4Adapt). For this purpose, a dedicated manual was established: a living document named “Stakeholder and Citizen Engagement in Climate Adaptation: A DIY Manual” (Wehbe, M., et al., 2024). The aim of this manual is exactly to explain in a better way the previous steps, giving an easier guide to regional and local authorities to engage stakeholders and citizens throughout the six main steps of the Climate Change adaptation planning process described in the Regional Adaptation Support Tool (RAST) (Climate-Adapt, n.d.). To have access to this manual just click on the picture below (Figure 18)

Figure 18. RAST DIY MANUAL (Wehbe, M., et al. 2024)

1.3.3. List of documents proposed in this project

On these bases, for the aims of this project and to involve regional partners, replicators and stakeholders, the following documents were sent to participants:

- *6 regional demonstrators' Factsheets (one for each demonstrator region)*
- *6 stakeholders' Factsheets (one for each demonstrator region)*
- *4 regional replicators' Factsheets (one for each replicator region)*
- *7 projects and articles database (six simplified database that include scientific papers and sites founded during the scientific review and tailored to the demonstrator region and one common to all the replicator regions with the full list of article and projects)*
- *10 regional Backgrounds and impact chains (one for each replicator e demonstrator regions)*
- *6 user manuals (Six for the demonstrator regions, with some tailored indications; this document included essential indications for the correct development of exercises, on how result can be gathered, and how the validation procedure should be performed)*

The material produced is and discussed to determine the adaptation strategies is available in the following chapter (D1.3, Regional demonstrators adaptations strategies; D1.3, Regional replicators adaptations strategies), instead all other documents related to feedbacks obtained by regional partners, replicators and stakeholders, on which Factsheets are mostly based, can be found in Annex chapter (D1.3, Annex).

The following figure (Figure 18) summarizes the procedure adopted to define the exercises used as the basis for developing the Factsheets. In the first column, highlighted in orange, the main phases of the implementation process, as indicated by RAST, are shown. The second column, highlighted in green, details the aspects that make up each phase, connecting them to the project task to which they are closely related. The third column, highlighted in blue, provides brief examples of what can be expected from the corresponding feedback. Finally, the rightmost column indicates the exercises created for both the stakeholders and the partners of MountResilience.

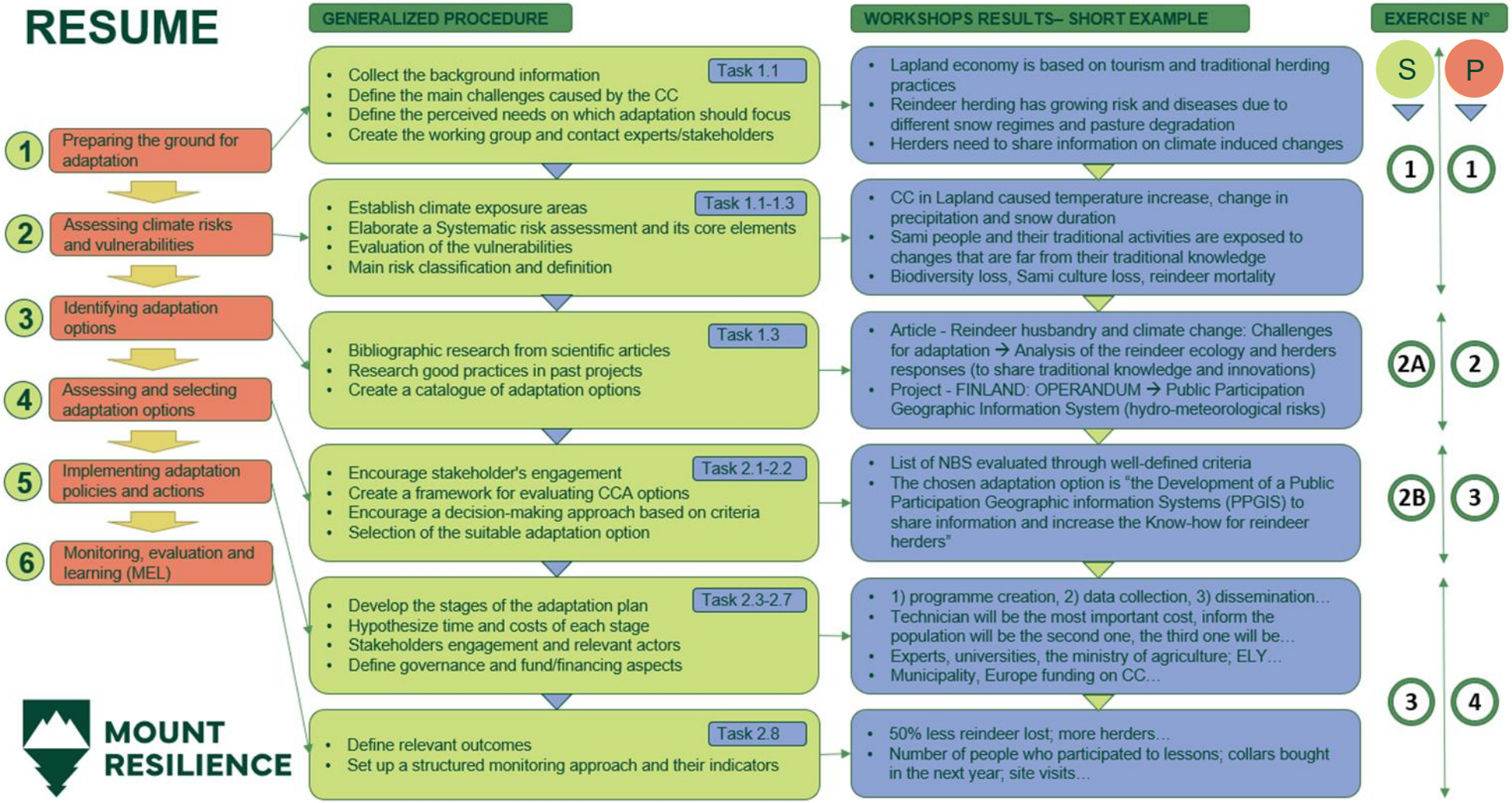


Figure 19. Factsheet exercise definition based on Project tas*ks* (UMIL, 2024)

2. Regional demonstrators adaptations strategies

Starting from the outputs obtained by the documentation listed in the first chapter it was possible to define important aspects for the definition of tailored adaptation practices. In this chapter the results were summarized in Factsheets, one for each replicator region, underlining main outcomes: a solution for each main discussed area touched by climate change effects is proposed after a brief discussion, and then, a final adaptation strategy is suggested.

2.1. GABROVO FACTSHEET

2.1.1. Regional Baseline and Impact Chain

Geography, evidence of climate change (mainly temperature and rainfall changes), and the associated risks and hazards are key factors that can strongly shape people's views on climate change and their adaptation priorities. This is also evident from the Impact Chains resulting from the first workshop (Innsbruck, 2024). This chapter was used as a basis for regional partners and stakeholders' participants to the Factsheet exercises, to underline main regional aspects and CC problems in their territory.

REGIONAL BACKGROUND

Geography

The municipality of Gabrovo, situated in the North Central Region of Bulgaria, spans an area of 556km² and is home to approximately 65,813 people as of January 2022, with 90% residing in urban areas (Eurostat, 2022). Gabrovo's landscape 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 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. (Municipality of Gabrovo 2021).

Climate

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 165 mm and increasing to 297 mm in the summer (D1.2, p. 14). The Hristo Smirnenski Dam, located 8 km southeast of the town, serves as the primary water source for Gabrovo (Republic of Bulgaria, 2018). Rising temperatures are expected to alter seasonal patterns, resulting in the absence of permanent snow cover. This change affects soil regimes and plant growth, favouring the spread of invasive species (D1.2, p. 17).

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, putting further stressing on forests and leading to greater damage from fires and storms (The World Bank Group, 2021).

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. The variability in precipitation, with increased rainfall in winter and decreased rainfall in summer, presents significant challenges. 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).

Public health risks

Decreased summer rainfall leads to prolonged droughts and heatwaves. Droughts have multiple impacts on forest ecosystems, 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 (Gabrovo Municipality 2020). Climate change exacerbates these effects, necessitating higher energy consumption for cooling. Additionally, the combination of extreme temperatures and increased humidity can worsen air pollution. In 2014, Gabrovo experienced two exceedances of the alert threshold for sulphur dioxide, highlighting the severity of the issue. 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; D1.2, p.18).

MAIN CLIMATE HAZARDS

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 (D1.2, p. 17). 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).

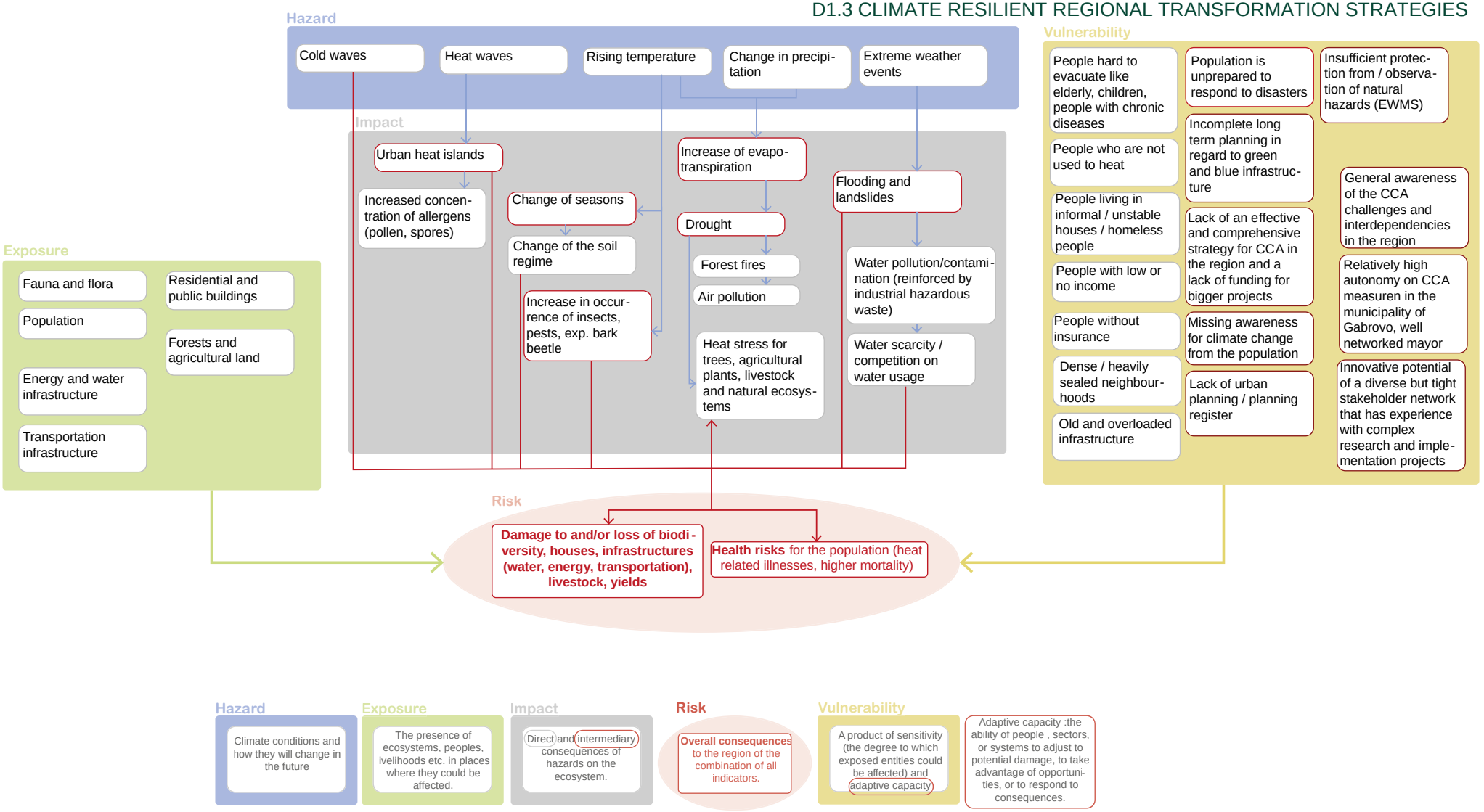


Figure 20. Gabrovo Impact Chain – Exercise baseline (ZSI)

2.1.2. Gabrovo Factsheet resume

Figure 21. Gabrovo Local Council (G-LCL material)

The major aspects related to Climate Change, already identified in D1.2 by the interviewees, as well as the critical points emerging from data analysis (The World Bank Group, 2021), were also recognised during the validation phase of the exercises. The Local Council identified a lack of institutional frameworks and funds needed to cover knowledge gaps (D1.2; p. 21-22).

Data acquired revealed the relevance of natural hazards such as wildfires, high temperatures, water scarcity, health impacts and urban environment issues, considered among the highest risk factors.

During the Local Council *"3 main climatic hazards have been identified – increase in temperature, extreme precipitation, dangerous phenomena (storm, hurricanes wind)"* (G-LCL). These choices certainly influenced the research conducted in the database which, on one hand, focused on material related to the establishment of green areas (*"Water against Climate Change. Sustainable water management in urban areas*" and *"INUNDATIO"* projects were, for example, chosen multiple times by the participants), on the other hand, after what emerged during the interviews, focused also on issues related to fires and drought: *"Fire and floods resulting from climate hazards,*

threatening citizens, economy, and biodiversity are especially visible in the city because of the high degree of urbanization" (D1.2; p. 21).

Solutions for Climate Resilient Transformation

The discussion of contributions brought through the framework developed in MountResilience, which involved quadruple helix stakeholders, revealed a series of needs and solutions related to Climate Change. Below, adaptation strategies based on this feedback are introduced, organized by main topics and linked to the findings from deliverable D1.2.

Discussed area: Risk management and natural disasters

Regarding the topic of green infrastructures, the focus was primarily on articles and projects related to monitoring systems designed to prevent damage to people and infrastructure, rather than exploring solutions linked to forest management methods (which are also present in the database). Early Warning Monitoring Systems (EWMS) emerged as a particularly sensitive topic, with detailed implementation suggestions indicating a budget of €190,000 and a timeline of 24 months (G-EP). Participants assessed these systems with high scores for implementability and effectiveness, showing nearly identical levels of agreement.

In general, forests were consistently ranked as critical "risk" areas, with only one exception. One participant highlighted that "the increase in temperatures leads to a very serious risk associated with the occurrence of forest fires and the potential drying up of springs" (G-EP), emphasizing the need for accurate data collection on climate change patterns in Gabrovo.

Solution suggested for the implementation	Strengths	Weaknesses and challenges
Early monitoring warning system for floods and fires	• *Preventing loss of life and infrastructures damages* • *Faster response to emergency* • *Community information and sense of security*	• *Setup and operational costs* • *Municipality resources and operators are needed* • *Need for an appropriate management, with maintenance, and updates*

Discussed area: Sustainable water resource

In the second case, the necessity of sourcing water from alternatives to the aqueduct network is clear. The practices identified include rainwater harvesting, green roofs, and rainwater treatment. This underscores the emphasis placed on the urban gardening project for Gabrovo in the final exercise, reflecting participants' overarching vision of "sustainable green city areas" and "sustainable urban resilience" (G-EP). Regarding water resources, key themes included the exploration of "*new methodologies for assessing and utilizing underground water resources*" (G-EP), the need for updated management policies, and the development of strategies for water resource usage, alongside the continual demand for funding. Overall, both sets of results

indicate that themes related to "*innovative technological solutions and ecosystem-based approaches*" (D1.2; p. 22) consistently emerged.

Solution suggested for the implementation	Strengths	Weaknesses and challenges
Rainwater harvesting and water reuse system for irrigation, with photovoltaic power supply	• *Groundwater, freshwater and tip water preservation* • *Lower energy consumption and less bills for irrigation* • *Water availability during dry periods* • *Increased water retention*	• *High costs: installation and maintenance* • *Dependent on weather conditions* • *Photovoltaic systems need space in the city*

Discussed area: Raising awareness

Concerning the population, the impact of climate change (CC) on human health has been acknowledged as one of the significant health risks identified, as noted in D1.2: "*Extreme weather events pose significant health hazards, especially for vulnerable populations such as the elderly*" (D1.2, p. 18). Stakeholders recognize the need for action on "*raising awareness about the risks associated with sun exposure and high temperatures*" (G-EP). However, some participants deemed this danger less relevant, indicating a variation in the perceived risk associated with health factors. Similarly, biodiversity loss received a comparable assessment, possibly because a portion of the population is less exposed to these issues.

Solution suggested for the implementation	Strengths	Weaknesses and challenges
Raising awareness about Climate Change risks	• *Low costs and easy to be implemented* • *Population and stakeholders' participation* • *Inform on risks, preventing bad practices and actions* • *Encourages the adoption and the acceptance of sustainable practices* • *Base for climate policies and action and solution acceptance*	• *Unpredictability of people* • *Slow results and hard to be measured* • *Difficulties to engage stakeholders and lack of interest* • *Quality of the information provided*

Discussed area: Stakeholders' engagement

It was emphasized that aspects related to involvement, awareness, and the establishment of frameworks, as highlighted in D1.2—specifically, "*the need for greater awareness and participation, financing, and legislative support*" and "*finding appropriate financing*" (D1.2, p. 29)—re-emerged in the selected articles and projects. This underscored the necessity for "*a change in the population's attitude,*" "*cooperation with communities,*" and "*stakeholder awareness*". Although these considerations were less prominent than more technical solutions or

those related to perceptions of city life, the relationships among various stakeholders remained consistently important in the Factsheet data, aligning with the findings from D1.2.

Solution suggested for the implementation	Strengths	Weaknesses and challenges
Tool for monitoring and evaluating Climate Change **(Connected to Lapland – same topic)**	• *Stakeholders' engagement* • *Adaptation strategies better evaluation* • *Accountability and procedures transparency* • *Decision-maker awareness*	• *Costs can't be easy defined in the first phases* • *Taken decisions can be influenced politically* • *Not tangible results at the beginning* • *Requires technical experts*

Discussed area: Green infrastructures

Among the three main aspects indicated during the validation phase, the one concerning temperature received less attention in the database search, with only a few cases and primarily linked to greenery systems for cooling down outdoor spaces. Despite this, solutions linked to the increase of the green infrastructures are seen as necessary by participants, both for a better city livelihood and for runoff mitigations

Solution suggested for the implementation	Strengths	Weaknesses and challenges
Increase green roofs and green areas	• *Urban heat island effect mitigation* • *Decreasing health risk for old people and workers* • *Cooling effects; less energy use* • *Runoff control* • *Better air quality*	• *Needs a high initial investment* • *Builders may have interest in creating green areas* • *Public may prefer parking areas* • *Not all buildings can support green roofs* • *Long-term planning, management and maintenance*

GABROVO - SUGGESTED CLIMATE RESILIENCE ADAPTATION STRATEGY

For a densely populated area like Gabrovo, the discussion highlighted key topics related to water supply issues and the management of public green spaces, as well as the prevention of disasters caused by droughts, floods, and fires (D1.3, Annex, Gabrovo). To support this, an interdisciplinary strategy is recommended, focusing on two main factors: improving the quality of life in urban environments while protecting and managing natural resources. The planning of green and blue infrastructures (such as green roofs, parks, green spaces, permeable pavements, trees, riparian zones, and wetlands) can act as natural buffers to reduce runoff and heatwaves, while improving well-being. However, maintaining such infrastructures requires a reliable water supply, which can be sourced through recycling urban water or using rainwater harvesting systems. It is advised to utilize renewable energy sources, like solar power, to operate irrigation systems.

To reduce risks upstream, a useful strategy would involve forest management, focusing on native species and active management practices, such as planting and selective timbering, to mitigate fire and storm risks. The re-naturalization of watercourses and the creation of low-lying areas to prevent flooding are also recommended. Where these measures are insufficient, there should be an enhancement of preventive systems, including the development of a real-time flood and fire monitoring system, improved weather stations, sensors, and alerts for residents through new technologies, such as phone messaging (D1.2, p.26; D1.3, Annex, Gabrovo). A small-scale pilot project based on this dual system can serve as a model for replication in other densely populated areas.

To ensure the strategy is effective, collaboration is essential, taking advantage of the already strong multi-level governance connections (D1.2, p. 26) to coordinate with key stakeholders. These include national authorities, to provide guidance on policies for monitoring and adaptation actions, in line with the National Climate Change Adaptation Planning and Strategies (Bulgarian Ministry of Environment and Water, 2020), as well as local and regional stakeholders, such as local environmental NGOs, business and construction companies involved in green infrastructure projects, meteorological and water management agencies, and universities (D1.2, p. 24). Citizens should also be involved to increase climate awareness and create a collective vision for transforming the city (D1.2, p.28). This would enable an integrated management approach to climate change issues related to forestry, monitoring, and water, in accordance with Bulgarian climate changes communications (United Nations Framework Convention on Climate Change, 2022).

This strategy, combining nature-based solutions with technology to build climate resilience in the Gabrovo region, would address both short-term hazards and long-term adaptation needs. In order to do so, access to funds that meet Gabrovo's various needs should be sought, such as European Union funds (D1.2, p.27), including the EU Cohesion Fund, the European Green Deal, Horizon Europe, or LIFE programmes, as well as national funding (Republic of Bulgaria, 2018). Additionally, partnerships with the private sector should be explored, especially for co-financing green infrastructure projects and implementing early warning systems.

The suggested strategy for Gabrovo enhances resilience in this densely populated area by improving living conditions through green infrastructure and providing flood protection via early warning systems. This approach, once successfully implemented in a pilot area, can serve as a replicable model for other cities in the region.

2.2. LAPLAND FACTSHEET

2.2.1. Regional Baseline and Impact Chain

Geography, evidence of climate change (mainly temperature and rainfall changes), and the associated risks and hazards are key factors that can strongly shape people's views on climate change and their adaptation priorities. This is also evident from the Impact Chains resulting from the first workshop (Innsbruck, 2024). This chapter was used as a basis for regional partners and stakeholders' participants to the Factsheet exercises, to underline main regional aspects and CC problems in their territory.

REGIONAL BACKGROUND

Geography

Lapland is the Northernmost region in Finland and most of its population live on or above the Arctic circle. With a population of 178,530 spread over 1,000,366 km² it is very sparsely populated. The municipalities of Enontekjo and Utsjoki have a large area with around 0,22 inhabitants per square kilometre. A part of the population belongs to the Sámi, Europe's only indigenous people. 17,3% of the population in Lapland was at risk of poverty in 2021 (D1.2, p. 32). There are 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 to a higher risk to Climate Change, especially in case of extreme events or other effects of Climate Change as they are further away from accessing essential services (D1.2, p. 30).

Climate

Winter begins in mid-October in Lapland and lasts for about 200 days (6.5 months). As a large portion of Lapland is above the Arctic Circle, it experiences Polar Night where the sun does not rise in winter, in Northernmost Finland this lasts for 51 days. In winter, the average temperature does not rise above 0°C. In summer, the average temperature is between 6°C and 16°C. Summer starts in June and ends in August, and during this season the region also experiences polar days, when it does not get dark (D1.2, p.31).

Sámi

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 1,500 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 makes reindeer herding less economically viable (Tennberg et al., 2017).

Economy

The economy of Lapland consists mainly of tourism, forest bioeconomy, mining and metal industries and agriculture, including reindeer husbandry. Tourism accounts for 5.7% of regional GDP. 50% of tourists are from outside of the country, which is higher than the Finnish average (D1.2, p.32). 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 centres (Regional Council of Lapland, 2017). Generally, tourism has a strong social license in Lapland and is perceived to bring more benefits than disadvantages.

Landscape

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 (D1.2, p.32).

MAIN CLIMATE HAZARDS

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, and 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 at the beginning in autumn and at the end in spring.
Extreme weather events will become more frequent causing flooding, especially in urban areas, however, considering exposure, vulnerabilities and adaptive capacity, the flood risk is set to decrease.
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 (D1.2, p.34).

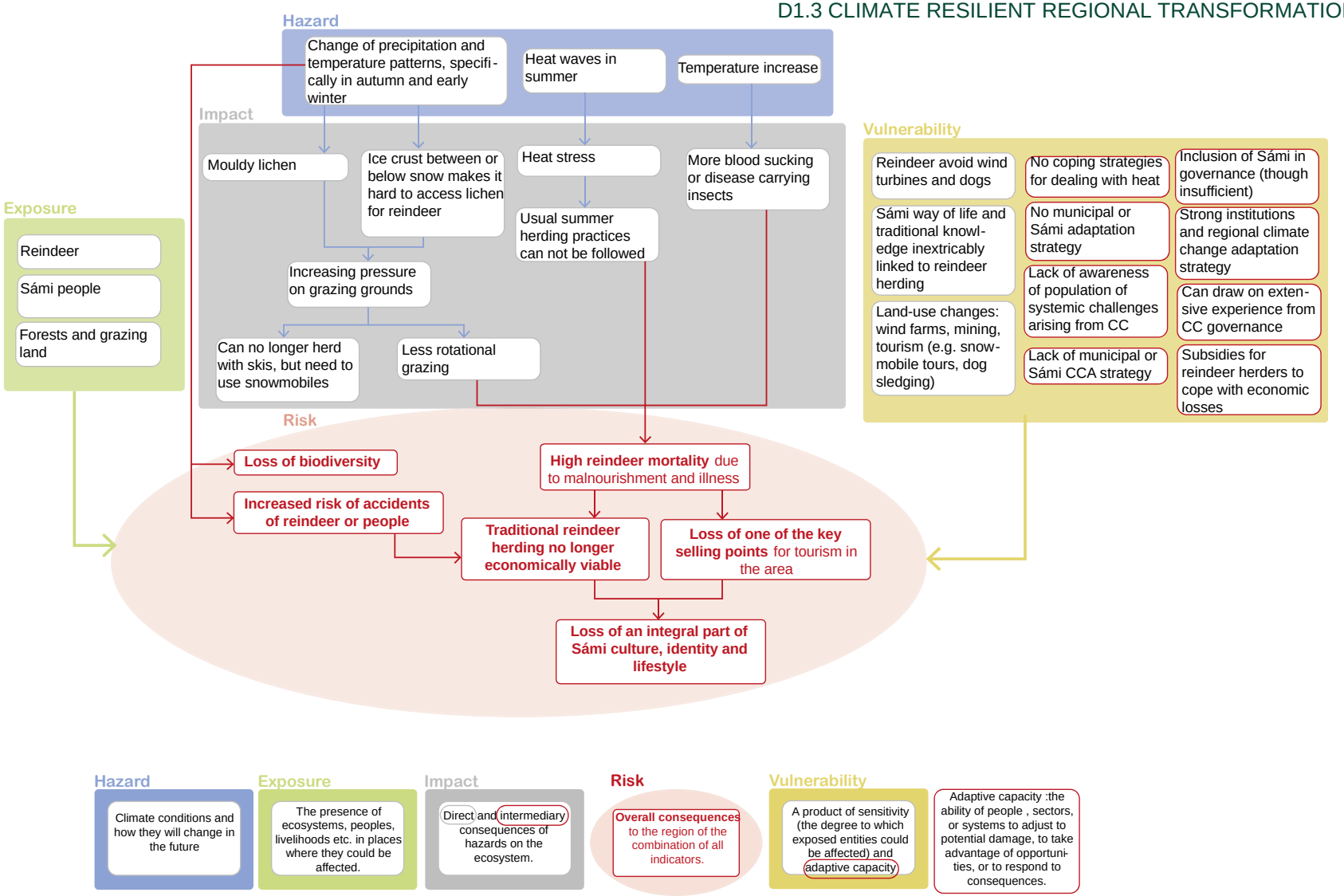


Figure 22. Lapland Impact Chain (Focus: Reindeer herding) – Exercise baseline (ZSI, 2024)

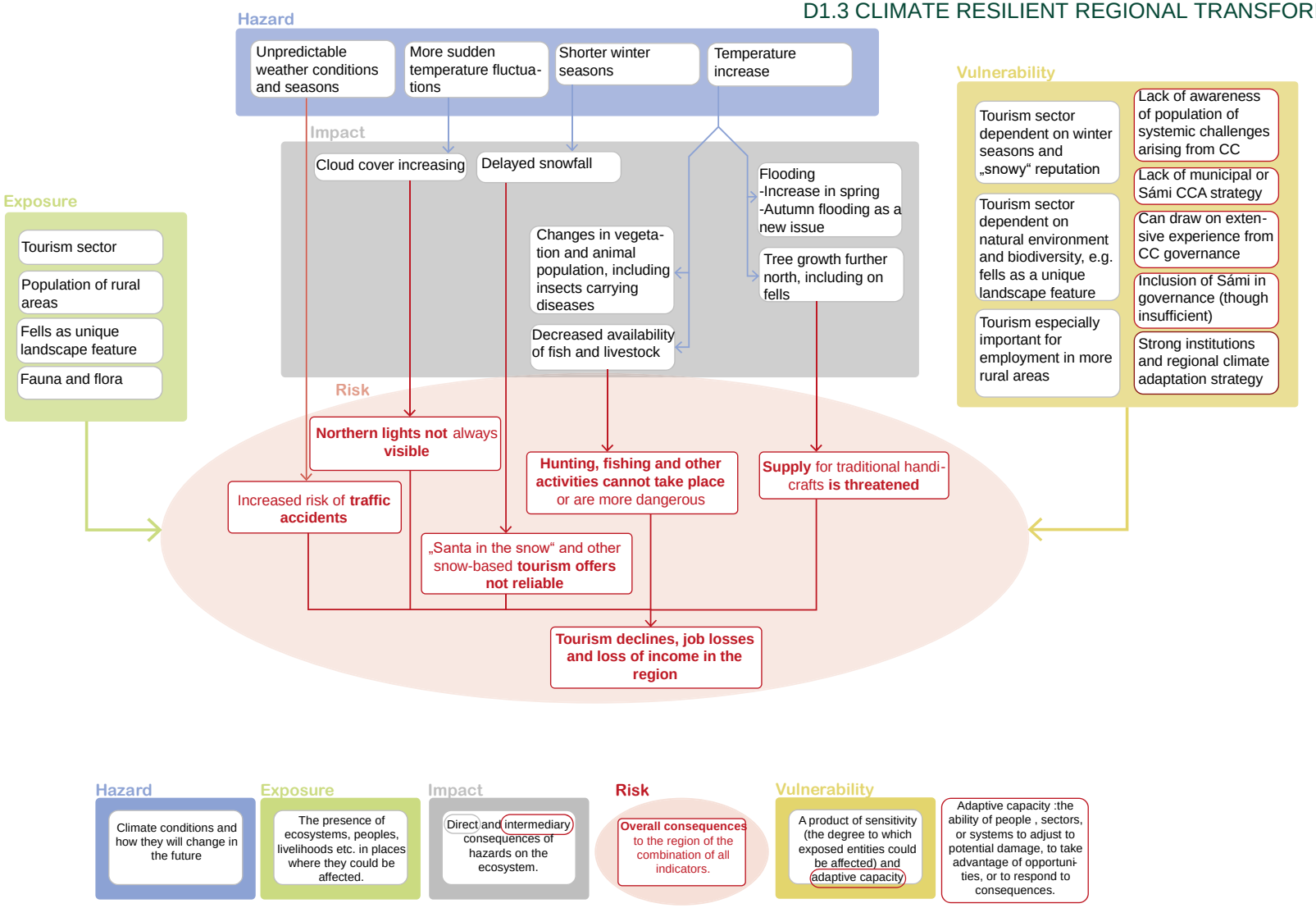


Figure 23. Lapland Impact Chain (Focus: Tourism sector) – Exercise baseline (ZSI, 2024)

2.2.2. Lapland Factsheet resume

Figure 24. Reindeers in Inari natural environment (Source: https://www.pexels.com/it-it/)

The Lapland region is often considered sparsely populated in comparison with other European regions (D1.2; p. 30). However, local council representatives assert that, "*Historically, this is not the case. Lapland's population over the past 60 years has differed significantly from long-term historical trends*" (L-LCL). This observation holds particularly true when compared to similar latitudes, such as northern Canada, Siberia, and other regions experiencing similar climatic conditions. It is clear that Lapland is the region most far from the "common" Climate Change issues faced by other regional demonstrators and replicators. Nonetheless, it can still share many solutions with these regions, particularly regarding challenges related to ski resorts management and tourism diversification.

Due to its geographical diversity, many aspects of life in Lapland are tied to traditional characteristics and local communities, including reindeer herding (D1.2; p. 35-36) and the presence of the Sámi people and their culture, which is at risk of being lost as they seek better living conditions (Tennberg et al., 2017). In fact, their livelihood is threatened by CC and competitors in the use of environmental resources, such as tourism and industries.

. Consequently, during the validation processes for Lapland, several considerations regarding Sámi engagement emerged, such as, "*there are nine Sámi languages, three in Finland*" (F-EP) and "*the majority of Sámi people don't*

live in Sámi homeland, and modernization is also changing traditional livelihoods" (F-EP). These insights highlight the challenges Lapland faces in effectively engaging its local population.

Solutions for Climate Resilient Transformation

The discussion of contributions brought through the framework developed in MountResilience, which involved quadruple helix stakeholders, revealed a series of needs and solutions related to Climate Change. Below, adaptation strategies based on this feedback are introduced, organized by main topics and linked to the findings from deliverable D1.2.

Discussed area: Traditional lifestyle

Aspects that consider local culture emerged among the researched projects and feedback received, as everyone's lifestyle is affected. For instance, it was noted that "*changes in the region's fish, grouse, or moose harvests—whether negative or positive—as well as changes in reindeer herding practices, will all impact the local community*" (L-LCL). Furthermore, "*a significant portion of the population, even those not from reindeer herding families, relies on natural resources as part of their lifestyle. When these resources change, people must adapt their way of living*" (L-LCL). Thus, it is understandable that stakeholders are interested in aspects related to year-round subsistence livelihoods that can provide resources for both animals and humans.

In this context, participants highlighted existing projects aimed at protecting Arctic foxes from the extinction, restoring biodiversity, and enhancing tourism to promote cultural heritage, effectively integrating nature and local economies. Climate change impacts both Sámi and non-Sámi residents because "*our comfortable life here relies on imported energy, food, and raw materials, which adds context to discussions on self-sufficiency*" (L-LCL). Additionally, while the lack of job opportunities may not directly affect administrative or national levels, it can alter the way people live in the region and, consequently, their culture.

Solution suggested for the implementation	Strengths	Weaknesses and challenges
Forest restoration and management, including selective timbering	• *Habitat type maintenance (reindeer)* • *Biodiversity support* • *Carbon sequestration* • *Sustainable resources* • *Local economy and livelihood support* • *Avoid invasive species*	• *Ethical concerns, societal barriers* • *Political climate links* • *Maintenance and reforestation costs* • *Long term planning* • *High risk of mismanagement*

Discussed area: Winter tourism

This topic is intrinsically linked to the main focus of the regional demonstrator: tourism. As noted, "*the influence of the tourism sector as the primary employer in Lapland is recognized as crucial for climate change adaptation (CCA) efforts*" (D1.2; p. 44), often providing essential support for local communities. The promotion of tourism at multiple levels is evident in its swift recovery from the pandemic. For instance, "*in 2023, the number of*

internationally registered overnight stays in Lapland increased by 22% compared to 2022, while the overall growth for all of Finland was 15.4%" (L-LPL).

Tourism also plays a central role in discussions about urban life. The regions of Utsjoki and Enontekiö frequently engage in conversations regarding the challenges associated with short-term rentals, such as those offered by Airbnb, and the potential implementation of a tourist tax to mitigate the negative impacts of tourism (L-LPL). Despite these challenges, there is a prevailing sentiment that the tourism sector should remain connected to local traditions and culture. This calls for "*a deeper analysis of the long-term benefits of cultural tourism*" as a means of fostering local identity. Indeed, the projects and articles explored were those focused on sustainable tourism that prioritizes local culture.

Solution suggested for the implementation	Strengths	Weaknesses and challenges
Development of Year-Round Tourism	• *Year-round and long-term benefits* • *Businesses, employees, and local communities' opportunities* • *Customer's safety* • *Seasonal dependency reduced* • *Heritage and cultural preservation*	• *Population acceptance* • *Reaction by actors in the tourism sector are unknown* • *Resource management and over-tourism related problems* • *Risk of degradation of natural sites*

Discussed area: Sharing knowledge

Stakeholders viewed the development of culture-based tourism and year-round tourism differently, with research focusing on eco-tourism and experience-based options. Consequently, the proposed exercises for the Factsheet creation highlighted a search for opportunities related to snowless tourism and the subarctic area in general, where "*more information is needed on the growth of year-round tourism demand*" (L-EP). However, this does not imply a departure from technology; rather, the selection of solutions to be implemented has influenced the decision to utilize Public Participation Geographic Information Systems (PPGIS), which stakeholders identified as necessary, albeit not their first choice in terms of impact and feasibility.

When searching for related articles and projects, some participants noted that "*more information is needed on the implementation of smartphone apps*" (L-EP) and highlighted "*missing information on marketing challenges and opportunities*" (L-EP). Additionally, negative impacts on winter tourism are attributed to unstable weather conditions and fluctuating temperatures, factors that must be considered for any potential tourist transitions.

Solution suggested for the implementation	Strengths	Weaknesses and challenges
Participation Geographic Information Systems (PPGIS)	• *Monitoring impact* • *Data collection and accuracy* • *People's awareness and acceptance of adaptation and solutions* • *Local communities' involvement*	• *Usability and effectiveness* • *Broad group engagement* • *Training and dissemination may be long and not accepted* • *Limited access for rural communities*

	• *More localized information*	

Discussed area: Reindeer herding and nature

Tourism is closely linked to practices involving animals, such as reindeer herding, which is prominently highlighted in the Impact Chain (D1.2; p. 35). During the validation process, reindeer herding was identified as being highly exposed to various stresses, although solutions specifically addressing reindeer did not generate significant interest in the database. The causes of stress on reindeer, particularly the effects of rising temperatures leading to numerous biological changes (e.g., alterations in aquatic ecosystems, changes in snow and water levels, shifts in reindeer behaviour, and impacts from tourism), were thoroughly considered.

One aspect that emerged during the interviews (D1.2; p. 36) was related to vegetation, notably the northward shift of the tree line. A participant noted, "*In the village of Utsjoki, there is a mountainside on the opposite side of the river valley that was covered by scattered trees 40–50 years ago. Now it is a mountain birch forest. Previously, this mountainside marked the tree line, but now the forest line has extended to that point*" (L-LCL). This transformation is significant because if open tundra becomes forested, it affects the ground layer vegetation, which in turn impacts reindeer herding. Such changes can lead to alterations in food availability, loss of potential grazing spaces, and an increase in tree-associated pests and berry yields in the ground layer.

Given these dynamics, considering "*additional information on species adaptation to artificial solutions*" (L-EP) may be crucial, especially in light of ethical questions such as "*should nature be allowed to change naturally?*" (L-EP). This concern is also evident in the research on restoration and nature-based solutions related to forests, natural ecosystems, tundra, peatlands, and tree-line management.

Solution suggested for the implementation	**Strengths**	**Weaknesses and challenges**
Restoring and prevent native lichens and moss pastures for reindeer herding **(Suggested)**	• *More food availability* • *Biodiversity improvement and invasive species reduction* • *Reduced costs* • *Reindeer health improvement in natural conditions*	• *Additional food may be still necessary* • *Slow and distant in time effects* • *High risk of failure* • *Sensitive to future climate variation*

Discussed area: Fishing

An interesting aspect, still connected to the previous considerations and one that was less emphasized in the interviews (though it did emerge during the construction of the Impact Chain), is the issue of traditional fishing and the changes resulting from rising temperatures. Participants highlighted that "*fishing and other subsistence uses of nature are important traditional livelihoods*" (F-EP) and that "*freshwaters, rivers, and lakes are key elements of the landscape*" (F-EP). Among these concerns is the gradual decline of salmon populations, which the Natural

Resource Institute Finland (LUKE) suggests may be attributed to climate change, alongside human activities. It was reported that "*the loss of salmon due to the invasion of humpback salmon was not recognized*" (L-LCL).

In discussions regarding the humpback salmon and the fishing ban, it was emphasized that "*the loss of salmon due to the invasion of humpback salmon was not recognized*" (L-LCL). Participants also noted the "*need to create foresight plans so that changes don't catch the community by surprise, allowing them to avoid a shock reaction*". However, no scientific articles or projects specifically addressing this issue were identified by participants.

Solution suggested for the implementation	Strengths	Weaknesses and challenges
River re-naturalization and fish management **(Suggested)**	• *Preserve traditional livelihood* • *Biodiversity improvement* • *Support native fish population* • *River quality* • *Protected habitat*	• *Intensive initial cost and labour* • *Resistance from industries* • *Less evident effects for the population* • *Changing river status may be difficult due to channelling or pollution*

Discussed area: Services and municipality

Referring to the activities previously described the selection done by participants from the database highlights the necessity of engaging stakeholders and citizens. This engagement is vital for disseminating information and fostering an understanding and acceptance of the consequences of climate change, as previously noted in the regional transformative capacities (D1.2; p. 48-49).

On one hand, climate change directly affects the municipality and key industries, such as tourism and reindeer herding. On the other hand, uncertainties related to climate change—such as those impacting health and services—can indirectly influence the municipality's administration. The wellbeing services county is responsible for providing these services and managing their costs; thus, these factors can affect political decision-making and the ability to capitalize on the opportunities that change may present.

If climate change creates significant challenges for these industries, it will pose risks to the municipality's economy and, consequently, its capacity to provide services due to fluctuations in tax revenue from these sectors. Therefore, comprehensive stakeholder involvement is essential (D1.2; p. 49). As stated, "*a forward-thinking municipality is less likely to face financial collapse when one or more industries falter. Foresight also helps ensure that changes won't come as a complete surprise*". From this the necessity to correctly inform citizens and stakeholders (and particularly municipality) making them aware of climate change concrete effects on population, economy and services provided.

Solution suggested for the implementation	Strengths	Weaknesses and challenges
Tool for monitoring and evaluating Climate Change	• *Stakeholders' engagement* • *Adaptation strategies better evaluation*	• *Costs can't be easy defined in the first phases*

	• *Accountability and procedures transparency* • *Decision-maker awareness*	• *Taken decisions can be influenced politically* • *Not tangible results at the beginning* • *Requires technical experts*

LAPLAND - SUGGESTED CLIMATE RESILIENCE ADAPTATION STRATEGY

A strategy that promotes long-term sustainability, cultural preservation, and economic resilience is suggested: regarding lifestyle aspects, sustainable reindeer herding management is necessary in the face of unpredictable snow patterns and access to their primary food source, lichens. As indicated by Reindeer Husbandry book (Svein Disch Mathiesen et al., 2023), practices such as supplementary feeding, grazing areas, migration routes, habitat restoration, and animal management need to be integrated with Sámi knowledge; a combination of modern technology with traditional practices can ensure respect for cultural heritage and livelihoods, increasing resilience and preventing interference with industries competing for the land dedicated to them (D1.2, p. 35).

This is closely related to the region's dependence on winter tourism, with the need to reconsider various aspects of skiing considering rising temperatures. A consortium-based management of ski facilities, with large-scale coordination, seems a good choice, as does diversifying tourist activities that include practices like hiking, wildlife watching, and cultural tours that highlight Sámi heritage. This would also improve the efficiency of facilities and transportation systems (D1.3, Annex, Lapland). Developing year-round services and strategically planning the use of natural resources, such as energy and food production, in accordance with the Lapland Climate Strategy 2030 (Lapland regional council publication, 2011), can enhance the sustainability of these solutions.

Lastly, to support decision-making and raise stakeholder awareness of the changing environmental conditions due to climate change, the development of a PPGIS (Public Participation Geographic Information System) is suggested to gather information from local communities, reindeer herders, Sámi people, and tourism operators. A tool like this will help municipalities, first and foremost, avoid land-use conflicts and assist regional and local actors in better managing risks (Finland’s National Climate Change Adaptation Plan 2022).

The lack of CCA governance and the inadequate representation of local communities (D1.2, p. 41) calls for the creation of working groups composed of representatives from various sectors, from the local level (local planners, herders' associations, local communities) to the national level (tourism operators, the Sámi Parliament and climate council, NGOs, industry, and academia) (D1.3, p. 44). A multi-level approach is also necessary to combine public funding, private investments, and international support (D1.2, p. 50).

The European Green Deal, LIFE Programme, and EU Cohesion Fund can provide financial support for technical projects related to sustainable tourism and reindeer management adaptation strategies. National funds like indicated in Finland’s National Climate Change Adaptation Plan (Lapland Ministry of Agriculture and Forestry, 2014) and regional initiatives can support Sámi culture and sustainable development. Access to private financing and co-funding adaptation projects for the sustainability of the tourism sector and food supply for reindeer is also suggested. While this strategy may not have a significant impact on mitigation, focusing primarily on resilience, a

deeper understanding of climate impacts and the sharing of information will help develop additional projects that are accepted by the local population (D1.3, Factsheet, Lapland).

An information-sharing strategy among different land users, designed to prevent land-use conflicts and support both traditional practices and tourism, forms an essential knowledge base for regional and national authorities to manage the effects of climate change effectively.

2.3. PIEDMONT FACTSHEET

2.3.1. Regional Baseline and Impact Chain

Geography, evidence of climate change (mainly temperature and rainfall changes), and the associated risks and hazards are key factors that can strongly shape people's views on climate change and their adaptation priorities. This is also evident from the Impact Chains resulting from the first workshop (Innsbruck, 2024). This chapter was used as a basis for regional partners and stakeholders' participants to the Factsheet exercises, to underline main regional aspects and CC problems in their territory.

REGIONAL BACKGROUND

Geography

Piedmont (Piemonte) is an Italian north western Alpine region formed by 43% of mountainous territory (the Alps and Apennines) and 31% of the hilly territory and home to 4.34 million inhabitants (OECD, 2021). 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 et al., 2017). Piedmont is also home to the Po Basin, which has a drainage area of 70,000 km² in Italy (with an additional 4000 km² located in Switzerland and France), of which 41,000 km² are in montane ecosystems and 29,000 km² 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). Piedmont 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). The Po Valley is the largest agricultural area in Italy, as well as a main industrial area, and is 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 regarding Climate Change (D1.2, p. 52).

Agriculture

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/farm) and sectoral point of view. In mountainous areas of Piedmont, grasslands are 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 M cattle (around 50 % of the national stock) and 6 M 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).

Economy and population

In addition, the social and economic structure of the region has also 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%) (Piedmont Region, 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 industrialization over the last decades, which generally also saw a larger shift towards more people moving to industrial centres (Piedmont Region, 2020). However, this trend has generally led to changes in the landscape, with more abandoned agriculture land, causing concern on 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 (D1.2, p.57).

MAIN CLIMATE HAZARDS

The core climate hazards for the region are an increase in temperature (mainly for higher elevations above 1500m) and changing precipitation patterns (ARPA & Piemont Region, 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 (Navarro et al., 2022). 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. 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).

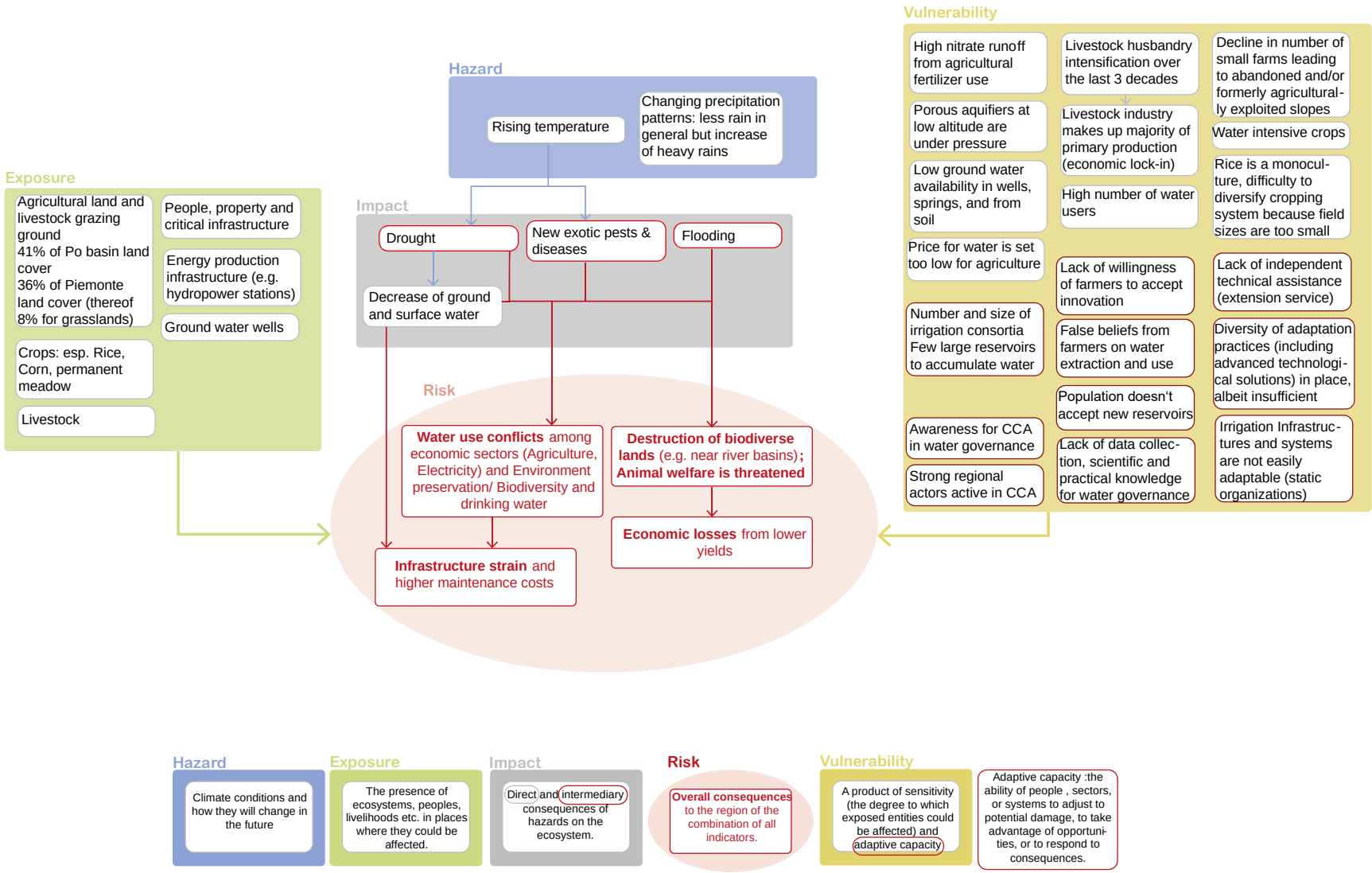


Figure 25. Piedmont Impact Chain (Focus: Irrigation) – Exercise Baseline (ZSI, 2024)

2.3.2. Piedmont final considerations

Figure 26. Cultivated fields in Alba, Piedmont (Source: https://www.pexels.com/it-it/)

The Piedmont region is characterized by water-intensive agriculture, with rice, wine, fruit, and annual crop production, particularly in the southeaster regions along the riverbeds (Sapino et al, 2020), all crops that require a lot of water throughout the year. It is no surprise, therefore, that during the Local Council all stakeholders started the discussion around the water-related issues and their hypothetical solutions, providing a "*different point of view depending on the institution or sector they belonged to*" (P-LCL).

Solutions for Climate Resilient Transformation

The discussion of contributions brought through the framework developed in MountResilience, which involved quadruple helix stakeholders, revealed a series of needs and solutions related to Climate Change. Below, adaptation strategies based on this feedback are introduced, organized by main topics and linked to the findings from deliverable D1.2.

Discussed area: Water management
Water scarcity and drought-related issues were frequently highlighted during the local council meetings, particularly in light of the projection that "*water needs are expected to rise in a business-as-usual scenario*" (D1.2;

p. 56). This scenario poses a potential source of conflict, (also D1.3, D1.3, Regional demonstrators adaptations strategies, Valais), and the "*changing precipitation patterns present significant hazards for the region*" (Arpa & Piedmont Region, 2020), altering the typical timing of water availability for agricultural practices. These two fundamental aspects underscore the regional "*challenge between small and large reservoirs*" (P-EP), necessary for farmers to have a reliable water supply during the summer months, which hinders effective "*management of water sources under abnormal climatic conditions*" (P-EP). This situation has been classified as high risk and is further evidenced by numerous proposed tools aimed at improving groundwater storage.

Optimizing management among the various organisations and users is crucial, not only to provide water to farmers efficiently and reduce costs but also to ensure a prompt response during emergencies. While the priorities for using water resources are known, the internal usage methods of each consortium are defined within complex emergency plans: "*the priorities for the use of water resources are known, but the internal use methods of each entity are defined within the emergency plans and are extremely complex*" (P-EP). As indicated in D1.2 and supported by this feedback process, there is a pressing need for a "*water management emergency plan in exceptional cases*" (P-EP). The fragmentation among the various consortia and entities remains a significant challenge, despite the "ongoing process of regional reorganization of irrigation entities" (P-EP).

Solution suggested for the implementation	Strengths	Weaknesses and challenges
Develop a Tool for Water Management – Decision-Support (DS) Tool - to mimic water availability and anticipate critical scenarios	• *Water availability in real time data* • *Farmers and consortia conflicts reduced by the presence of an established decision-making mechanism* • *Final users' security* • *Better cooperation and data sharing* • *Water wasted reduction* • *Less costs for end users*	• *Changes are hard to be accepted by farmers* • *Hard developing and programming phases* • *Requires more technical experts* • *Depending on data correctness*
Increasing storage & reservoirs using natural basins and rain weather harvesting systems	• *Protect crops during droughts* • *Floods mitigation* • *Biodiversity increase* • *Less use of freshwater and groundwater*	• *Lack of population acceptance* • *High initial costs* • *Bad managements* • *Space needed*

Discussed area: Agriculture

Many participants highlighted the "*inefficient water usage practices in agricultural pricing models and regulations*" (D1.2; p. 56) concerning water resources, particularly targeting the agricultural sector, which is identified as the primary area of exposure to climate change. Water-related issues significantly impact the region's economy, as emphasized in D1.2. In the deliverable it was noted that "*the most important agricultural products in Piedmont are cereals (e.g., rice and corn) and livestock, the latter accounting for nearly half of the final agricultural production in Piedmont*" (ESTAT, 2004).

Despite a generally high level of awareness regarding water scarcity challenges—especially in agriculture—there remains a pressing need for improved monitoring and optimization of water usage at the individual level. This need was underscored by the feedback received, which focused on both organizational and economic aspects, particularly rising costs related to catastrophic events. Increased periods of intense rainfall elevate the risk of flooding and, to a lesser extent, landslides (Navarro et al., 2022; Tiranti & Ronchi, 2023). Consequently, "*environmental damages, loss of production, and reduced profitability*" (P-EP) were identified as major risks. Discussions also emerged regarding food protection and crop damage prevention from floods, which included considerations for utilizing insurance and technologies related to canalization. Such measures are essential, particularly since they can serve as "*a method of drainage that could be 'helped' by reducing upstream resources during extreme weather events*" (P-EP).

Economic losses in the agricultural sector, especially for water-intensive crops like rice, jeopardize the quality of Piedmont's product chain. This situation is particularly damaging in mountain areas, which are witnessing a decline in traditional agricultural and pastoral activities, resulting in depopulation and land abandonment (D1.2; p. 62). Reducing costs and promoting effective water management also necessitate an "*upgrade in water use*" (P-EP). In conditions of resource scarcity, optimization is crucial: "*the irrigation infrastructure is largely characterized by a fragmented system of public and private consortia*" (D1.2; p. 60). Additionally, it must be noted that "*climate change affects management costs, including maintenance, on-call, and overtime expenses for operators*" (P-EP).

Solution suggested for the implementation	Strengths	Weaknesses and challenges
Innovation in crop irrigations techniques	• *Less water usage* • *Less pollution from fertilizers* • *Improved crops quality and resistance* • *Soil preservation* • *Can be easily integrated with other solutions*	• *Long times to be adopted and accepted by farmers* • *Initial investment and more maintenance* • *Bad management can cause soil degradation* • *Not applicable to all crops (e.g., rice)*

Discussed area: Knowledge

For both agriculture (including livestock management) and water management, a collaborative approach is essential for engaging various stakeholders, particularly the extensive network of consortia and end-users, such as farmers (D1.2; p. 62). This approach should encompass both involvement and dissemination, particularly through promoting knowledge transfer among farmers (D1.2; p. 64). Feedback revealed a desire for a "*stronger bottom-up, partnership-oriented approach*" and a need to "*centralize coordination and simplify rule-setting*" (D1.2; p. 72). Participants noted that "*qualitative knowledge of water resources can facilitate better distribution among all actors involved*" and emphasized the necessity for "*coordinated public-private action to address climate change challenges*". The validation council underscored the importance of these projects in fostering an increasingly conscious and efficient use of water resources (P-LCL).

Solution suggested for the implementation	Strengths	Weaknesses and challenges

Raising awareness about Climate Change risks **(Connected to Gabrovo – same topic)**	• *Low costs and easy to be implemented* • *Population and stakeholders' participation* • *Inform on risks, preventing bad practices and actions* • *Encourages the adoption and the acceptance of sustainable practices* • *Base for climate policies and action and solution acceptance*	• *Unpredictability of people* • *Slow results and hard to be measured* • *Difficulties to engage stakeholders and lack of interest* • *Quality of the information provided*

Discussed area: Biodiversity		
Feedback also highlighted biodiversity, which "*reflects the geo-morphological and bio-climatic features of the area, including the presence of three biogeographical regions (Alpine, Continental, and Mediterranean)*" (D1.2; p. 52). This issue is not only directly related to climate change but also reflects the consequences of changes in the agricultural sector. For instance, "*the development of new irrigation infrastructure*" could lead to further destruction of biodiversity and conservation efforts in the area (D1.2; p. 56). This challenge is further exacerbated by pollution and CO2 emissions, although feedback suggests that their impact may be less significant than what emerged in the interviews. Additionally, tourism received limited consideration in this context, despite the fact that "*natural and cultural heritage, as well as local communities, are strongly affected by processes of climate change*" (D1.2; p. 61).		
Solution suggested for the implementation	**Strengths**	**Weaknesses and challenges**
Integration of Climate Change adaptation into the work of local authorities **(Connected to Tyrol – same topic)**	• *High impact* • *Provide policy coherence and awareness* • *Community and decision-maker involvement* • *Holistic approach*	• *Actual system is difficult to be changed* • *Dependent on decision-makers and political will* • *Political, administrative and local barriers* • *Low financial resources*

PIEDMONT - SUGGESTED CLIMATE RESILIENCE ADAPTATION STRATEGY

Among the various issues addressed in the Piedmont region, the central focus was on sustainable water resource management, which is crucial for the agricultural sector, but also for drinking water availability and electricity production. This topic involves an interdisciplinary assessment and implementation process that requires continuous coordination and engagement with stakeholders. It also includes the development of a comprehensive regional strategy that addresses key economic, social, and environmental aspects. To support this, a monitoring framework will be established to track the effectiveness of the solutions implemented and assess potential risks within the region. A useful objective to be implemented within a climate change adaptation would be to increase the summer water supply, given the shortage of storage basins, in order mitigate the effects of changing rainfall patterns and glacier melting (D1.3, Annex, Piedmont). As said, this strategy would entail a close monitoring process as well as the involvement of different levels of stakeholders. A process which should be governed at the regional level and which would entail a lot of coordination work, also in order to assess the potential use conflicts due to the presence of a fragmented system of public and private consortia (D1.2 p. 60; D1.3, Annex, Piedmont). This could be achieved through the implementation of engineering solutions, such as dams or the use of abandoned quarries as water reservoirs, as well as natural retention areas, reforestation, and soil conservation efforts, in line with the first section of Piedmont Regional Climate Change Strategy (Piedmont Region, 2022). More specific techniques, like rainwater harvesting or recycling wastewater and sludge, could also support agriculture, but would require improved resource controls to prevent the spread of pollutants.

It would also be useful to focus downstream on three key points: encouraging farmers to adopt new water-saving irrigation techniques, although these are not feasible for certain crops like rice; reducing water losses along the canal systems, even though some reintegration into the soil can be beneficial for vegetation maintenance in certain areas; and finally, implementing integrated water service management. While this approach may not solve water scarcity, it can be a solid foundation for preserving the resource and improving its use, in line with the Guidelines for Climate Change Adaptation at the local level in the Alps (Alpine convention, 2015). The development of faster, more impactful decision-making mechanisms requires both efforts to streamline or consolidate the numerous consortia and agencies involved, enhancing their decision-making and operational capacities, and to improve regulatory management. A unified group for centralized coordination and the simplification of local procedures is necessary, not only for better resource use in normal conditions, but also for emergency situations, where the needs of the agricultural, drinking water, and hydropower sectors must be efficiently coordinated. Based on this, investing in technological infrastructure, such as software for the swift and clear management of water usage data and real-time monitoring systems, would be beneficial (D1.3, Annex, Piedmont).

To achieve these goals, it is necessary to adopt bottom-up approaches, ensuring that all stakeholders are involved early in the planning and implementation process with the establishment of a working group involving different expertise. Greater collaboration depends on effectively informing stakeholders through shared working groups that include the Regional Government and local municipalities, which would lead and coordinate the strategy to ensure alignment with local needs and EU policies, along with new bodies granted decision-making power across the region (D1.2, p. 72). Main stakeholders involved in the working

group should include water companies (especially consortia), farmers and agricultural associations, agricultural cooperatives, NGOs, technical institutions, environmental and research organizations, administrative authorities, and individual farmers who will need to directly implement new efficiency practices (D1.2, p. 66). This strategy can serve as a key starting point to ensure a broad and coordinated effort to adapt to the impacts of climate change in Piedmont by leveraging diverse funding sources: European Structural and Investment Funds, Life programs, National and Regional funds such as the Italian National Recovery and Resilience Plan, Public-Private Partnerships, and collaboration with private companies, including local pioneers interested in improving agriculture and energy management.

This strategy will ensure a sustainable water supply in Piedmont, crucial for agriculture, drinking water, and energy production, creating a resilient and well-managed system for water use. Moving forward, this framework can be expanded region-wide, using pilot projects to refine techniques like efficient irrigation, water storage solutions, real-time monitoring and decision-making rules.

2.4. RÂU SADULUI FACTSHEET

2.4.1. Regional Baseline and Impact Chain

Geography, evidence of climate change (mainly temperature and rainfall changes), and the associated risks and hazards are key factors that can strongly shape people's views on climate change and their adaptation priorities. This is also evident from the Impact Chains resulting from the first workshop (Innsbruck, 2024). This chapter was used as a basis for regional partners and stakeholders' participants to the Factsheet exercises, to underline main regional aspects and CC problems in their territory.

REGIONAL BACKGROUND

Climate

The period from 2021 to 2050 is predicted to bring significant changes to the climate in Sibiu County, according to regional climate models (DP1.2 p. 74, Bojariu et al., 2021). Under the moderate scenario, the mean annual temperature is expected to rise to 10.2 °C in Sibiu and 8.3 °C in Păltiniș. If greenhouse gas emissions (GHGs) continue at the current rate or higher, temperatures could increase even more rapidly to 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. Conversely, the intensity and frequency of heavy precipitation events are predicted to increase. 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. Additionally, the risk of wildfires remains high under both low emissions and high emissions scenarios discussed in the article (Navarro et al., 2022).

Agriculture

Agriculture challenges due to Climate Change are the focus of the regional demonstrator. Romania has a highly fragmented structure of agricultural land and ownership, being mostly fragmented small farms (Tebaldi & Gobjila, 2018). 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 salinization (due to the impossibility of the salts contained in the water being absorbed by the plants or infiltrating into the deep layers of the soil) and further biodiversity loss. 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 (D1.2, p.78).

Extreme events

Extreme weather events, such as heavy rainfall, will increase the risk of landslides, especially in urban areas expanded for construction at the expense of agricultural land. This aligns with national predictions indicating that mountain areas will experience rapid floods due to increased heavy rainfall (Romanian Ministry of Environment, 2017). 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 destabilize forest ecosystems and increase the risk of forest fires. The wildfire risk in Sibiu County is already high and is expected to remain so until the end of the century (Navarro et al., 2022).

Conversely, increased heavy precipitation, melting snow and torrential rainfalls leading 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; Romanian Ministry of Environment, Water and Forests, 2017; Navarro et al., 2022; World Bank Group, 2023). The structural integrity of rural roads deteriorates due to heavier rainfall and flooding, particularly affecting dirt and gravel roads. This infrastructure degradation further complicates access to and cultivation of agricultural lands (D1.2, p.79).

As poor people have increased reliance 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 are not working in the most efficient way, regardless of the value they are producing by taking care of the land and the traditions (D1.2, p.79).

MAIN CLIMATE HAZARDS

The agricultural sector in the mountainous areas of Sibiu County, specifically in the regions of Cristian and Râu Sadului, faces significant risks due to Climate Change. These risks 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 within the agricultural sector (D1.2, p.78). The primary natural hazards driving these risks include emerging heat waves, extreme weather events, rising temperatures, and changes in precipitation patterns. Elevated temperatures, shortened growing seasons, reducing 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 (D1.2, p.79; Agora Est Consulting, 2016).

High temperatures and heat waves are 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 further affects meadow composition, lowering the nutritional value of grass, which in turn diminishes livestock farming efficiency, negatively impacts animal health, and degrades food quality (Romanian Ministry of Environment, Water and Forests, 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 shortages also sharpen competition on water for consumption, industry, tourism and energy production (D1.2, p.78-79).

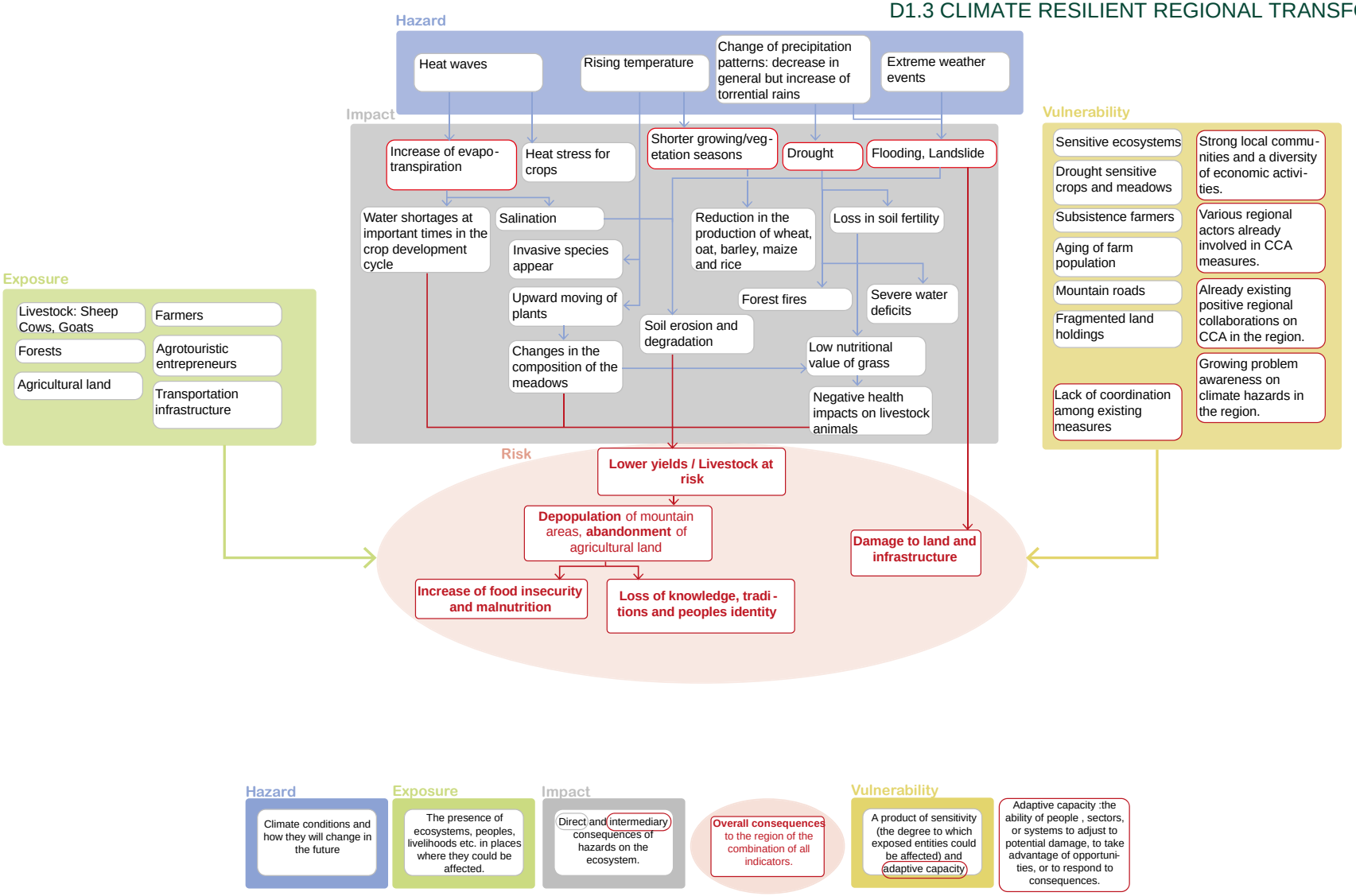


Figure 27. Râu Sadului Impact Chain (Focus: Agriculture) – Exercise baseline (ZSI, 2024)

2.4.2. Râu Sadului Factsheet resume

Figure 28. Visit at Râu Sadului project fields (Source: R-LCL material)

Among the challenges posed by Climate Change, land use changes, soil erosion, and meadow problems were recognized by all partners as the central issue. The Climate Change risks identified are the same as in other regions (extreme weather conditions, heavy rains, and high temperatures), because Romania is also expected to experience both a decreasing trend in the amount of seasonal precipitation (with an average monthly reduction of 8-9% in summer until 2050) and a significant average monthly increase in temperature, that could increase by 3°C in summer (Bojariu et al., 2021). Both these aspects are also visible in mountain agriculture.

Solutions for Climate Resilient Transformation

The discussion of contributions brought through the framework developed in MountResilience, which involved quadruple helix stakeholders, revealed a series of needs and solutions related to Climate Change. Below, adaptation strategies based on this feedback are introduced, organized by main topics and linked to the findings from deliverable D1.2.

Discussed area: Soil trophicity

One of the key points arising from previous considerations is the loss of soil fertility, which has led to an increased demand for amendments. While this issue was identified during direct interviews, it was not emphasized as much as in the feedback received. As noted, "*high temperatures and heat waves are expected to affect annual agricultural production by reducing crop yields, increasing pest infestations, and causing fertility loss*" (D1.2; p. 78). Therefore, it is not surprising that "*both teams identified pastures as the area exposed to risk*" (R-LCL), with erosion and pasture degradation highlighted as major problems in the exercises (R-EP).

The vision of creating "*meadows with higher productivity and biodiversity, climate-resilient*" (R-EP) necessarily involves participants advocating for the use of organic or foliar fertilizers, bio stimulants, and nitrifying bacteria—solutions identified as relatively easy to implement—to support humus formation. Soil amendments aimed at promoting the growth of existing species with high nutritional value, along with overseeding, are all strategies intended to enhance productivity and prevent further deterioration, as reflected in the projects and articles searched in the database. This approach also includes traditional practices use, with participants emphasizing "*the importance of both rational grazing and the sustainable solutions proposed in the project*" (R-EP).

Solution suggested for the implementation	Strengths	Weaknesses and challenges
Integrated Meadow Management (mowing, mulching, overseeding, fertilizing, and alternate grazing and mowing)	• *New technologies for soil analysis* • *Soil health and fertility enhancement* • *Resilient pasture* • *Soil erosion and preservation* • *Can protect wide mountain areas*	• *Soil degradation if not well managed* • *Risk related to use of soil improvers* • *Greater management time and costs* • *Lack of experts*

Discussed area: Soil management in protected areas

The overarching request for methods to regenerate fields addresses not only agricultural interests but also environmental protection. As noted, "*increased heavy precipitation, melting snow, and torrents lead to floods, landslides, and further soil erosion on sloping lands, particularly where soils are most vulnerable*" (D1.2; p. 78). Participants emphasize the need to combine solutions that benefit both nature and local communities. In this context, there is a clear interest in projects within the Natura 2000 framework, such as the initiative for effective grassland management at a landscape scale in Transylvania, which is included in the database. Additionally, there is a focus on the "*administrative, political, and logistical support required by local authorities to manage protected areas*" (R-LCL).

Solution suggested for the implementation	Strengths	Weaknesses and challenges
Invasive species management in protected areas	• *Can help agriculture by removing anthills, weeds and invasive new species*	• *Management risks due to the area protection rules*

	• *Native plants and natural habitats protection* • *Fire risk reduction* • *Increase in soil quality and value*	• *High in costs and time* • *Disturbance of protected ecosystems* • *High risk of maladaptation*

Discussed area: Depopulation and land abandonment

While some areas require protection due to external pressures and urban expansion (D1.2; p. 83), others are facing abandonment, particularly in the depopulated mountain regions. It is not surprising that participants identified mountain area abandonment as the highest-impact exposure field, followed by the decline in livestock numbers and the resulting decrease in farming and cultivated areas. The "*loss of soil fertility, which adversely affects both plant and grass growth as well as the land's infrastructure necessary for cultivation*" (D1.2; p. 79), leads to not only "*socio-economic losses*" (R-EP) but also social conflicts and a general degradation of the environment, making it more vulnerable to climate change. This concern is evident in participants' feedback, who consistently emphasized the need for a "*sustainable model for conservation and rural development in Special Areas of Conservation*" and the "*core principles for successfully implementing and upscaling Nature-based solutions—Harnessing the power of ecosystems for adaptation to climate change*" (R-EP).

Solution suggested for the implementation	Strengths	Weaknesses and challenges
Traditional practices (e.g., rotational grazing) for mountain areas	• *Traditional practices preservation and use* • *Prevent depopulation* • *Elder population acceptance* • *Preserve meadows quality* • *Improving biodiversity and natural regeneration* • *Low-cost* • *Wild-fires reduction*	• *Limited effectiveness* • *Conflict with sheep farmers* • *Requires initial knowledge transfer by involving elder population*

Discussed area: Technology and dissemination

Considering this point, the importance of *"improving knowledge exchange and local problem awareness*" (D1.2; p. 94) is reiterated. Without effective dissemination and understanding, solutions may not be accepted or implemented. In this context, the Local Council groups noted that "*both teams selected population acceptance as one of the top three criteria*" (R-LCL). One barrier to implementation appears to be "*skepticism towards non-traditional methods among different groups*" (D1.2; p. 84). However, due to the observed loss of farming traditions, the introduction of new technologies does not seem to face significant resistance. In fact, interviews highlighted that the use of drones (D1.2; p. 86) and findings from the impact chain (D1.2; p. 86) indicate that the decline in efficiency in agricultural practices is often linked to a diminishing appreciation for these methods, particularly among small farmers.

It is clear that "*there is a need for awareness raising and behavioural change*" (D1.2; p. 84) and that "*the establishment of new network-building and collaboration-supporting platforms or formats is indispensable*" (D1.2; p. 94). To realize this vision, it is essential to engage individuals with the necessary skills to manage the fields—currently identified as lacking—and to adopt a more targeted approach to dissemination. For example, during the Local Council meeting, there was extensive discussion about promoting the project at local festivals (e.g., setting up a stand) and through television shows (R-LCL), as well as gathering materials for publications.

Solution suggested for the implementation	Strengths	Weaknesses and challenges
Education in the use of emerging technologies in Mountain Area Pastures	• *Increase population acceptance* • *Collaboration between stakeholders* • *Increase productivity and efficiency* • *Better data collection and monitoring*	• *Initial costs for installation and training* • *Limited access in remote areas* • *Technological problems may annoy traditional farmers*

Discussed area: Tourism and forestry

Lastly, regarding tourism, Râu Sadului aims to promote its cultural heritage and serves as a significant starting point for rural and outdoor activities, such as hiking (Commune of Râu Sadului, 2024). As noted in both the interviews and D1.2, "*the region is particularly known for its rich cultural, architectural, and historical heritage*." However, local economies and livelihoods, especially those dependent on tourism and forestry, are particularly vulnerable to climate change. As stated in D1.2, these sectors need support through ecologically sustainable and environmentally friendly farming solutions to combat challenges like "*heavy torrential rainfall, which triggers landslides and adversely affects annual agricultural production, forestry, local economies, and livelihoods*" (Iojă et al., 2022). Despite this, tourism was only briefly mentioned by participants in the initial background discussions.

Solution suggested for the implementation	Strengths	Weaknesses and challenges
Forest restoration and management, including selective timbering **(Connected to Lapland – same topic**)	• *Habitat type maintenance* • *Biodiversity support* • *Carbon sequestration* • *Sustainable resources* • *Local economy and livelihood support* • *Avoid invasive species*	• *Ethical concerns, society barriers* • *Political climate links* • *Maintenance and reforestation costs* • *Long term planning* • *High risk of mismanagement*

RÂU SADULUI - SUGGESTED CLIMATE RESILIENCE ADAPTATION STRATEGY

Following observations conducted for Gabrovo (D1.3, Gabrovo, Annex), stakeholders identified mountain soil degradation as a central issue. This has cascading negative effects, impacting agriculture and livestock farming

on one side—leading to depopulation of mountain areas due to lack of income—and resulting in biodiversity loss and the disappearance of valuable species on the other (D1.3, Râu Sadului, Annex). For a region with a vulnerable economy already facing a decline in traditional agricultural and pastoral practices (D1.2, p.72), a strategy is recommended that provides immediate, small-scale outcomes, positively impacting the local economy. One suggestion is to introduce new management technologies (such as drones, remote sensing, and precision agriculture) and water-preserving irrigation systems, which seem well-received by rural populations (D1.2, p.86).

Aligned with Romania's and county strategy (Romanian Minister of Environment, Water and Forests, 2024; Sibiu County Council, 2022) this approach should include sustainable soil management by promoting drought-resistant crop varieties, restoring degraded soils and carbon content (for example, by enhancing soil fertility through sustainable practices and natural fertilization), and reinforcing agriculture by preserving traditional practices like rotational grazing, terracing, and protection of permanent grasslands. Where conservation agriculture may not be sufficient, the use of natural fertilizers—such as livestock manure or composted plant waste—is recommended to improve yield, while carefully managing associated risks. This strategic goal also aligns with promoting biodiversity by increasing crop diversity, re-vegetating degraded areas, conserving natural resources, and preserving native ecosystems. To support these efforts, it is recommended to establish working groups with governmental entities to address trophic levels even in protected soils (e.g., Natura 2000 areas) where operational options remain challenging (D1.3, Râu Sadului, Annex).

In order to achieve these objectives, practices should be adopted to improve education and climate change awareness, fostering a mutual understanding (D1.2, p. 93) with training activities for farmers and local communities focusing on sustainable techniques and improved soil management. Collaboration among key stakeholders—including government authorities (for forests, water, and agriculture), universities and research institutions, industrial companies, NGOs, environmental organizations, and especially local farmers' and herders' associations—will be essential for planning initiatives (D1.2, p. 87). Additionally, the creation of a coordinating entity to manage access to funds for local communities is suggested (D1.2, p. 93). European development funds, such as the European Agricultural Fund for Rural Development (EAFRD), regional cooperation projects, and public-private partnerships that connect small local businesses with producers, can provide vital support.

Applying this strategy to a small pilot area, with clear monitoring indicators and regular assessments, can serve as a foundation for scaling up action. This can contribute to building resilience in the Râu Sadului region, enhancing agricultural sustainability and the health of local ecosystems.

2.5. TYROL FACTSHEET

2.5.1. Regional Baseline and Impact Chain

Geography, evidence of climate change (mainly temperature and rainfall changes), and the associated risks and hazards are key factors that can strongly shape people's views on climate change and their adaptation priorities. This is also evident from the Impact Chains resulting from the first workshop (Innsbruck, 2024). This chapter was used as a basis for regional partners and stakeholders' participants to the Factsheet exercises, to underline main regional aspects and CC problems in their territory.

REGIONAL BACKGROUND

Geography

The climate in the northern and central part of the Tyrol region 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). 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. Its provincial capital and largest city in terms of population is Innsbruck with a total area of 12,648 km^2 it is the third largest federal state of Austria, well known for its alpine landscape with high peaks, deep valleys and numerous glaciers (Tirol Werbung, 2024; D1.2, p. 95). 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 (3,798 m) and Wildspitze (3,768 m), and its second largest glacier, Gepatschferner, covering an area of 17.6 km^2. The Inn River, which flows through Tyrol for 212.5km, is Tyrol's longest river (D1.2, p. 95).

Economy

Tourism is an important source of income for the whole region, especially winter tourism, accounting for almost half of the annual stays. The economic dependency on tourism generally increases with the distance from the cities: in some remote areas tourism is the only, or at least the main, source of income (Steiger & Stötter, 2013). Tyrol's economy is strongly based also on the industrial sector, with the highest gross values in the year 2020 generated by manufacturing that was € 4.77 billion, followed by 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).

Temperature

Since 1900, the temperature in the European Alps has risen to 2°C, particularly at 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 2080 (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. 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).

Precipitation

By the end of the 21st century, Climate Change under the high emission scenario 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 (D1.2, p. 67). This shift will lead to more intense and irregular rainfall, increased rain-on-snow events, and a higher frequency of rapid snowmelt, exacerbating the risk of floods and landslides. The rising temperatures, causing the snowline to ascend by approximately 150 meters per degree Celsius, will diminish snow cover 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).

Ecosystem

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 to 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 1,500–2,000 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).

MAIN CLIMATE HAZARDS

Between 65% and 95% of the European glaciers will be lost at the end of the 21st century. Most of Austria's glaciers are below 3,200m, 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 (D1.2, p. 99).

Climate change has significant effects on tourism, especially in Alpine regions. On one side the retreat of glaciers poses challenges for glacier ski resorts, with shrinking glaciers narrowing or interrupting existing ski slopes and the need of ski operations that requires ongoing technical adaptation to protect their infrastructure. On the opposite side 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).

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, transports, infrastructures and buildings. Floods, debris flows, avalanches etc. can lead to enormous costs for reconstruction and damage, reinforced by past mistakes in spatial planning and the lack of legally binding regulations (TransAlp, 2022).

Urban heat islands refer to the phenomenon that 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).

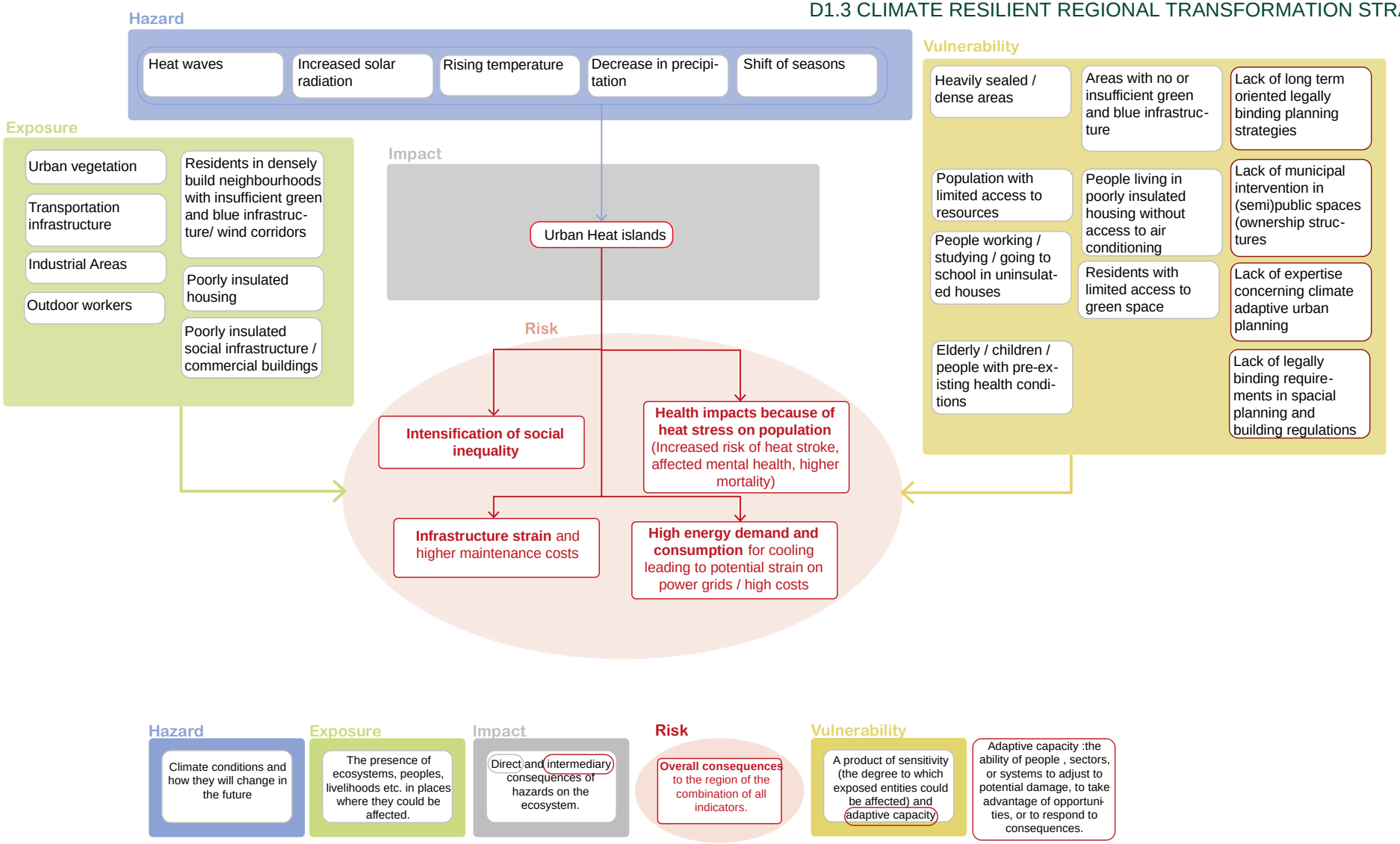


Figure 29. Tyrol Impact Chain (Focus: Heat) – Exercise baseline (ZSI, 2024)

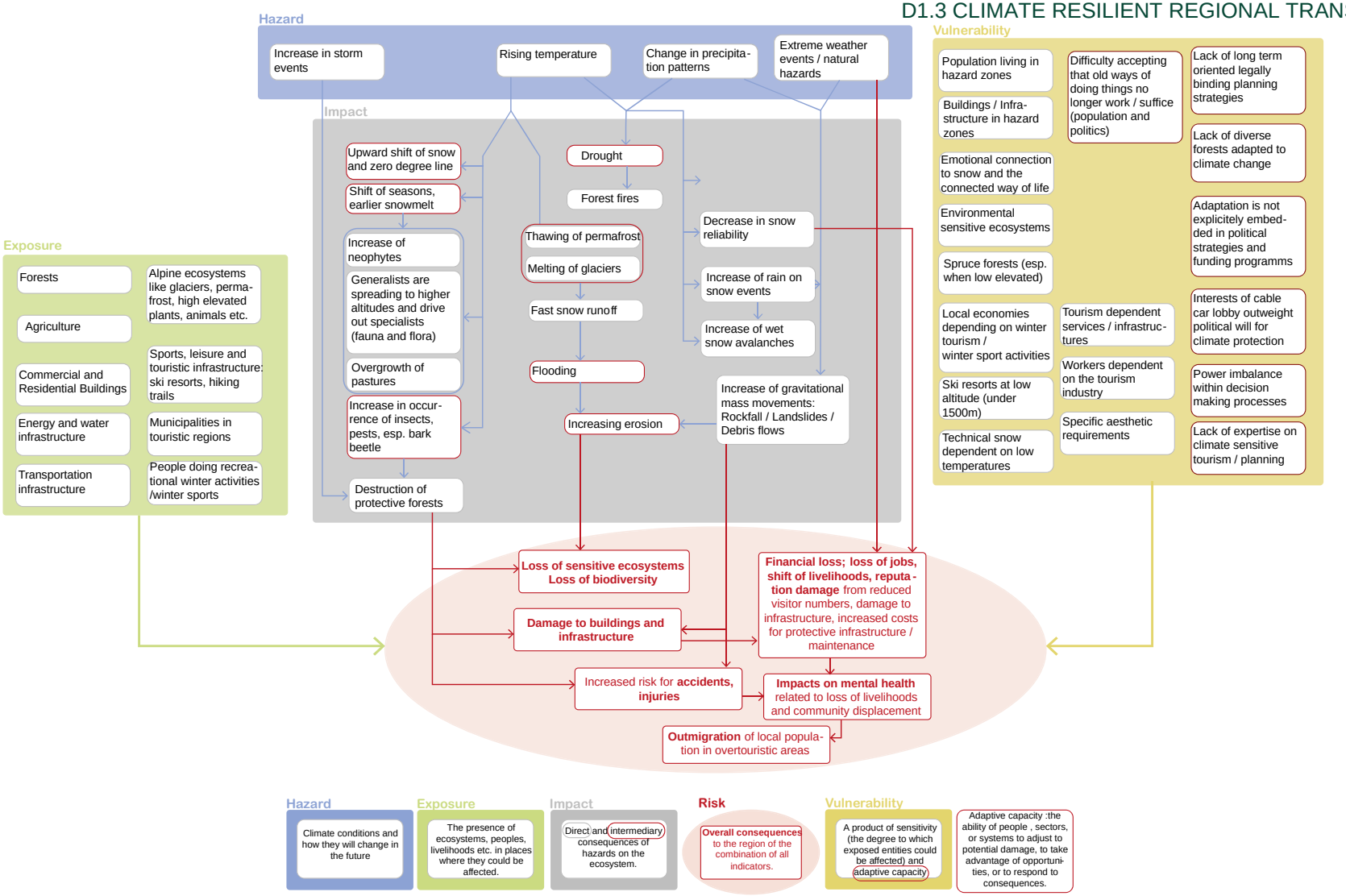


Figure 30. Tyrol Impact Chain (Focus: Nature) – Exercise baseline (ZSI, 2024)

2.5.2. Tyrol Factsheet resume

Figure 31. Tyrol Local Council (T-LCL material)

The working groups of Tyrol, including the Local Council, immediately showed a clear choice of the most important exposure fields to Climate change for the region, dividing the work carried out and the related feedback into two groups: *Building & heat*, and *Nature & tourism*. Additionally, it was suggested that the solution to be implemented should be a combination of both these arguments (T-EP) at the end of the review process.

Solutions for Climate Resilient Transformation

The discussion of contributions brought through the framework developed in MountResilience, which involved quadruple helix stakeholders, revealed a series of needs and solutions related to Climate Change. Below, adaptation strategies based on this feedback are introduced, organized by main topics and linked to the findings from deliverable D1.2.

Discussed area: Buildings and heat
In the Austrian Alps, average temperature change predictions indicate an increase of 0.8–1.2°C (low/high emission scenarios) by the 2030s, 1.6–2.6°C by the 2050s, and 2.8–4.2°C by the 2080s (Steiger & Stötter, 2013).

Existing buildings and structures are inadequate to cope with rising temperatures and the heat island effect, which not only challenge infrastructure but also increase the vulnerability of the local population (D1.2; p. 112).

Current adaptation measures to address heatwaves and the heat island effect in buildings are generally deemed insufficient (D1.2; p. 106). Consequently, the primary objective is to "*prevent buildings from overheating*" (T-EP), which is a medium to long-term goal. Urban areas and densely populated regions are particularly exposed, leading to a focus on re-naturalization systems, guidelines for mitigating overheating, and cooling solutions in the database. The issue impacts not only infrastructure costs, including energy and water use, but also public health, placing additional burdens on residents and workers. The most significant health risks identified include increased stress on the population, strain on the healthcare system, heightened social inequality, and financial loss (T-EP).

Solution suggested for the implementation	Strengths	Weaknesses and challenges
Changes in the buildings and settlements, avoiding overheating through active and passive measures	• *More data and simulation* • *Better comfort and livelihood* • *Quality of living spaces and life in general* • *Less air conditioning (heating in winter) and energy consumption* • *Long term sustainability*	• *Initially expensive* • *Difficult to be implemented in the existing buildings* • *Limited effectiveness*

Discussed area: Nature and tourism

"*Tyrol's economy relies heavily on the industrial and tourism sectors*" (D1.2; p. 96), and "*the region's self-image and identity are deeply rooted in its mountainous landscapes*" (D1.2; p. 104). According to participants, climate change impacts both agriculture and the Alpine ecosystem as a whole, leading to job losses and damage to the ecosystem—identified as a major risk area—which also affects sports and tourism. In this context, the database offered solutions related to ecotourism and natural mountain tourism, echoing themes discussed in Lapland, particularly concerning the "*development of tourism offers independent of snow*" (T-LCL), which was noted for its high feasibility. Validated solutions included cultural and experiential tourism initiatives focused on forest conservation, natural environment protection, enhancements to the ski industry, optimization of resorts, and management of cross-country tourism. This aligns with the notion that "*tourism in Tyrol is centered around the idea of unspoiled nature*" (D1.2; p. 104) that should be preserved.

Regarding skiing, participants noted that the topic is too broad, as it means different things to each resort. Some suggested it is more of a "*mission*" (T-EP) due to the challenges and acceptability of making "*mountain resorts less dependent on snow and ski tourism*" (T-EP), as well as the potential economic consequences for local communities. Nevertheless, "*more intense and irregular rainfall, increased rain-on-snow events, and a higher frequency of rapid snowmelt*" (D1.2; p. 98) have become characteristic features of the Tyrolean mountains, posing challenges not only for skiing but also for sports, leisure activities, and hiking trails (T-EP).

Solution suggested for the implementation	Strengths	Weaknesses and challenges
Transformation of mountain resorts with all-year tourism innovations	• *Monitoring implementation* • *Citizen and stakeholder's involvement* • *Natural landscapes preservation and conservation* • *Tourism adaptation, eco-tourism, diversification* • *Economic effect on the population*	• *Broad concept, hard to be understood and explained* • *Long implementation timeline* • *Long term returns and vision* • *Uncertainness of success and effects* • *Cultural and local resistance; path dependent*

Discussed area: Green & blue infrastructures

The management of green and blue spaces is central to the previous two themes. Selected solutions from the database include integrated city management, green and blue infrastructures, pocket parks, and tools for managing and innovating urban greenery and traffic. Green areas were identified as having high feasibility and effectiveness, making them ideal for addressing issues such as flooding, heatwaves, livelihood, and passive heat mitigation (T-EP).

Heat stress also indirectly impacts health, leading to various challenges that arise from the increase in both indigenous and new disease vectors (such as mosquitoes, bugs, and ticks) and new plants with high allergenicity (D1.2; p. 96). This underscores the importance of effective management of blue and green infrastructures.

Solution suggested for the implementation	Strengths	Weaknesses and challenges
Green & blue infrastructure implementation	• *Better air quality* • *Protection from heavy weather events* • *Reduced health risk* • *Better biodiversity and life quality*	• *High installation and maintenance costs* • *Expensive for public* • *Limited space in city* • *Long time to be effective*

Discussed area: Sharing knowledge and policy actions

To address climate change effectively, greater awareness and knowledge at all levels are essential. There is currently a "*lack of awareness and sensibilization not only among the local population but also among local governments and economic actors*" (D1.2; p. 105). Furthermore, even when high-level political actors and decision-makers recognize the need for climate change adaptation, ambitious policies and concrete actions are often lacking (D1.2; p. 111), primarily due to political barriers.

Participants sought solutions to enhance decision-making, such as employing climate coaches, facilitating knowledge sharing among citizens, using questionnaires to gather data, promoting participation, and implementing multi-governance/management plans. The growth of awareness and the involvement of local authorities were identified as highly effective strategies, leading to the recommendation for the "*installation of citizen councils*" (T-EP) to discuss environmental issues.

Solution suggested for the implementation	Strengths	Weaknesses and challenges
Integration of Climate Change adaptation into the work of local authorities	• *High impact* • *Provide policy coherence and awareness* • *Community and decision-maker involvement* • *Holistic approach*	• *Actual system is difficult to be changed* • *Dependent on decision-makers and political will* • *Political, administrative and local barriers* • *Low financial resources*

TYROL - SUGGESTED CLIMATE RESILIENCE ADAPTATION STRATEGY

In the discussions among participants of the Local Council, as well as in interviews from the previous deliverable (D1.2, p. 97), the concept of unspoilt nature emerged as central to Tyrol's identity and self-image, along with its importance to tourism. This encompasses not only the typical challenges associated with winter tourism but also the need for efficient accommodations for both workers and tourists. Traditional architecture, often insufficient for heatwave protection, calls for a general renewal of the urban environment (D1.3, Annex, Tyrol).

A climate change mitigation strategy for Tyrol must therefore consider effects on both tourism and housing. In terms of tourism, sustainable slope management practices are necessary: these would support artificial snow with high-efficiency snowmaking systems, utilize renewable energy sources, and rely on water sources that do not impact other sectors, such as recycled water (D1.3, Tyrol, Annex). Additionally, there is significant potential to expand a year-round tourism offering, focusing on sustainable activities like mountain biking, hiking, wellness, culinary experiences, culture, and eco-tourism that avoid adding pressure through over-tourism. Taking into account the problems associated to traditional buildings, an energy efficiency strategy is needed to reduce energy consumption both in winter for heating and in summer to combat heatwaves (D1.2, p. 99). This may include natural cooling systems, such as green or white roofs and green walls. Where these adaptations aren't feasible—such as in classic Tyrolean wooden buildings—the adoption of modern insulation and energy-efficient ventilation systems is recommended. These should ideally use renewable sources and local materials (e.g., biomass, solar energy, and heat pumps) that preserve traditional architecture, as outlined in the Austrian Strategy for Adaptation to Climate Change (Austrian Federal Ministry for Sustainability and Tourism, 2017). In addition, territorial risk mitigation strategies, such as reforestation, can help create more resilient forests. This would mitigate temperature impacts and reduce risks of wildfires, avalanches, and floods affecting these structures, in line with the Climate Action Plan 2.0 (Permanent Secretariat of the Alpine Convention, 2021).

To achieve these goals, it is beneficial to involve various stakeholders: tourism businesses, winter resort consortia, hotel operators, local communities, and forest services on one hand, and construction companies, municipalities

(for managing building regulations), local associations, and homeowners on the other. Information and incentives for efficiency improvements, along with innovative data and projects from research institutes or multi-level actions by Klar managers, can facilitate this process (D1.2, p. 108). These initiatives can be supported through various funding types. For small projects, energy audits and incentives to aid homeowners and support renovations (subsidized by the Austrian federal government) are available, alongside regional and national grants, bank loans, tax deductions, and incentives for renewable resource use (e.g., solar panels). EU Cohesion Funds and the European Regional Development Fund (ERDF) can be used for large-scale projects, with funds such as Horizon Europe to promote eco-friendly tourism supported by local governments. Additionally, the EU LIFE Programme and national funds are especially recommended for forest management and natural landscape protection.

Thus, Tyrol's strategy is designed to enhance building energy efficiency and sustainable environmental resource management while simultaneously promoting sustainable tourism, ensuring long-term resilience in specific areas with a replicable model across the region (D1.3, Annex, Tyrol)

2.6. VALAIS FACTSHEET

2.6.1. Regional Baseline and Impact Chain

Geography, evidence of climate change (mainly temperature and rainfall changes), and the associated risks and hazards are key factors that can strongly shape people's views on climate change and their adaptation priorities. This is also evident from the Impact Chains resulting from the first workshop (Innsbruck, 2024). This chapter was used as a basis for regional partners and stakeholders' participants to the Factsheet exercises, to underline main regional aspects and CC problems in their territory.

REGIONAL BACKGROUND

Geography

Valais is the third largest canton of Switzerland, with 348,503 inhabitants, located in the Southwest of Switzerland, bordering both Italy and France. The river Rhône is the largest river in the region. The region is often described as the water tower of Europe. However, surrounded by the Valais Alps in the South and Bernais 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. 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 (D1.2, p.114).

Precipitation

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 altitude and less at high altitudes (Mourey et al., 2022). With 80% of 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).

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 also 'Suonen' or 'Bisses' in French) (D1.2, p.114). Water is channelled 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 meltwater, 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 obligations to contribute to their maintenance. There has been a decrease 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 the cultural landscape of the region (Achermann & Liechti, 2012). In addition, they contribute to a historical culture of collaboratively managing the commons in the region.

Water

The main sectors for water use are tourism (in particular skiing), hydropower, agriculture and residential areas. To cope with decreasing snowfall, or just to always ensure high quality slopes, the use of artificial snow has become common. To supply the water, artificial reservoirs and an underground piping system had to be dug up, which has come with different environmental costs. Peaks in water use in the ski-resort of Verbier could be observed especially at the end of the year, in the February holidays, but also between mid-July and mid-August (presumably high season for summer tourism). With the decline of traditional agriculture and more commercial irrigation, agriculture has also been taking up more water resources (D1.2, p.119).

Hydropower plays a big role in the region's economy and water economy. Valais produces nearly 30% of Switzerland's hydropower. Dams are often situated near irrigated areas or village and towns, and some are also used for multiple purposes (such as supplying water to irrigation) (Flaminio & Reynard, 2023).
According to the Swiss constitution, water management falls into the prerogative of the cantonal level. However, in Valais it usually falls into the responsibility of the municipalities, as most rivers (apart from the Rhône) are owned by the municipalities. Currently, there exists no cross-cantonal mechanism for water use management, which has led to conflicts in the past in particularly dry periods. Private companies are currently the only ones holding data for water use. They are unlikely to share those data to maintain competitive benefits. In the Val de Bagnes, comprising two municipalities, Bagnes and Vollèges, the flow of the Dranse river is greatly reduced by the Mauvoisin dam in the upper valley (D1.2, p.114). Despite high availability of water, the supply of drinking water has been a source of concern (Aubin, 2011).

MAIN CLIMATE HAZARDS

By mid-century (2060), temperature will increase around 2°C in summer in a low emissions scenario and 4°C in a high emission scenario, and 2°C and 6°C respectively by 2085. In winter, by mid-century, temperatures are set to rise less than 1°C and up to around 2°C by mid-century and less than 1°C and up to 4°C by 2085. The heat stress on population, however, remains very low until the end of the century, even under the worst-case scenario, due to existing sensitivity and adaptive capacity (D1.2, p.117-118).

While the risk of wildfire is currently considered very low, it would remain so under a low emissions scenario but rise to a medium risk under a worst-case scenario by the end of the century (D1.2, p.118).

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 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. Yet the overall drought risk (taking into account vulnerabilities, exposure, and adaptive capacity) remains very low in all emission scenarios (Navarro et al., 2022).

Especially in regions of medium altitude (ca. 1,000-2,000m above AMSL) precipitation will increasingly fall in form of rain rather than snow. Even at high altitudes (above 2,000m AMSL), which represent a large part of the Canton's surface area, rain will increase by 10-20% compared 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 (D1.2, p.119).

It is likely that by the end of the century, more than two thirds of the glaciers in Valais will be melted. Some glaciers will have completely vanished, others will remain but very small. For example, the Aletsch glacier surface will likely reduce by 70% and the volume by 90% by the end of the century. 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 meltwater 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 (D1.2, p.118). 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 meltwater (Schneider et al., 2016). The risk of river floods and on population and on infrastructure therefore will decrease by the end of the century in all emissions scenarios (Navarro et al., 2022).

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 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). Currently, there is a lack of transparent decision making and the benefits and costs of water are unequally distributed. Adaptive activities so far have focused mostly on retrospective coping, but there is a need for more proactive and foresighted solutions (D1.2, p.126).

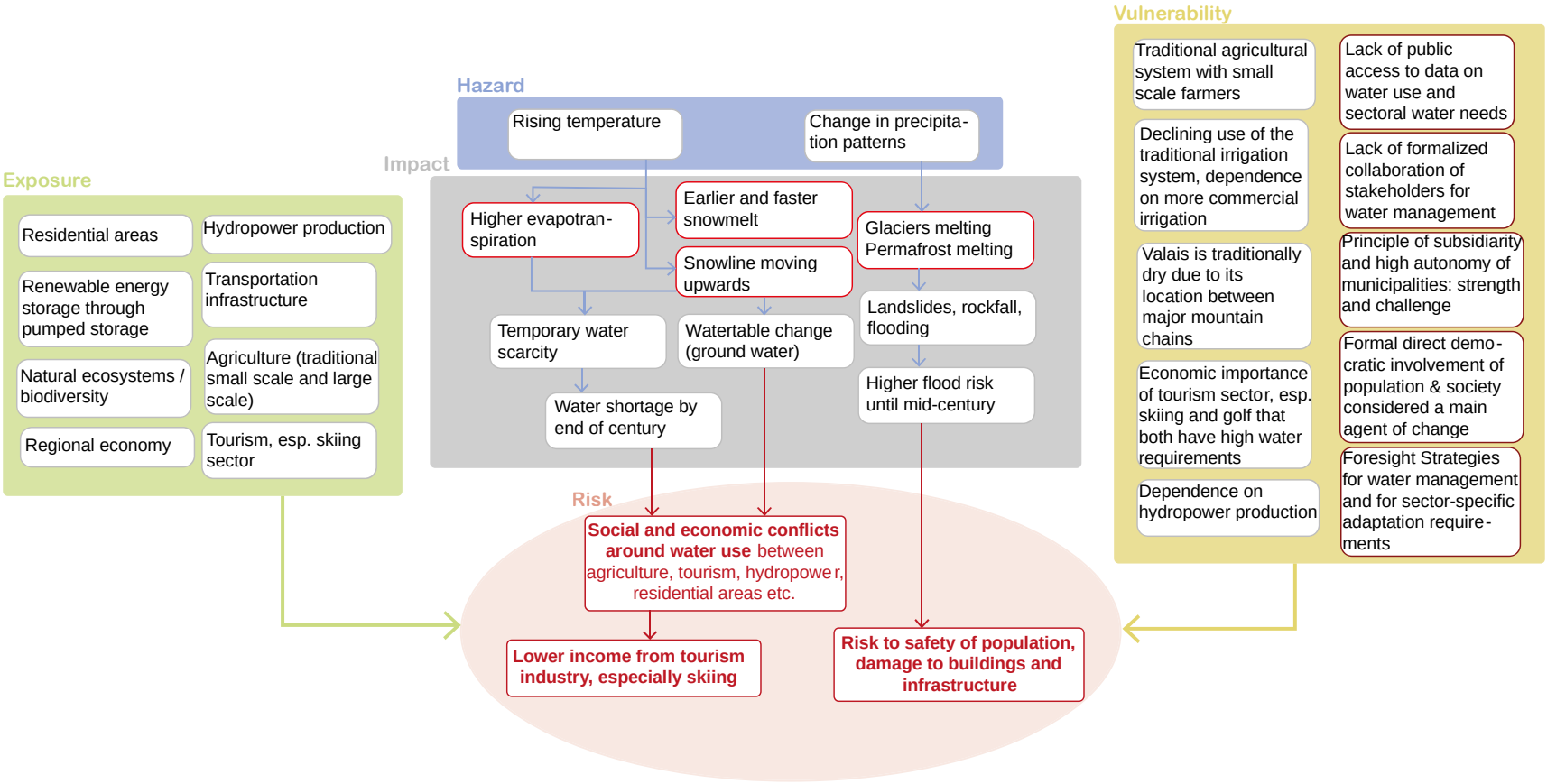


Figure 32. Valais Impact Chain (Focus: Winter) – Exercise baseline (ZSI, 2024)

2.6.2. Valais Final considerations

Figure 33. The ski touristic city of Zermatt, Valais (https://www.pexels.com/it-it/)

After one-on-one interviews with council members, providing in-depth feedback on regional challenges and solutions from various stakeholders, the Valais Local Council worked on categorizing the feedback into three main areas: academia and tourism, citizen engagement and policy, as well as community and policy (V-LCL) to ensure a clear understanding of their contributions. An interesting approach was taken by the Local Council, dividing the feedback based on the scale of the stakeholders' area of interest: local, regional, and national.

Solutions for Climate Resilient Transformation

The discussion of contributions brought through the framework developed in MountResilience, which involved quadruple helix stakeholders, revealed a series of needs and solutions related to Climate Change. Below, adaptation strategies based on this feedback are introduced, organized by main topics and linked to the findings from deliverable D1.2.

Discussed area: Data digitalization and sharing

One of the first needs (shared with Piedmont) is the capacity to inform stakeholders and users nationally to improve decision-making. "*Direct benefits thanks to improved resources management, and enhanced capacities for action and impact*" (V-EP), which can only be achieved by overcoming the barrier to proactive and foresighted water management; this is caused among others by the lack of transparent monitoring of water uses and needs (D1.2; p. 126). Providing new open-source data should therefore be the starting point: solutions were identified for glacier and water monitoring, with more accurate measures for water management, continuous monitoring systems, and the use of new and modern technologies, including artificial intelligence (V-EP). "*Continuous monitoring of glaciers and water allows for informed decisions and effective adaptation measures*" (V-EP), with actions often linked to natural systems, such as forests and lakes, for the preservation of resources through successful interventions. Additionally, this also aims at identifying risks, such as landslides and flooding, and fostering community collaboration and long-term engagement (V-LCL).

Solution suggested for the implementation	Strengths	Weaknesses and challenges
Transformation of data into inclusive digital interface for an informed decision-making process.	• *Enhanced system for qualitative and quantitative monitoring.* • *Real time data viability* • *Fast reactions in case of extreme events* • *Population awareness and security*	• *Long-term commitment* • *Access to initial data* • *Continuous maintenance, development and related costs* • *Technological barrier for rural areas* • *Needs for a collaboration between different stakeholders* • *Control on data collection, accuracy and transformation processes*

Discussed area: Management of water resources

The management of water resources is directly linked to data and continuous monitoring. Water needs are projected to rise in a business-as-usual scenario, particularly in urban areas and livestock farming (Milano & Reynard, 2022). This increase will significantly impact economies that are heavily dependent on water availability, particularly in the two most important industries in the region: hydropower and tourism (D1.2; p. 119).

Interview participants noted specific issues related to water usage during peak tourist seasons and discussed how to effectively manage these priorities (D1.2; p. 124). As example, in winter season villages of few hundreds of inhabitants can grow ten times due to skiers' presence.

In terms of hydropower, it is important to note that the Canton of Valais monitors overall water quality and manages usage rights and regulations for hydropower production (Canton du Valais, 2013). Additionally, integrating renewable energy sources can help mitigate the effects of climate change and ensure a more sustainable energy supply for the region (V-EP).

Currently, there is sufficient water, and the issue is not yet widely recognized by the public. However, there is a significant risk of decreased water availability, which could lead to social divisions (V-EP) and potential conflicts over water usage. Proposed solutions include managing the watersheds of the region's rivers and lakes, creating snow water reservoirs, promoting sustainable resource management, protecting ecosystems, and implementing integrated water management practices. As highlighted by the local council, Valais emphasizes the importance of stakeholders' perceptions in mountainous areas, advocating for the co-creation of solutions rather than unilateral implementation (V-LCL).

Solution suggested for the implementation	Strengths	Weaknesses and challenges
Regeneration of humid area for integrated management of water resources	• *Flood and drought mitigation* • *Water flow regulation* • *Water resource protection* • *Biodiversity increase* • *Better management for end users* • *Carbon sequestration*	• *Long time to be fully operational* • *High costs for slow results* • *Land use priorities could be different*

Discussed area: Sustainable agriculture

Water scarcity significantly affects consumption across various sectors, particularly agriculture (D1.2; p. 130). Adopting sustainable agricultural practices can alleviate pressure on water resources while promoting environmental sustainability. Additionally, "*a return to the techniques used by our parents and grandparents*" (V-EP) may enhance resilience.

In this context, the local council adopted a holistic approach that considers essential human and social dynamics (V-LCL). The research identified solutions acceptable to the local population, such as sustainable and transitional agriculture, food production based on available water resources, and methods to prevent soil erosion and degradation. However, a significant regional risk has been identified: the rapid pace of changes and the inability to adapt to the impacts of agricultural production (V-EP).

To improve the current situation, greater coordination among policymakers, farmers, and funding sources is deemed essential (V-EP).

Solution suggested for the implementation	Strengths	Weaknesses and challenges
Sustainable agricultural practices implementation	• *Less dependence on water availability* • *Economic and environmental benefits* • *More resilience against Climate Change effects* • *Soil preservation* • *Works at family level can prevent land abandonment* • *Traditional knowledge preservation with new techniques integration*	• *Barrier on changes by farmers* • *Knowledge and awareness lack* • *Less production in early years* • *Long term effects*

Discussed area: Water policies

Despite the need for integrated planning and management of water resources, "*a strongly sectoral policy continues to prevail*" (D1.2; p. 123). This has led participants to emphasize the importance of political and economic factors, such as for water use priorities or experts that can consider a holistic approach. With increasing tensions and growing cultural divides, numerous political debates occur each year at both federal and regional levels. For instance, *"every two years, on average, a vote defines the future framework related to climate change*" (V-EP).

Efforts to experiment with new water governance approaches are underway (D1.2; p. 130), and the recent appointment of a Cantonal Water Delegate has renewed interest in improving water governance in Valais (D1.2; p. 129). However, the focus must be extended beyond this initiative. The database includes selected articles, projects, and proposals related to coordination among local stakeholders, tools for anticipating water-related issues, management frameworks, methods for creative discussions (especially at the national level), and interrelations across multiple governance levels.

The "*current debate on water is intensifying, with five parliamentary actions already in 2024*". There is a risk of major conflicts arising after 2035 due to changes in water legislation, a topic that the Ministry of Defense also prioritizes. Several new initiatives are currently underway in parliament. Participants hope that a new national group dedicated to water, similar to the Local councils created for MountResilience, will address these issues effectively, fostering the best mechanisms, synergies, and relationships to overcome the low interoperability of systems between the 26 Cantons and federal offices.

Solution suggested for the implementation	Strengths	Weaknesses and challenges
Activate Influential parliamentary groups related on water	• *Collaboration between different sectors* • *More efficient actions focused on water* • *More political awareness on CC* • *Political and decision makers involvement*	• *Participatory and engagement process could be hard and not pleasant* • *Slow and long-time process and changes* • *Political priorities are different* • *Effectiveness of the group*

VALAIS - SUGGESTED CLIMATE RESILIENCE ADAPTATION STRATEGY

Discussions surrounding the Valais region highlighted a range of issues, both in terms of content (from glaciers to agriculture) and level (from local to national). However, the most valuable area for developing a climate adaptation strategy appears to be the one related to water, linked to the need for monitoring, data sharing, agricultural use, and energy management (D1.2, p. 118; D1.3, Annex, Valais).

A suggested strategy would focus on the sustainable management of water resources to address reduced availability and variability due to glacial retreat and changing precipitation patterns. This objective can be achieved on two levels: operational and territorial. The operational level requires structured water governance across sectors

(D1.2, p. 123), involving transversal decision-makers (D1.3, Annex, Valais) who can also prioritize different water uses in emergency situations. This would be supported by advanced water monitoring (e.g., remote sensing and IoT sensors) for real-time data and flood/landslide prevention. The territorial level focuses on precision irrigation systems and efficient agricultural practices (especially for vineyards and fruit farming) and the preservation of biodiversity through restoration of aquatic ecosystems, wetlands, and ponds to create wildlife refuges.

Strengthening problematic alpine areas (rivers, slopes, flood-prone zones) is essential, with targeted projects to mitigate risks through re-naturalization, reforestation, riparian buffer zones, and maintenance of mountain pastures/agricultural areas. For the strategy to be effective, it must also consider tourism aspects (D1.2, p. 117) by promoting storage facilities for peak season needs, both for drinking water and sustainable hydropower development, or by enhancing existing infrastructure with more efficient pump systems (Bundesrat, 2022).

Achieving these goals requires engagement from stakeholders at multiple levels: at the local level, awareness campaigns and educational programs for citizens and local communities are essential (D1.2, p. 130); experts, farmers, and tourism operators would provide direct feedback on water needs, while municipalities, academic and research institutions, water organizations (in agriculture, energy, and water sectors), and NGOs would play crucial roles in the coordination. At a higher level, Cantonal and national government involvement is needed. Various funding opportunities can help achieve these objectives: the Interreg Alpine Space Fund, Green Climate Fund, European funds for rural areas, and the EU LIFE Programme to support biodiversity, agriculture, and tourism, while Public-Private Partnerships and federal programs or CO_2 reduction funds may be valuable for water management (Bundesrat, 2022).

This Climate Resilience Adaptation Strategy is designed to secure water resources, reduce flood risk, and protect natural ecosystems through collaboration, coordinated actions, monitoring, and environmental nature-based solutions at a local scale that manages water resources from source to end-user. Implemented consistently in certain areas, it can serve as a model for other parts of Valais.

3. Regional replicators adaptations strategies

Starting from the outputs obtained by the documentation listed in the first chapter it was possible to define important aspects for the definition of tailored adaptation practices. In this chapter the results were summarized in Factsheets, one for each replicator region, underlining main outcomes: a solution for each main discussed area touched by climate change effects is proposed after a brief discussion, and then, a final adaptation strategy is suggested.

3.1. CATALONIA FACTSHEET

3.1.1. Regional Baseline and Impact Chain

Geography, evidence of climate change (mainly temperature and rainfall changes), and the associated risks and hazards are key factors that can strongly shape people's views on climate change and their adaptation priorities. This is also evident from the Impact Chains resulting from the first workshop (Innsbruck, 2024). This chapter was used as a basis for regional partners' participants to the Factsheet exercises, to underline main regional aspects and CC problems in their territory.

REGIONAL BACKGROUND

Geography

Catalonia is a region located in the north-eastern part of the Iberian Peninsula, with an area of 32,091 square kilometres and a population of 7.6 M people, bordered by the Mediterranean Sea (east), France (north), Aragon region (west) and Valencia region (south). The region consists of the provinces Girona, Barcelona, Tarragona, and Lleida (Rodriguez, 2024). Catalonia includes coastal areas, plains and valleys, but also mountains: they form 46% of Catalonia area, with 32% of the municipalities and 4.5% of the total population, and 30% of Catalonia is included in the Pyrenees; this mountain region (in the north) includes 163 municipalities and 2.8% of the total population. These mountains play a crucial role in the regional climate, biodiversity and touristic offers (Rodriguez, V.,2024; D1,2, p. 131).

Economy

Catalonia is a well-developed and industrialized region in Spain, home to the automotive, chemicals, pharmaceuticals and electronics industries (ICEX, 2024). Agriculture have also many active sectors, like wine and olive oil productions, and fruits and vegetables farms, especially in the Ebro River Valley. Tourism is a great economic driver, not only for Catalonia's famous beaches or for the city life, but also for cultural landmarks and for mountain activities, like hiking, trekking, adventure sports, ski, sustainable tourism and leisure, and a sustainable bio-economy (Bioregions Facility; 2024).

Temperatures

Catalonia lies entirely in the Mediterranean basin, characterized by summer droughts and precipitation concentrated in spring and summer, relatively rainy winters (Rodriguez, 2024). If coastal areas in Catalonia have usually mild winters with average temperatures ranging from 8-12°C and hot summers averaging 25-30°C, the situation is different for mountain areas: in the Pyrenean regions there are cold winters (with temperatures below the 0) and cool summers (with 10-22°C). Climate change projections provided by most models confirm that there will be an increase in the average annual temperature between +0.9°C to +2°C for the period between 2031 and 2050 in all seasons of the year, but this fact could be more relevant during the summer and in the Pyrenees (Institute of Catalan Studies and the Government of Catalonia, 2017).

Precipitations

Rains also varies from costal to mountain areas: if places near the sea receive normally 600-800 mm of rain in a year (320 mm in the semi-arid central Ebro valley) in the mountain area it can exceed 1,000 (2000mm in the Pyrenees and Cantabrian mountains), with intense heavy rains events that can lead to floods and natural hazards. Despite this most models are suggesting a decline in precipitation levels, episodes of torrential rain may also increase, with increasing probabilities of episodes exceeding 200 mm of precipitation in twenty-four hours (D1.2, p. 132).

MAIN CLIMATE HAZARDS

Challenges

The severity and duration of droughts could increase significantly due to the combined effect of higher temperatures and the decline in precipitations. This will notably impact forest fire risk (Selkimäki et al., 2012), which has been increasing during the last decades. Catalonia also needs to prevent the depopulation of mountain areas, where many villages are below 5000 people (with high risk of disappearing because of the population concentrating in big cities) and act against the decrease in family farms and extensive livestock (D1.2, 134).

Needs

The main economic sectors in the mountain areas include tourism, sport and leisure. Agriculture and farming are also common practices, particularly in mountains that will be exposed to severe and long drought periods. Increasing temperatures and heavy rain may have a negative impact on both. Water and biodiversity are main climate challenges of the region. Important needs also include social aspects, decision making support systems, governance approaches and social innovation & community-based solutions (Global Market Research and Analysis, 2018).

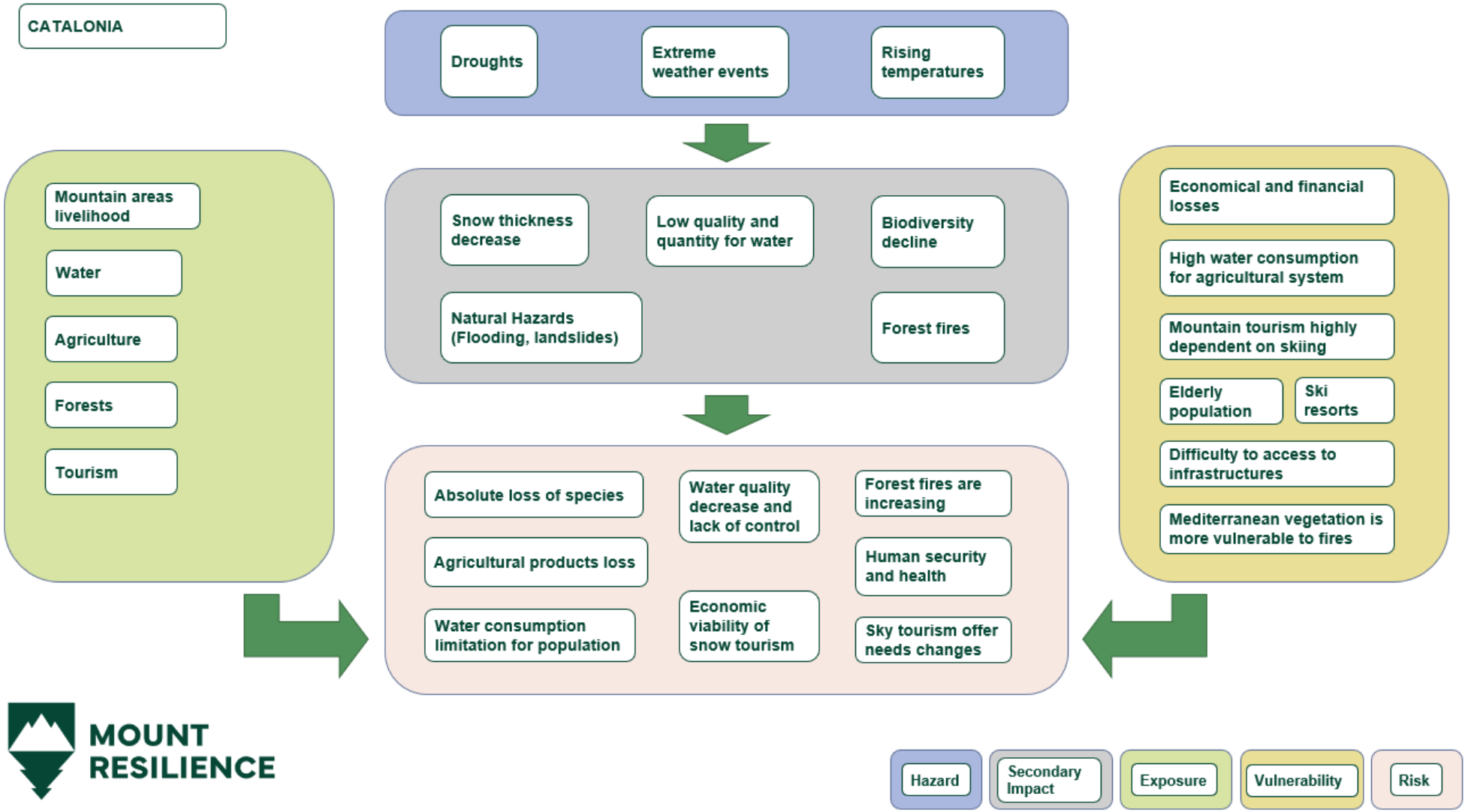


Figure 34. Catalonia Simplified Impact Chain, based on Innsbruck workshop - (UMIL 2024, based on ZSI, 2024)

3.1.2. Catalonia final considerations

Figure 35. A mountain field in Catalonia (Source: https://www.pexels.com/it-it/)

Following the feedback obtained from the participants, a key point clearly emerges for the region of Catalonia: most of the regional challenges are related to water. Despite the variable characteristics in terms of precipitation, with for example, the Ebro River basin characterised by both a continental and semi-arid tendency (Loidi, 2017), and precipitation ranges that can even reach 2,000 mm per year in the Pyrenees and Cantabrian mountains (D1.2; p 132), the central interest in this issue from the stakeholders is evident.

Solutions for Climate Resilient Transformation

The discussion of contributions obtained through the framework developed in MountResilience was applied to regional replicators too, involving quadruple helix stakeholders. In that case participants didn't provide specific solutions after a Local Council validation. Below, adaptation strategies based on this feedback are introduced, organized by main topics and linked to the findings from deliverable D1.2.

Discussed area: Water resources

Water-related issues range from management – with projects/articles for better water use, proper water management, quality and quantity control and preservation, including the use of forecasting mechanisms and availability models – to those that impact the following three different exposure areas: agriculture, forests, and tourism. These three sectors, as identified in D1.2, are already included in the Catalan Strategy for Adapting to Climate Change 2021-2030 that "*highlights actions corresponding to natural systems (forests and forestry), socioeconomic areas (agriculture and livestock), and the general territory (mountains)"* (D1.2; p 134).

Solution suggested for the implementation	Strengths	Weaknesses and challenges
Develop a Tool for Water Management – Decision-Support (DS) Tool - to mimic water availability and anticipate critical scenarios **(Connected to Piedmont – same topic)**	• *Water availability in real time data* • *Farmers and consortia conflicts reduced by the presence of an established decision-making mechanism* • *Final users' security* • *Better cooperation and data sharing* • *Water wasted reduction* • *Less costs for end users*	• *Changes are hard to be accepted by farmers* • *Hard developing and programming phases* • *Requires more technical experts* • *Depending on data correctness*

Discussed area: Tourism

The Catalan economy is indeed based on a strong services sector and tourism (D1.2; p 313); on the tourism side, issues related to drought and rising temperatures (identified as high-impact) emerge, while there is also, as in Tyrol, the need to find solutions for skiing, as evidenced by the search in the database for slope management techniques, new technologies, but also NbS, and considerations on the sustainability of the skiing offer.

Solution suggested for the implementation	Strengths	Weaknesses and challenges
Transformation of mountain resorts *with all-year tourism innovations* **(Connected to Tyrol – same topic)**	• *Monitoring implementation* • *Citizen and stakeholder's involvement* • *Natural landscapes preservation and conservation* • *Tourism adaptation, eco-tourism, diversification* • *Economic effect on the population*	• *Broad concept, hard to be understood and explained* • *Long implementation timeline* • *Long term returns and vision* • *Uncertainness of success and effects* • *Cultural and local resistance; path dependent*

Discussed area: Agriculture

Although no specific articles and projects were selected in this regard, except for NbS in general, the issue of agriculture, linked to the "*intensive agriculture exerts severe pressure on freshwater resources of the Ebro River Basin, especially in terms of nutrient and pesticide fluxes from agricultural fields, while a combination of intense irrigation and excessive and inefficient fertilization*" (D1.2; p 132) and about forests degradation, where "*a general negligent forest management and, most recently, afforestation of abandoned farmland, face a particularly high risk*

from large fires" (Selkimäki et al., 2012). Both were mentioned in the exercises, highlighting also problems related to biodiversity.

Solution suggested for the implementation	Strengths	Weaknesses and challenges
Innovation in crops irrigations techniques **(Connected to Piedmont – same topic)**	• *Less water usage* • *Less pollution from fertilizers* • *Improved crops quality and resistance* • *Soil preservation* • *Can be easily integrated with other solutions*	• *Long times to be adopted and accepted by farmers* • *Initial investment and more maintenance* • *Bad management can cause soil degradation* • *Not applicable to all crops (e.g., rice)*

Discussed problem: Stakeholder's relationships
Similarly, to various regional demonstrators investigated (particularly Piedmont and Tyrol for this case), there is also a need for a better relationship with stakeholders and policymakers, with a search for articles and projects related to people engagement, strategies, and frameworks. This also refers to the search for approaches among the various end users, due to "*conflicts for water management*" (C-EP) that were indicated as the most relevant risk in the Catalonia region. Looking at that, there is the need of a policy involvement with an integrated approach, that considers multiple aspects related to Climate Change.

Solution suggested for the implementation	Strengths	Weaknesses and challenges
Integration of Climate Change adaptation into the work of local authorities **(Connected to Tyrol – same topic)**	• *High impact* • *Provide policy coherence and awareness* • *Community and decision-maker involvement* • *Holistic approach*	• *Actual system is difficult to be changed* • *Dependent on decision-makers and political will* • *Political, administrative and local barriers* • *Low financial resources*

CATALONIA - SUGGESTED CLIMATE RESILIENCE ADAPTATION STRATEGY

Water management and agriculture emerged as the main priorities from the exercises carried out by the partners (D1.3, Annex, Catalonia), with some references linked to all-year sustainable tourism.

A suggested strategy for Catalonia should focus on building a robust foundation for water resource management: to secure sufficient summer supply for the tourism and agriculture sectors, it is recommended to upgrade water storage basins and Natural Water Retention Areas, including wetlands and re-naturalized areas, as well as implement aquifer recharge systems. The reuse of treated wastewater for non-potable agricultural and industrial purposes and rainwater harvesting can help address shortages. This strategy should be supported by a real-time monitoring system and relevant authorities to ensure clear and efficient water management and distribution, according to the Strategy of the Pyrenees Areas (OPCC, 2023).

Once an efficient monitoring system has been established, as well as an appropriate decision-making process for managing the water resource among various end users, it will be possible to focus on the agricultural sector in a similar way to Piedmont (D1.3, Regional demonstrators adaptations strategies, Piedmont) by adopting water-efficient practices (e.g., soil sensors, drip irrigation) and sustainable land use, alongside precision agriculture technologies and drought-tolerant, water-efficient crop varieties. For winter tourism (as seen in the Tyrol case), a year-round diversification approach is recommended, promoting rural tourism (hiking, cultural and heritage tourism) and agritourism (wine, food). In these areas, tourist facilities should be upgraded with sustainable water systems, and in areas where ski resorts remain prominent, technologies should be implemented to enhance artificial snowmaking, reducing the use of potable water. The establishment of an integrated body for the management of water resources, tourism, and agriculture sectors is highly recommended (D1.3, Annex, Catalonia; ESCACC30).

Key stakeholders to be involved in the overall process include the Catalonian government (departments of water, tourism, agriculture and mountain), municipalities, water management companies and agencies, agricultural associations and cooperatives, tourism operators, environmental NGOs, and research institutions. Great importance should have the involvement of the Catalan Climate Change Office and the Advisory Council for Sustainable Development of Catalonia (CADS) who is facing CC (D1.2, p. 134) with is Catalan Strategy for Adapting to Climate Change 2021-2030 (ESCACC30, 2023). Achieving these goals requires collaboration across stakeholders, drawing on funding from the Green Climate Fund, EU Cohesion Fund, European Structural Fund, and Public-Private Partnerships (PPPs) for water management, as well as the EU LIFE Programme, Horizon Europe (Spanish MITECO, 2020), regional and national funds for sustainable tourism research and tourism promotion, the European Agricultural Fund for Rural Development, private partnerships, and grants to support local farmers in transitioning to climate-resilient practices.

By adopting these strategies, Catalonia can address water scarcity, build a resilient tourism industry, and secure agricultural productivity. It is recommended to draw from projects in the Piedmont and Tyrol regions to evaluate the best approach for implementation.

3.2. FRIULI-VENEZIA GIULIA FACTSHEET

3.2.1. Regional Baseline and Impact Chain

Geography, evidence of climate change (mainly temperature and rainfall changes), and the associated risks and hazards are key factors that can strongly shape people's views on climate change and their adaptation priorities. This is also evident from the Impact Chains resulting from the first workshop (Innsbruck, 2024). This chapter was used as a basis for regional partners' participants to the Factsheet exercises, to underline main regional aspects and CC problems in their territory.

REGIONAL BACKGROUND

Geography

The Friuli-Venezia Giulia region shows a complex territory that encompasses different environments, such as sea, swamps, plains, hills and a mountain area composed principally by Julian Alps and Prealps. It borders with Austria (north), Slovenia (east), the Veneto region (west) and the Adriatic Sea (south). The population is approximately 1.19 million people, and its density varies significantly passing through the higher concentrations in urban areas and along the coast, to the sparsely populated mountains (OECD, 2023; Tikkanen, 2024).

Economy

Friuli-Venezia Giulia is characterized by various industrial (from manufacturing to wood elaboration) and finance (insurance and banking) activities. In addition to this, the agricultural and service sectors are very important: the agriculture is well developed with crops such as corn, soybeans, vegetables), but also in mountain areas with the renowned wine production. Farming, with livestock and dairy quality products (like Montasio or San Daniele Ham) is as well a driver for the region, related to the agronomical and agricultural services. The tourism sector ranges from the attractivity of the Adriatic coast to the natural parks and protected areas of the Alps, including winter sports, biking, hiking, climbing, and cultural tourism.

Temperatures

Temperatures are mild in the coastal areas of the region, where daily values rarely drop under -5 °C or rise above 33 °C. In mountains average daily temperatures can vary from -6°C to 2°C in winter and from 12°C to 24°C in summer. The higher temperatures affect the snow cover, and impact the tourism sector at low altitudes. In summer heatwaves can pose a risk to workers and tourists participating in sports activities, with an increasing risk on people health.

Rains

In coastal areas annual rainfall is about 1.000-1.200 mm while in the Alps precipitations is higher, reaching 1.600-1.800 mm, with more than 3.000 mm in Julian Pre-Alps (AcegasApsAmga & DMG-UNITS, 2014). Mountains receive significant rainfall throughout the year, with the highest amounts typically in late spring and autumn, and frequent snowfalls in winter, despite less precipitation. Summer, in contrast, is typically drier, but afternoon thunderstorms are common. With CC a generalized increase in precipitation is predicted in winter and a decrease in summer, with a total decrease in a year (Caloiero et al., 2023). this could cause drought problems that will strongly affect agriculture,

especially in the central plains of the region with a deep-water table. For the Alpine area, an increase of extreme precipitation (and in the number of wet days) is expected in the short and long term, especially in winter.

MAIN CLIMATE HAZARDS

Challenges

Overheat can bring significant changes in many Alpine areas: higher frequency and intensity of heat waves combined with dry periods affect citizen health and behaviour, water, snow-cover, agriculture and many others heat-related risks. They can also facilitate the generation of wildfires and disruption of the biodiversity and on landscapes in mountains. On the other hand, heavy rains in short periods could be dangerous in Alpine steep valleys, where it would increase the risk of landslides (in summer), of avalanches (in winter), and in densely populated areas where few green spaces and impermeable areas (Pagani et al., 2022).

Needs

Mountain tourism is particularly affected by Climate Change. Special attention is required for Alpine buildings and infrastructures that might encounter challenges in guaranteeing customers' health. Similarly, the mountain landscape needs adaptation actions, due to the increasing natural disasters and biodiversity loss. Energy increasing costs depending on decreasing hydropower supply affects plants and facilities, that needs appropriate initiatives, with a stronger green transition into the region. Important needs also include social aspects, decision making support systems, governance approaches and social innovation & community-based solutions (Italian Ministry of the Environment, 2022b).

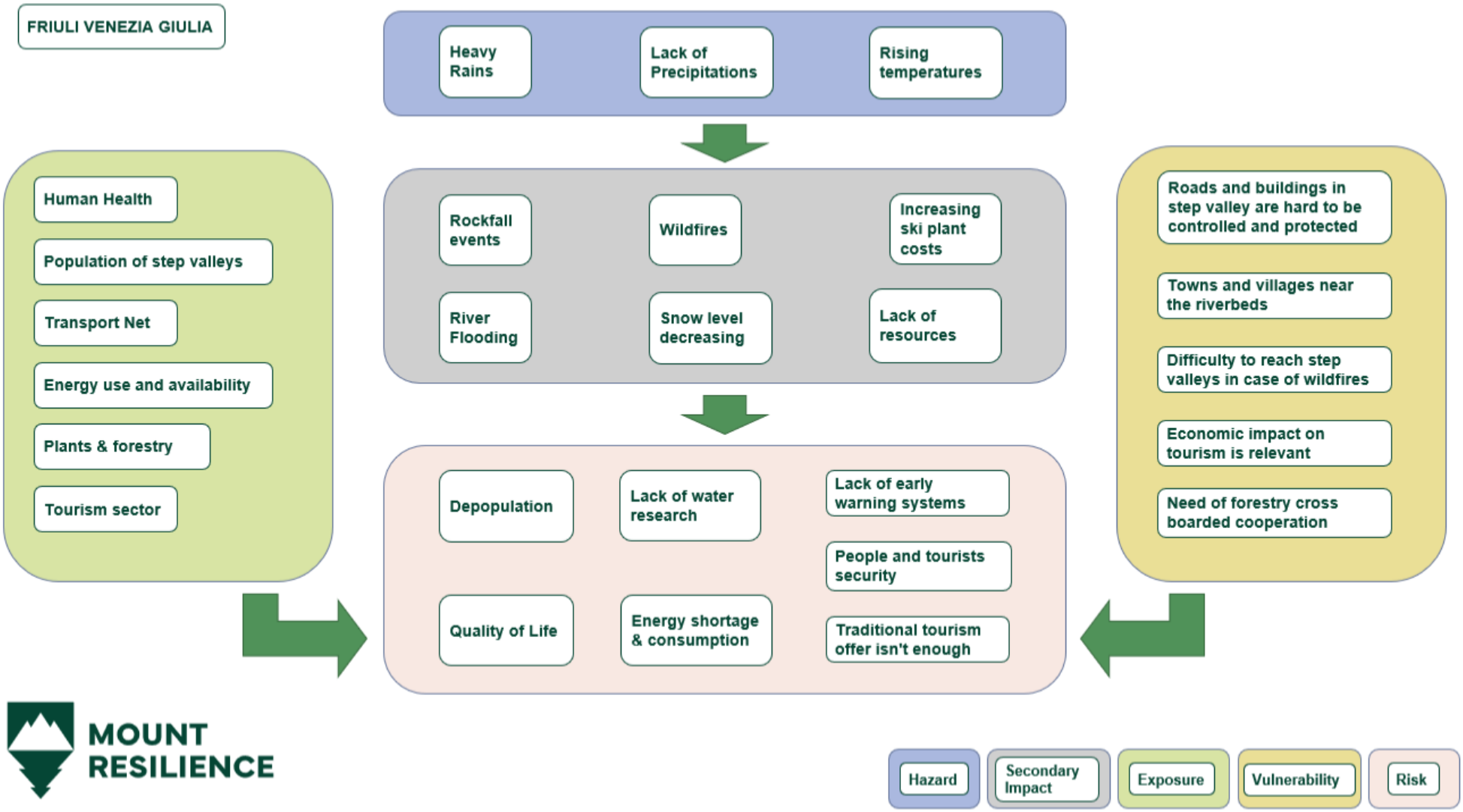


Figure 36. Friuli-Venezia Giulia Simplified Impact Chain, based on Innsbruck workshop - (UMIL 2024, based on ZSI, 2024)

3.2.2. Friuli-Venezia Giulia final considerations

Figure 37. Monte Lussari – a mountainous village near the Montasio plateau (Source: https://www.pexels.com/it-it/)

Friuli-Venezia Giulia, as a replicating region, has identified its reference sectors with a multidisciplinary approach, taking into consideration some initiatives and projects already present in their mountain area, in addition to the project/articles provided by the database.

Many of the concepts discussed seem to converge with those identified by the PNRR Green Communities "*project financed by PNRR and managed by Gemonese Mountain Community*" (F-EP), from which participants drew inspiration, i.e., projects "*which include interventions of agroforestry assets and water resources management, energy efficiency, development of sustainable tourism and the integration of mobility services, development of sustainable agricultural business models*"; in this sense, as well as with Tyrol and Piedmont, there are also similarities with Gabrovo, Râu Sadului, and Valais regarding wildfires, water resource use, infrastructures, transport, and dependence on winter tourism.

Solutions for Climate Resilient Transformation

The discussion of contributions obtained through the framework developed in MountResilience was applied to regional replicators too, involving quadruple helix stakeholders. In that case participants didn't provide specific solutions after a Local Council validation. Below, adaptation strategies based on this feedback are introduced, organized by main topics and linked to the findings from deliverable D1.2.

Discussed area: Tourism

Tourism-related areas of exposure are particularly notable, as they are strongly affected by rising temperatures and the resulting changes in snowfall patterns, which impact winter sports. Additionally, these changes affect residents in terms of health, quality of life, transportation, energy, and water availability. Participants view these areas as interconnected, emphasizing the need for a sustainable and diversified tourism model that does not rely on snow or artificial snowmaking. There is a recognized decline in tourism, with concerns such as "*quality of life/reduced number of tourists*" (F-EP) and "*human health (for every living species) and low tourist area*" (F-EP) being raised. Stakeholders in the mountain regions are encouraged to promote a different kind of tourism *"green and slow*" (F-EP). An example highlighted is a village that "purchased e-bikes for tourists" (F-EP). This demonstrates a clear connection with other regional initiatives in the tourism sector.

Solution suggested for the implementation	Strengths	Weaknesses and challenges
Slow and sustainable tourism	• *Local population knowledge and awareness strengthened* • *Local population involvement* • *Sport and health* • *Decrease in smog* • *Less environmental impact* • *Preserve local culture* • *Economic benefits due to the extended tourist season*	• *High costs for change* • *Local population actions and acceptance* • *Limits and changes may be not accepted by tourists* • *Distant in time economic benefits* • *Risk of failure due to wrong planification*

Discussed area: Natural threats

There is notable interest in environmental issues, such as biodiversity loss; however, aspects related to natural disasters, like flooding, appear to have a limited impact on the region. Despite changes in precipitation increasingly affecting local livelihoods and ecosystems (AcegasApsAmga & DMG-UNITS, 2014), participants to the exercises for Factsheets do not consider these issues to be among their top concerns. The same is true for agriculture, where interest levels differ from nearby regions like Piedmont, likely due to specific regional characteristics.

In contrast, concerns about water scarcity have emerged more prominently. Participants highlighted a "project financed by PR FESR 2021-2027 that aims to implement pilot projects on small mountain aqueducts. This initiative seeks to ensure the quality and continuity of water services for small communities in remote mountain areas through digitalization, particularly by employing smart solutions based on IoT technologies" (F-EP).

Among environmental challenges, wildfires are identified as a significant risk. Ongoing afforestation projects and "*interventions financed by national funds are aimed at preventing and combating forest fires. These efforts include the establishment of firefighting water reserves and tanks for water accumulation to mitigate the risk of such disasters in the inner mountain areas*" (F-EP).

Solution suggested for the implementation	Strengths	Weaknesses and challenges
Traditional practices (e.g., rotational grazing) for mountain areas **(Connected to Râu Sadului – same topic)**	• *Traditional practices preservation and use* • *Prevent depopulation* • *Elder population acceptance* • *Preserve meadows quality* • *Improving biodiversity and natural regeneration* • *Low-cost* • *Wild-fires reduction*	• *Limited effectiveness* • *Conflict with sheep farmers* • *Requires initial knowledge transfer by involving elder population*

Discussed area: Participation

Regarding potential solutions, a key issue identified is the lack of interaction among stakeholders and the need for effective engagement methods, such as multidisciplinary approaches and awareness of climate change. These elements are essential for determining the best adaptation mechanisms. In this context, the preference for projects involving meetings, workshops, or environmental education in schools is evident.

Examples of suggestions include "*projects aimed at involving young people in the policies of mountain areas and sustainable development, such as the cooperation project livGAL: a living lab for the FVG LAG areas, financed by the LEADER Programme 2023-2027, along with initiatives for active citizenship in remote mountain regions*". Additionally, concerns were raised regarding the "*lack of teachers*".

Solution suggested for the implementation	Strengths	Weaknesses and challenges
Meeting and workshop with school children	• *Low cost* • *Early awareness and knowledge* • *People involvement* • *Future decision-makers oriented vision* • *Environmental education*	• *Low number of teachers* • *Difficulty in being able to clearly explain difficult concepts to children* • *Long time to be effective (for the future)* • *Only young people are involved*
Multidisciplinary participatory approach to stakeholder engagement (local administration and employees in the agriculture, silviculture, energy sector)	• *Low costs* • *Stakeholders' involvement in multiples fields* • *Promotes innovative solutions* • *Better resource management*	• *Communication between different stakeholders is complex* • *Lack of stakeholder's awareness in the opportunities of nature-based solutions systems* • *Stakeholders conflict between different interests*

Discussed area: Energy and buildings		
The need to improve the energy performance of structures and homes was also considered, though not at high levels, but with suggestions regarding other initiatives in the mountain areas, such as "*Project financed by PR FESR 2021-2027 as part of inner areas strategy –'Smart Village' intervention - Activation of renewable energy community and other interventions*" (F-EP). The aim remains to "*promote the energy transition as an opportunity for innovation and sustainable and inclusive development*" (F-EP). It was also noted that there are "*Mountain municipalities adhering to the Covenant of Mayors for Climate and Energy initiative*" (F-EP), with the purpose to achieve a reduced energy impact "*according to EPBD recast*" (F-EP). These challenges, like the one related to tourism, closely align with the topics addressed by Tyrol.		
Solution suggested for the implementation	**Strengths**	**Weaknesses and challenges**
Changes in the buildings and settlements, avoiding overheating through active and passive measures **(Connected to Tyrol – same topic)**	• *More data and simulation* • *Better comfort and livelihood* • *Quality of living spaces and life in general* • *Less air conditioning (heating in winter) and energy consumption* • *Long term sustainability*	• *Initially expensive* • *Difficult to be implemented in the existing buildings* • *Limited effectiveness*

FRIULI-VENEZIA GIULIA - SUGGESTED CLIMATE RESILIENCE ADAPTATION STRATEGY
Tailored to the unique environmental and socio-economic landscape of the Friuli Venezia Giulia region (D.12, p. 135) and based on participant feedback (D1.3, Friuli-Venezia Giulia, Annex), an effective strategy would focus on slow tourism and energy-efficient building practices, while also preventing rural depopulation. Promoting the use of renewable energy sources and improving the energy efficiency of both public and private buildings is a crucial first step to reduce emissions and lower energy demand. This would increase citizens' awareness and acceptance, aligning with Italian Ecological Transition Plan (Italian Ministry of the Environment, 2022a) Smart buildings, equipped with green walls and roofs where possible, or natural ventilation and insulation systems, like those in Tyrol, could help achieve this goal. Integrating new technologies in historical centres is essential, not only for sustainability, but also to preserve the appeal to tourists. The decline in traditional winter tourism can be addressed through innovative, sustainable slope management and artificial snowmaking methods, as practiced in Tyrol, guiding the shift towards year-round tourism. Focusing on cultural heritage to support local economies and promoting slow tourism itineraries (e.g., hiking, cycling, and cultural trails) is vital. Investment in eco-friendly infrastructure, such as facilities for e-bikes (D1.3, Regional replicators adaptations strategies, Friuli-Venezia Giulia), can further support this goal. Integrating these routes with agro-tourism and rural areas will incentivize the preservation of mountain regions (as for Râu Sadului) and encourage sustainable land use. Improving soil health through traditional slope farming techniques, implementing water-saving irrigation systems

(Ministry of Agriculture, Food Sovereignty and Forests, 2022) and renovating existing water supply infrastructure could complete the tourism supply chain (Autonomous Region of Friuli-Venezia Giulia, 2022).

For the recommended strategies, a central organization supporting new tourism paths and renewing infrastructure would be beneficial. This could involve regional tourism boards, tourism operators, construction companies, homeowners, farmers, agricultural cooperatives, energy providers, and cultural NGOs. This group would include regional government departments, municipalities, and ARPA FVG (ARPA FVG, 2018), one of the main bodies implementing regional CCA policies (D1.2, p. 138). Suggested funding sources include the European Agricultural Fund for Rural Development, European Social Fund, Interreg programs, LIFE program, Life CLIMA, as well as Italian and Regional Grants (Italian Ministry of the Environment, 2022b), with support for rural housing upgrades and tourism infrastructure via funds such as the LEADER Program 2023-2027 (D1.3, Regional replicators adaptations strategies, Friuli-Venezia Giulia). Local partnerships are also recommended to promote sustainable tourism and actions on buildings.

By adopting these strategies, Friuli Venezia Giulia can enhance energy efficiency and sustainable tourism, laying the foundation for mountain repopulation, slope management, and the region’s economic strengthening.

3.3. PRIMORJE-GORSKI KOTAR FACTSHEET

3.3.1. Regional Baseline and Impact Chain

Geography, evidence of climate change (mainly temperature and rainfall changes), and the associated risks and hazards are key factors that can strongly shape people's views on climate change and their adaptation priorities. This is also evident from the Impact Chains resulting from the first workshop (Innsbruck, 2024). This chapter was used as a basis for regional partners' participants to the Factsheet exercises, to underline main regional aspects and CC problems in their territory.

REGIONAL BACKGROUND

Geography

Primorje-Gorski Kotar County represents a relatively large area of 7,931 km² (the land area of the county is 3,587km², while the marine area covers 4,344km²) and it is the sixth largest region in Croatia with around 296.000 inhabitants. The county shares a northern border with Slovenia and the other ones with Croatia regions. The county consists of three microregions: the coastal, the islands and the mountain (Gorski Kotar) areas. The County is characterized by a huge karst geological structure of the soil (almost all protected parts of the mountain area of Gorski Kotar are related to the phenomenon of karst), extremely important for water supply and to preserve groundwater high-quality (D1.2, p. 139).

Economy

The geographical position and diverse natural features of the marine area, from the richly indented coast and islands to the heavily forested mountain part of Gorski Kotar, have determined the economic and social development of the County (Kozlica, Radunovi & Kovaÿiÿ, 2022): while the mountain area of is important for agriculture, wood industry and represents a strategic reserve of drinking water and ecosystem services (for the whole Republic of Croatia), the main centre for business, administration, economy and culture is the city of Rijeka.

Temperatures

Primorje-Gorski Kotar County is characterized by a moderately continental climate, but it changes from coast to mountain. Particularly in Gorski Kotar, where rich forests grow, there are harsh winters with heavy snowfall and mild summers, far from the heat of coastal areas. In fact, in mountains, winter averages temperatures can range between – 5 to 3°C (with peaks of -10°C) and summer ones between 10°C and 22°C. The predicted global warming will cause noticeable changes in this ecosystem (Meteoblue, n.d.).

Precipitations

The mean annual precipitation changes greatly across the county, with coastal areas receiving less rainfall compared to the mountainous inland areas. Annual precipitations are usually around 1,000-1,600 mm year, but in last years a great increase is reported, with values that can overcome 2,000 mm and some mountain areas that could have reached the 3,000 mm: this rainfall contributes to the lush vegetation and to the typical dense forests of the region (Tourist board Gorski Kotar, 2022). Despite this, summer in Gorski Kotar have usually long dry periods

and for all watercourses there is a very pronounced decreasing trend in average annual flows (Ugarković, I. et al., 2011)

MAIN CLIMATE HAZARDS

Challenges

The hydrographic condition of the county is very heterogeneous: excluding last years, the capacities of natural springs are significantly reduced during summer dry periods, and part of the water is exploited for water supply. Other challenges are related to the increase in the intensity of short-term heavy rainfall, to hazards related to torrential flows, to the rising risk of forest wildfires and to the energy availability (D1.2, p. 140).

Needs

If watercourses trend of average annual flows is decreasing, there is still a need to irrigate the city gardens, and this generally causes a problem for water ecosystems mainly placed in the mountain part of the county. Primorje-Gorski Kotar County needs to face also to problem related to infrastructures costs due to natural hazards and heatwaves, and to the energy consumption. Important needs are also related to social aspects, to decision making support systems, to governance approaches and social innovation & community-based solutions (D1.2, 141-142).

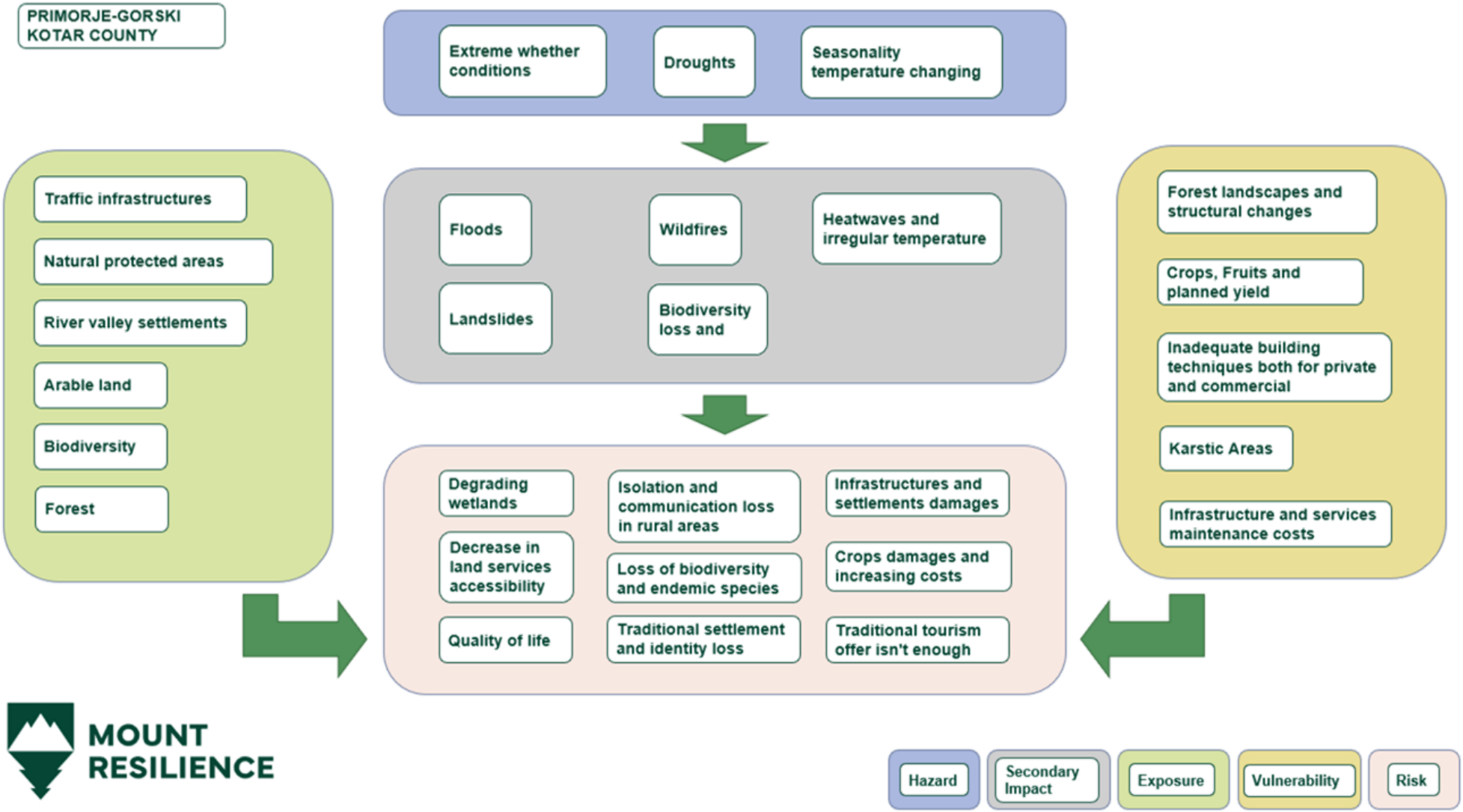


Figure 38. Primorje-Gorski Kotar Simplified Impact Chain, based on Innsbruck workshop - (UMIL 2024, based on ZSI, 2024)

3.3.2. Primorje-Gorski Kotar final considerations

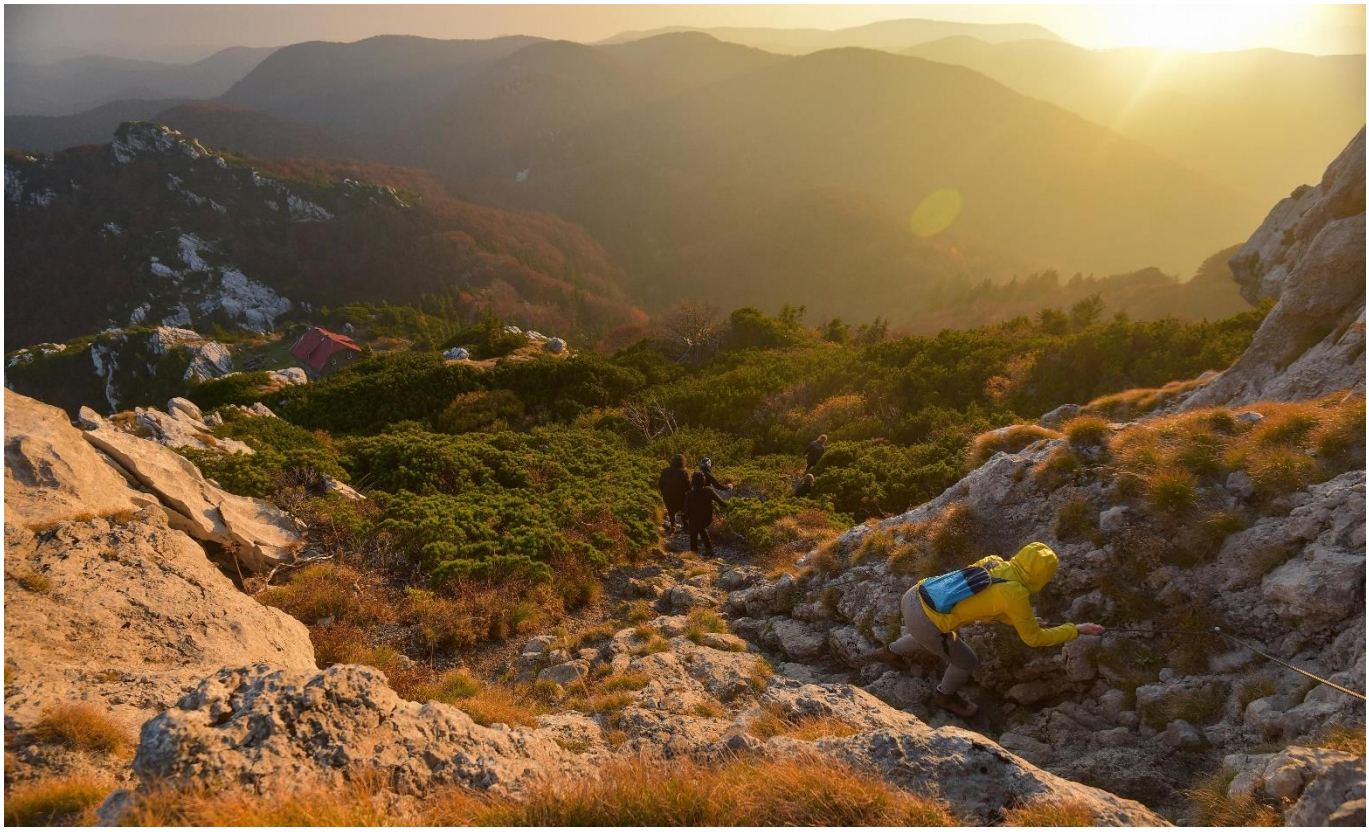


Figure 39. Primorje-Gorski Kotar County mountains, Malo Selo, Delnice (https://www.pexels.com/it-it/)

We can start citing a participant comment "*Gorski Kotar region is an economically underdeveloped area, and Climate Change adaptation should be directed to long-term sustainable improvement of life conditions and life quality. Also, due to lack of systematic Climate Change information on impacts and risks, a broader stakeholder consensus is needed on priority Climate Change areas and needed investments.*" (G-EP). The replicator region of Primorje-Gorski Kotar is indeed dealing with multiple effects of CC due to its geographic characteristics, given by the configuration of three different climates, respectively from the island, coastal, and highland areas (D1.2; p. 140). This structure is reflected both in the regional priorities for the adaptation strategy, which includes 10 sectors such as "*water resources, agriculture, forestry, fisheries and aquaculture, biodiversity, energy, tourism, health, spatial planning, and risk management*" (D1.2; p. 142),

Solutions for Climate Resilient Transformation

The discussion of contributions obtained through the framework developed in MountResilience was applied to regional replicators too, involving quadruple helix stakeholders. In that case participants didn't provide specific solutions after a Local Council validation. Below, adaptation strategies based on this feedback are introduced, organized by main topics and linked to the findings from deliverable D1.2.

Discussed area: Risk management and natural disasters

The participants' interest in technological aspects is evident, as the solutions frequently selected from the database included projects and articles focused on decision tools, mobile applications, monitoring systems, and modelling techniques. Within the monitoring category, there were requests for the "*development of a risks database*," "*development of an early-warning system*," and "*geographic information (GI) development in rural areas*" (G-EP). These requests are closely aligned with the challenges faced in Gabrovo, as participants from Primorje-Gorski Kotar also prioritized the INUNDATIO project. Additionally, suggestions such as "*monitoring climate impacts and systematically predicting negative effects (floods and droughts) in the Gorski Kotar area would enable better and more efficient long-term management,*" along with remarks like "*the Gorski Kotar area lacks warning systems*" (G-EP), highlight the difficulties these regions encounter in data collection.

Solution suggested for the implementation	Strengths	Weaknesses and challenges
Robust and reliable forecasting for meteorological and climate services	• *Better deliver tailored predictions* • *Decision-makers more informed* • *More precise and locally defined data* • *Disaster prevention* • *People security and awareness*	• *Initially very expensive and needs continue funds and control* • *Not easy to be managed and implemented* • *Technical reparation is needed* • *Reaching stakeholders may be difficult*

Discussed area: Integrated strategy

Secondly, the exercises highlighted the need to connect various fields to foster better relationships between communities and stakeholders, including the universities of Zagreb and Rijeka, which are essential participants in this process. The previously mentioned technologies can facilitate this connection. Among the suggestions were calls for "*a platform for systematic communication among all relevant stakeholders regarding climate change challenges, which would raise awareness and improve the quality of life in the Gorski Kotar area*". Participants also emphasized that "*stakeholders at the national level, local farmers, and residents must be involved to implement significant changes*" and noted that *"it may be difficult to connect and communicate with private forest owners*" (G-EP). This underscores the challenges, similar to those observed in Lapland and Valais, that are often overlooked. To encapsulate these ideas, one participant suggested: "*an integrated strategy for climate change adaptation that includes data collection, comprehensive interdisciplinary analysis, community involvement, and tailored geographic information (GI) and nature-based solutions (NbS)*" (G-EP).

Solution suggested for the implementation	Strengths	Weaknesses and challenges

Integration of Climate Change adaptation into the work of local authorities **(Connected to Tyrol – same topic)**	• *High impact* • *Provide policy coherence/ awareness* • *Community and decision-maker involvement* • *Holistic approach*	• *Actual system is difficult to be changed* • *Dependent on decision-makers and political will* • *Political, administrative and local barriers* • *Low financial resources*

Discussed area: Nature and agriculture
Turning to environmental issues, participants identified the most relevant exposure areas as forests, pastures, arable lands, and protected natural areas. One interesting request was for a tool to monitor 200 areas, similar to those in Gabrovo. Impacts from landslides and wildfires were rated as having only medium impact. In the exercises, solutions for agriculture and management were categorized as having low implementability and effectiveness. Notably, one participant viewed droughts as a low-impact challenge and wetlands as areas of low exposure. However, as previously noted in D1.2 and the regional background, climate change is expected to lead to a reduction in underground water supplies in Gorski Kotar, lowering groundwater levels and damaging forest ecosystems (Kozlica, Radunović & Kovačić, 2022, p. 9f). Consequently, climate change is likely to pose challenges for agriculture in Gorski Kotar, similar to those faced in Piedmont, where "*the agricultural and horticultural sectors need to increase water availability and strengthen the resilience of the landscape to adapt to the effects of climate change, including heat, drought, and flooding*" (G-EP).

Solution suggested for the implementation	**Strengths**	**Weaknesses and challenges**
Landscape adaptation in marginal mid-mountain areas	• *Sustainable agriculture practices boost* • *Motivated new stake holders* • *Environmental protection* • *Biodiversity prevention* • *Soil erosion mitigation* • *Carbon sequestration*	• *Convincing current farmers to adapt* • *National-level policy-makers involvement is challenging* • *Long term resources/investments* • *Unpredictable and long-time effects*
Integrated tools for sustainable management of Protected Areas and Natura 2000 sites	• *Participatory planning* • *Biodiversity and ecosystem health conservation* • *Clear procedures* • *Eco-tourism and farming opportunities*	• *High costs for rural areas* • *Difficulty in developing new monitoring and management systems* • *Limited effects* • *Risk of maladaptation on natural habitats* • *Maintenance and control by experts*

Discussed area: Fishing
The most significant risks identified in Primorje-Gorski Kotar include biodiversity loss, damage to infrastructure and settlements, and vegetation degradation. Habitat degradation is also a concern; for instance, "*the expected rise in the temperature of the Adriatic Sea by 1.4-2.2°C by 2070 is likely to have a significant impact on aquaculture, leading to a reduction or even disappearance of native fish species and an increase in invasive*

species" (D1.2; p. 139). This situation connects the region to similar challenges faced in Lapland. However, no specific cases emerged during the exercises or from the database research, aside from the identification of river basins as high-impact exposure areas.

Solution suggested for the implementation	Strengths	Weaknesses and challenges
River re-naturalization and fish management **(Connected to Lapland – same topic)**	• *Preserve traditional livelihood* • *Biodiversity improvement* • *Support native fish population* • *River quality* • *Protected habitat*	• *Intensive initial cost and labour* • *Resistance from industries* • *Less evident effects for the population* • *Changing river status may be difficult due to channelling or pollution*

Discussed problem: Depopulation

Finally, participants' impressions included thematic related to the population livelihood and health, such as the following one: "*the main challenge in the area of Gorski Kotar is to enhance the quality of life by implementation of Climate Change measures/activities*" (G-EP). Participants' statements refer more to general concepts, such as population, natural environment, quality of life, and infrastructure (all indicated as high-impact areas), rather than, for examples, mountains or sea specific aspects. Among all, the issue of "*depopulation and demographic changes due to a progressive ageing of the local population along with a deep lack and inadequacy of the territorial development policies*" (G-EP), which is shared with Râu Sadului and partially with Piedmont. For this reason, it was indicated as probably working solutions for rural communities "*Small scale NbS*" (G-EP). Implement sustainable tourism and the territorial management could be an effective way to prevent depopulation in rural areas, where the local policies were inefficient.

Solution suggested for the implementation	Strengths	Weaknesses and challenges
New territorial governance tools for sustainable tourism pilot projects	• *Counteract depopulation and poverty* • *Promote eco-friendly tourism* • *Highlights the wealth of natural, cultural-historical and local craft* • *Develops an economic engine for rural areas* • *Increased competitiveness & attractiveness.*	• *Rural areas disadvantaged in terms of competitiveness* • *Progressive and long changes* • *Population resistance* • *Requires a structured coordination*

PRIMORJE-GORSKI KOTAR - SUGGESTED CLIMATE RESILIENCE ADAPTATION STRATEGY

A strategy tailored to the Gorski Kotar region should begin by addressing risk management, conserving natural ecosystems, and tackling rural depopulation, where access to services and jobs is more challenging (Primorje-Gorski Kotar County, 2021). This can be achieved through integrated community-focused approaches to revitalize

these areas. Regional discussions have highlighted the pressing need to address climate-related hazards such as extreme weather events and landslides (D1.3, Annex, Primorje-Gorski Kotar).

The recommended starting point is to develop a real-time early warning system for flood and landslide risks (using remote sensing technology, as suggested in Valais) combined with public information and evacuation plans, as well as the creation of dedicated database systems. Once vulnerable areas are identified, environmental management should include reforestation plans, slope stabilisation, erosion control measures, and green infrastructures such as water retention areas, river re-naturalisation, and buffer zones. Land maintenance activities, including terraces and controlled grazing, are also essential. Protecting biodiversity and maintaining soil health are crucial, and the region should increase protected area management (D1.3, Regional replicators adaptations strategies, Primorje-Gorski Kotar) along with sustainable forestry and regenerative agriculture, particularly in areas prone to degradation (such as in the Regional Demonstrator of Râu Sadului). To decrease depopulation phenomena, it is advisable to promote agri-tourism and eco-tourism, including the use of predictive technologies for weather forecasting and extreme weather conditions (Croatian Ministry of Environment and Energy, 2017) and the development of remote work and connectivity initiatives. There is a strong consensus on the importance of creating decision-making procedures and establishing effective collaboration among various stakeholders and decision-makers.

Engaging governmental representatives, such as regional development agencies like Prigoda (OECD, 2024) and municipal planning authorities, and forestry/protection/housing departments for permits and projects is essential. Additionally, NGOs, research institutions, civil protection agencies, tourism operators, and local communities are key stakeholders to involve in preserving and disseminating results. To achieve these objectives, accessing European funding is recommended: the EU Cohesion Fund, European Union Solidarity Fund, and Horizon Europe for monitoring efforts; the EU LIFE Programme, European Regional Development Fund, and the European Agricultural Fund for Rural Development for nature restoration and agricultural projects; and incentives for residents (e.g., grants, tax breaks, and housing subsidies) to encourage the population to stay in mountain areas

Implementing this strategy will strengthen the region’s climate resilience, mitigate risks, and create sustainable economic opportunities, while preserving the region's biodiversity. Success in these mountainous areas could serve as a model for rural resilience. But for a complete strategy also the relation of mountains with coastal areas (Višnja, 2019) should be taken in account.

3.4. SUBCARPATHIAN REGION FACTSHEET

3.4.1. Regional Baseline and Impact Chain

Geography, evidence of climate change (mainly temperature and rainfall changes), and the associated risks and hazards are key factors that can strongly shape people's views on climate change and their adaptation priorities. This is also evident from the Impact Chains resulting from the first workshop (Innsbruck, 2024). This chapter was used as a basis for regional partners' participants to the Factsheet exercises, to underline main regional aspects and CC problems in their territory.

REGIONAL BACKGROUND

Geography

Podkarpackie (Subcarpathian region) is a region in the south-eastern corner of Poland, at the eastern border of the EU, in the north-eastern outer part of the Carpathian Mountains, with an area of 17,846 Km² and a population of around 2.1 M people. Poskarpackie shares a border with Ukraine (east) and with Slovakia (south). Mountains consist of 46% of the total area, with 70 out of the 160 region's municipalities and 36% of the total population. The regional capital, Rzeszów, applies to host the Permanent Secretariat of the European Carpathian Convention (D1.2, p. 143).

Economy

Podkarpackie region has some key sectors, like aerospace industry, automotive, machinery and metalworking, but the economy in the mountain regions is based mostly on tourism, sports, leisure, agriculture and farming. Tourism activities include hiking, trekking, wildlife experiences, skiing and others winter sports, but also visits to historical sites. In agriculture, crops, fruits and vegetables are common cultivars and activities uses new precision techniques. Farming, in particular sheep for mountain areas, is oriented to meat and cheese products (Podkarpackiego, n.d.; D1.2, p.144).

Temperatures

The Podkarpackie Region experiences a temperate continental climate, characterized by hot summers and cold winters: In extreme winter conditions the temperatures in the mountainous areas can drop below -10°C, instead summer temperatures in plains and urban areas can occasionally exceed 30°C; average temperature ranges are 14 to27°C in summer and -5° to +3°C in winter. The temperature increase in the Carpathians is evident: according to recent studies, the region will experience an increase of about to 3.0-4.5˚C during this century (UNEP).

Precipitations

The region receives from moderate rainfall, with annual precipitation averaging around 700-1,000 mm. In the mountainous areas the range is forecast to increase to 1,000-1,300 mm, with significant precipitation concentrated in spring and summer, that includes snowfall in winter (Karpaty.info). Climate change forecasts indicate a more irregular and heavier rainfall, with more frequent drought periods (UN Environment Programme, n.d.) in the summer (as well as an increased water scarcity) and an increase in winter precipitations (changes in snow cover are predicted).

MAIN CLIMATE HAZARDS

Challenges

The most pressing risks related to Climate Change affect the sectors of water, forestry, biodiversity, tourism and agriculture, that is particularly important and vulnerable to climate change (Kundzewicz et al., 2018). The severity and the duration of droughts could increase significantly, due to the combined effect of increased temperature and lower precipitation; that will result in lower river flows and water availability. On the opposite side, heavy rains will lead to an increased risk of floods, erosions, and landslides. Increasing forest fire risk during the last decades, droughts and heatwaves are also driving challenges, linked to the tourism sector, as well as shortened snow seasons and an upward shifting snow line (D1.2, p. 143).

Needs

The protection and preservation of natural environments are regional pillars: Podkarpackie region needs adaptation strategies to prevent hazards (Czekaj, 2020): floods, wildfires, economic and livelihood losses, impaired ecosystem functioning, and loss of species. A diversification of the tourism sector (e.g., ecotourism) is needed when planning tourism strategies, to avoid the dependence on snow cover and to face the shortened snow seasons. Fresh water, virgin forests and grasslands, have a crucial role as hotspots for biodiversity and habitats for large species. Governance and social aspects are also important needs (Rzeszów City Council, 2019).

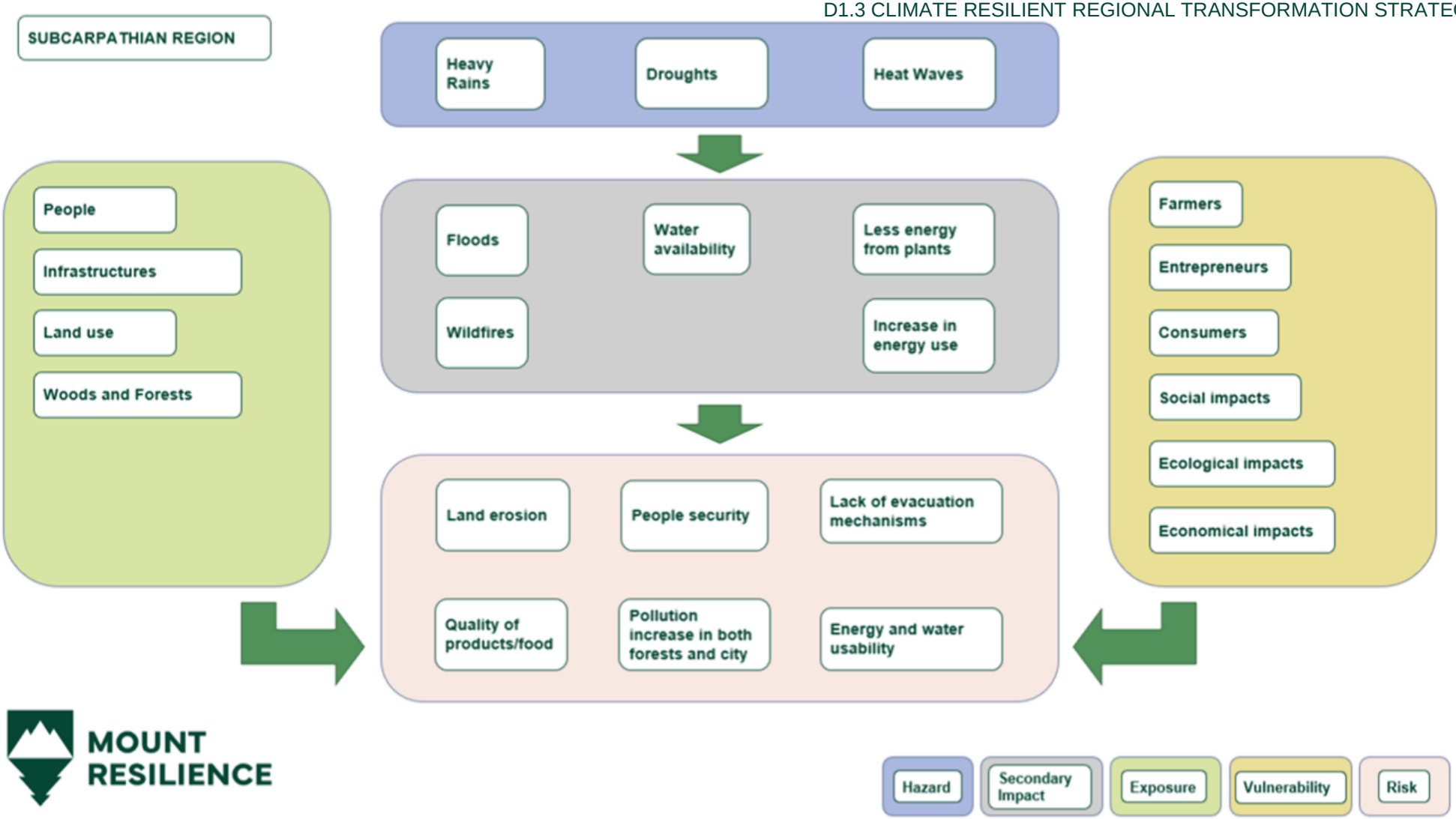


Figure 40. Subcarpathian Region Simplified Impact Chain, based on Innsbruck workshop - (UMIL 2024, based on ZSI, 2024)

3.4.2. Subcarpathian region final considerations

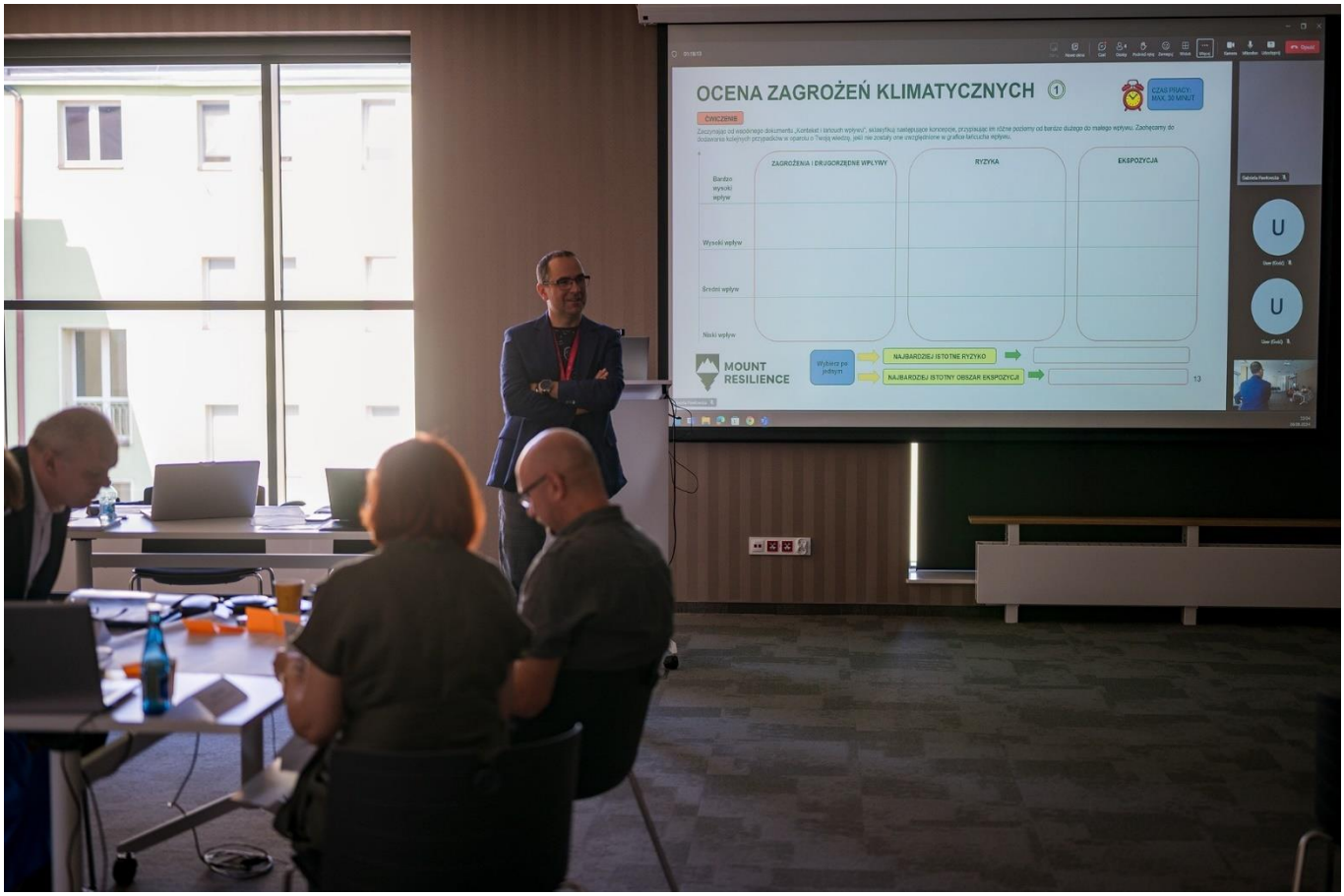


Figure 41. Subcarpathian region meeting organized to work on the exercises (Source: S-EP material)

Subcarpathian replicators generally had no specific comments on the exercises proposed, but main aspects can still be found in the results collected, because the section on articles/projects from the database was well used, choosing information in an orderly manner both from projects and from articles. First of all, the increase in temperatures and the change in meteorological patterns are the factors that have been highlighted as the ones having the greatest impact; this is linked to apprehensions about water scarcity and dangerous natural events, such as fires, floods, and landslides (there considered as high-impact events, unlike in many other regions), phenomena that are connected to damage exposure to infrastructure, to the population (with tourists that are primarily at risk), but also to agriculture.

Solutions for Climate Resilient Transformation

The discussion of contributions obtained through the framework developed in MountResilience was applied to regional replicators too, involving quadruple helix stakeholders. In that case participants didn't provide specific solutions after a Local Council validation. Below, adaptation strategies based on this feedback are introduced, organized by main topics and linked to the findings from deliverable D1.2.

Discussed area: Agriculture and City

Since agriculture employs the largest number of skilled workers in Poland, both in absolute and relative terms, this sector is particularly important from an economic standpoint. However, it is also highly vulnerable to climate change (Kundzewicz et al., 2018, p. 1516f). Perhaps for this reason, the challenges most frequently identified in the exercises relate to agricultural support, which is connected to various issues such as mountain abandonment, environmental degradation, and especially water scarcity, the latter being recognized as the greatest risk.

Regarding this aspect, participants explored systems for improving landscapes, including agricultural practices (as seen in Râu Sadului and Piedmont), as well as urban greenery (Gabrovo). In relation to urban issues, they specifically highlighted nature-based solutions, such as the implementation of small water retention areas, as the most feasible and effective measures. They emphasized the need for "*retention systems*" (S-EP) and "*retention of rainwater in the soil*" (S-EP) as essential strategies for climate change adaptation.

Solution suggested for the implementation	Strengths	Weaknesses and challenges
Innovation in crops irrigations techniques **(Connected to Piedmont – same topic)**	• *Less water usage* • *Less pollution from fertilizers* • *Improved crops quality and resistance* • *Soil preservation* • *Can be easily integrated with other solutions*	• *Long times to be adopted and accepted by farmers* • *Initial investment and more maintenances* • *Bad management can cause soil degradation* • *Not applicable to all crops (e.g., rice)*
Increase green roofs and green areas **(Connected to Gabrovo – same topic)**	• *Urban heat island effect mitigation* • *Decreasing health risk for old people and workers* • *Cooling effects; less energy use* • *Runoff control* • *Better air quality*	• *Needs a high initial investment* • *Builders may have interest in creating green areas* • *Public may prefer parking areas* • *Not all buildings can support green roofs* • *Long-term planning, management and maintenance*

Discussed area: Nature

The previous considerations are linked to the land use data, which indicate that "*54.0% of the region is agricultural land, 39.0% is forested or covered by wooded and shrub areas, and 5.0% is developed or urbanized land*" (D1.2; p. 143). This land distribution certainly influences adaptation priorities, primarily concerning the agricultural sector, but also affecting natural environments. Although issues related to forests and biodiversity may not be perceived as significant—possibly due to the region's characteristics, such as the fact that "*the Carpathians are the second-largest mountain range in Europe and serve as one of the most important forests in terms of biodiversity*" (D1.2;

p. 143)—there is still a sense of risk. This perception is evident in the database search for monitoring systems, similar to findings in Valais and Gabrovo.

Solution suggested for the implementation	Strengths	Weaknesses and challenges
Early monitoring warning system for floods and fires **(Connected to Gabrovo – same topic)**	• *Preventing loss of life and infrastructures damages* • *Faster response to emergency* • *Community information and sense of security*	• *Setup and operational costs* • *Municipality resources and operators are needed* • *Need for an appropriate management, with maintenance, and updates*

SUBCARPATHIAN REGION - SUGGESTED CLIMATE RESILIENCE ADAPTATION STRATEGY

An effective strategy for Subcarpathian Region, where water scarcity issues are not yet central, should focus on enhancing green infrastructure and agriculture, along with creating an alert system for extreme events (floods, landslides, and fires) with the aim to safeguard the local population and improve data-driven decision-making systems.

Starting with environmental aspects, a combined approach for agriculture and public green space management is recommended: green infrastructures (parks, permeable parking lots, trees, shadowing green spaces) should be included to mitigate floods, heatwaves, and preserve urban biodiversity; natural retention areas (wetlands, riparian buffers, retention areas) and blue infrastructures in peri-urban and agricultural lands should be considered too as local solutions to increase resilience. Both these objectives require efficient water and energy usage systems, similar to those suggested for Gabrovo. For agriculture, it is recommended to implement soil stabilization practices, such as traditional techniques, crop rotation, and terracing, and to improve water management in water-stressed areas by promoting agroforestry systems (Werners S. et al., 2014). Cooperative networks focused on drought-resistant and local/traditional crop varieties, sustainable methods, and regenerative farming practices can also support effective soil and water management. At the management level, it's suggested to adopt an integrated system of sensors and remote sensing technologies, to gather real-time information on temperature, precipitation, and soil moisture. Data sharing and warning systems will also help communities take proactive actions in case of extreme weather events. Monitoring systems can further be used to identify early signs of environmental degradation, aiding in biodiversity preservation efforts (Polish Ministry of the Environment, 2023; D1.3, Annex, Subcarpathian region).

A task force to work on these objectives should involve the three levels of Subcarpathian governance (D1.2, p.145), environmental agencies, agricultural cooperatives and farmers, local universities, NGOs, planning authorities, research institutions, and citizens with information mechanisms in place; a participatory governance is recommended (De Bortoli, 2024). To support these initiatives, various funds are available: EU LIFE Programme, Horizon Europe, national and regional funds for data infrastructure and technology implementation, the European Agricultural Fund for Rural Development, and Public-Private Partnerships (PPPs) for sustainable agriculture and green infrastructure development. Participation in initiatives such as the Carpathian Convention (Carpathian

convention, n.d.) can assist in securing diverse funding sources and stakeholder involvement (Socio-economic analysis of the Carpathian area, 2007).

Creating an accessible online platform for sharing data with stakeholders will enable informed decision-making in agriculture, urban planning, and conservation. By implementing this adaptation strategy, the Subcarpathian region can strengthen climate resilience across green infrastructure, agriculture, and monitoring, promoting proactive, data-informed adaptation measures to enhance public safety (Carpathian convention, n.d.).

4. Considerations on the regional Factsheets and strategies for climate adaptation

The core of the work conducted during the validation process, built around the exercises completed by participants from various regions, led to the collection of insights, data, suggestions, and ideas related to CC adaptation. The exercises not only helped participants to understand the challenges related to Climate Change and the possibilities for adaptation but allowed them to identify the most useful solutions for their regions and to reach ideas for implementing them, as outlined in the previous chapter. This section presents some cross-cutting considerations related to the previous outputs, both those preceding the transmitted results (in the first section) and those derived from the analysis of the responses provided with the collected material.

4.1.1. Final outputs

After the interactions with the Local Councils Coordinators (named exercise leaders in some cases), who were in charge to deliver, collect and resume the results, and to organize the validation councils, it was possible to identify the following failure factors, as already noticed in D1.2 interviews and workshops (D1.2; p.155):

- *Tight timelines;*
- *Language barriers;*
- *Technical-scientific topics;*
- *Stakeholder engagement.*

TIGHT TIMELINES:

Early outputs: it may seem obvious, but the first key finding to be underlined for anyone undertaking a similar validation process in the future is that there is no single method that will be universally accepted to achieve the desired results within the correct timelines and processes. In fact, all the Local Councils Coordinators approached the validation process differently: some mostly via email, others in person, some through individual meetings, and others with minimal contact, with significant variations even in the originally defined timelines.
To accommodate regional partners and to allow the process to take place during the summer months (due to the project's timeline), considering that physical attendance at a workshop might not be feasible for everyone, the exercise was designed as a "personal exercise", that could be done at home before the Local Council. The exercises were simplified to require about two hours of work, with examples, instructions and additional material, to permit to everyone the correct compilation before the validation process in the already planned Local Council. Despite this, timelines were extended until the final deadline, and despite various individual meetings with the Local Councils Coordinators and regional partners, many of the results were not submitted as indicated.

Final outputs: one of the most common complaints from participants was the unrealistic timeframes set for the exercises. Many comments were like "*the estimated time for each exercise is far too short*" (P-LCL) and in particularly that the "*time envisaged for exercise 2 is too short*" (P-PGL). This led to difficulties in completing tasks thoroughly, with some participants choosing to focus on only a few aspects of the exercises, and that can lower the sensitivity of data acquired. Exercises of the sort are challenging, for the time commitment required for working people: one

participant noted "*when I saw that it would take 2 hours to complete, I didn't even start. This is too much to ask*" (L-EP). It's clear that more flexible timelines and better guidance on the tasks would improve participation and outcomes.

LANGUAGE BARRIER:

Early outputs: in terms of coordination, the most challenging factor for participants seen by Local Council Coordinators in the organization phase was certainly the English language. Despite being a European project, many participants struggled with the language. While this might be expected in remote areas of Lapland, for example for Sami stakeholders, where *"Some issues in Local Councils because they can't speak in English and they do them apart"* (L-LCL), it also occurred in regions like Piedmont and Gabrovo, where the time to dedicate to the translation was a factor: "*We don't have time to translate the Factsheets and the only thing what is possible is to summarize them in English*" (G-LCL).
Fortunately, in many cases the issue was resolved as suggested, as in Finland " *Validation exercises translated in Finnish, sent translated to everyone to do them at home*" which was indeed the recommended procedure during preparation meetings and was adopted by several participants. But language is indeed a factor to be considered.

Final outputs: as already seen in early outputs, the English language also posed a significant challenge. Some participants highlighted difficulties in understanding the materials due to insufficient English proficiency: one participant expressed frustration, saying, "*I don't understand English well enough to complete it. It's frustrating because the work is surely important, and this could have been an opportunity to make an impact*" (L-EP). This issue points to the need for translation tools or a dedicated intermediary to ensure that language barriers do not hinder participation. However, it's important to note that using technology (like instant translation using app or pc programmes) to address this may not be feasible in some rural areas where access is limited, further complicating the inclusivity of such projects.

TECHNICAL-SCIENTIFIC TOPICS:

Early outputs: the third challenge was the complexity of the topics addressed. Climate Change adaptation strategies, and particularly the requirement to search solutions in a database and propose implementation methods (even if guided by the exercise), were certainly difficult for most participants, who typically are not involved in scientific articles, projects, or use technical terms. *"Exercises are complicated"* (G-LCL) is one of the most used definitions of the work proposed before their execution.
"For us, it's difficult to identify sources. We will do it for them… there is no time to see what is the result that refers to the database, is impossible either for us… We didn't go through these databases deeply so. This is the part we're missing," (P-LCL), was one of the explanations related to the regional replicators (exercise 2) and stakeholders (exercise 2A) missing answers, and this confirm the necessity to transpose this information to a User-friendly tool, ad indicated in the Task.

Final outputs: the technical aspects of the project faced criticism principally regarding the database and the clarity of the information provided. For instance, Local Council members expressed concerns about the approach and found that many of the articles "*provide information rather than actionable solutions*" (T-LCL). Moreover, the ability to assess the implementability of solutions was questioned, with some participants noting that the descriptions were insufficient for making informed decisions. One particularly important issue raised was the difficulty in estimating the costs of larger nature-based solutions projects at this stage (P-LCL). Furthermore, the volume and complexity of the

information provided were overwhelming for some, as expressed by participants who struggled with tasks that were deemed "*too difficult, lengthy, and confusing*" (L-EP). For example, many participants decided to use the database only as inspiration, giving their own solution. This feedback emphasizes the need for more straightforward and user-friendly scientific content to facilitate informed decision-making.

STAKEHOLDER ENGAGEMENT:

Early outputs: the final challenge concerns the process of stakeholders' engagement, which is always complex (as seen in D1.1 engagement processes). This is true not only for the reasons mentioned earlier, but also due to the data that were requested: *"We should also provide now opportunities and prospects. I underline this because it's really a way to engage much better with the people"* (V-LCL). The suggestion emphasized that it's not discussing the challenges that draws people in but offering them concrete implementation opportunities. Participants' works recognition is also important: *"for us it's important to make people feel important. Make them feel aware of what is going on"* (P-LCL). Finally, due to the methodology, problems related to software or technical aspects were not relevant.

Final outputs: stakeholder engagement received mixed feedback. Many participants appreciated the effort, noting the exercises were beneficial for collaboration and praising the work put into the project. However, concerns were raised about the relevance of the international examples, especially by those from regional contexts, who found it hard to relate. One participant mentioned that many projects were from other countries, making it difficult to connect with local needs. Additionally, some stakeholders struggled with time constraints due to heavy workloads. Despite these challenges, others completed the exercises with enthusiasm and found value in the process.

EXERCISE STRUCTURE:

the structure of the exercises was another area of concern. Many found the method to be challenging, particularly due to the PowerPoint format, which was deemed cumbersome, and the database in Excel. For this reason, for some participants "*the optimal solution was not based on the aggregate score but rather on the expert's opinion.*" (R-LCL) and "*filling out tables and working within that format proved to be inefficient*" (T-LCL). There were suggestions for a more bottom-up approach, allowing stakeholders to develop a method more aligned with their specific contexts, and this is due partially to the structure of RAST tool and TranformAr manual. Moreover, the necessity of some tasks was questioned, with participants unsure of how they contributed to their broader goals: many didn't see the necessity of exercises 2 and 3, or found them unclear, complex and hard (S-PGL; T-LCL). Despite these challenges, there was a recognition of the need to keep the exercise framework aligned with the original plan to maintain coherence across the consortium.

4.1.2. Additional notes

Some positive aspects were identified during the preliminary phase. Generally, many partners have shown interest in defining the exercises, trying to understand correctly the work that must be done and emphasizing the importance to find results useful for their regional projects. In particular, regional replicators were asked to be involved in this working phase (P-PGL) even if according to the project structure they were not supposed to be deeply involved in this task. However, form a first analysis this involvement process has been important to better understand their

priorities and to help future MountResilience tasks that will focus on the replication and uptake of the implemented solutions.

Regarding the overall process implemented to develop the regional factsheets and strategies, even if it was underlined in several cases that the exercises were not so easy, the overall process was deemed as interesting: "*if it's very difficult it's because is a different approach to what we do with our normal tasks. But just to show you that we had some very good surprises and interesting surprises"* (V-LCL) and *"the exercise was very difficult for the stakeholders, but we had very good representation"* (T-LCL) and finally *"We found the exercise to be beneficial for our joint efforts while reflecting upon possible solutions for PGKC replicator area"* (P-PGL). This last comment shows that sending the exercises folder also to replicators, even if initially not foreseen in the project phase, is certainly recommended for future projects organized in a similar manner.

Concerning the underlined technical difficulties of the exercises, there have also been cases where the issue was handled coherently, as in the case of Tyrol, where they produced *"Questionnaire for the Local Councils to fill, which was a little bit easier than the PowerPoint task*" (T-LCL). This was done to make it more operationally intuitive and understandable for people who worked from home; the organizers then took care of entering the collected responses into the Factsheet structure.

4.1.3. Concluding considerations on the validation process

The whole validation process involved numerous stakeholders and project partners, belonging to the quadruple helix, between the six demonstrator regions and the four replication regions. The participants involved in the process among all regions were as follows: 65 from project partners' institutions, 80 from the local councils' stakeholders (Figure 42).

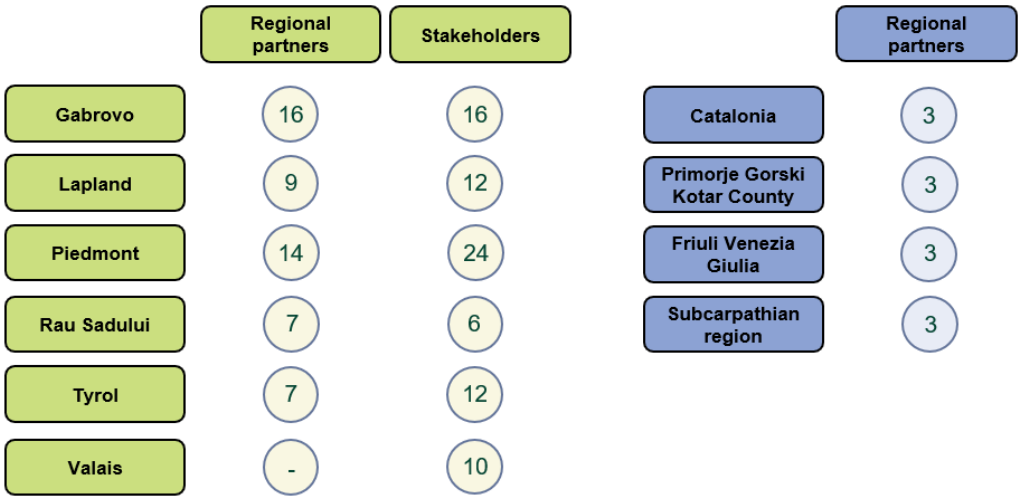


Figure 42. List of partners and stakeholders that participated at the factsheet's exercises (UMIL, 2024)

The outputs obtained from this validation phase by regional demonstrators, replicators, and stakeholders are presented below. The outputs focus mainly on the strengths and weaknesses of the tools (and subsequent exercises) used for gathering information, divided by topic.

In conclusion, the exercises used in the validation process, which led to the creation of the Factsheets, proved effective, though they also revealed areas for improvement.

One major challenge was the language barrier, highlighting the need for translation and communication tools. However, this is especially difficult in rural areas with limited access to technology, where the involvement of these communities is often crucial. An intermediary figure to manage translation and one-on-one communication with participants, as seen in this project, would be essential. Additionally, participants emphasized the importance of a user-friendly online tool to simplify the selection of solutions from the database, which will be critical for future projects and replicators.

Collecting information on Nature-based Solutions (NbS) was vital for the project deliverable. Participants contributed by helping identify and select these solutions, forming the project's foundation. While some criticized the exercises for their complexity, particularly regarding scientific content, they were generally completed and provided valuable information. Flexibility in completing the exercises at home was helpful for many, though it also posed challenges, such as hindering discussions within Local Councils. Although feedback from Local Councils was limited, their role in validating this highly technical information, especially when workshops were not used, was crucial.

A key contradiction remains for future work: the exercises need more time to account for the schedules of Local Councils and to allow thorough responses but reducing the amount of information required isn't a viable option. Breaking down the exercises into smaller topics could help, but this risks overwhelming stakeholders, who want to be involved without being overburdened, as this could lead to disengagement. Balancing thoroughness with stakeholder involvement remains a significant challenge. Nevertheless, with proper organization and management by regional representatives and Local Councils, stakeholder participation was secured, and the time required for the exercises was not an insurmountable issue.

4.1.4. Concluding considerations on the regional strategies

The definition of regional strategies highlighted a fundamental aspect of the MountResilience project. Namely, that opportunities offered by climate change solutions and climate resilience adaptation strategies can be shared among various regions facing similar challenges, even if these regions may appear quite different. The main shared aspects can reasonably be simplified and outlined as shown in the following figure (Figure 43):

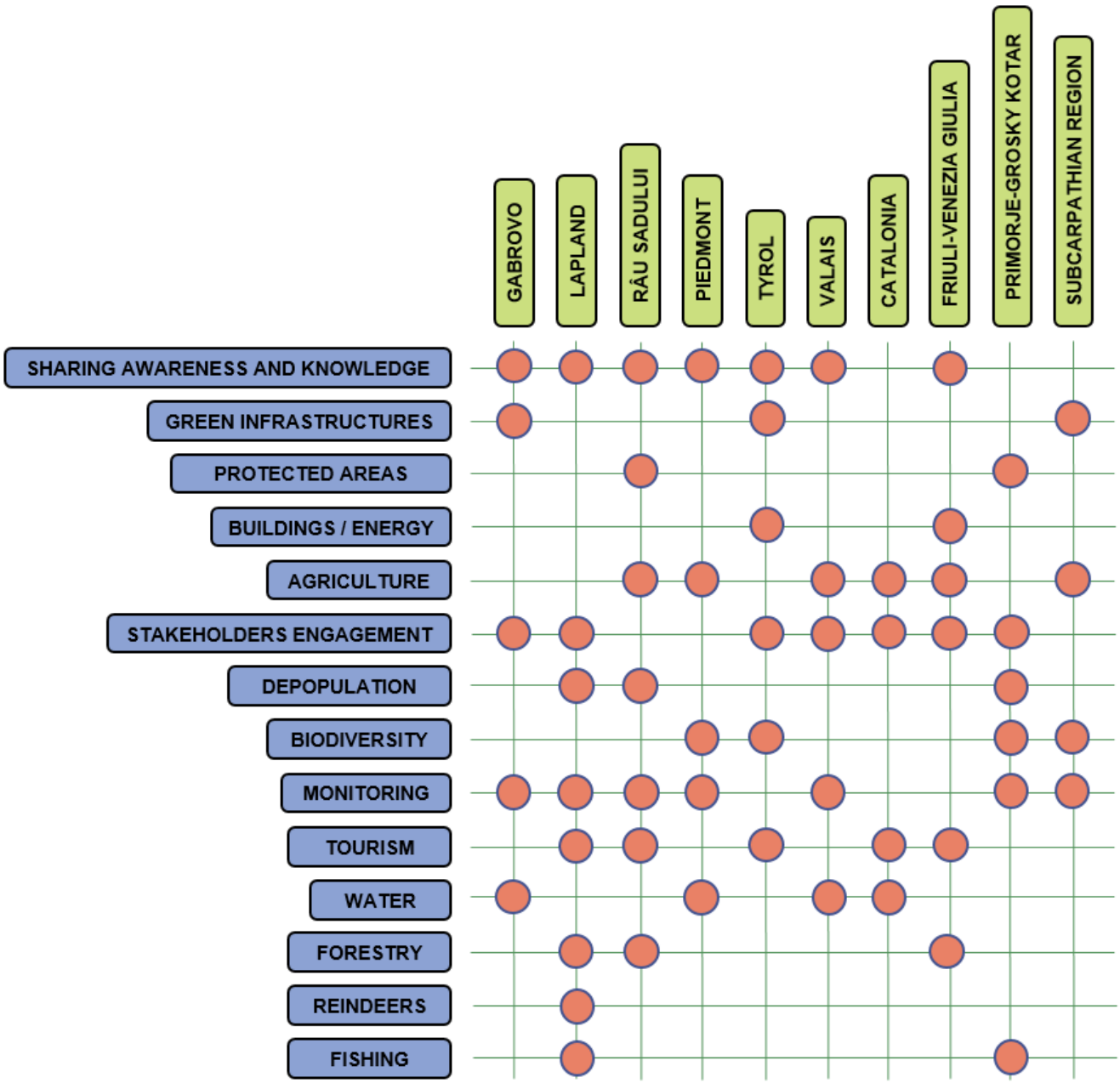


Figure 43. Key discussion areas with proposed solutions, divided by region (UMIL, 2024)

Based on these aspects, already identified in the respective climate resilience adaptation strategies (D1.3, Regional demonstrators adaptations strategies; D1.3 Regional replicators adaptations strategies), the following interconnections between regions can be considered as useful for a collaboration based on similar challenges, with the opportunity to build bilateral meetings to share knowledge, information, practices and projects across each region.

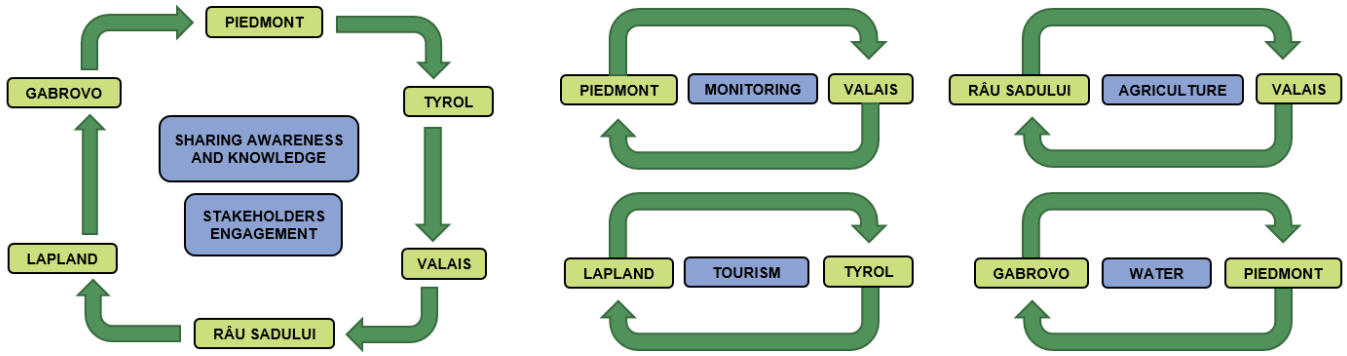


Figure 44. Suggested collaborations and meeting for information sharing (UMIL, 2024)

Finally, with attention to the activities that will be carried out by the regional replicators, we suggest that they approach the planning of their respective projects by considering the opportunities provided by regional demonstrators who share with them specific areas of challenges and solutions related to climate change, as indicated below.

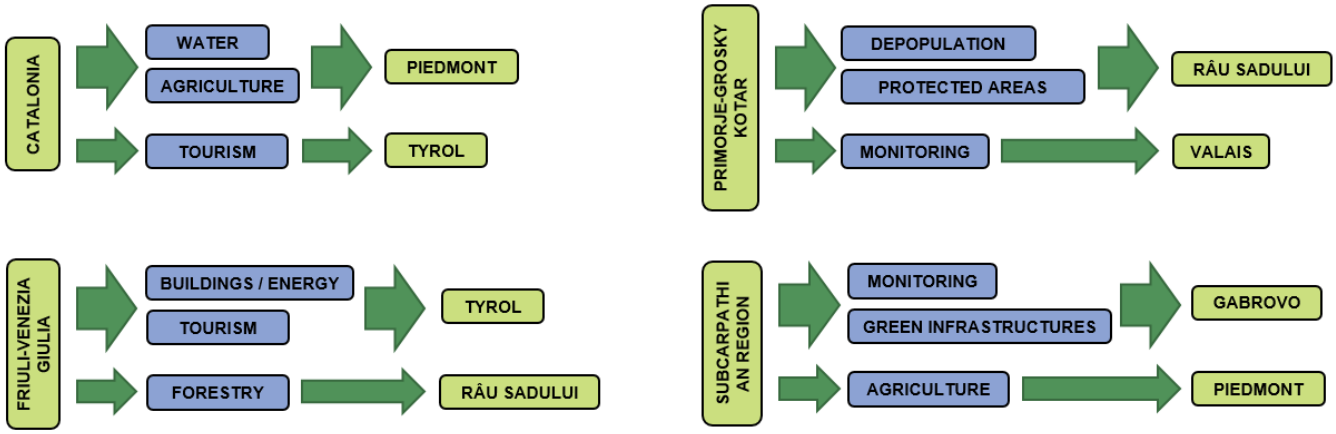


Figure 45. Suggested key areas on which reg. replicators should focus on for the replication process (UMIL, 2024)

In conclusion, the suggested climate change adaptation strategies for the 6 regional demonstrators and the 4 regional replicators highlights how a collaborative approach, based on similar characteristics, can be critical for achieving stronger resilience in a coherent and informed way. These regions, while diverse in their specific culture, geography, societal and economical features, share similar issues intensified by climate change (as shown in previous figure 43). The strategies developed for each of them aim to respond to these phenomena promoting actions specific to each region, but they can also be readily adopted by other European regions according to their specific needs.

Collaboration between stakeholders represent a cornerstone of knowledge exchange, experience-sharing, and the development of practical solutions among the various regions, offering a mutual support system that transcends national borders. This approach not only increases the efficiency of CC responses, due to their implementation and testing in diverse contexts, but also fosters European cohesion, uniting regions into an interconnected resilience network. Through this, regions will be better prepared to address the shared climate challenges.

5. Annex

5.1. Conceptual understanding

5.1.1. Important terms from D1.1 and D1.2

In the following section are listed some important definitions related to D1.1 and D1.2 deliverables, that were the base for the conceptual work done in D1.3.

Nature-based Solutions (NbS)

Nature-based solutions (NbS) are actions to protect, sustainably manage and restore natural and modified ecosystems in ways that address societal challenges effectively and adaptively, to provide both human well-being and biodiversity benefits (IUCN, 2016). NbS are built on local, specific challenges and embed nature conservation practices with positive implications for social wellbeing, safety, and economic development. NbS are grounded on ecosystem approaches, ecosystem protection and restoration, sustainable land management, green infrastructure, and issue-specific approaches (e.g., disaster risk reduction, ecosystem-based adaptation) (Box 1) (EEA, 2021). NbS are increasingly considered in climate-related policies. For instance, in the context of the Paris Agreement, more than 60% of Nationally Determined Contributions (NDCs) include planned nature-based adaptation actions, of which half provide measurable targets, most of them focused on forests (Seddon et al., 2021, 2020). On the EU level, several recent strategies explicitly refer to NbS, such as e.g., the EU Green Deal, the EU Biodiversity Strategy to 2030, the Farm to Fork strategy and the EU adaptation strategy

Socio-Technical-Ecological Systems (STES)

A Socio-Technical-Ecological Systems (STES) framework is an approach that integrates social, technical, and ecological dimensions to understand complex systems (McPhearson et al., 2022; Ollivier et al., 2018). The STES approach recognizes that human societies are deeply intertwined with technological systems and natural environments, and interactions among these dimensions shape the functioning and resilience of entire systems. STES frameworks aim to elucidate the interdependencies, feedback loops, and dynamics between social, technical, and ecological components within a given context. By considering these interactions holistically, STES frameworks provide valuable insights into how changes in one aspect of the system can ripple through and impact other components, thus offering a comprehensive understanding of complex socio-technical-ecological phenomena.

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., damage caused by an increase in the frequency of coastal flooding due to sea level rise).

Adaptation

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, behavioral 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 behavioral change targeting measures (Leitner et al., 2020).

Adaptive 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 et al., 2020). Adaptive capacity is one of the key objectives of the project and describes a wide spectrum of locally available competences, skills and assets that can be deemed relevant for properly addressing systemic issues to adjust to and prevent potential damages stemming from climate change.
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.

Climate change adaptation

Adaptation refers to adjustments in ecological, social or economic systems in response to actual or expected climatic stimuli and their effects. It refers to changes in processes, practices and structures to moderate potential damages or to benefit from opportunities associated with climate change (UNFCCC definition)

Transformative adaptation

Transformative Adaptation has emerged to underline how adaptation measures to protect communities against climate impacts can be developed in a long-lasting, transformative manner by addressing the root causes of vulnerabilities and enabling radical change in interconnected Socio-Technical-Ecological systems. It expands the practice of Climate Adaptation with the concept of transformation implying that adaptation measures can be a tool to leverage fundamental change of a (regional) system that is not fit to withstand the accelerating social and ecological risk of climate change - in other words it is a tool for ensuring climate resilient mountain regions. 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. 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.

Risks

Drawing from the IPCC's 6th Assessment Report, risk is defined as the potential for adverse consequences for human or ecological systems, acknowledging the diversity of values associated with such systems. Relevant adverse consequences can be understood as "*those on lives, livelihoods, health and wellbeing, economic, social and cultural assets and investments, infrastructure, services (including ecosystem services), ecosystems and species*". (Reisinger et al., 2020, p. 4). Risk is a composite variable comprising three key components: Hazards, Exposure and Vulnerability.

Key risks are a tool further used in practice by looking at climate impact chains. Key risks emphasize the severe adverse consequences for humans within socio-technological-ecological systems resulting from the interaction of climate-related hazards with vulnerabilities of exposed systems. Unlike traditional risk frameworks, system risks consider the systemic nature of climate impacts, spanning multiple sectors and spatial scales. They highlight the interconnectedness of socioeconomic and environmental factors, underscoring the need for holistic risk assessment approaches (Field et al., 2014).

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 of 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).

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 and Adaptive Capacity

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 houses that are built in a way that will be severely damaged by the flooding are vulnerable to it.

Impact Chain (IC)

Impact chains 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., 2024) and has since been used in a variety of vulnerability assessments and adaptation planning (Buth et al., 2015; Menk et al., 2023). The choice of each system risk was based on the local circumstances, considering the focus of each demonstrator activity. For the identification of the risks, it was used the method of climate impact chains, which is an ongoing, iterative, and co-creative process in close exchange with experts and practitioners of the demonstrator regions.
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).
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.

Ecosystem services (ES)

Ecosystem services can be described as the tangible and intangible benefits that ecosystems provide to humans, including essential goods such as food, freshwater, and timber, as well as recreation or spiritual meaning. In addition, they also comprise goods and services key to guarantee people’s health, safety, and potentially bare survival and reproduction of ecosystems, including humans living within them.
Mountainous regions, encompassing diverse geographic, topographic, and ecological systems, are crucial providers of ecosystem services with significant local, regional, and global implications (Adler et al., 2022; Grêt-Regamey et al., 2012; Klein et al., 2019; Knight, 2022). Understanding the interconnectedness of climate risks in these regions, the alteration of ecosystem functions and processes, and the need for transformative adaptation is essential. This interconnectedness forms the basis for evaluating a key aspect concerning the effectiveness of transformative adaptation. By using ecosystem services and their evolution as proxies, the stakeholders involved in transformation

may unveil the effect of the proposed or enacted transformative steps to capture whether and how the implemented measures are promoting long-term adaptation and a sustainable human-nature relationship.

Systemic risk assessment (SRA).

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.
Given the complexity and heterogeneity of the regional dynamics shaping CCA responses, it was followed a mixed-methods research design (Poth, 2023). Regional structural data analysis and systemic risk analysis (SRA) were therefore combined 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.
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, it was employed the method of climate impact chains (IC).

5.1.2. Useful concepts

Brief list of further definitions from Phusicos (2019) that can help to understands the meaning of some solutions and choices reported in the regional Factsheets

Ecosystem approach

A strategy for the integrated management of land, water and living resources that promotes conservation and sustainable use in an equitable way. Application of the ecosystem approach will help to reach a balance of the three objectives of the Convention on Biological Diversity: the conservation of biological diversity, the sustainable use of the components of biological diversity; the fair and equitable sharing of the benefits arising out of the utilization of genetic resources. It is based on the application of appropriate scientific methodologies focused on levels of biological organization which encompass the essential processes, functions and interactions among organisms and their environment. It recognizes that humans, with their cultural diversity, are an integral component of ecosystems (UNEP, 2021).

Ecosystem restoration

The process of halting and reversing degradation, resulting in improved ecosystem services and recovered biodiversity. Ecosystem restoration encompasses a wide continuum of practices, depending on local conditions and societal choice. Depending on objectives, restored ecosystems can follow different trajectories: (1) from degraded natural to more intact natural ecosystems (often by assisting natural regeneration); (2) from degraded, modified ecosystems to more functional modified ecosystems (e.g., restoration of urban areas and farmlands); (3) from modified ecosystems towards more natural ecosystems, providing that the rights and needs of people who depend on that ecosystem are not compromised (UNEP, 2021).

Sustainable land management

The stewardship and use of land resources, including soils, water, animals and plants, to meet changing human needs, while simultaneously ensuring the long-term productive potential of these resources and the maintenance of their environmental functions (IPCC, 2018). Please note that land management refers to specific land use categories, such as e.g., in the context of GHG reporting: cropland, forest land, wetlands, grassland, settlements, other land. There are other land use classification systems, such as e.g., LUCAS (Eurostat ,2006). Smith et al. (2020) provide an overview of the effects of land actions to tackle global challenges, including adaptation.

Green infrastructure

A strategically planned network of natural and semi-natural areas with other environmental features designed and managed to deliver a wide range of ecosystem services. It incorporates green spaces (or blue if aquatic ecosystems are concerned) and other physical features in terrestrial (including coastal) and marine areas. On land, green infrastructure is present in rural and urban settings (European Commission).

Disaster risk reduction

Disaster risk reduction is aimed at preventing new and reducing existing disaster risk and managing residual risk, all of which contribute to strengthening resilience and therefore to the achievement of sustainable development. Annotation: Disaster risk reduction is the policy objective of disaster risk management, and its goals and objectives are defined in disaster risk reduction strategies and plans. (Source: UNNDR Sendai Framework Terminology on Disaster Risk Reduction).

5.2. Guideline for the Factsheets compilation

This chapter includes all the material sent to the participants who was involved in the validation and implementation process for this deliverable of MountResilience, providing a guideline for future works: through the slides here listed stakeholders interested in understanding, choosing and implementing NbS can be engaged, and information about each individual region can be obtained in an efficient way. There was be included: (i) Slides for regional demonstrators' partners, including medium level exercises, (ii) slides for regional demonstrators' stakeholders and regional replicators' partners, including easy level exercises, (iii) the user manual with a provided list of possible solutions for the regional replicator area. All this should help to build a solid basis for future transformative visions.

5.2.1. Regional demonstrators' partners Factsheet

The following images show the slides that were sent to regional demonstrators' referents, to be sent to all partners. These slides include the exercises inspired to the RAST project for the obtainment of all data needed for the Factsheets creation.

Figure 46. Factsheet slides (9 images) - Regional Demonstrator's workshop for project partners (UMIL, 2024)

EXERCISE INTRODUCTION

THE MOUNTRESILIENCE PROJECT:

WHAT? Horizon project in line with EU Mission on Adaptation to Climate Change

WHERE? 10 European regions and communities located in mountainous areas

WHO? 47 partners from 12 different European countries

WHY? Increase regions capacity to adapt to climate change and to transition towards a climate-resilient society

HOW? Through a tailored workshop to produce NbS adaptation strategies

FOR WHO? For regional demonstrators' partners, who have a huge knowledge about the project thematic

WHAT WE WILL USE:

THE RAST TOOL

To proceed with a punctual and understandable definition of a well-tailored adaptation strategy for each regional demonstrator, providing coherent NbS, we must follow a **step by step scheme**. The Regional Adaptation Support Tool (RAST- Climate ADAPT 2024) can be an assistance in the searching and decision-making work, **through 6 guiding steps**, aligned with the key features of climate adaptation policy processes. The following **fact-sheet** takes its form from that, and results will help local and regional authorities with the implementation of climate change adaptation strategies and plans.

TIME NEEDED:

This is the suggested working time. Each step will be controlled by the Exercise Leader or you can take it in account if you are doing this at home. **Total time is about 2 hours.**

MODALITY:

Working steps are made to be executed **by single participant**, but some of them could be easer performed in little groups. If needed your referent will give you appropriate instruction on how to work.

Compilation examples: pages 7-8

RESUME:

EXERCISE 1 → Determining priorities of local stakeholders, evaluating regional background Impact chains.

EXERCISE 2 → Determining already existing solutions, based on a scientific database. Be aware of challenges they can try to solve and related beneficial impacts.

EXERCISE 3 → Evaluating relevant NbS tailored on the regional challenges, including the project suggested solution, through some defined criteria.

EXERCISE 4 → Implementing strategies for the selected NbS. Then hypothesize main aspects, such as costs, times and actors. Finally add information about outcomes, indicators and funding/financing options.

MOUNT RESILIENCE

2

PREPARING THE GROUND FOR ADAPTATION 1

EXERCISE

The first action to be performed is to **define the main characteristics of the region**, such as their geographical structure and economy. This exercise will provide a first information screening.

1) **Read the material** in the attached files and resume them in "Background", "Challenges" and "Needs" columns. Add relevant information not included if you have.

15 min.

BACKGROUND	CHALLENGES	NEEDS

Now, to understand the base for the Regional Demonstrator activities, the Impact Chain (IC) should be analysed.

1) **Select the Exposure** area you think should be considered for your region (if not provided by the Exercise Referent).
2) For that exposure area**, define most important factor from the IC** for each of the following columns and try to **connect them with lines vulnerabilities and risks;** add if not included in the IC.
3) Then, for the risks column, **define the one that you consider as the most important to face** (put an "X" on it).

This procedure will provide an informed basis for the consequent bibliographic research and the implementation of effective transformative adaptation activities, so use results for next exercises.

EXPOSURE AREA →

15 min.

HAZARDS	IMPACTS	RISKS → CHALLENGES	VULNERABILITIES

MOUNT RESILIENCE

SINGLE EXERCISE

WORKING TIME: 30 MINUTES

3

IDENTIFYING ADAPTATION OPTIONS 2

EXERCISE

After the main risks were set, we should find good solutions based on a scientific base (article and EU projects)
1) **Using the article and project database, find and write in the appropriate columns** the related information and add more details if you know them.
2) Then, considering information written, **chose and define a NBS** among them.

SOURCE	MAIN CHALLENGES	SOLUTIONS	EXPECTED IMPACTS	RELEVANT INFORMATION

NBS SUGGESTED →

MOUNT RESILIENCE

SINGLE EXERCISE

WORKING TIME: 30 MINUTES

4

ASSESSING AND SELECTING ADAPTATION OPTIONS 3

EXERCISE

Now, after the research, it's time to select the adaptation options to be implemented.
1) Look to NBS listed and add the suggested NBS from the previous exercise (or another relevant one if already listed).
2) **Give to each NBS criteria a value from 1 (lowest) to 5 (highest)** based on its relevance (look at page 8 if not clear).
3) **Define 3 driving criteria** (put as "X" on them) and then, based also on that, **decide the winning NbS** to be implemented.

	NBS LIST	CRITERIA RELEVANCE										
		Effectiveness	Failure risk	Policy boost	Secondary beneficials	Benefit distributions	Solution Urgency	Realization cost	Maintenance cost	Community acceptability	Level of the changes	Adverse forces/Barriers
1	**Project proposal:** Public Participation Geographic Information Systems (PPGIS) - To collect and share information on climate change, to increase the know-how of reindeer herding and tourism.											
2	**NbS provided:**											
3	**NbS provided:**											
4	**NbS provided:**											
5	**NbS provided:**											
6	**NbS provided:**											
7	**NbS provided:**											
8	**NbS suggested:**											
	WINNING NBS N°											
	DRIVING CRITERIA											

MOUNT RESILIENCE

SINGLE EXERCISE

WORKING TIME: 30 MINUTES

5

IMPLEMENTING ADAPTATION POLICIES AND ACTIONS 4

EXERCISE

Determined the winning NbS, now it's time to develop the implementation strategy, starting from some crucial points:
1) Starting from the Winning NBS **define the roadmap** for the implementation, hypothesizing stages, relative times, costs and actors to be considered. 15 min.
2) Indicate the **outcomes, funding and monitoring aspects** that should be taken into account, evaluating them at the best of your personal knowledge. 15 min.

WINNING NBS N°

IMPLEMENTATION STAGES	SET-UP TIME	PROJECT PHASE	COSTS	MAIN ACTORS

OUTCOMES	
INDICATORS	
FUNDING & FINANCING	

MOUNT RESILIENCE

VISION →

SINGLE EXERCISE

WORKING TIME: 30 MINUTES

6

COMPILATION EXAMPLE

EXERCISE 1

BACKGROUND	CHALLENGES	NEEDS
Climate: In winter, the average temperature does not rise above 0° C and in the summer, the average temperature is between 6° C and 16° C Sami: Traditional practices, like reindeer herding, are carry on by Sami people, with their huge cultural heritage.	Rainfall during winter is becoming increasingly common, producing a layer of ice over the snow that reindeer have difficulty digging through to access food	Stakeholder involvement and communication is needed to create a collaborative climate adaptive plan for Lapland, specifically in the Sami people of the region

EXPOSURE AREA → Reindeer ← It can be given by your referent

HAZARDS	IMPACTS	RISKS → CHALLENGES	VULNERABILITIES
Heatwaves in summer	Heat stress	Traditional herding practice no more convenient	Missing subsides for Sami
Change in snow precipitation	Loss of likens	Higher reindeer mortality	Land use changes

EXERCISE 2

Direct outputs from the activities

Medium or long-term, referring to a societal challenge (social, ecological, technological)

Anything that may affect implementation or desired impacts

SOURCE	MAIN CHALLENGES	SOLUTIONS	EXPECTED IMPACTS	RELEVANT INFORMATION
L2.1.2 - Reindeer husbandry and climate change: Challenges for adaptation	• Pasture loss • Snow-cover changing • Insects	• Seasonal strategies • Adaptation Plans • Technical solutions	• Reindeer health • Knowledge transfer • Better herders loverhoods	Technical solution couldn't be accepted by Herders

NBS SUGGESTED → Reindeer Feeding **OR** Create an app that, based on temperature, weather and location, can suggest how much additional food reindeer should need. ← Note: you can put a simplified NBS or try to be more specific

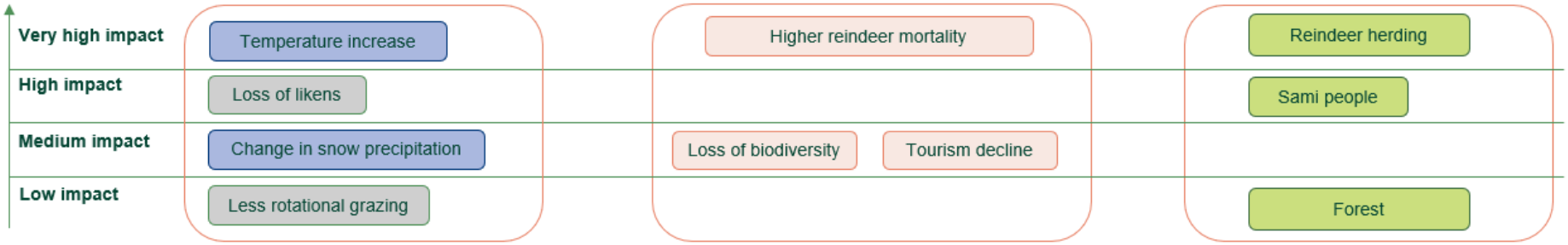
MOUNT RESILIENCE

7

COMPILATION EXAMPLES

NOTE: This is a common example on how exercises should be done. We took Lapland region as a base only for organizational reasons, but naturally you must perform it for your own region!

EXERCISE 1



EXERCISE 2

SOLUTION	CHALLENGES	BENEFICIAL IMPACTS	ARTICLE/PROJECT	RELEVANT INFORMATION
Seasonal strategies and adaptation plans for reindeers herding	• Pasture loss • Snow-cover changing • Insects	• Reindeer health • Knowledge transfer • Better herders loverhoods	• L2.1.2 - Reindeer husbandry and climate change: Challenges for adaptation	Technical solution couldn't be accepted by Herders

IS THIS A:
(Put at least a X on each line)

Policy	Awareness Knowledge	Technical Technological	NBS	Others I don't know
	X		X	

MOUNT RESILIENCE

8

Thank you for your attention!

Get in touch

Anna Giorgi
Full professor
Anna.giorgi@unimi.it

Stefano Sala
ProjectManager
Stefano.sala1@unimi.it

Gloria Coatti
Project officer
Gloria.Coatti@unimi.it

Luca Giupponi
Researcher
Luca.giupponi@unimi.it

Matteo Vizzarri
Researcher
Matteo.Vizzarri@nimi.it

Dario Pezzotti
Researcher
Dario.Pezzotti@unimi.it

MOUNT RESILIENCE

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or CINEA. Neither the European Union nor CINEA can be held responsible for them.

Swiss partners have received funding from the Swiss State Secretariat for Education, Research and Innovation (SERI).

5.2.2. Regional demonstrators' stakeholders and regional replicators' partners Factsheet

Following images composes the slides that were sent to regional demonstrators' referents, to be sent to all stakeholders, and to regional replicators' participants. These slides include the exercises inspired to the TransformAr project for the obtainment of all data needed for the Factsheets creation.

Figure 47. Factsheet slides (10 images) - Regional Demonstrator's workshop for stakeholders and replicators (UMIL, 2024)

EXERCISE INTRODUCTION

THE MOUNTRESILIENCE PROJECT:

WHAT? Horizon project in line with EU Mission on Adaptation to Climate Change

WHERE? 10 European regions and communities located in mountainous areas

WHO? 47 partners from 12 different European countries

WHY? Increase regions capacity to adapt to climate change and to transition towards a climate-resilient society

HOW? Through simplified exercises, to produce NbS knowledge and a base to determine adaptation strategies.

FOR WHO? For regional replicators partners who needs to understand what challenges to face, determining priorities and adaptation options

To share participants knowledge on climate change challenges and solutions.
This will establish a base to define actions, evaluations and adaptation strategies at a regional level, aiming at defining sustainable adaptation practices for mountain areas.
This exercise will also lead us to understand if this framework can be optimized

These exercises can be done offline, by sending material via e-mail

OPTIONAL: You can send this folder to any stakeholder that you think could be interested in participating in this validation process and in implementing local adaptation to climate change

WHAT WE WILL USE:

TransformAr

THE TRANSFORMAR APROACH

To engage stakeholders in an easy way and with solid workshop base we have based this exercise on TransformAr, a project financed by the European Union's H2020 innovation action program. Considering the already owned information, we adapted that workshop guide to our needs, to create an understandable and solid base for collecting and validating information.

EXERCISE 1

Determining priorities of local stakeholders, classifying hazards and risks, based on the already determined regional information and impact chains.

EXERCISE (A + B)

Determining already existing solutions, based on a scientific database, and be aware of challenges they can try to solve and related beneficial impacts.

EXERCISE 3

Determining, based on the given regional project NBS and on the determined NBS, how the solution can be implemented and main aspects to be considered.

MOUNT RESILIENCE

2

EXERCISE INTRODUCTION

In this pages are explained the methodology and the purpose of the exercises proposed in the replicators factsheet document. Here you will find also instruction and suggestion on how to correctly perform the exercises and collect the data.

HOW TO PERFORM THE EXERCISE

GENERAL INFORMATION

- You need to compile exercises in English language
- **Compilation Examples can be found in the at pages 8-9**
- Feel free to add any relevant aspect not included in the exercises, like notes, suggestions or information about your region useful for the validation
- **The deadline to send back this document is the 13th September**
- OPTIONAL: If you want to share this folder to other stakeholders (in that case thanks!) remember to explain them the project and the deadlines, then send us back all the "Replicators factsheet" you have collected

Time needed for the compilation of each exercise is suggested at the top of the relative page. **Total time needed is about 2 hours.**

Working steps are made to be executed **by a single participant,** so insert information at the best of your knowledge!

EXERCISE NOTES

EXERCISE 1

Simplified impact chain (provided in *Background and Impact Chain* document) has already many cases of hazards, impacts, risks and exposure in it. Just copy them in the appropriate space, adding more information if you have any

EXERCISE 2 (A+B)

The database (*Article and project database*) is huge! Try to work on this file by using excel options for keywords and for ordering the columns. We suggest to search articles and project looking mostly at challenges and beneficial effects

EXERCISE 3

Remember to choose two NBS that are efficient and transformative (based on answers done in previous exercises) and avoid the NBS geared towards the social and political fields

Compilation examples: pages 8-9

WHAT YOU SHOULD VERIFY

- Read the exercises and understand how they should be performed before starting
- Add a final page where you can add problems, missing works, suggestions and other relevant information if you need it
- Cheek that all steps are answered correctly and in English
- Collect information in a clear and optimized way, summarizing when needed. Remember to do a scientific procedure when possible
- Send back this document to the task T1.3 working group. Do that before the deadline and in a complete and comprehensive way

MOUNT RESILIENCE

ASSESSING CLIMATE RISKS 1

WORKING TIME:
30 MINUTES

EXERCISE

Starting from the shared "Background and Impact Chain" classify the following concepts by assigning them different levels from very hight impact to low impact. Feel free to add more cases based on your personal knowledge if they are not included in the Impact Chain graphic.

	HAZARDS AND SECONDARY IMPACTS	RISKS	EXPOSURES
Very high impact			
High impact			
Medium impact			
Low impact			

MOUNT RESILIENCE

Choose one

MOST RELEVANT RISK

MOST RELEVANT EXPOSURE AREA

4

DETERMINE EXISTING SOLUTIONS 2A

EXERCISE

Defined the exposure area and given a level of importance to risks in your region, find good existing solutions from the given "Projects and Articles Database" (and from your own knowledge) and try to add relevant information/suggestions if you have.

WORKING TIME: 40 MINUTES

SOLUTION	CHALLENGES	BENEFICIAL IMPACTS	ARTICLE/PROJECT	RELEVANT INFORMATION	IS THIS A: (Put at least a X for each line) Policy	Awareness Knowledge	Technical Technological	NBS	Others I don't know

MOUNT RESILIENCE

SOLUTIONS FROM YOUR PERSONAL EXPERIENCE →

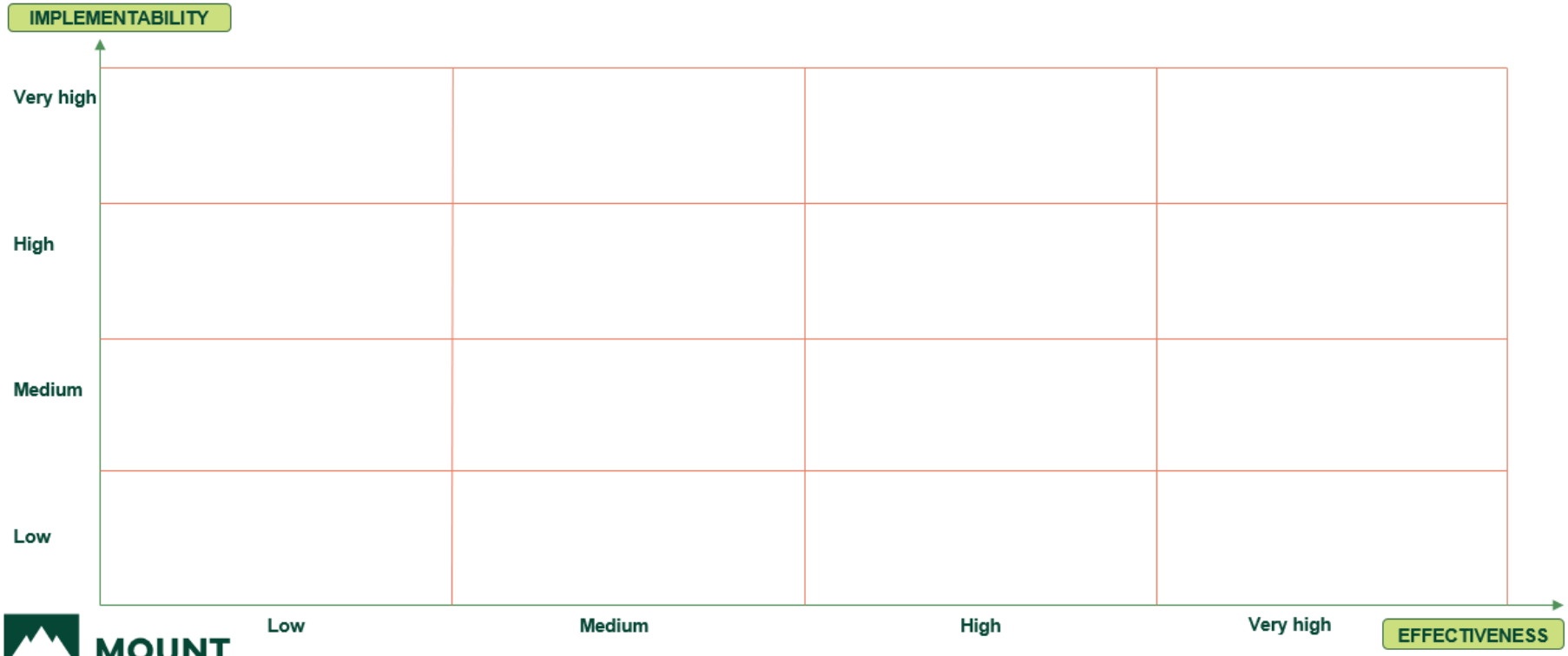
5

DETERMINE EXISTING SOLUTIONS 2B

WORKING TIME:
20 MINUTES

EXERCISE

Now, take the tailored solution you have found in the previous exercise and insert them in the following table, considering their effectiveness and implementability.



MOUNT RESILIENCE

6

DETERMINE EXISTING SOLUTIONS 3

WORKING TIME: 30 MINUTES

EXERCISE

Select two NBS from the 2B exercise (you should consider the ones with high implementability-effectiveness) and try to add information for their implementation, as shown below.
Note that ***Outcomes*** are results expected you want to reach and ***Indicators*** are factors that can validate them (e.g. If an *Outcome* is "Lectures for climate change awareness", an *Indicator* could be "Number of participants"). If you don't know how to complete a box, such as for the *Financing and cost* one, just try to add relevant information (for example, on how you would find them or on what parts of that solution are the most expensive in your opinion).

CHOSEN NBS 1		CHOSEN NBS 2	
SOLUTION STRENGTHS AND WEAKNESSES		SOLUTION STRENGTHS AND WEAKNESSES	
SOLUTION IMPLEMENTATION STAGES		SOLUTION IMPLEMENTATION STAGES	
OUTCOMES		OUTCOMES	
INDICATORS		INDICATORS	
FINANCINC AND COSTS		FINANCINC AND COSTS	
ACTORS INVOLVED		ACTORS INVOLVED	

MOUNT RESILIENCE

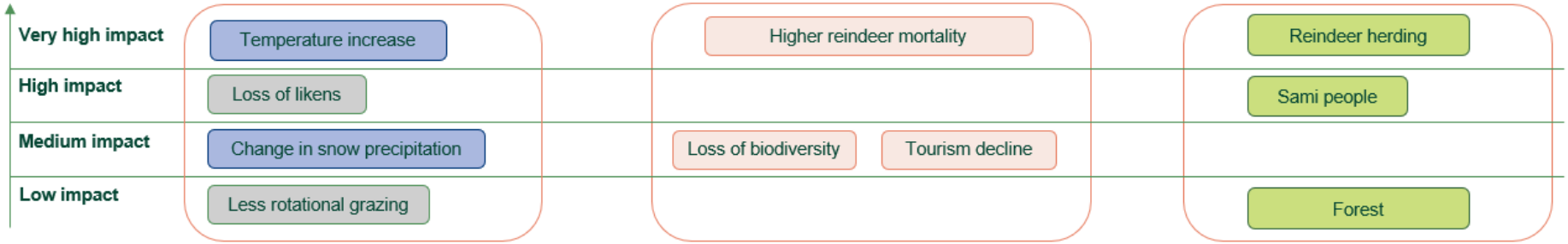
FINAL CONSIDERATIONS

7

COMPILATION EXAMPLES

NOTE: This is a common example on how exercises should be done. We took Lapland region as a base only for organizational reasons, but naturally you must perform it for your own region!

EXERCISE 1



EXERCISE 2

SOLUTION	CHALLENGES	BENEFICIAL IMPACTS	ARTICLE/PROJECT	RELEVANT INFORMATION
Seasonal strategies and adaptation plans for reindeers herding	• Pasture loss • Snow-cover changing • Insects	• Reindeer health • Knowledge transfer • Better herders loverhoods	• L2.1.2 - Reindeer husbandry and climate change: Challenges for adaptation	Technical solution couldn't be accepted by Herders

IS THIS A:
(Put at least a X on each line)

Policy	Awareness Knowledge	Technical Technological	NBS	Others I don't know
	X		X	

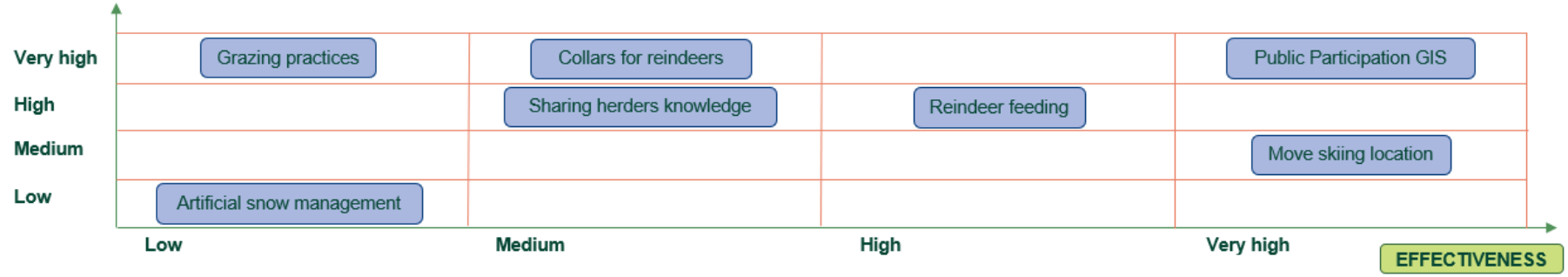
MOUNT RESILIENCE

8

COMPILATION EXAMPLES

EXERCISE 3

IMPLEMENTABILITY



EXERCISE 4

CHOSEN NBS Public Participation Geographic Information Systems (PPGIS)

SOLUTION STRENGTHS AND WEAKNESSES
STRENGHTS: Low cost; improve the knowledge. WEAKNESSES: Effective use

SOLUTION IMPLEMENTATION STAGES
Contact associations; Questionnaires; Creating the platform; dissemination days

OUTCOMES
Connect 50% reindeer herders association; list of best practices for reindeer herding

INDICATORS
Numbers of participants; site visit; application download

FINANCINC AND COSTS
Around 10.000 euros for the platform creation; EU financing project called "XXXX"

ACTORS INVOLVED
Reindeer associations; University; Sami Council

MOUNT RESILIENCE

FINAL CONSIDERATIONS

- Exercise n° 1 was too easy and n° 2A instead was too hard.
- I would add some solutions related to pollinators for our region
- Solution "XXXX" inserted in the database was useless in my opinion
- Information "XXXX" about the regional background is wrong

9

Thank you for your attention!

Get in touch

Anna Giorgi
Full professor
Anna.giorgi@unimi.it

Stefano Sala
ProjectManager
Stefano.sala1@unimi.it

Gloria Coatti
Project officer
Gloria.Coatti@unimi.it

Luca Giupponi
Researcher
Luca.giupponi@unimi.it

Matteo Vizzarri
Researcher
Matteo.vizzarri@unimi.it

Dario Pezzotti
Researcher
Dario.Pezzotti@unimi.it

MOUNT RESILIENCE

Co-funded by the European Union

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or CINEA. Neither the European Union nor CINEA can be held responsible for them.

Swiss partners have received funding from the Swiss State Secretariat for Education, Research and Innovation (SERI).

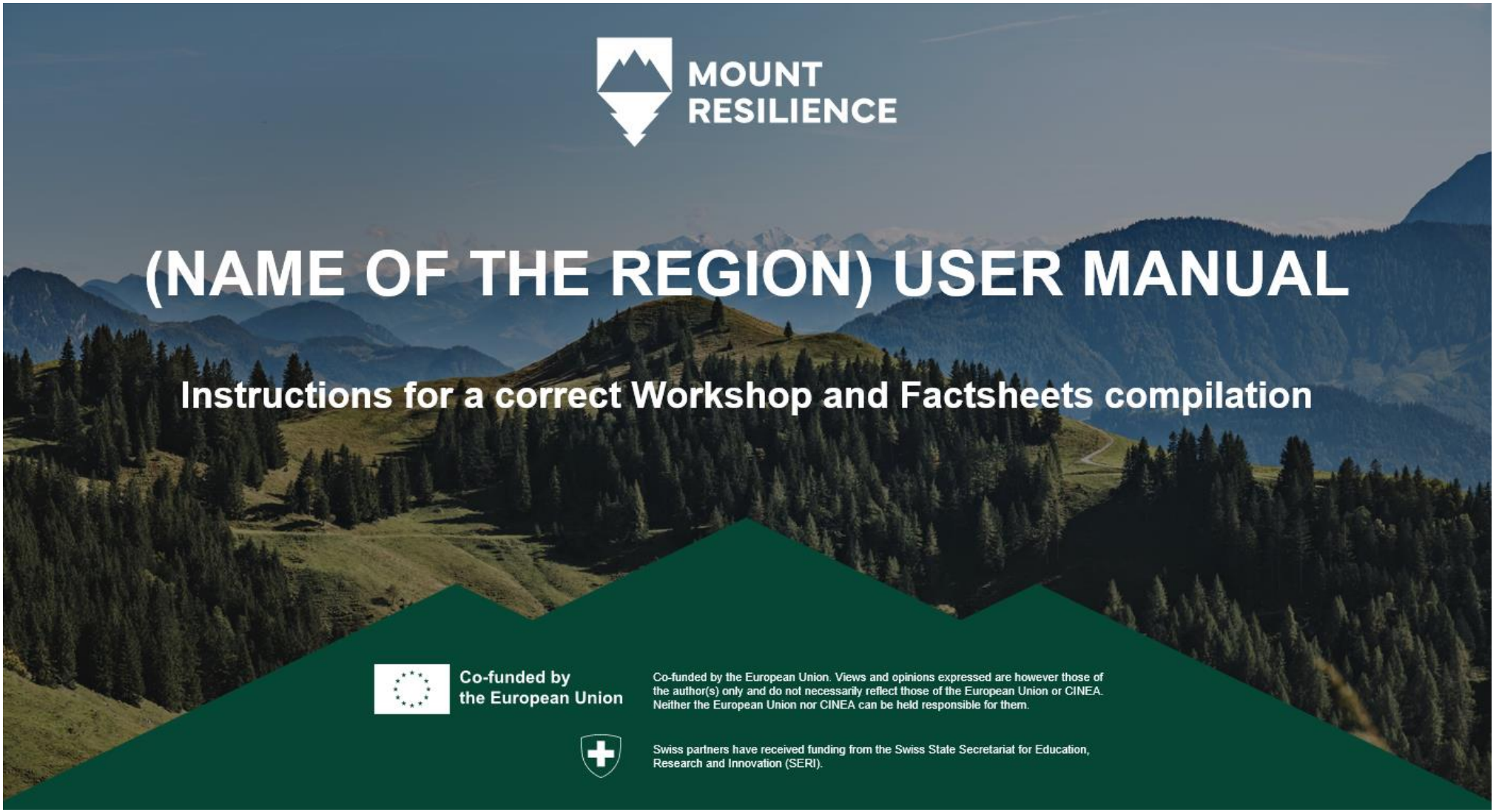


Figure 48. Factsheet slides (7 images) - User manual for the exercitation leader (UMIL, 2024)

THE VALIDATION PROCESS

THIS IS THE USER MANUAL!
- **In pages 1 and 2 are explained the methodology and the purpose of the exercises (Factsheet) that you will use**
- **In page 3 – 7 you will find how to perform the exercises, specific instructions on what to ask to participants and general instructions on how to collect data**

HOW?

Through a tailored workshop, based on factsheets for each regional demonstrator, to produce NbS adaptation strategies. These exercises can be done **online** (in physical working groups or through platform meetings) or **offline** (by sending material via e-mail)

FOR WHO?

For **stakeholders and replicators** who know their territory and that are interested in implementing local adaptation to climate change

Stakeholder / Replicators Folder

WHAT WE WILL USE: TransformAr

THE TRANSFORMAR APROACH

TransformAr is a project financed by the European Union's H2020 innovation action program. This easy **working table guide** will help us to engage stakeholders to provide solid answers.

PARTNERS

For **regional demonstrators' partners**, who have a huge knowledge about the project thematic

Regional partners Folder

STAKEHOLDERS

WHAT WE WILL USE: RAST

THE RAST TOOL

The Regional Adaptation Support Tool (RAST- Climate ADAPT 2024) can be an assistance in the searching and decision-making work, **through 6 guiding steps**, aligned with the key features of climate adaptation policy processes.

MOUNT RESILIENCE

RESUME OF THE EXERCISES

FACTSHEET for regional stakeholders / replicators — **PARTNERS**

EXERCISE 1	EXERCISE 2 (A+B)	EXERCISE 3
Determining priorities of local stakeholders, classifying hazards and risks, based on the already determined regional information and impact chains.	Determining already existing solutions, based on a scientific database, identify challenges they can try to solve, and related beneficial impacts.	Determining, based on the given regional project NBS and on the proposed NBS, how the solution can be implemented and main aspects to be considered.

FACTSHEET for regional demonstrators' partners — **STAKEHOLDERS**

EXERCISE 1	EXERCISE 2	EXERCISE 3	EXERCISE 4
Determining priorities of local stakeholders, evaluating regional background Impact chains.	Determining already existing solutions, based on a scientific database. Be aware of challenges they can try to solve and related beneficial impacts.	Evaluating relevant NbS tailored on the regional challenges, including the project suggested solution, through some defined criteria.	Implementing strategies for the selected NbS. Then hypothesize main aspects, such as costs, times and actors. Finally add information about outcomes, indicators and funding/financing options.

MOUNT RESILIENCE

Exercises are basically composed to be performed **by a single participant** (but you can do them in groups following user instructions provided in the next pages)

Exercises needs a medium time of **2 hours** to be compiled by participants. Make sure they have the time to complete them!

USER INSTRUCTIONS – STAKEHOLDERS

HOW TO PERFORM THE EXERCISE

BY WORKING GROUP

- Define pauses, reading times and the number of working groups (better more than one) depending on participants and on how you want to collect data
- If you want to create more interactive working groups, we suggest to use big panels for exercise pages and let people work on them with post-it
- Let people work using their own language if they prefer

BY E-MAIL

- Prepare an email with the Factsheet folder to all participants (it includes the "Projects and Articles Database" and the "Background and Impact Chain" documents)
- Add a deadline for feedbacks and remember to keep in touch with them with reminders

GENERAL

- Remember to translate information if you think than people couldn't understand them, and do the same after you have received their feedbacks
- You can organize a meeting for the results validation after you have collected feedbacks
- **Compilation Examples can be found in the Stakeholders Factsheet document**

HOW TO COLLECT DATA

EXERCISE 1

- Collect data creating a list of the suggested Hazards/Impacts, Risks and Exposures, adding at least a graphic/database where can be seen how many participants selected them and the impact given
- Make a list for chosen risks and exposure area

EXERCISE 2A

- To be sure to validate a larger part of the database you should assign a different Exposure area to each participants or little groups, to let them search in different areas
- Make a unique column for all solutions, organizing them by choices and numbers
- Resume relevant solution from participants personal experience

EXERCISE 2B

- To be sure to validate a larger part of the database you could let participants use all the regional database instead than the solutions related to chosen exposure area
- Make a unique graph for all solutions, putting them in a position corresponding to their medium classification an adding relevant information

EXERCISE 3

- **To improve data collection, you should assign different NBS to each participant/group**
- Organize and collect information in an appropriate table, unifying similar concepts when is possible. Do the same for final suggestions
- Define for these NbS solutions if they are (A - Feasible but costly/not socially accepted/not transformative; B – Efficient and transformative) based on answers done

WHAT YOU SHOULD VERIFY

MOUNT RESILIENCE

- Verify to have sent the correct workshop package to Regional Demonstrators partners and to stakeholders, expecially if you are working offline
- Read the exercises and verify to have understood how they should be performed
- Keep a list of the participants on a file where you can add presences, problems, missing works, suggestions and other relevant information
- When you have collected all participants results, make sure they will have understood all the steps and answered correctly to them
- Collect information in a clear and optimized way, summarizing them when needed, but remember to do a scientific procedure when possible
- If you see that some relevant information are missing during your collecting activity, think about to personally contact the participants
- send back the material collected to the task T1.3 working group before the written deadline and in a complete and comprehensive way

USER INSTRUCTIONS – REPLICATORS

HOW TO PERFORM THE EXERCISE

BY E-MAIL

- Prepare an email with the Factsheet folder to all participants (it includes the "Projects and Articles Database" and the "Background and Impact Chain" documents)
- Add a deadline for feedbacks and remember to keep in touch with them with reminders

GENERAL

- Remember to translate information if you think than people couldn't understand them, and do the same after you have received their feedbacks
- You can organize a meeting for the results validation after you have collected feedbacks
- **Compilation Examples can be found in the Replicators Factsheet document**

HOW TO COLLECT DATA

EXERCISE 1

- Collect data creating a list of the suggested Hazards/Impacts, Risks and Exposures, adding at least a graphic/database where can be seen how many participants selected them and the impact given
- Make a list for chosen risks and exposure area

EXERCISE 2A

- To be sure to validate a larger part of the database you should assign a different Exposure area to each participants or little groups, to let them search in different areas
- Make a unique column for all solutions, organizing them by choices and numbers
- Resume relevant solution from participants personal experience

EXERCISE 2B

- To be sure to validate a larger part of the database you could let participants use all the regional database instead than the solutions related to chosen exposure area
- Make a unique graph for all solutions, putting them in a position corresponding to their medium classification an adding relevant information

EXERCISE 3

- **To improve data collection, you should assign different NBS to each participant/group**
- Organize and collect information in an appropriate table, unifying similar concepts when is possible. Do the same for final suggestions
- Define for these NbS solutions if they are (A - Feasible but costly/not socially accepted/not transformative; B – Efficient and transformative) based on answers done

WHAT YOU SHOULD VERIFY

- Read the exercises and verify to have understood how they should be performed
- Keep a list of the participants on a file where you can add presences, problems, missing works, suggestions and other relevant information
- When you have collected all participants results, make sure they will have understood all the steps and answered correctly to them
- Collect information in a clear and optimized way, summarizing them when needed, but remember to do a scientific procedure when possible
- If you see that some relevant information are missing during your collecting activity, think about to personally contact the participants
- send back the material collected to the task T1.3 working group before the written deadline and in a complete and comprehensive way

MOUNT RESILIENCE

USER INSTRUCTIONS – REGIONAL PARTNERS

HOW TO PERFORM THE EXERCISE

BY WORKING GROUP

- Define pauses, reading times and the number of working groups depending on participants and on how you want to collect data
- Add the group icon to exercises and choose the proper instructions
- If you want to create more interactive working groups, we suggest to use big panels for exercise pages and let people work on them with post-it
- Let people work using their own language if they preferer
- Remember to consider at least 30 min more time, for pauses, to solve problems, extra-times and for a brief final discussion between participants

BY E-MAIL

- Prepare an email with the Factsheet folder to all participants (it includes the "Projects and Articles Database" and the "Background and Impact Chain" documents)
- Add a deadline for feedbacks and remember to keep in touch with them with reminders

GENERAL

- Remember to translate information if you think than people couldn't understand them, and do the same after you have received their feedbacks
- You can organize a meeting for the results validation after you have collected feedbacks
- **Compilation examples can be found in the Regional demonstrators' partners Factsheet document**

HOW TO COLLECT DATA AND EXERCISES NEEDS

EXERCISE 1

- Collect information on Background, Challenges and Needs in a unique table
- Make a resumed Impact Chain with suggested Hazards, Impacts, Vulnerabilities and Risks. Then collect and list chosen Exposure areas and Risk, counting them
- To be sure that participants will undercover all Exposure Areas you should assign them before the exercise start, dividing them in equal numbers

EXERCISE 2

- Make a unique column for all solutions, organizing them by choices and numbers
- Resume relevant solution from participants personal experience
- Be sure that participants have suggested a NBS and organize the answers received
- This exercise, in a working table, could be done by groups around 3 people

EXERCISE 3

- **Insert as first the project solution proposal and the list of NBS solution** (consider in a large sense of the term) on which participants will work. You can choose by your own, if you consider some of them more interesting to be evaluated. **If you have problems you can just take them from the list showed in the following page** (but try to be more specific based on your personal knowledge about regional challenges)
- If this exercise is a done by working groups you should let them propose and take by the Database list
- Collect value given to Criteria for each NBS and define mean values
- Define for these NbS solutions if they are (A - Feasible but costly/not socially accepted/not transformative; B – Efficient and transformative) based on answers done
- Organize Winning NBS and Driving criteria

MOUNT RESILIENCE

USER INSTRUCTIONS - REGIONAL PARTNERS

EXERCISE 4

- Participants must work on various NBS. To simplify that, you could define the Winning NBS before the exercise start, dividing them in equal numbers among participants.
- **Secure that at least some participants will work on "Project proposal" solution**.
  You can also consider to do this exercise twice, adding the "Project proposal" to the winning NBS exercise.
- Resume all answers, organizing them by choices and numbers in an understandable way
- Make sure to organize results with a same criteria for all answers collected. We suggest classifying them with a range, as listed below, for this exercise:

IMPLEMENTATION STAGES	SET-UP TIME	PROJECT PHASE		COSTS	
Be sure that all of them are operable. Make sure to write your important comments at the end of the collecting phase	Less than 1 month 1 month – 3 months 3 months – 1 year 1 year – 3 years More than 3 years	Starting Planning Execution Monitoring Closing	Beginning Middle part Ending	Low Medium High	Then, based on answers collected, define a cost range for the NBS

WHAT YOU SHOULD VERIFY

- Verify to have sent the correct workshop package to Regional Demonstrators partners and to stakeholders, expecially if you are working offline
- Be sure to have understood and completed all the exercises be and to have defined collecting modalities fore send factsheets to the participants or before to start the workshop
- Keep a list of the participants on a file where you can add presences, problems, missing works, suggestions and other relevant information
- When you collect the exercises make sure that participants have understood all the steps
- When you collect the exercises make sure that participants have answered to all of them
- Collect information in a clear and optimized way, summarizing them when needed, but remember to do a scientific procedure when possible
- If you see that some relevant information are missing during your collecting activity, think about to personally contact the participants
- send back the material collected to the task T1.3 working group before the written deadline and in a complete and comprehensive way

MOUNT RESILIENCE

USER INSTRUCTIONS – REGIONAL PARTNERS

EXERCISE 3 | **NBS PROVIDED LIST**

NbS provided: Green infrastructures – Network of natural, semi-natural and artificial green spaces, delivering a wide range of Ecosystem Services. Usually, these spaces are represented by urban and peri-urban forests, street trees, and other green spaces such as lawns. These infrastructures are efficient to mitigate the effect of urban heat island, and enable to improve air quality.
NbS provided: Mapping techniques – Facilitate the assessment of ecosystem health, biodiversity distribution, land use patterns, and habitat connectivity. They provide valuable insights for conservation planning, resource management, and decision-making by identifying priority areas for protection, restoration, or sustainable use.
NbS provided: Early monitoring system – The timely and systematic collection of data to assess environmental conditions, detect changes, and inform decision-making for proactive management of natural resources and ecosystems. This approach includes deploying sensors, satellite imagery, and other technologies to monitor climate variables.
NbS provided: Management plan – Integrate scientific research, stakeholder input, and monitoring to ensure adaptive management and long-term sustainability. This approach includes defining conservation goals, assessing current conditions, identifying threats and opportunities, and outlining specific measures and timelines for implementation.
NbS provided: Urban greenery – Incorporation of green spaces and element into urban environment and infrastructure. It includes solutions as green walls, green rooftops, urban farm. These green spaces enhance the biodiversity in the cities and improve air quality. They are also good for mental and physical health of citizens.
NbS provided: Blue infrastructures – The strategic planning and development of natural or nature-based features to manage water resources sustainably and improve resilience to climate change impacts. By leveraging natural systems, blue infrastructures help promote sustainable water management practices and the conservation of coastal and aquatic ecosystems.
NbS provided: Forest management – Sustainable planning and management of forest landscapes balancing ecological and economic benefits. Sustainable management of forest landscapes promotes climate resilience, biodiversity conservation, watershed protection, carbon storage, and the socio-economic well-being of communities dependent on forest resources.
NbS provided: Increase & share knowledge – Exchange of information, best practices, and research findings related to the use of natural processes and ecosystems for addressing environmental challenges. Encourages networks of regional knowledge.
NbS provided: Stakeholder engagement – Participatory and collaborative efforts with all parties who have interest or stake in the environmental project. Stakeholder engagement enhances the relevance and acceptance of nature-based solutions through shared responsibility for environmental outcomes.
NbS provided: Decision Making Processes/tools – Creating a structured approach designed to give clarity and insight to make informed sustainable choices. Effective decision-making processes/tools create transparent, inclusive, and evidence-based planning and management for sustainable development.

MOUNT RESILIENCE

PROJECT PROPOSAL FOR GABROVO

Green Infrastructure (GI) strategy and early warning monitoring systems (EWMS) – Map the urban green environment, co-develop the GI strategy and improve rainwater harvesting and tree planting. Study and design the EWMS, raising of the general population and capacity building of the municipal administration

Figure 49. Factsheet slides – Suggested solutions from the database for the exercitation leader based on Gabrovo background (UMIL, 2024)

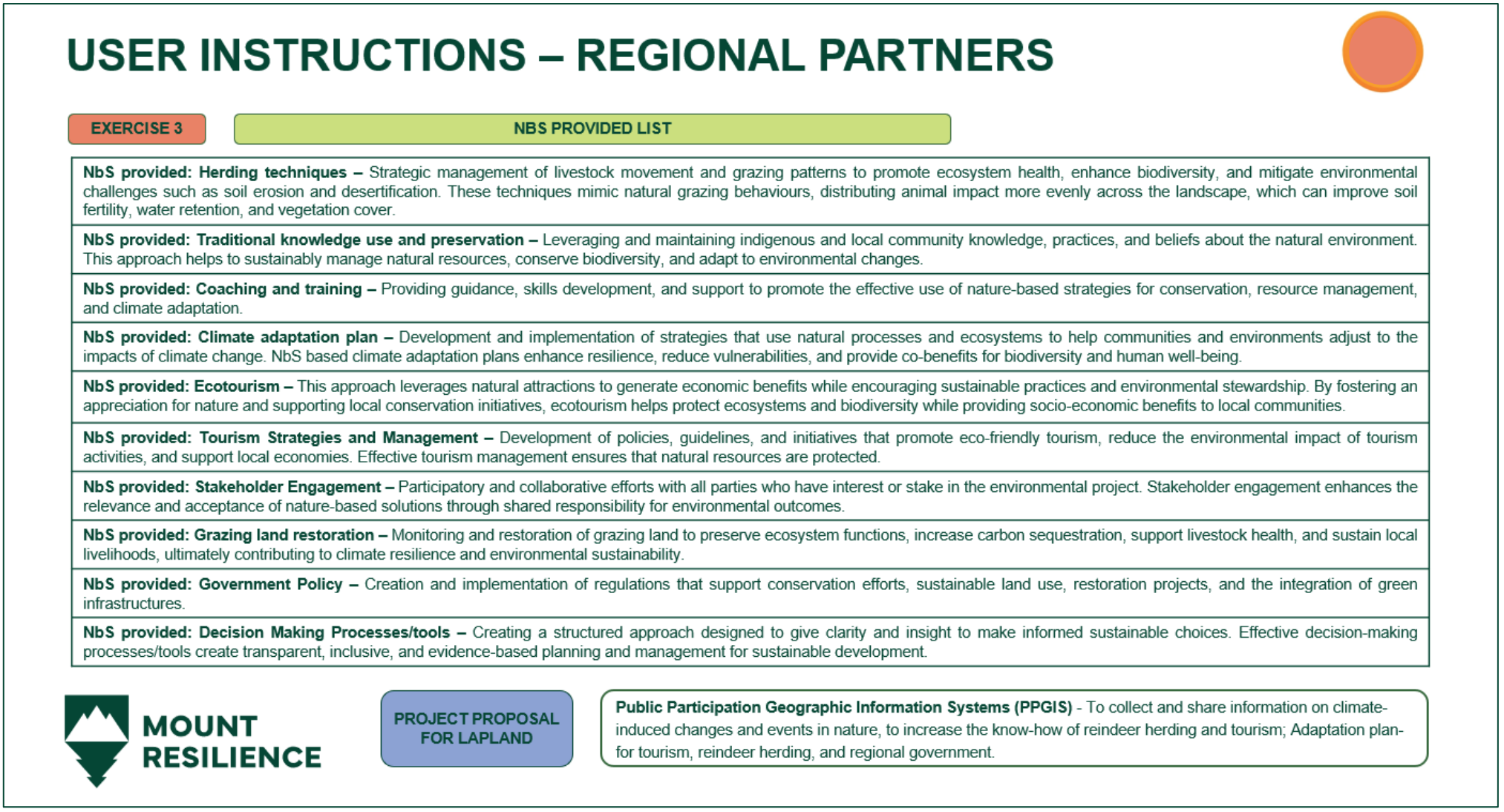


Figure 50. Factsheet slides – Suggested solutions from the database for the exercitation leader based on Lapland background (UMIL, 2024)

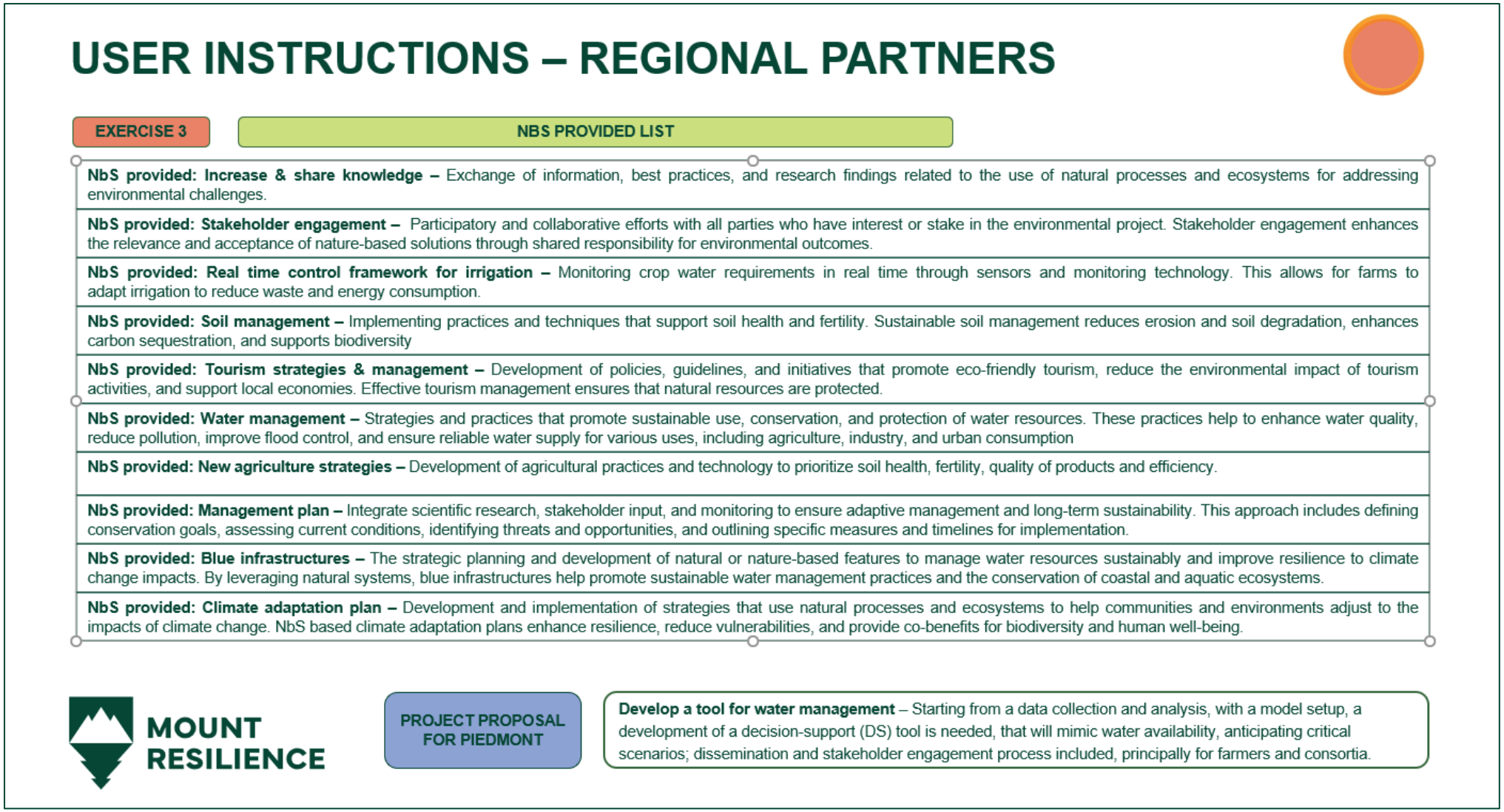


Figure 51. Factsheet slides – Suggested solutions from the database for the exercitation leader based on Piedmont background (UMIL, 2024)

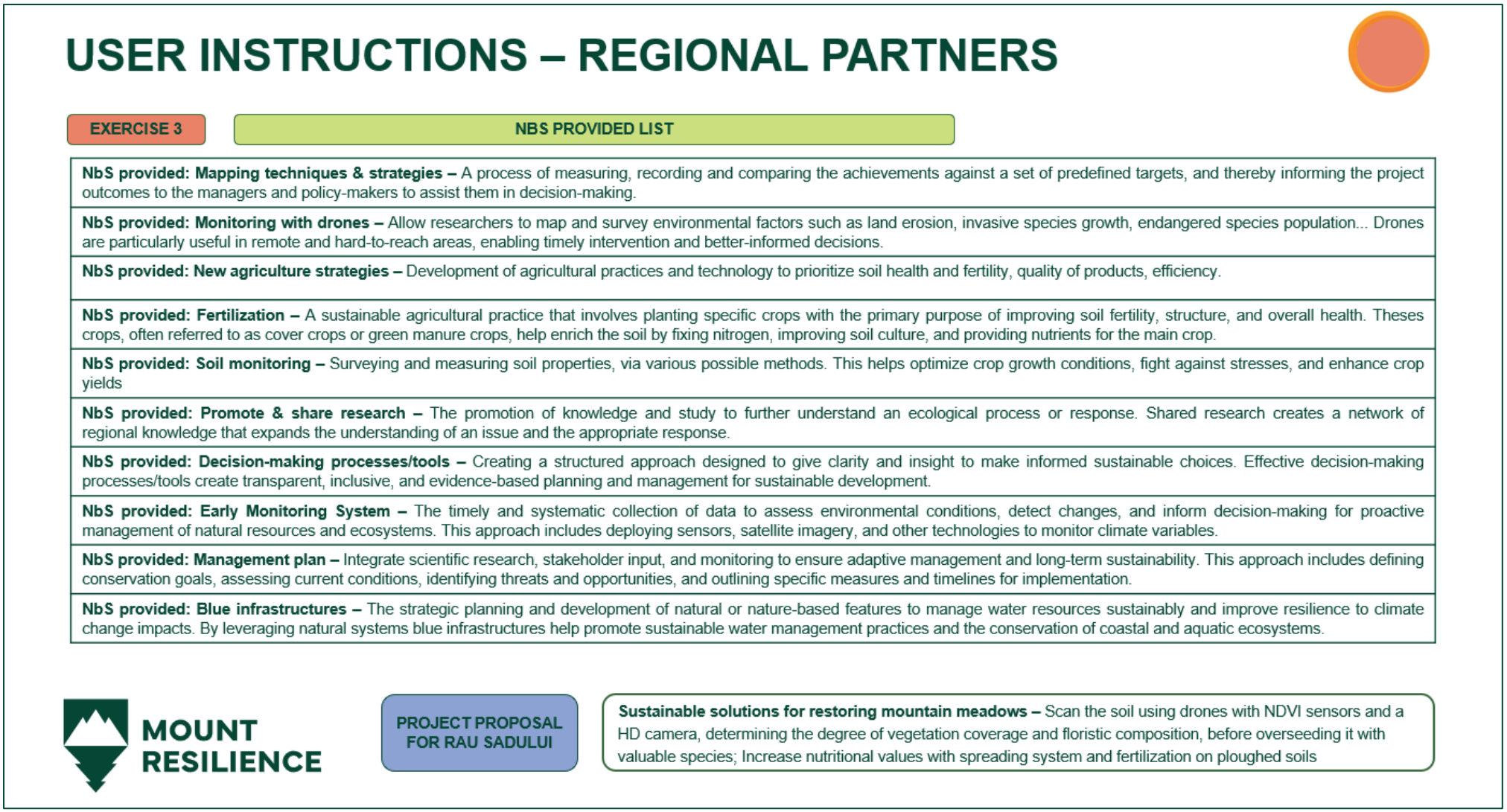


Figure 52. Factsheet slides – Suggested solutions from the database for the exercitation leader based on Râu Sadului background (UMIL, 2024)

USER INSTRUCTIONS – REGIONAL PARTNERS

EXERCISE 3

NBS PROVIDED LIST

NbS provided: Green Infrastructure – Network of natural, semi-natural and artificial green spaces, delivering a wide range of Ecosystem Services. Usually, these spaces are represented by urban and peri-urban forests, street trees, and other green spaces such as lawns. These infrastructures are efficient to mitigate the effect of urban heat island, and enable to improve air quality.
NbS provided: Tourism Strategies and Management – Development of policies, guidelines, and initiatives that promote eco-friendly tourism, reduce the environmental impact of tourism activities, and support local economies. Effective tourism management ensures that natural resources are protected.
NbS provided: Government Policy – Creation and implementation of regulations that support conservation efforts, sustainable land use, restoration projects, and the integration of green infrastructure.
NbS provided: Urban Greenery – Incorporation of green spaces and element into urban environment and infrastructure. It includes solutions as green walls, green rooftops, urban farm. These green spaces enhance the biodiversity in the cities and improve air quality. They are also good for mental and physical health of citizens.
NbS provided: Ecotourism – This approach leverages natural attractions to generate economic benefits while encouraging sustainable practices and environmental stewardship. By fostering an appreciation for nature and supporting local conservation initiatives, ecotourism helps protect ecosystems and biodiversity while providing socio-economic benefits to local communities.
NbS provided: Monitoring techniques and Strategies – A process of measuring, recording and comparing the achievements against a set of predefined targets, and thereby informing the project outcomes to the managers and policy-makers to assist them in decision-making.
NbS provided: Climate adaptation plan – development and implementation of strategies that use natural processes and ecosystems to help communities and environments adjust to the impacts of climate change. NbS based climate adaptation plans enhance resilience, reduce vulnerabilities, and provide co-benefits for biodiversity and human well-being.
NbS provided: Ski slope management – Relocating the slopes to improve the quantity and the quality of the snow for skiing activities. Slopes can be relocated to areas of higher elevation or north-facing areas that get less direct sunshine that causes melting late in the season.
NbS provided: City restoration – Adapting the city and existing buildings to make them more resilient to the effects of climate change. This can involve, for example, renovating old buildings with innovative solutions (passive cooling system) to make them more energy-efficient.
NbS provided: Passive cooling system – Use of natural processes to cool a building without the use of mechanical systems. These systems focus on heat gain control and heat dissipation, using natural resources like wind, sun and soil to improve thermal comfort with low or no energy consumption.

MOUNT RESILIENCE

PROJECT PROPOSAL FOR TYROL

Innovative solutions for adaptation – Changes in the buildings and settlements (using thermodynamic simulations); designing and testing a transformation process for the tourism sector; develop a CEC platform for Climate and Circularity consulting purposes; Use AI sensors and create a monitoring tool

Figure 53. Factsheet slides – Suggested solutions from the database for the exercitation leader based on Tyrol background (UMIL, 2024)

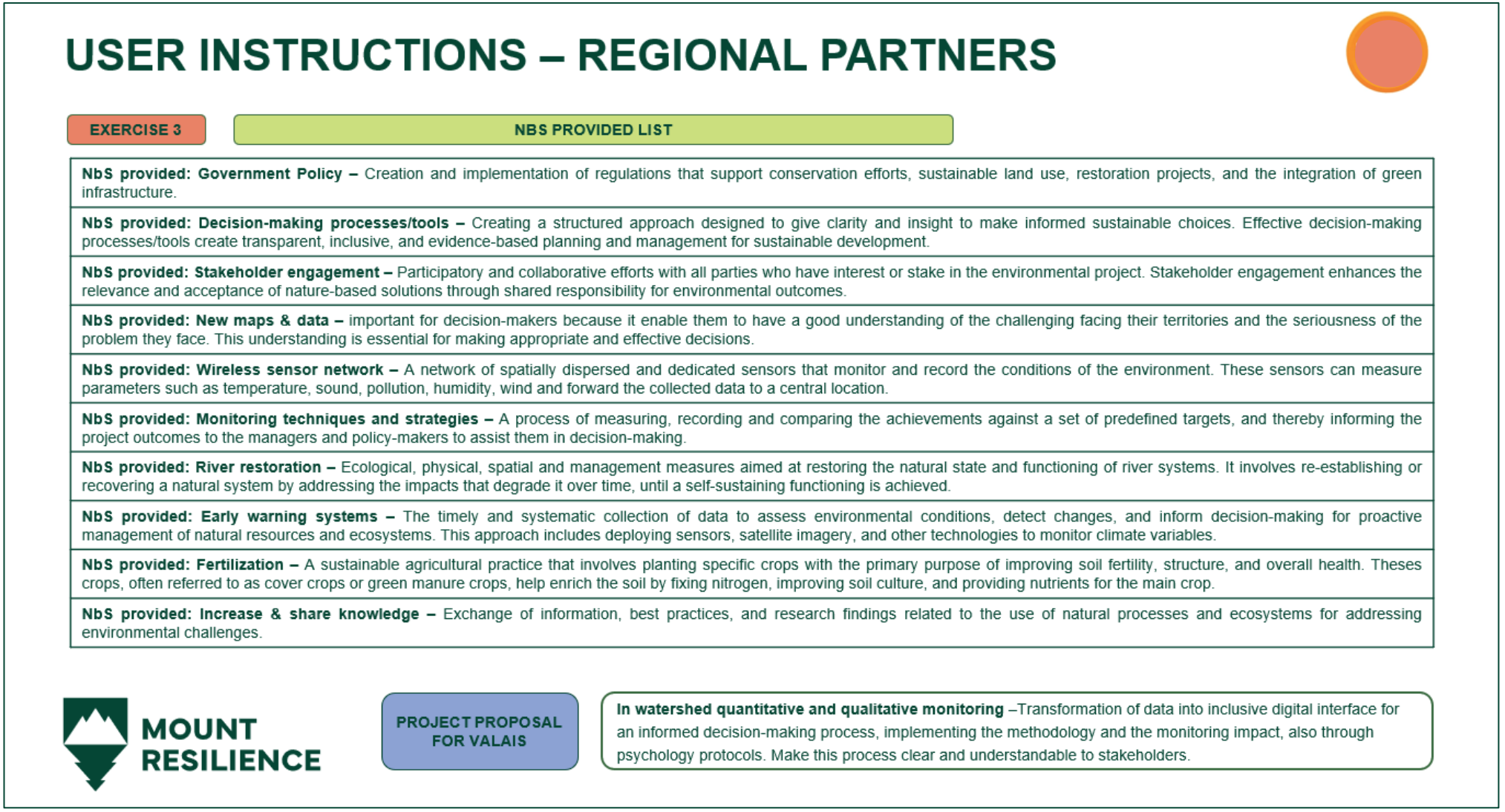


Figure 54. Factsheet slides – Suggested solutions from the database for the exercitation leader based on Valais background (UMIL, 2024)

5.3. Factsheet timeline

Table 1. Creation and distribution timeline for Factsheets (UMIL, 2024)

Activity	Date
Factsheets for regional demonstrator partners – delivered by email	16/07/2024
Factsheets for regional demonstrator stakeholders - delivered by email	16/07/2024
Factsheet for regional replicators partners – delivered by email	26/07/2024
Additional instructions for partners and stakeholders - delivered by email	01/08/2024

5.4. Factsheet distribution list

Table 2. List of participant's leaders from each regional demonstrator project who was in charge to distribute, collect and validate processes through Local Councils (UMIL, 2024)

Region	FIGURES (pseudonymized)	Papers collected
Gabrovo	Local council leader (G-LCL) Exercise participant (G-EP)	Partners' Factsheets: 6 Stakeholders' Factsheet: 7 Local council date: 28/08/2024 Feedback Date: 30/08/2024; 12/09/2024
Lapland	Local council leader (L-LCL) Exercise participant (L-EP)	Partners' Factsheets: 1 (resumed) Stakeholders' Factsheet: 2 (resumed) Local council date: 04/2024, validation done online in September Feedback Date:16/09/2024
Piedmont	Local council leader (P-LCL) Exercise participant (P-EP)	Partners' Factsheets: 2 (resumed) Stakeholders' Factsheet: 2 (resumed) Local council date: 13/09/2024; 20/09/2024 Feedback Date: 10/09/2024; 19/09/2024; 25/09/2024

Râu Sadului	Local council leader (R-LCL) Exercise participant (R-EP)	Partners' Factsheets: 3 (resumed) Stakeholders' Factsheet: 1 (resumed) Local council date: 12/09/2024 Feedback Date: 17/09/2024
Tyrol	Local council leader (T-LCL) Exercise participant (T-EP)	Partners' Factsheets:2 (resumed) Stakeholders' Factsheet:2 (resumed) Local council date: 10/09/2024 Feedback Date: 13/09/2024
Valais	Local council leader (V-LCL) Exercise participant (V-EP)	Partners' Factsheets: 1 (resumed) Stakeholders' Factsheet: 3 (resumed) Local council date: 18/07/2024; 20/08/2024 Feedback Date: 16/09/2024; 18/09/2024
Catalonia	Partners group leader (C-PGL)	Replicators' Factsheets: 1 (resumed) Feedback Date: 30/09/2024
Friuli-Venezia Giulia	Partners group leader (F-PGL)	Replicators' Factsheets: 3 Feedback Date: 23/09/2024
Primorje-Gorski Kotar	Partners group leader (P-PGL)	Replicators' Factsheets:3 Feedback Date: 12/09/2024
Subcarpathian region	Partners group leader (S-PGL)	Replicators' Factsheets: 1 (resumed) Feedback Date: 16/09/2024

5.5. Factsheet in detail

Starting from the outputs obtained by the documentation listed in the previous chapter it was possible to define important aspects for the definition of tailored adaptation practices. In this chapter are presented the relevant outcomes obtained by exercises proposed to regional partners and stakeholders for the Factsheet definition (resumed in chapter 2). Note on the exercises: feedback obtained by participants were collected, organized and summarized at the best possibilities. For exercises 2A the lines in highlighted in green were recognized as NbS by participants.

5.5.1. Gabrovo

5.5.1.1. REGIONAL DEMONSTRATOR PARTNERS

A participative process is fundamental for the success of CC adaptations, because a collaboration with local authorities and stakeholders is needed to correctly implement NbS and let them to be accepted by the population. This chapter resumes and analyses regional demonstrators' exercises, condensing Factsheet outcomes and underlining the main aspects (negative or positive) that came out from the validation process made up by Local Councils.

Table 3. Outputs from Exercise 1 (a) – Gabrovo Regional Demonstrator Partners Factsheet (UMIL, 2024)

BACKGROUND	CHALLENGES	NEEDS
URBAN GREEN AREAS		
High temperatures in summer, coupled with decreased precipitation led to droughts. Tap water is used to irrigate the lawns and the trees in city garden areas. Gabrovo is at the feet of Balkan Mountains; area affected by extreme weather events	Heat stress for trees and lawns; more stress due to drought periods. Inefficient and expensive use of drinking water (tap water) for irrigation. Water scarcity and floods risk: Increasing temperature: long dry periods followed by intensive rains. Managing better the green system. Environmental pollution; keep green areas into the city; reduce floods effects on infrastructures	Rainwater harvesting systems design which can use roofs and retention buildings areas around the green areas. Modernization of the existing irrigation system. More technical solutions for sustainable watering. Involve more stakeholders
FOREST AND AGRICULTURE		
In the north central region are estimated 50% of Natura 2000 protected areas. Balkan Mountains influence both cold and Atlantic air masses. Gabrovo has both very hot and dry periods. High level of humidity in winter season	Very humid winters mean higher air pollution; Rising temperatures alters seasonal patterns, permanent snow cover, drought and water scarcity. Different precipitation patterns can cause extreme events. Decline in the snowfall causes heat stress, tourism reduction and agricultural impacts. High risk of forest fires; heatwaves and cold waves also; crop failures and yield declines	Adaptation to Climate Change. Plantation of more trees. Harvesting rainwater systems. More monitoring stations for early alarms in case of floods and fires

Table 4. Outputs from Exercise 1 (b) – Gabrovo Regional Demonstrator Partners Factsheet (UMIL, 2024)

HAZARDS	IMPACTS	RISKS → CHALLENGES	VULNERABILITIES
		URBAN GREEN AREAS	
• *Heatwaves* • *Rising temperatures* • *Change in precipitations* • *Cold waves* • *Extreme weather events*	• *Drought* • *Increase of evapotranspiration* • *Increased irrigation bills* • *Urban heat islands* • *Pollution* • *Flooding* • *Health risks*	• *Grass and trees suffering* • *Soil erosion* • *Heat island effects* • *Loss of biodiversity* • *Higher flora mortality* • *Healthcare system overload* • *Infrastructure destructions*	• *Air pollution* • *Lass shaded places* • *Deterioration of people's comfort and health* • *Higher energy consumption* • *Food supply and mobility* • *Public health risks* • *Old and overloaded infrastructures* • *Missing monitoring green systems* • *Insufficient protection from natural hazards and people without insurance* • *Lack of funds* • *Lack of staff*
		FOREST AND AGRICULTURE	
• *Heatwaves* • *Rising temperatures* • *Change in precipitations* • *Extreme weather events*	• *Heat islands* • *Seasonality change* • *Increase of evapotranspiration* • *Flooding* • *Landslides* • *Change in the soil regimes* • *Change in forest fires seasonality*	• *Infrastructure's damage due to erosion, droughts and floods* • *Air pollution increasing* • *Impact on agriculture* • *Loss of biodiversity* • *Insect outbreaks or diseases* • *Greater damages from storms*	• *Incomplete long-term planning* • *Old and overloaded infrastructures* • *People (in particular older generations) not used to heat and diseases* • *People are unprepared to respond to disasters* • *People with low or no income are hard to be evacuated* • *Lack of wildfires monitoring systems* • *Lack of funds to implement CCA practices*

Identifying adaptation options

Table 5. Outputs from Exercise 2 – Gabrovo Regional Demonstrator Partners Factsheet (UMIL, 2024)

SOURCE	MAIN CHALLENGES	SOLUTIONS	EXPECTED IMPACTS	RELEVANT INFORMATION
		URBAN GREEN AREAS		
Project: Water against Climate Change. Sustainable	Water availability; Water management	Use of technologies for rainwater harvesting; New rules on urban	Lower water and energy use; lower bills; more green	Needing of effective tools for water management

water management in urban areas		planning; greater use of technologies	technologies; Stakeholders' engagement	
Project: Nature and LED based rainwater treatments	Increased demand of drinking water; droughts	Collection and use of rainwater for green areas	Less energy consumption; less impacts on health; better water efficiency	\
Article: Comprehending the multiple 'values' of green infrastructure – Valuing nature-based solutions for urban water management from multiple perspectives	Ecological degradation	Water reclamation systems	Water reuse: more water available	\
Article: Suitability pre-assessment for decoupling in-sewer captured streams to support urban blue-green climate adaptation measures	Floods; water scarcity	Water managing; water availability; food control	In sewer captured streams	1/3 of the investigated stream length appear higher medium suitable
		FOREST AND AGRICULTURE		
Article: Greenery system for cooling down outdoor spaces: Results of an experimental study	Heatwaves	More green area; cooling buildings; wellbeing; more trees	Shadowing green infrastructure	Attracting key scientific
Participant suggestion	Water scarcity; Temperatures	Pergola with less permeable plants including a monitoring station	Control weather condition; rainwater harvesting; water reuse; shadowing	Suggested NbS
Article: Tree planting: A double-edged sword to fight Climate Change in an era of megafires	Wildfires	Forest restoration	Policymakers need to do evaluations carefully	May cause problems relative to wildfires
Project : INUNDATIO - Automation of the modélisation des risques d'inondation dans les eaux d'amont des bassins	Floods; wildfires	Monitoring systems: early warning systems	Early warning system predicting of disasters; on-time reactions	Emerging plans based on monitoring, preventing actions plans in case of disasters, technical solution for prevention
Participant suggestion	High level of damage from fires; changes in biodiversity	Development of early warning systems	Effective risk management	\
Participant suggestion	Understanding Climate Change	Emergency plans based on monitoring	Risk mitigation; vulnerability analysis	\
Participant suggestion	Prevention	Novel approaches for early detection	Wildfire's prevention	\
Participant suggestion	Climate changes	Decision making tools for the forestry	Forestry improvement; prevent forest dieback	\

Participant suggestion	Wildfires	Wood sector management; fewer flammable landscapes	Forest restoration	\
Project: GIFT - Green Infrastructure for Forest and Trees	Biodiversity lost and green infrastructures destruction	Monitoring system; new policy implementation	Green system; reduce mortalities; technical improvement	Technical solution for prevention

Assessing and selecting adaptation options

Table 6. Outputs from Exercise 3 – Gabrovo Regional Demonstrator Partners Factsheet (UMIL, 2024)

NBS LIST	CRITERIA RELEVANCE: Effectiveness	Failure risk	Policy boost	Secondary beneficials	Benefit distributions	Solution Urgency	Realization cost	Maintenance cost	Community acceptability	Level of the changes	Adverse forces/Barriers
DRIVING CRITERIA	●						●	●			
Comprehending the multiple 'values' of green infrastructure – Valuing NbS for urban water management from multiple perspectives	2	3	4	3	2	5	5	3	5	5	4
Nature and LED based rainwater	3	3	3	2	4	5	2	3	4	5	4
Sustainable water management in urban areas	4	4	4	3	3	2	3	4	5	5	4
Rainwater harvesting system for irrigation with photovoltaic power supply	5	4	3	4	3	4	4	4	5	5	4
DRIVING CRITERIA		●		●			●				
Green infrastructures (GI) strategy and early warning monitoring systems (EWMS) – Map and develop the urban green infrastructures and improve rainwater harvesting and tree planting	5	2	1	5	5	4	5	4	5	5	3
Pergola with less flammable plants	2	1	1	5	2	1	3	2	5	3	1

Create a new model for the involvement of young peoples into activities for nature protection	4	3	3	5	3	2	4	1	4	4	2
Policy instruments to support green infrastructures	2	5	5	3	2	1	5	4	3	2	5
The collection and the reuse of cleaned rainwater for urban green areas	4	5	2	5	4	5	5	5	4	3	4
Green infrastructures; tree diversity; vegetation cover	5	2	2	5	4	5	4	5	4	4	3
Emerging plans based on monitoring	5	2	2	5	4	5	4	5	4	4	3

DRIVING CRITERIA

Green infrastructures (GI) strategy and early warning monitoring systems (EWMS) – Map and develop the urban green infrastructures and improve rainwater harvesting and tree planting	4	3	2	3	4	1	1	3	1	1	2
Term-vision cameras for monitoring and early prevention of forest fires and wildfires	5	5	1	4	3	4	4	2	2	1	2

DRIVING CRITERIA

Mapping of green systems	4	5	4	3	4	3	3	1	5	3	3
Rainforest harvesting and planting	2	2	3	3	4	4	2	2	4	3	4
Early warning system	5	3	4	4	4	5	4	3	5	3	4
Watering system	4	2	3	5	4	5	4	3	4	3	2

Driving criteria selected were Effectiveness, Failure risk, Secondary beneficial, and Realization costs.

Implementing adaptation actions

SUGGESTED SOLUTION: Rainwater harvesting system for irrigation with photovoltaic power supply

Table 7. Outputs from Exercise 4 (a) – Gabrovo Regional Demonstrator Partners Factsheet (UMIL, 2024)

IMPLEMENTATION STAGES	SET-UP TIME	PROJECT PHASE	COSTS	MAIN ACTORS
Assignment for design	3 months	Early	Low	Project members
Design	6 months	Early	High	Designer's company
Implementation	6 months	Middle	High	Construction company
OUTCOMES	Green city parks in the summer; lower bills for irrigation			
INDICATORS	Quantity of rainwater used for irrigation			
FUNDING & FINANCING	EU horizon project			

SUGGESTED SOLUTION: The collection and the reuse of cleaned rainwater for urban green areas

Table 8. Outputs from Exercise 4 (b) – Gabrovo Regional Demonstrator Partners Factsheet (UMIL, 2024)

IMPLEMENTATION STAGES	SET-UP TIME	PROJECT PHASE	COSTS	MAIN ACTORS
Feasibility study	2 months	Early	Low	Urban planners, Hydrologists
Design and planning	3 months	Middle	Medium	Landscape architects, engineers

Stakeholders' engagement	1 months	Middle	low	Local community, NGOs, government
Infrastructure development	6 months	Late	Hight	Construction companies, local government
OUTCOMES	Increased water retention, enhanced green urban areas			
INDICATORS	Volume of rainwater collected and re-used; area of green spaces improved			
FUNDING & FINANCING	Government grants; EU grants			

5.5.1.2. REGIONAL STAKEHOLDERS

A participative process is fundamental for the success of CC adaptations, because a collaboration with local authorities and stakeholders is needed to correctly implement NbS and let them to be accepted by the population. This chapter resumes and analyses regional stakeholders' exercises, condensing Factsheet outcomes and underlining the main aspects (negative or positive) that came out from the validation process made up by Local Councils.

Assessing Climate Risks

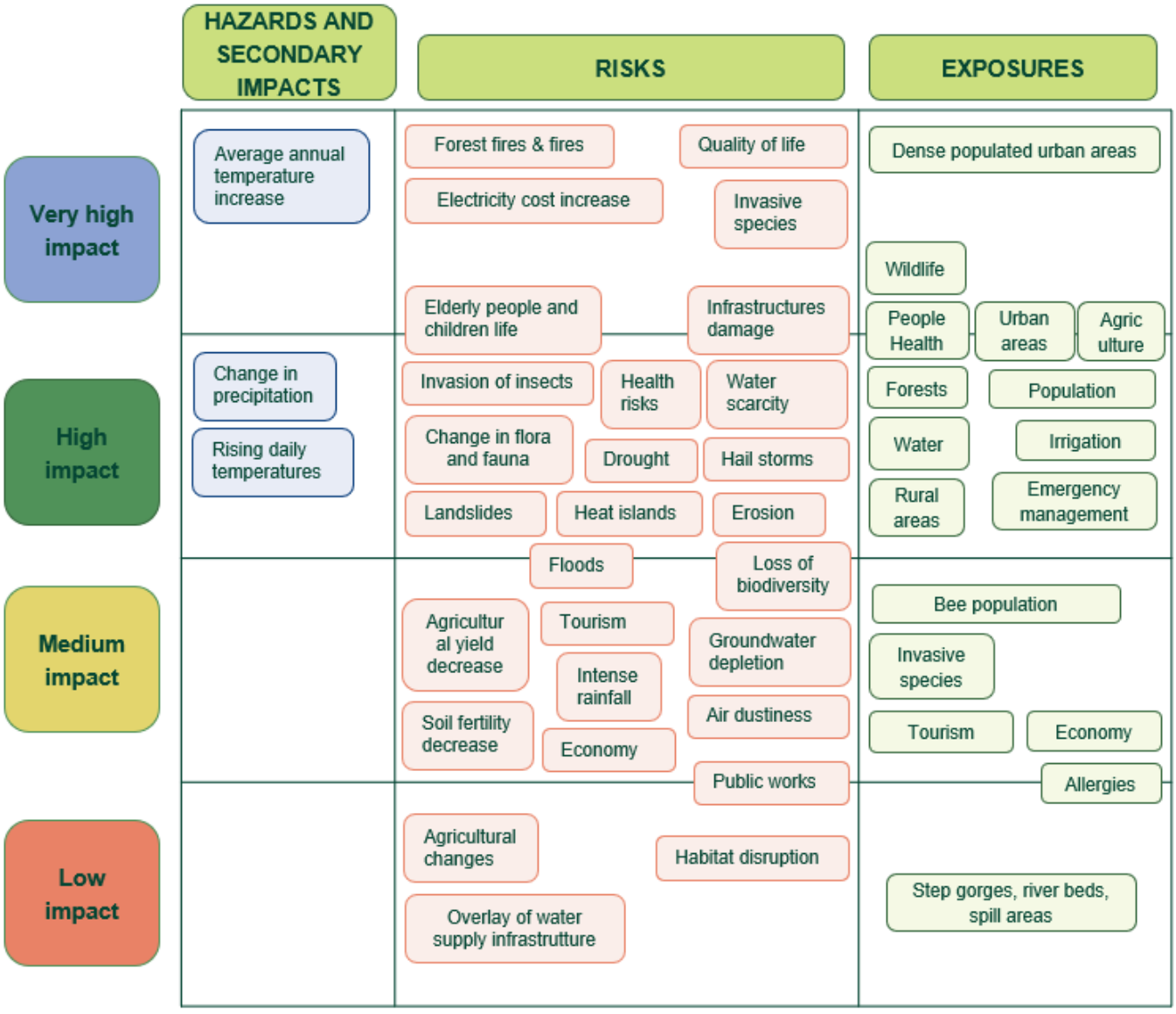


Figure 55. Outputs from Exercise 1 – Gabrovo Stakeholders Factsheet (UMIL, 2024)

Determine existing solution

Table 9. Outputs from Exercise 2A – Gabrovo Stakeholders Factsheet (UMIL, 2024)

ARTICLE/PROJECT	SOLUTION	CHALLENGES	BENEFICIAL IMPACTS
Article: Heat vs. Health: Home Office under a Changing Climate	Raising awareness about risks and health prevention	Organization; protocols that need quick responses	Avoiding exposure to risk factors; providing information to house Managers
Participant suggestion	Improved infrastructure with drinking fountains and rest areas /shadows/	Financing for constructing and maintaining infrastructure; need of additional/ alternative water sources	Decreasing of risks
Participant suggestion	Renovation of housing	Lack of financing	Lack of financing
Participant suggestion: Our planet, our future – EU edition	Adaptation of the economy and agriculture. Introducing innovations	Financing; human resources and competencies; entry into foreign economic territories	Change in people's attitude; opportunity for speculation; opportunity for new successes and achievements
Article: Climate regulation ecosystem services and biodiversity conservation are enhanced differently by climate- and fire-smart landscape management	Planting forests	Extinguishing/planting equipment, lack of Early Warning System, change in biodiversity	Raising awareness; ban on open fires; early warning system
Participant suggestion	Afforestation	Biodiversity; soils; financing	Fresh air; lack of water regime
Article: Thermal properties of green, white and other building roof materials and solar insolation	Green roofs	Lack of investment and interests	Decrease of temperatures. More oxygen
Participant suggestion	Identifying risk areas and zones	Identifying heat islands, hydrological studies for underground waters	Better quality of life; reduce economic losses
Participant suggestion	Restoration of Irrigation Systems Department	Infrastructure renovation; innovative solutions; sensors	Better access to water resources; increasing of yields; decreasing of agriculture costs
Participant suggestion	Improving management of water bodies	Proper management decisions	Better quality of service offered
Participant suggestion	Boreholes, rainwater harvesting, other innovations	Lack of financing, monitoring and control	Providing additional/ alternative resources
Participant suggestion	Increasing green areas, afforestation	Heat stress, difficult adaptation	Improving the quality of life (air quality, health effect)
Project: Improving the energy efficiency of buildings through BIM and RFID technologies	Energy efficiency of residential buildings, program for purchasing of air conditioners	Lack of coordination between public authorities, financial restrictions	Health deterioration; better buildings
Project: Integration of Climate Change adaptation into the work of local authorities	Public health and awareness campaigns	Low interest and awareness	Increased social engagement; sustainable constructions
Participant suggestion	Green areas in neighbourhoods	Expensive maintenance; vandalism	Lowering the temperatures in the areas

Project: A Method to Contrast the Impact of Extreme Precipitation: A Case Study from Central Italy	Park areas without asphalt	Financing for building and maintenance	Lowering the temperatures
Participant suggestion	Socializing of riverside territories	Spilling of river waters and destructing of built infrastructure	Recreation areas with acceptable daytime temperatures

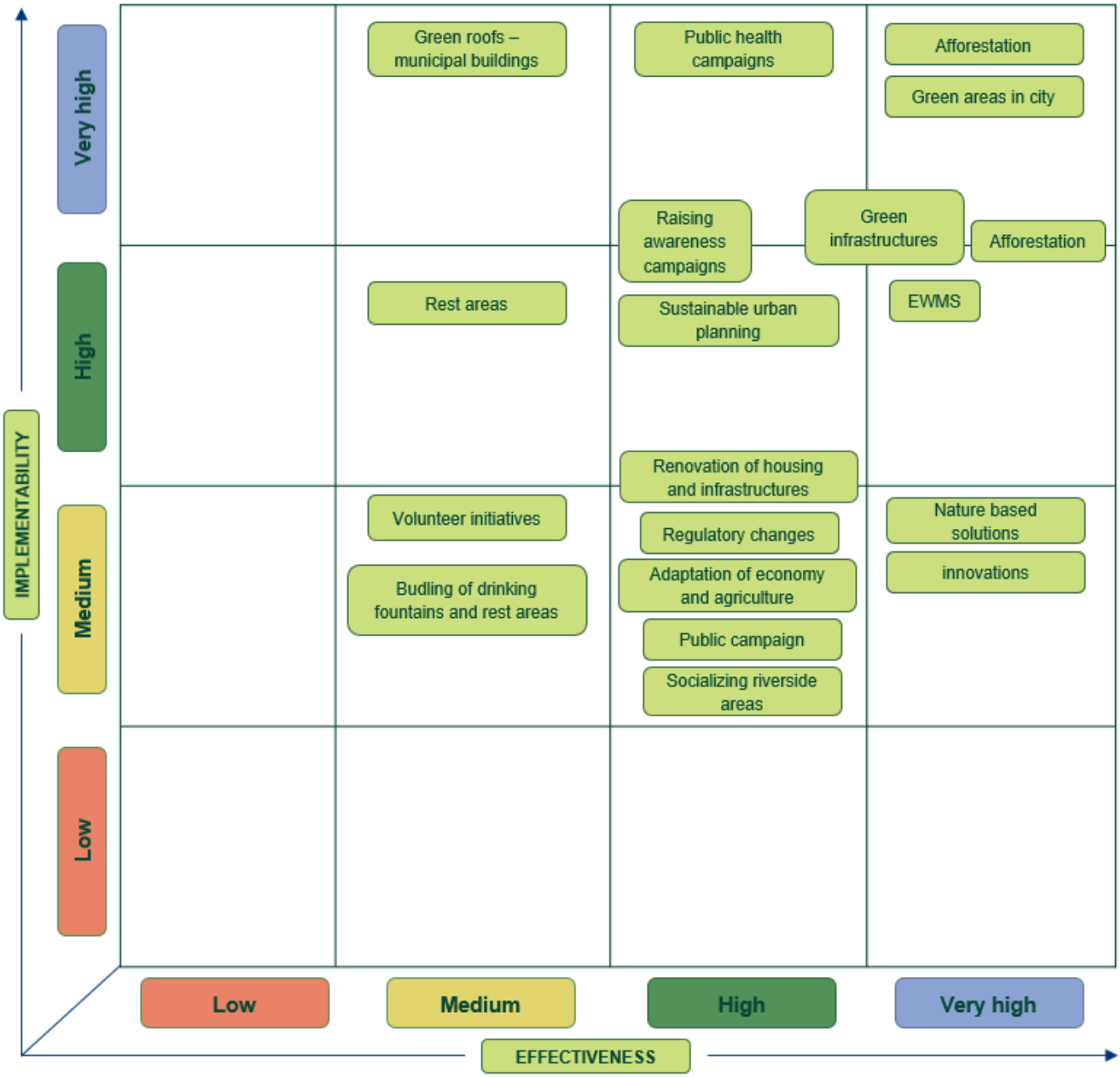


Figure 56. Outputs from Exercise 2B – Gabrovo Stakeholders Factsheet (UMIL, 2024)

Implementation suggestions

Table 10. Chosen mitigation and adaptation solution to CC by Stakeholders - Gabrovo

Raising awareness about risks
SOLUTION STRENGTHS: low costs; avoiding exposure to risks **SOLUTION WEAKNESSES:** irresponsibility of people; creating organizations **SOLUTION IMPLEMENTATION STAGES:** selection of channels for raising awareness; creating organizations; support **OUTCOMES:** raised awareness **INDICATORS:** reduced number of affected people by high temperatures **FINANCINC AND COSTS:** national and municipal budget – 25,000 euros **ACTORS INVOLVED:** municipality; media; house managers
Planting forests
SOLUTION STRENGTHS: better air quality; drought and flood management; improvement of soil fertility **SOLUTION WEAKNESSES:** financial and human resources **SOLUTION IMPLEMENTATION STAGES:** identifying suitable areas and plant species; afforestation, monitoring **OUTCOMES:** improved green infrastructure management **INDICATORS:** area/number of planted trees **FINANCINC AND COSTS:** national/ municipal budget **ACTORS INVOLVED:** municipality; Forestry Department; communities
Green roofs
SOLUTION STRENGTHS: better air quality; decrease of temperatures **SOLUTION WEAKNESSES:** lack of investment interests **SOLUTION IMPLEMENTATION STAGES:** raising awareness campaigns; demonstration project, residential buildings projects

OUTCOMES: better air quality; decrease of temperatures

INDICATORS: area of green roofs built

FINANCINC AND COSTS: external financing

ACTORS INVOLVED: municipality; private property owners; businesses

Identifying risk areas

SOLUTION STRENGTHS: management of green and blue infrastructure; reduce economic losses

SOLUTION WEAKNESSES: lack of financing

SOLUTION IMPLEMENTATION STAGES: pre-investment studies; developing methodology and relevant management system; monitoring

OUTCOMES: improved quality of life; reduced costs

INDICATORS: strategy developed; urban development plans

FINANCINC AND COSTS: national/municipal budget; EU projects

ACTORS INVOLVED: national authorities; regional Water Supply Association; municipality

Increasing green areas

SOLUTION STRENGTHS: improving life quality; decreasing health risks; lowering temperatures

SOLUTION WEAKNESSES: financing; investor interests in building vacant green areas; public dissatisfaction due to lack of parking spaces

SOLUTION IMPLEMENTATION STAGES: Mapping of existing public green areas, strategy for sustainable development of green infrastructure; designing & projects; realization (building/constructing); maintenance

OUTCOMES: increased green areas; improved management of the green infrastructure; better quality of life of the population; reducing carbon footprint and temperatures

INDICATORS: existing green areas renovated; new green areas built; area of built green zones, number of people who will benefit

FINANCINC AND COSTS: EU projects; national/ municipal budget; public – private partnerships, 7,500,000 euro

ACTORS INVOLVED: municipality, businesses, communities, stakeholders, public institutions

Improving living environment

SOLUTION STRENGTHS: improving the quality of life; sustainable constructions and residential buildings; decreasing costs

SOLUTION WEAKNESSES: lack of coordination of public authorities

SOLUTION IMPLEMENTATION STAGES: research; strategy; investments; realization

OUTCOMES: renovated buildings and infrastructure; better quality of life

INDICATORS: renovated residential buildings; renovated public buildings

FINANCINC AND COSTS: national/ municipal budget; private property owner's budget

ACTORS INVOLVED: national/ regional/ municipal authorities; private owners; businesses; communities.

5.5.2. Lapland

5.5.2.1. REGIONAL DEMONSTRATORS' PARTNERS

A participative process is fundamental for the success of CC adaptations, because a collaboration with local authorities and stakeholders is needed to correctly implement NbS and let them to be accepted by the population. This chapter resumes and analyses regional demonstrators' partners exercises, condensing Factsheet outcomes and underlining the main aspects (negative or positive) that came out from the validation process made up by Local Councils.

Preparing the ground for the adaptation

Table 11. Outputs from Exercise 1 (a) – Lapland Regional Demonstrator Partners Factsheet (UMIL, 2024)

BACKGROUND	CHALLENGES	NEEDS
Lapland is the Northernmost region in Finland and most of the population live on or above the Arctic Circle. With a population of 178,530 spread over 1,000,366 km² it is very sparsely populated. The municipalities of Enontekiö and Utsjoki have a large area with about 0,22 inhabitants per square kilometre. A part of the population belongs to the Sámi, Europe's only indigenous people. Sámi form a majority in Utsjoki municipality, and the Sámi region consists of three municipalities (Enontekiö, Utsjoki and Inari) and in the reindeer herder cooperative (Lapin paliskunta in the municipality of Sodankylä). Reindeer herding is both Finnish and Sámi livelihood. The travel and tourism industries are important for Lapland with over 800.000 travellers from abroad every year, mostly in the wintertime. There is a lot of diversity in Lapland, with almost 600 km from the southernmost border to the northernmost point.	Demographic challenges (out-migration and aging) influence the economy. Tourism is strongly centred into travel centres and is highly focused on the wintertime season. Long distances cause challenges for transportation and logistics. Land-use causes conflicts between livelihoods (forestry, reindeer herding, tourism, mining and energy production).	In travel and tourism business, the shoulder seasons of winter and especially summer and autumn time traveling needs to be developed. A general knowledge of awareness of Climate Change and adaptation to it is needed. Support for land-use conflicts is needed. The sustainability of companies needs to be enhanced.

Table 12. Outputs from Exercise 1 (b) – Lapland Regional Demonstrator Partners Factsheet (UMIL, 2024)

HAZARDS	IMPACTS	RISKS → CHALLENGES	VULNERABILITIES
• *Invasive species* • *Drought* • *Heatwaves* • *Changes in snow conditions*	• *Fishing tourism collapses and traditional fishing suffers* • *Changes in vegetation (tundra), lack of water, citizen impacts* • *Changes in behaviour of reindeers* • *Tracks and routes are weak, lack of snow to activities, effects of reindeer feeding*	• *Trying to take advances from the new species of fishes* • *Suffering reindeer winter pastures* • *Land-use conflicts* • *Rising costs of maintenance of tracks and routes. Economic challenges for tourism and reindeer herding.*	• *Citizens need to move, or they have no income.* • *Reindeer feeding increases and makes reindeer herding unprofitable* • *Increase in land-use pressure in the arctic area* • *Ageing population*

Identifying adaptation options

Table 13. Outputs from Exercise 2 – Lapland Regional Demonstrator Partners Factsheet (UMIL, 2024)

SOURCE	MAIN CHALLENGES	SOLUTIONS	EXPECTED IMPACTS	RELEVANT INFORMATION
Project: Reindeer Geographical Information System (GIS) (Porot-paikkatieto -hanke)	Herding problems related to wide areas and Climate Change	Geospatial data on reindeer herding of the region; GIS	Better management and planning of land use for herding; research improvement; data analysis; stakeholder engagement	\
Project: Global drivers, local consequences: Tools for global change adaptation and sustainable development of industrial and cultural Arctic “hubs”	To ensure long term sustainability of factors in Arctic, lack of a common framework.	Creation and implementation of regional development strategies that reconcile new economic opportunities with traditional livelihoods; increase the resilience of both new and existing industries and livelihoods against environmental, economic and political changes in the Arctic. PPGIS	Tourism models; participatory processes; planning; sustainable oriented policies; regional governance	\
Project: Toward Just, Ethical and Sustainable Arctic Economies, Environments and Societies	Coping with inequitable and unjust practices in economic and political development on the territory.	Negotiation tool for stakeholders to Arctic development; labelling standard for just/ethical regulatory standards in its JUSTscore framework.	Better evaluation of decisions; create transparency; sustainable development.	\
Project: Combining protection with other forms of land use in the natural boreal forests of the Syöte area	Inadequate regulation of nature tourism (hiking, riding, mountain biking, fishing, husky and reindeer safaris) to preserve the area's ecological value.	Eco-tourism; experience tourism; involve the local population and tourist businesses in preparing and carrying out a special ecotourism plan.	Stakeholders and citizen engagement; business development; all-year tourism; nature conservation; sustainable livelihoods.	SLO guidelines, PPGIS implementation and future scenario building conducted in relation to tourism, mining, forestry, indigenous culture and aquaculture.
Project: Climate-ADAPT	Lack of tools for monitoring and evaluating Climate Change adaptation strategies and plans	Decision making tools; policy; stakeholder engagement; monitoring.	Stakeholder engagement; monitor and adaptation strategies; shared knowledge network.	\

5.5.2.2. Assessing and selecting adaptation options

Table 14. Outputs from Exercise 3 – Lapland Regional Demonstrator Partners Factsheet (UMIL, 2024)

NBS LIST	CRITERIA RELEVANCE: Effectiveness	Failure risk	Policy boost	Secondary beneficials	Benefit distributions	Solution Urgency	Realization cost	Maintenance cost	Community acceptability	Level of the changes	Adverse forces/Barriers
DRIVING CRITERIA	●		●		●						
Public Participation Geographic Information Systems (PPGIS) - To collect and share information on Climate Change, to increase the know-how of reindeer herding and tourism.	3	3	4	3	4	2	2	2	3	2	2
Geospatial data on reindeer herding of the region - GIS	3	2	2	3	3	3	2	2	3	3	2
Negotiation tool for stakeholders to Arctic development; labelling standard for just/ethical regulatory standards in its JUSTscore framework.	3	2	2	3	3	2	2	2	2	2	2
Eco-tourism; experience tourism; involve the local population and tourist businesses in preparing and carrying out a special ecotourism plan.	2	1	1	2	2	3	2	2	3	2	2
Climate-ADAPT	4	3	5	3	4	3	2	2	3	2	2

Driving criteria selected were Effectiveness, Policy boost, and Benefit distribution.

Implementing adaptation actions

SUGGESTED SOLUTION: Climate-ADAPT

Table 15. Outputs from Exercise 4 (a) – Lapland Regional Demonstrator Partners Factsheet (UMIL, 2024)

IMPLEMENTATION STAGES	SET-UP TIME	PROJECT PHASE	COSTS	MAIN ACTORS
Preparing the ground for adaptation	2024	Early	Low	Municipalities
Assessing Climate Change risks and vulnerabilities	2025	Middle	Moderate	Municipalities and LUKE and FLTB
Identifying adaptation options	2025	Middle	Moderate	Municipalities and Luke and FLTB
Assessing adaptation options	2026	Middle	Moderate	Municipalities and Luke and FLTB
Implementing adaptation	2027	End	High	Municipalities and RCL
Monitoring and evaluating	2027-2028	End	Low	Municipalities
OUTCOMES	CC Adaptation plan for municipalities			
INDICATORS	Adaptation plans that will be published			
FUNDING & FINANCING	EU Horizon project			

5.5.2.3. REGIONAL STAKEHOLDERS

A participative process is fundamental for the success of CC adaptation strategies, because a collaboration with local authorities and stakeholders is needed to correctly implement NbS and let them to be accepted by the population. This chapter resumes and analyses regional stakeholders' exercises, condensing Factsheet outcomes and underlining the main aspects (negative or positive) that came out from the validation process made up by Local Councils.

Assessing Climate Risks

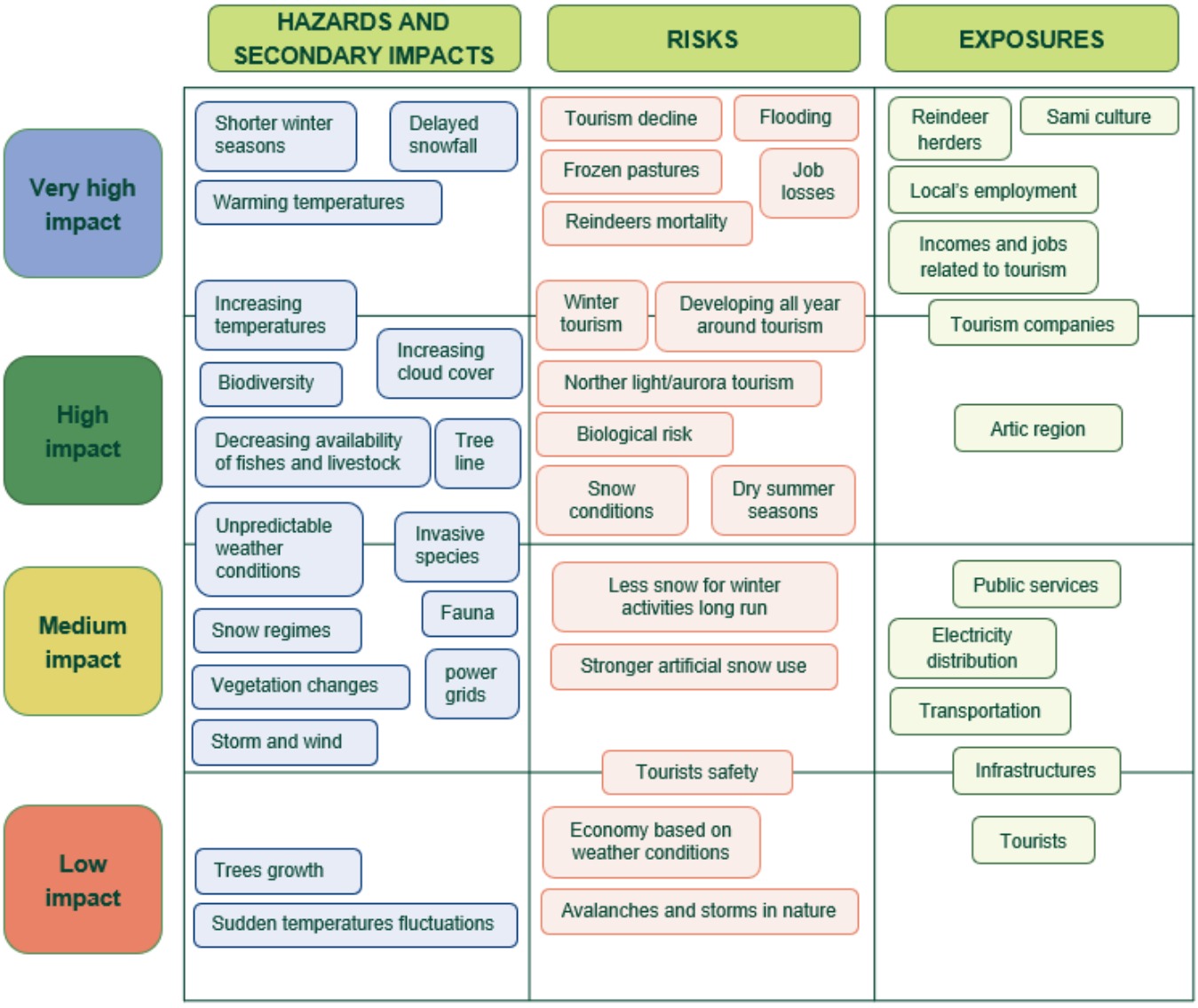


Figure 57. Outputs from Exercise 1 – Lapland Stakeholders Factsheet (UMIL, 2024)

Determine existing solution

Table 16. Outputs from Exercise 2A – Lapland Stakeholders Factsheet (UMIL, 2024)

ARTICLE/PROJECT	SOLUTION	CHALLENGES	BENEFICIAL IMPACTS
Project: OPEn-air laboratories for Nature based solutions to Manage hydro-meteorological risks	Shifting tourism towards sustainable development; snow preservation or production	Development of supplementary feeding capacity and smartphone app development; authenticity	More balanced resource use; extending the winter season regardless of natural conditions
Participant suggestion: POVAUS-project	Snow conditions data collection using a smartphone app	Expansive reindeer herding area, creating motivation for collection	Extensive reindeer herding area, creating incentives for collection
Participant suggestion: Arctic Europe Tourism Cluster	Development of year-round tourism	Strong demand for winter tourism	Year-round jobs
Article: Designing Conservation: From Sustainable Heritage to Sustainable Tourism (and vice versa)	Development of culture-based tourism	Respecting culture and not appropriating it	Keeping cultural heritage alive
Participant suggestion: Article: Climate change increases the risk of facing difficult winters in reindeer herding	Development of supplementary feeding capacity for reindeer herding	Food costs	Reduction in reindeer mortality, reindeer do not suffer from hunger
Participant suggestion: Restoration projects supporting biodiversity	Restoration of natural ecosystems	New forest management techniques	Stronger carbon sinks and increased biodiversity
Project: Conservation of Ylläs-Aakenus Western Taiga Forest Area in Lapland	Restoration of natural ecosystems	Protection alone is not enough; Climate Change alters ecosystems	Facilitates the movement and adaptation of nature to Climate Change
Participant suggestion: Tundra restoration programs	Restoration of mountain tundra nature	Lack of restoration methods for tundra areas	Preserving tundra landscapes and restoring ecosystem balance
Participant suggestion. Interreg Aurora Arctic Fox Project, artificial nests for the gyrfalcon	Restoration of peatlands and wetlands	Species adaptation to human-created solutions	Enhancing species' chances of survival amid Climate Change-induced changes
Participant suggestion: Wetland and peatland restoration projects	Management of the shifting tree line	Integrating agriculture and restoration	Improving carbon sinks and the functionality of aquatic ecosystems
Participant suggestion: local forest management projects and programs	Many community-based solutions in the table sound relevant	Forest management and reduction of grazing areas	Preserve tundra landscapes and reindeer herding areas
Participant suggestion:	Use local forests for cultural significance, tourism, hunting, and not only supply raw material to paper industry/construction	Community-owned Forest associations (yhteismetsä) still seem to log like it is 1952.	Traffic accidents reduction; hunting and fishing tourism; supply for handicrafts

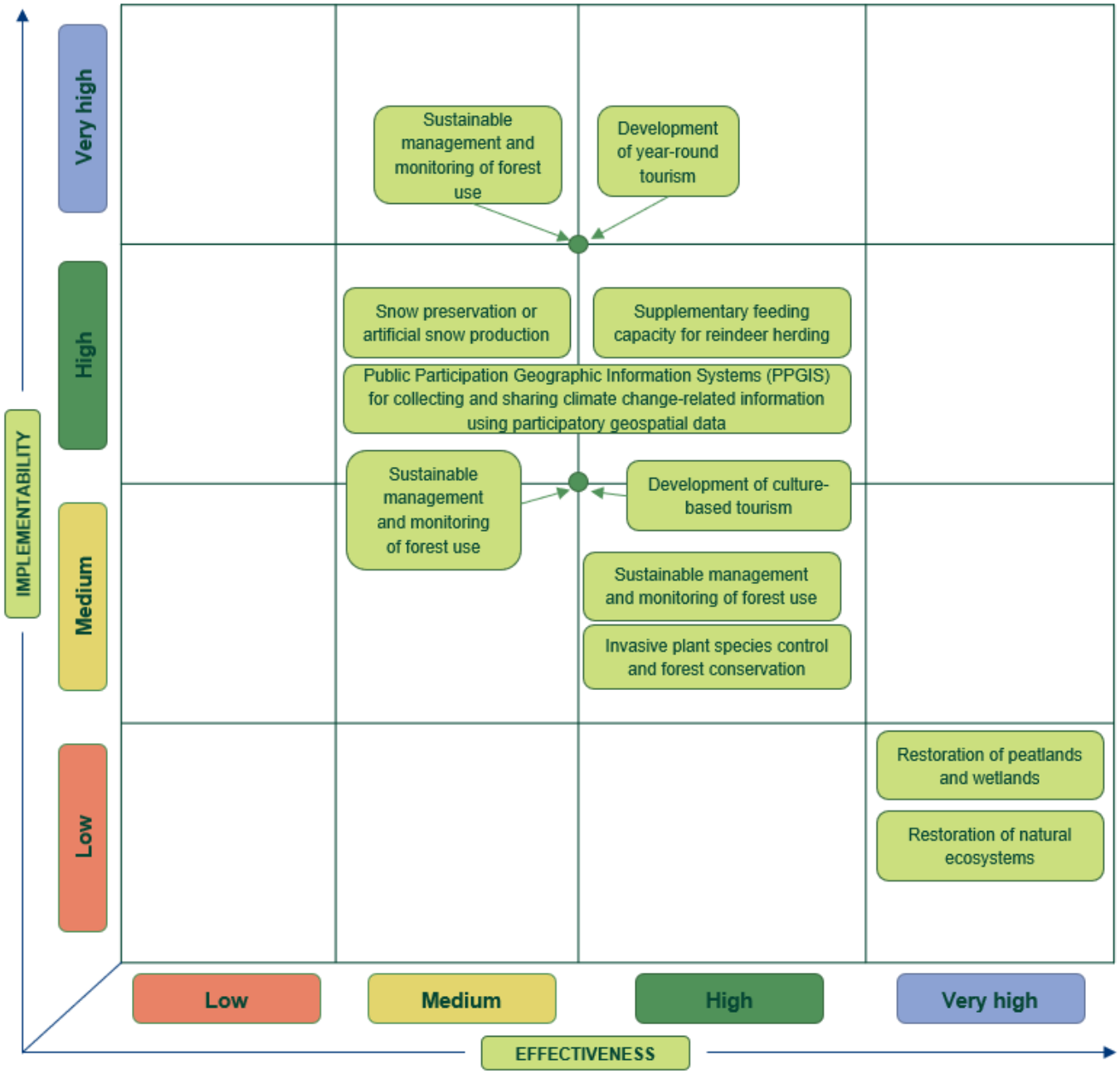


Figure 58. Outputs from Exercise 2B – Lapland Stakeholders Factsheet (UMIL, 2024)

Table 17. Chosen mitigation and adaptation solution to CC by Stakeholders - Lapland

Public Participation Geographic Information Systems (PPGIS)
SOLUTION STRENGTHS: the tool can assist in monitoring impact and help to understand adaptation and solutions; base information is already obtained **SOLUTION WEAKNESSES:** usability; effectiveness; the challenge is how to engage a broad group in reporting data **SOLUTION IMPLEMENTATION STAGES:** integrate local Knowledge and PPGIS structure; PPGIS dissemination **OUTCOMES:** \ **INDICATORS:** \ **FINANCINC AND COSTS:** \ **ACTORS INVOLVED:** \
Forest restoration and management, selective timbering
SOLUTION STRENGTHS: maintains a specific habitat type; investing in strengthening forest carbon sinks **SOLUTION WEAKNESSES:** high employment demand; ethical concerns (nature natural change or forestry practices?), political climate links; action and maintenance costs. **SOLUTION IMPLEMENTATION STAGES:** evaluation of forest use practices; planning of new methods **OUTCOMES:** \ **INDICATORS:** forest-related indicators, such as restored tundra area **FINANCINC AND COSTS:** first trial with project fundings **ACTORS INVOLVED:** municipalities, private forest owners, Metsähallitus (administrator of state-owned land and waters
Development of year-round tourism to reduce dependence on the winter season and create year-round jobs
SOLUTION STRENGTHS: great opportunities to provide benefits year-round; already known and attempted; long-term and extensive benefits: numerous businesses, employees, and local communities; customers' safety

SOLUTION WEAKNESSES: population acceptance; tourism reaction unknown

SOLUTION IMPLEMENTATION STAGES: Idea generation and product development for tourism services; marketing and sales

OUTCOMES: \

INDICATORS: number of tourists and usage of services

FINANCINC AND COSTS: businesses, regions, and public support is needed, for example, through projects

ACTORS INVOLVED: businesses, tourism regional organizations, transportation companies, regional authorities, municipalities.

5.5.3. Piedmont

5.5.3.1. REGIONAL DEMONSTRATORS' PARTNERS

A participative process is fundamental for the success of CC adaptations, because a collaboration with local authorities and stakeholders is needed to correctly implement NbS and let them to be accepted by the population. This chapter resumes and analyses regional demonstrators' partners exercises, condensing Factsheet outcomes and underlining the main aspects (negative or positive) that came out from the validation process made up by Local Councils.

Preparing the ground for the adaptation

Table 18. Outputs from Exercise 1 (a) – Piedmont Regional Demonstrator Partners Factsheet (UMIL, 2024)

BACKGROUND	CHALLENGES	NEEDS
In Piedmont, the unique combination of climatic conditions contributes to the rich biodiversity and productive agricultural practices. 36% of the territory is devoted to agriculture. The most important agricultural products are cereals (e.g., rice, corn) and livestock. Piedmont is experiencing an increase in temperature and a change in the precipitation patterns. Some of the related aspects are: intense rainfall events in the spring-summer period; rising temperatures; less snow in the mountains, glaciers reduction, sudden and intense weather events in summer.	Effective management of water resources for irrigation is crucial in the face of climate hazards. As longer periods of drought, especially during the growing season, become more common, efficient water management and use will be essential. The increasing risk of drought can lead to significant economic losses and depletion of groundwater reserves. Traditional crops and cultivation methods, without adaptation to the new climate conditions, are becoming increasingly challenging. Reduced snow storage in the mountains in winter and stress on crops in the summer period. Management of water excess/flooding during rainfall events and later during irrigation operations. Rice cultivation: sudden temperature changes and low water availability. Ground water: difficulty in recharge due to a lack of water availability and conflict of interest among who needs water.	Improve the efficiency in the use of water resources when they are available. Considering traditional and unconventional water storages to sustain agricultural activities during drought periods. A model channel network to improve the management of the water distribution for irrigation is needed, as for the knowledge of the water resource. Better water resource management: create forecasting models of temperature and water availability that can be used by both the consortia and farmers, managing the resource appropriately and to create a network between these two players.

Table 19. Outputs from Exercise 1 (b) – Piedmont Regional Demonstrator Partners Factsheet (UMIL, 2024)

HAZARDS	IMPACTS	RISKS → CHALLENGES	VULNERABILITIES
• *Rising temperatures* • *Changing in precipitation patterns* • *Water scarcity*	• *Droughts* • *Crop season lag* • *Less snow* • *Less ground and surface water*	• *Lower crop yields and crop loss* • *Infrastructure stress* • *Water management during irrigation periods* • *Decreasing of biodiversity* • *Water storage difficulty* • *Water conflicts among sectors*	• *Field crops production* • *Water intense crops water demanding (e.g., traditional rice cultivation)* • *Few large reservoirs to accumulate water*

• *Water excess*	• *Flooding damages* • *Glaciers melting*	• *Higher maintenance costs* • *Economic losses from agriculture* • *Biodiversity decrease* • *Fragmentation of rice fields*	• *Irrigation infrastructure and systems are not easily adaptable* • *Wells, springs and soils health due to low groundwater availability*

Identifying adaptation options

Table 20. Outputs from Exercise 2 – Piedmont Regional Demonstrator Partners Factsheet (UMIL, 2024)

SOURCE	MAIN CHALLENGES	SOLUTIONS	EXPECTED IMPACTS	RELEVANT INFORMATION
Project: Managing crop water saving with enterprise services	Integrated and innovative water management solution to individual and collective actors of irrigated agriculture	Information platform targeting mainly the needs of water procurement and management agencies to facilitate planning of irrigation water resources	Meteorology; water management; agriculture; irrigation; satellite technology; forecasting; services to farmers; support efforts to reduce water use; monetary and energy costs saving	Information platform to facilitate planning of irrigation water resource (e.g., irrigation districts), using a GIS Decision Support System
Project: Farming Tools for external nutrient Inputs and water Management	Effective and efficient monitoring; achieve optimum crop yield and quality; sustainability; agricultural resources management	Developing innovative and new farm capacities to help the intensive farm sector optimize their external inputs (nutrients, water management/ use)	Irrigation; smart sensors; GIS; participatory processes; water management; bridging sustainable crop production; fair economic competitiveness	FATIMA service considers the economic, environmental, technical, social and political dimensions in an integrated way
Project: Assuring water Availability in agriculture under changing CLIMAte conditions	Water shortage; floods and droughts	Innovative technologies, strategies and measures for agricultural and horticultural companies to adapt to declining water availability	Water recharge and quantity; resource access and usability; optimizing water use and preventing waste; farming and agriculture; knowledge sharing; updated maps and data	Tools and technology for the agricultural sectors to increase water availability and strengthen the resilience of water landscape to adapt to the effects of Climate Change
Project: Tool for regional-scale assessment of groundwater storage improvement in adaptation to Climate Change (TRUST)	Degradation of ground water	Innovative hydrological model to estimate the flows of the rivers that feed the aquifer in the study area and the variations of river flows induced by future climate scenarios (CMCC models)	Enhance water quantity and recharge; improve resource accessibility and usability; optimize water use; support agriculture and farming; share knowledge; develop new maps and data	The project aims to identify adaptation measures based on artificial aquifer recharge to mitigate the impacts of drought and water scarcity
Participant suggestion	Water management	An application for water management that optimizes water distribution for rice fields and simulates the flow through canal networks from the source to the fields	Better water use; prevent conflicts	By using forecast data to balance water demand with availability

Participant suggestion	Water excess/flooding	Water storage/ better hydraulic infrastructure; seasonal adaptation	Less Crop damage	Crops insurances
Participant suggestion	Water scarcity	Define most water-demand farm with DST	Reducing water demand	\
Participant suggestion	Irrigation's requirement	Optimize water management; crops that requires less water	Reducing water losses; decreasing ground water level	Knowledge of ground/surface water level

Assessing and selecting adaptation options

Table 21. Outputs from Exercise 3 – Piedmont Regional Demonstrator Partners Factsheet (UMIL, 2024)

NBS LIST	CRITERIA RELEVANCE: Effectiveness	Failure risk	Policy boost	Secondary beneficials	Benefit distributions	Solution Urgency	Realization cost	Maintenance cost	Community acceptability	Level of the changes	Adverse forces/Barriers
DRIVING CRITERIA	●					●	●				
Develop a tool for water management - Decision-support (DS) tool to mimic water availability and anticipate critical scenarios for farmers and consortia.	5 5	1 2	4 3	3 2	5 3	4 4	4 2	4 3	2 3	3 4	4 1
Improve new cultivation method for rice, to reduce the water usage for irrigation	4	3	5	2	1	4	2	5	4	5	1
Innovative hydrological model to estimate the flows of the rivers that feed the aquifer in the study area and the variations of river flows induced by future climate scenarios	2	2	1	3	3	3	4	4	1	2	3
Innovative technologies, strategies and measures for agricultural and horticultural companies to adapt to declining water availability	2	2	2	5	3	5	3	3	3	2	3
Information platform targeting mainly the needs of water procurement and management agencies to facilitate planning of irrigation water resources	5	1	3	3	4	3	4	3	4	3	4
DRIVING CRITERIA	●							●		●	

Water storage & reservoir	5	1	1	4	2	3	5	5	1	5	4
Less water demanding crops	3	2	1	2	3	3	3	2	3	4	4

Driving criteria selected were Effectiveness, Solution urgency, Realization costs, Maintenance costs and Level of the change.

Implementing adaptation actions

SUGGESTED SOLUTION: Develop a tool for water management - Decision-support (DS) tool to mimic water availability and anticipate critical scenarios for farmers and consortia.

Table 22. Outputs from Exercise 4 (a) – Piedmont Regional Demonstrator Partners Factsheet (UMIL, 2024)

IMPLEMENTATION STAGES	SET-UP TIME	PROJECT PHASE	COSTS	MAIN ACTORS
Daily updating	2-3 months	First part	Low	Farms, irrigation consortium, regional authorities
Data collection: retrieve old data available and buy and install new sensor for monitoring	6 months	Early stage	Medium	University
Sharing data/aims among stakeholders	3 months	First part	Medium	Irrigation consortium
Creation of a model for forecasting available water to distribute	6 months	Mid-stage	Medium	University
Creation of a model of the irrigation network	6 months	Mid-stage	Medium	University
Sharing data among stakeholders weekly/monthly during the irrigation season	1-2 year	Final stage	Low-Medium	Irrigation consortium, regional authorities, farmers
OUTCOMES	Efficient use of water for irrigation, better water management			

INDICATORS	Water availability, water management, irrigation, water utilization
FUNDING & FINANCING	EU Horizon Project

5.5.3.2. REGIONAL STAKEHOLDERS

A participative process is fundamental for the success of CC adaptations, because a collaboration with local authorities and stakeholders is needed to correctly implement NbS and let them to be accepted by the population. This chapter resumes and analyses regional stakeholders' exercises, condensing Factsheet outcomes and underlining the main aspects (negative or positive) that came out from the validation process made up by Local Councils.

Assessing Climate Risks

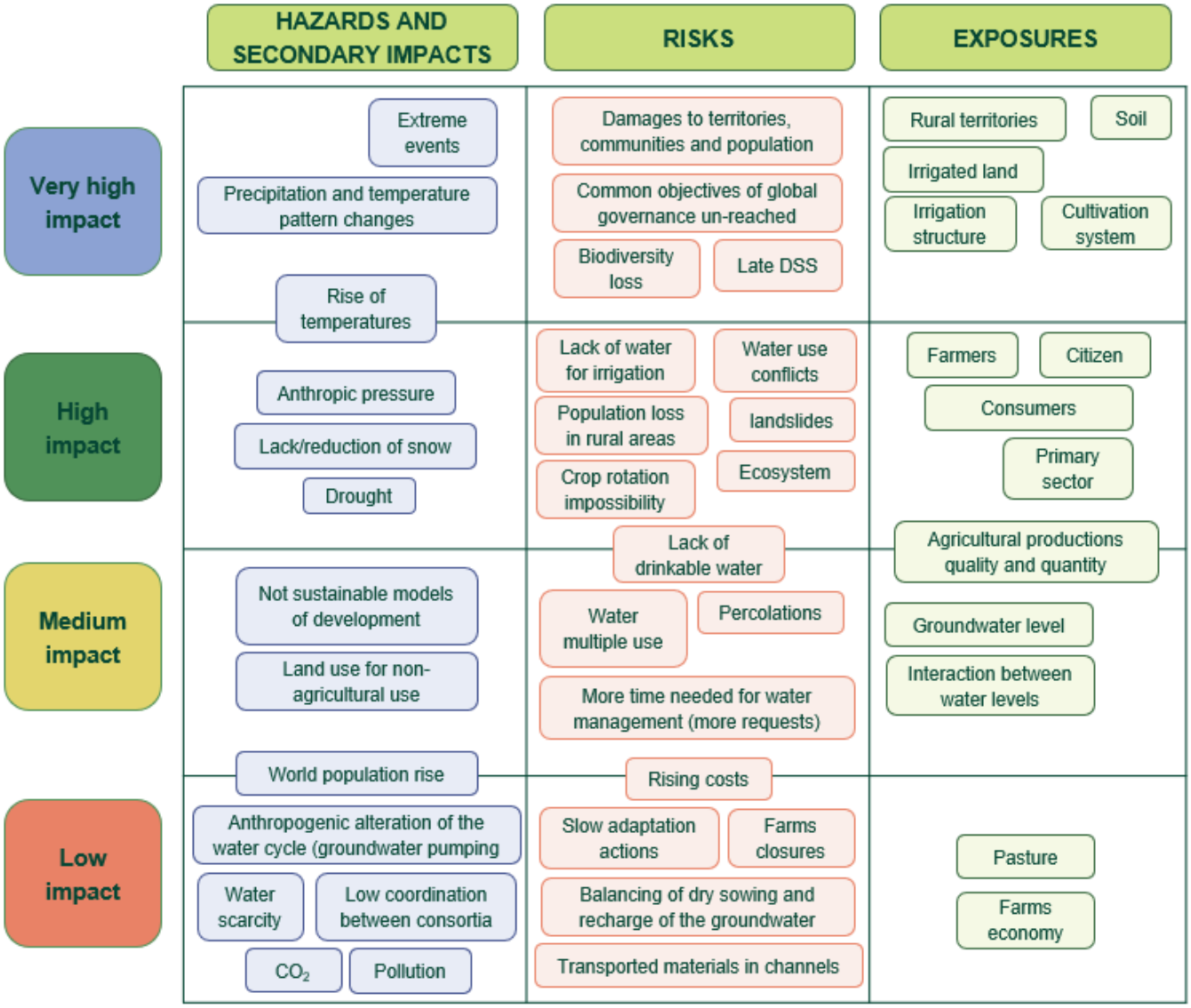


Figure 59. Outputs from Exercise 1 – Piedmont Stakeholders Factsheet (UMIL, 2024)

Determine existing solution

Table 23. Outputs from Exercise 2A – Piedmont Stakeholders Factsheet (UMIL, 2024)

ARTICLE/PROJECT	SOLUTION	CHALLENGES	BENEFICIAL IMPACTS
Participant suggestion	Training and education of citizens, and their awareness	Fake news; lack of knowledge and information	Awareness on CC; correct evaluation of Climate Change consequences
Participant suggestion	Data sharing and tools for irrigation	Difficulties in having useful information from different subjects	Irrigation efficiency improvement water reduction
Participant suggestion	Coordinated Governance	Administrative and legal simplification	Water management improvement
Participant suggestion	New crops and new agriculture procedures	Research on genomes; new techniques for cultivation	Water need reduction; growth of competitivity and income for farmers
Participant suggestion	Innovative irrigation methods	New ICT and TOOL supported methodologies	Water saving; competitivity growth
Participant suggestion	More resilient cities with innovative methods (NbS)	Non-agricultural land use	Increased percolation and drainage
Participant suggestion	Coordinated management of water resources within the consortium at a basin scale	Multiple use of the water resource	Greater efficiency of resource allocation between different uses
Participant suggestion	Drought contingency plan	Know-how ready in the event of an (increasingly frequent) lack of water	Allocating water proportionally to all companies within the consortium in the event of drought
Participant suggestion	Increased infrastructure maintenance costs	Damage due to fluctuations between the presence and absence of water within the network; transportation of materials	Reduction of management costs by the consortium borne by users
Participant suggestion	More reservoirs	Drought	Water available when absent

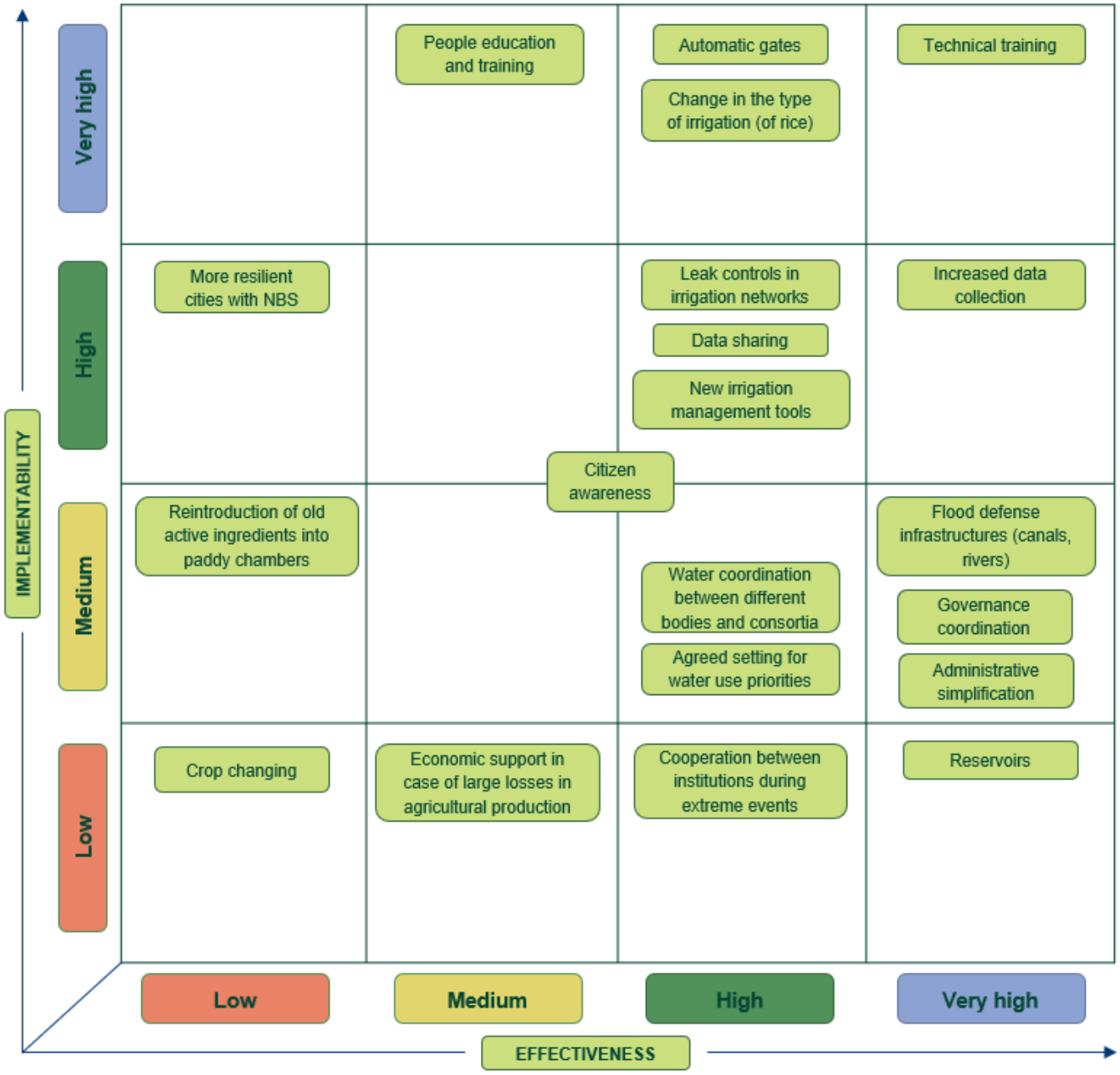


Figure 60. Outputs from Exercise 2B – Piedmont Stakeholders Factsheet (UMIL, 2024)

Implementation suggestions

Table 24. Chosen mitigation and adaptation solution to CC by Stakeholders - Piedmont

Innovation in crops irrigations techniques
SOLUTION STRENGTHS: water better use; water management **SOLUTION WEAKNESSES:** changes are hard to be accepted **SOLUTION IMPLEMENTATION STAGES:** \ **OUTCOMES:** competitive productions – Water saving **INDICATORS:** n° of hectares changed; water volume saved **FINANCINC AND COSTS:** \ **ACTORS INVOLVED:** farmers; ICT; universities; SMEs
Develop a tool for water management
SOLUTION STRENGTHS: water correct management for final users **SOLUTION WEAKNESSES:** \ **SOLUTION IMPLEMENTATION STAGES:** \ **OUTCOMES:** competitive productions; water saving **INDICATORS:** n° of hectares changed; water volume saved **FINANCINC AND COSTS:** \ **ACTORS INVOLVED:** farmers; SMSs; regional administration; university
Coordinated management of the resource within the consortium at basin scale
SOLUTION STRENGTHS: better distribution of water according to the priorities of use **SOLUTION WEAKNESSES:** difficult coordination, conflict of interest **SOLUTION IMPLEMENTATION STAGES:** agreements between stakeholders; creation of a database; real time sharing

OUTCOMES: greater knowledge about the distribution of water resources among all the entities involved

INDICATORS: water quantity IN and OUT

FINANCINC AND COSTS: purchase and maintenance of water quantification instrumentation

ACTORS INVOLVED: basin entities.

5.5.4. Râu Sadului

5.5.4.1. REGIONAL DEMONSTRATORS' PARTNERS

A participative process is fundamental for the success of CC adaptations, because a collaboration with local authorities and stakeholders is needed to correctly implement NbS and let them to be accepted by the population. This chapter resumes and analyses regional demonstrators' partners exercises, condensing Factsheet outcomes and underlining the main aspects (negative or positive) that came out from the validation process made up by Local Councils.

Preparing the ground for the adaptation

Table 25. Outputs from Exercise 1 (a) – Râu Sadului Regional Demonstrator Partners Factsheet (UMIL, 2024)

BACKGROUND	CHALLENGES	NEEDS
The conservation of grassland biodiversity is based on ameliorative measures of removing or diminishing the action of the limiting factors. The meadow must be treated like any arable crop, if we want economic efficiency from this way of agricultural use. In order to establish appropriate improvement measures and technologies, we need to establish in advance precisely the causes of the degradation of the meadow, because the application of any measure to improve the vegetation cover without removing the causes of its degradation, will be efficient only on short term. Râu Sadului: is a small community in Sibiu County, Romania, in the Carpathian Mountains, located at altitudes between 1500-1800 m asl. It has a population of 514 inhabitants as of 2021, and the main occupations are agriculture, forestry and tourism. Râu Sadului meadows are located in the protected area Frumoasa (Natura 2000 and Birds Directive). Climate: Annual temperature is expected to rise to 10.2 °C in Sibiu and 8.3 °C in Paltinis region due to CC. A decrease in both snow and rain is expected. Agriculture: Heat stress, water shortages, and decreased forage productivity from drought conditions.	Meadows's degradation is the main challenge in focus, associated with economic losses for farmers, depopulation and abandonment of traditional farming activities, loss of biodiversity, changes in vegetation patterns and composition due to Climate Change. Further challenges derive from the nature protection regulations (e.g., thriving of brown bear population attacking animals and humans), limited possibilities for intervention deriving also from CAP subsidies conditionalities. Reduction in snow cover and a shorter snowy period in winter. Droughts can have an average duration of almost four weeks, posing a high risk to agriculture. Higher rates of evapotranspiration, leading to soil salinization and further biodiversity loss. The health, productivity, and reproductive rates of farm animals suffer. Meadow quality will decrease, and valuable species will be lost.	Identification of innovative solutions that can meet both economic needs of local population and nature protection goals, funding to apply research results, support for governance and guidance for protected sites management, mitigation of trade-offs between nature protection regulations and human safety and survival in this type of environment. Stakeholder involvement to improve operational agriculture monitoring from local to government levels. Farming adaptation training pack and demonstration workshops on farms.

Table 26. Outputs from Exercise 1 (b) – Râu Sadului Regional Demonstrator Partners Factsheet (UMIL, 2024)

HAZARDS	IMPACTS	RISKS → CHALLENGES	VULNERABILITIES
• *Extreme weather conditions* • *Heavy rainfalls* • *High temperatures* • *Evapotranspiration* • *Snow and precipitation decrease* • *Depopulation* • *Broun bear attacks*	• *Soil erosion* • *Droughts* • *Evapotranspiration* • *Biodiversity loss* • *Soil salinization* • *Shorter snowy period in winter* • *Loss of traditions*	• *Abandoned lands* • *Fewer animals* • *Economic losses* • *Forest wildfires* • *Species competition and loss of biodiversity* • *Soil erosion* • *Meadows's degradation* • *Dangers to livestock* • *Depopulation of rural and mountain areas* • *Protected areas limited intervention possibilities*	• *Lack of income predictability* • *Land use changes or abandonment* • *Missing skills for land management* • *Limited resources and knowledge for adaptation practices* • *Meadow quality and diversity* • *Loosing small farmers and traditions* • *Degradation of mountain terrains* • *Unsafe environment*

Identifying adaptation options

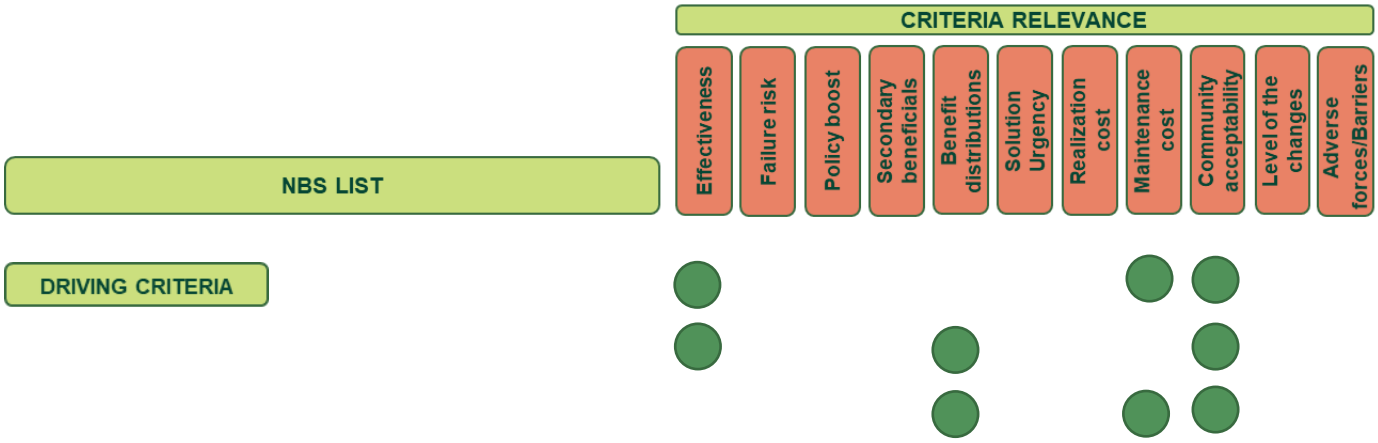
Table 27. Outputs from Exercise 2 – Râu Sadului Regional Demonstrator Partners Factsheet (UMIL, 2024)

SOURCE	MAIN CHALLENGES	SOLUTIONS	EXPECTED IMPACTS	RELEVANT INFORMATION
Project: Demonstrating cooperative approach for good management of Natura 2000 grasslands at landscape scale in Transylvania	To encourage continued good management by enlightened agri-environment and cooperative management schemes, linked also to marketing and economic viability	Management techniques, landscape-scale cooperation, well-targeted Regional Development Programme payments (especially agri-environment payments), and development of new products/better marketing	Improving local knowledge about biodiversity; management of protected grasslands; better soil for farming; food security; stakeholder engagement	Hay meadow and arable land ownership and management parcels are extremely small, typically between 0.2-0.5 ha. However, these small-scale mosaic areas of cultivated land are rich in habitats and species, which are threatened by changes of land use. This unique landscape is dependent on continued traditional management by small-scale farming communities, and on cattle farming to maintain hay meadows
Project: Managing land in common, a sustainable model for conservation and rural	Conflict between nature conservation and economic activities	Management schemes based on conservation outcomes on common land	Dissemination and transfer of the management actions; conservation on common land; and the	Main objective is to improve the conservation status of three priority habitats, while reducing the social conflicts

development in Special Areas of Conservation			methodology of monitoring using drones; soil conservation; habitat conservation	originating from the use of land for grazing by implementing integrated result-based management schemes
Article: Core principles for successfully implementing and upscaling Nature-based solutions	Standards for successful implementation of NbS	Framework and stakeholder importance	Better efficiency of the NbS implemented	
Article: Mustering the power of ecosystems for adaptation to Climate Change	Climate variability resulting in uncertainty about securing end-of-season grazing	Grassland management; fertilized hay meadows	Water quality regulation; carbon storage; erosion control; biodiversity conservation; aesthetic value	
Participant proposal: the research carried out by local partners	Increase the nutritional value of the meadows while maintaining biodiversity and protected species	Customized, environmentally friendly solutions, using soil amendments, bio stimulants, beneficial bacteria and organic fertilizers	Regeneration of meadows, higher productivity	ICDM Cristian Project Partner
Participant proposal	Meadow deterioration	Meadow regeneration using inputs allowed in organic farming in Special Areas of Conservation	Meadow	
Article: Expansion of the Invasive Plant Species Reynoutria japonica Houtt in the Upper Bistrit, a Mountain River Basin with a Calculus on the Productive Potential of a Mountain Meadow	Invasive plant species	Mountain meadow restoration	More food for animals; local plant reintroduction; face non-native species; economical losses quantification; mapping plant species	Many invasive plant species use interactions with their anthropic environment as a propagation factor and benefit from Climate Changes, which have become accentuated in the last decade. The way such species interact with Climate Changes, as well as their high specific ecological plasticity, gives them a consistent advantage over native plant species

Assessing and selecting adaptation options

Table 28. Outputs from Exercise 3 – Râu Sadului Regional Demonstrator Partners Factsheet (UMIL, 2024)



Tailored, sustainable solutions for restoring mountain meadows - Scanning the soil with drones, mowing, mulching, overseeding, fertilizing and grazing with sheep and cows.	4 4 4	3 3 2	2 2 1	3 3 2	5 3 1	3 3 3	3 3 3	3 1 2	5 5 5	4 1 4	1 1 4
Analysis of existing vegetation and nutritional value (protected species), Soil analysis – pH, and nutrients content.	3 3	2 3	3 3	3 3	3 3	3 3	1 1	1 1	4 4	5 1	1 1
Removal of anthills, weeds and woody vegetation that is not protected.	4 4	2 2	2 2	4 4	4 4	4 4	4 3	3 2	4 4	5 3	2 2
Soil amendments to support the growth of existing species with good nutritional value and nitrogen fixing (minerals allowed in organic farming) for the meadows situated in protected areas and fertilisers for conventional farming the grasslands outside protected areas	4	2	3	5	5	4	4	2	4	5	2
Overseeding with local species that are already present on the plot for the meadows situated in protected areas and with new cultivars with high nutritional value and better drought tolerance on the grasslands outside protected areas	3	4	3	4	4	3	4	2	3	4	2

Organic/ foliar fertilizers, bio stimulants and bacteria to support humus formation in soil for the meadows situated in protected areas and fertilisers for conventional farming the grasslands outside protected areas	4	2	3	5	5	4	4	2	4	5	2
Integrated meadow management, including mowing, mulching, overseeding, fertilizing and alternate grazing and mowing	5 4	2 2	3 3	4 4	4 4	4 4	3 4	3 3	4 3	4 4	2 2
Empowering the community – how to meet human needs with respect for nature	3	5	3	3	3	3	3	3	3	3	3

DRIVING CRITERIA

Managing land in common, a sustainable model for conservation and rural development in Special Areas of Conservation	5	2	2	4	5	4	5	2	5	5	3
Mountain meadow restoration with qualitative grass species	3	1	2	3	4	5	4	3	4	2	3
Sustainable solutions for fertilizing mountain meadows- Using proper base and foliar fertilizers for each mountain area based on specific environment conditions	3	2	1	2	4	3	3	3	2	1	2
Involving community in and share knowledge regarding CCA and nature risks	4	1	2	4	2	3	2	3	5	4	2

Driving criteria selected were Effectiveness, Benefit distribution, Failure risk, Maintenance costs and Community Acceptability.

Implementing adaptation actions

SUGGESTED SOLUTION: Integrated meadow management, including mowing, mulching, overseeding, fertilizing and alternate grazing and mowing.

Table 29. Outputs from Exercise 4 (a) – Râu Sadului Regional Demonstrator Partners Factsheet (UMIL, 2024)

IMPLEMENTATION STAGES	SET-UP TIME	PROJECT PHASE	COSTS	MAIN ACTORS
Scanning and assessment of existing vegetation	2 months	first year	medium	Râu Sadului Mayoralty, ICDM research (local project partners)
Soil analysis	2 months	first year	medium	Holland Farming
Product specifications to achieve targeted results according to plant needs (type and amount of amendment to be applied)	1 month	second year	low	ICDM
Procurement of amendments	1 month	second year	medium	Râu Sadului Mayoralty/ Holland Farming
Soil preparation	2 months	second year	medium	Râu Sadului Mayoralty
Application of amendments	1 month	second year	low	Râu Sadului Mayoralty
Monitoring of effects	3 years	second year	low	Râu Sadului Mayoralty ICDM
OUTCOMES	Higher yields improved nutritional value, higher grazing capacity of the meadow, improved resilience to Climate Change.			
INDICATORS	Biomass output, biomass composition, number of animals allowed on the meadow			
FUNDING & FINANCING	EU funded projects (like MountResilience), labour in-kind contribution of local people			

SUGGESTED SOLUTION: Management schemes based on conservation traditions and outcomes on mountain areas

Table 30. Outputs from Exercise 4 (b) – Râu Sadului Regional Demonstrator Partners Factsheet (UMIL, 2024)

IMPLEMENTATION STAGES	SET-UP TIME	PROJECT PHASE	COSTS	MAIN ACTORS
Prepare mountain terrain for overseeding	Depending on the quality of the terrain, after the winter season	Beginning	Medium	HFA/ICDM/ Râu Sadului
Soil samples to analyses nutrient potential of the soil	Before spring and autumn season/ throughout the project	Beginning	Medium	HFA/ICDM/ Râu Sadului
Drone scanning	Before spring and autumn season/ throughout the project	Middle	Medium	HFA/ICDM/ Râu Sadului
Overseeding with qualitative grass seeds	Before spring and autumn season/ throughout the project	Middle	Medium	HFA/ICDM/ Râu Sadului
Plan a workshop to address the late technology related to drone scanning, to monitor meadow grass cover and cross-species competitiveness	6 months	Late part	Approximatively 4K Euro for organization & training & transportation costs	Team members, Municipalities, Universities
Plan a workshop for farmers and experts to address their issues regarding meadow and soil quality	6 months	Late part	Low	Team members, Stakeholders experts, Universities, Farmers
OUTCOMES	Connect communities, Farmers, NGOs, Municipalities, Universities			
INDICATORS	Number of participants and communities interested in project goals			
FUNDING & FINANCING	EU Horizon Projects			

5.5.4.2. REGIONAL STAKEHOLDERS

A participative process is fundamental for the success of CC adaptations, because a collaboration with local authorities and stakeholders is needed to correctly implement NbS and let them to be accepted by the population. This chapter resumes and analyses regional stakeholders'' exercises, condensing Factsheet outcomes and underlining the main aspects (negative or positive) that came out from the validation process made up by Local Councils.

Assessing Climate Risks

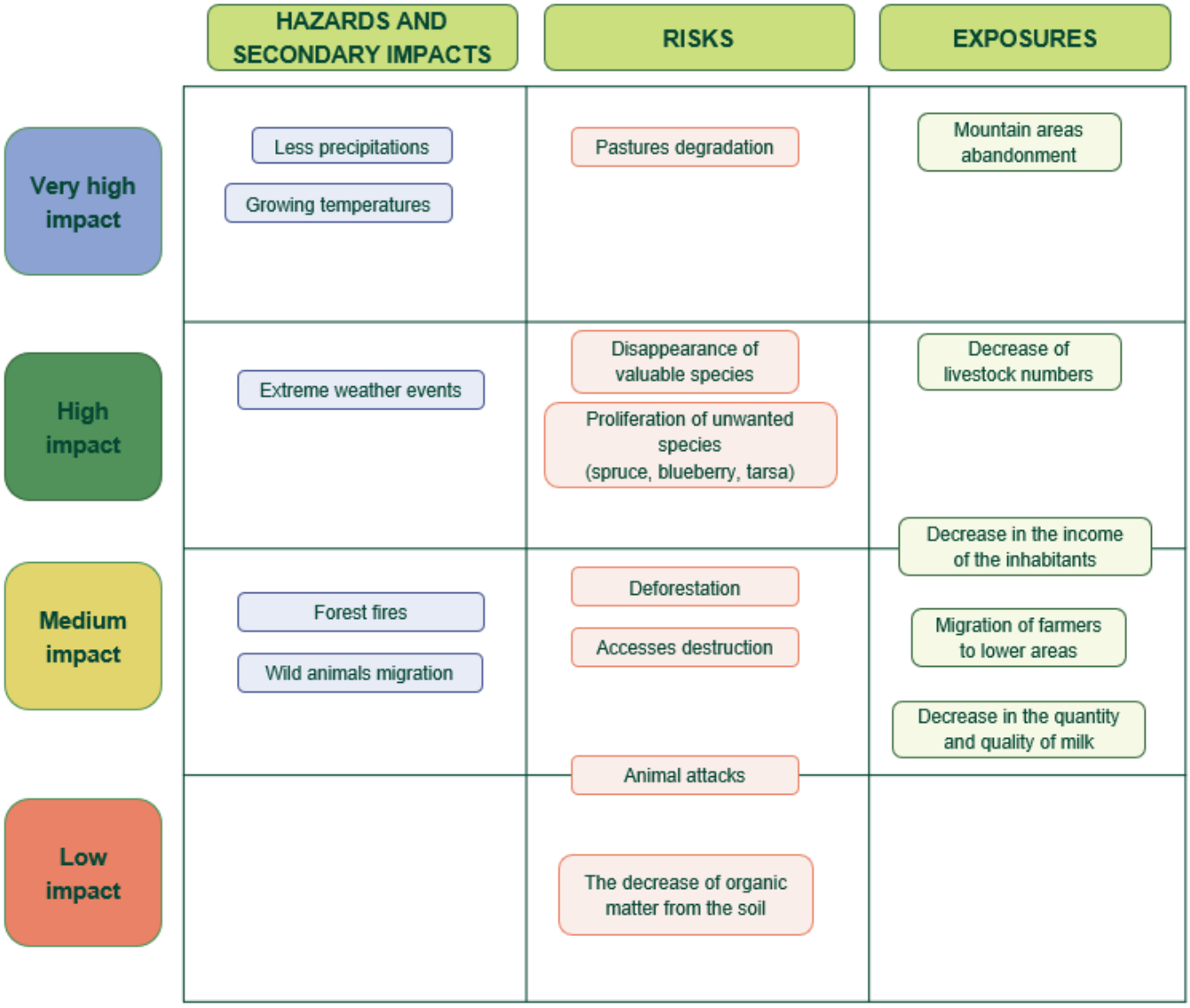


Figure 61. Outputs from Exercise 1 – Râu Sadului Stakeholders Factsheet (UMIL, 2024)

Determine existing solution

Table 31. Outputs from Exercise 2A – Râu Sadului Stakeholders Factsheet (UMIL, 2024)

ARTICLE/PROJECT	SOLUTION	CHALLENGES	BENEFICIAL IMPACTS
Participant suggestion	Removal of unwanted vegetation/ weeds	Difficult access	Regenerating valuable species
Participant suggestion	Drone interventions	Lack of internet signal (important for the use of drones); initial acquisition cost; qualified human resources	Increased efficiency; intervention efficiency; lower resource consumption; higher intervention accuracy
Participant suggestion	Rational grazing/ Grazing	Development/adoption of grazing systems	Propagation of valuable species
Participant suggestion	Education in the use of emerging technologies	Updating occupational standards and new occupations (drone operator)	New jobs; keeping young people in mountain areas; improving pastoral value
Participant suggestion	Overseeding	Natura 2000 protected area; species resilience and development under current conditions; average costs	Increased productivity and quality of forage (pastoral value); local farmer retention; increasing the quality of life of the population
Participant suggestion	Use of nitrifying bacteria	Soil analysis	Increasing soil trophicity; water retention, soil resilience
Participant suggestion	Soil amendments	Soil analysis; field species analysis	Maintaining biodiversity

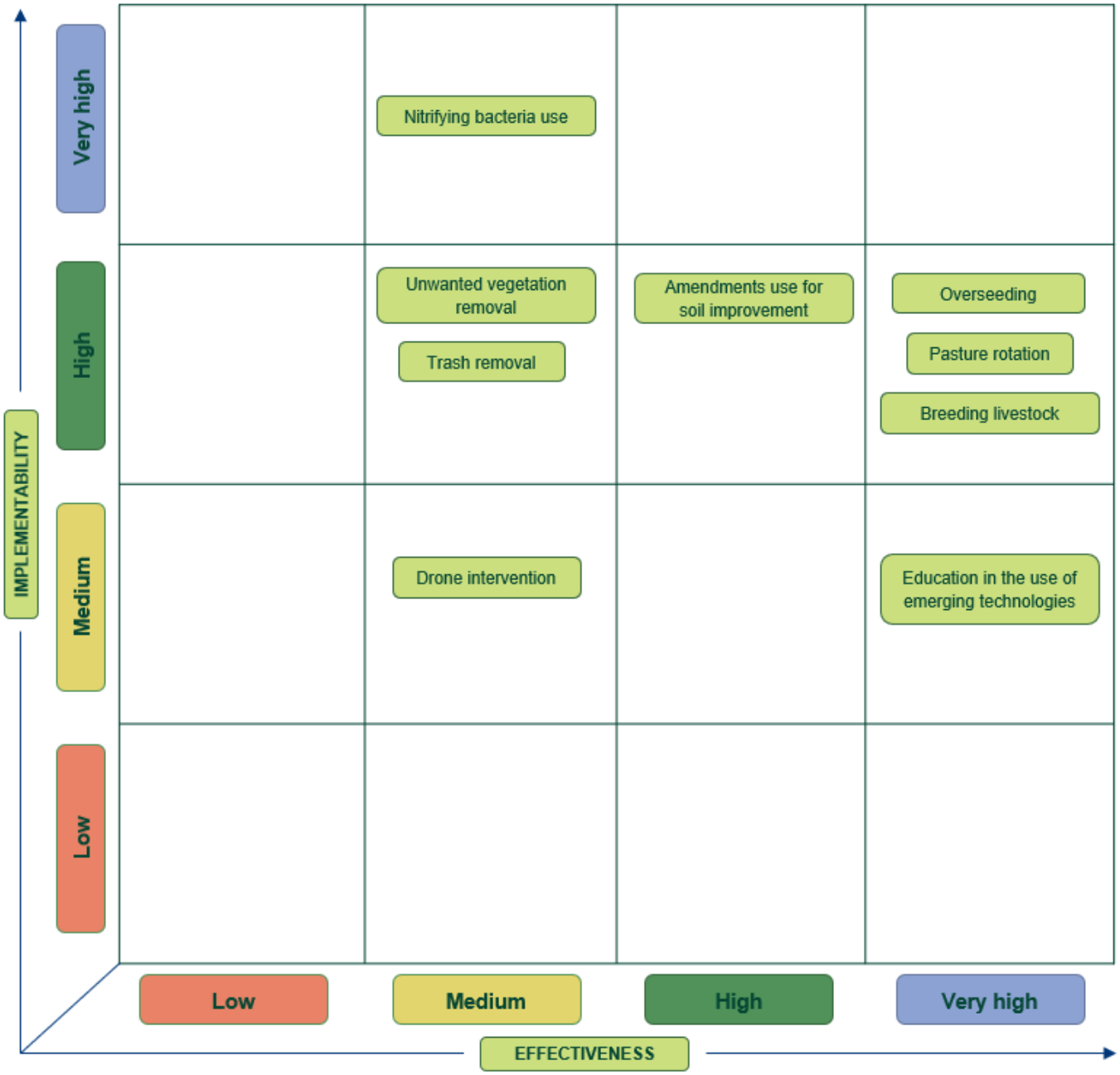


Figure 62. Outputs from Exercise 2B – Râu Sadului Stakeholders Factsheet (UMIL, 2024)

Implementation suggestions

Table 32. Chosen mitigation and adaptation solution to CC by Stakeholders - Râu Sadului

Rotational grazing
SOLUTION STRENGTHS: improving and conserving biodiversity **SOLUTION WEAKNESSES:** withdrawal of sheep farmers from the Alpine area **SOLUTION IMPLEMENTATION STAGES:** analysis of the pastoral value, determination of the degree of burden/ duration, number of plots, evaluation **OUTCOMES:** increasing feed quality **INDICATORS:** production (quantity, quality, number of animals), spore, area, number of farmers applying the solution, etc.) **FINANCINC AND COSTS:** APIA subsidies, own sources, projects **ACTORS INVOLVED:** pastors, local and central authorities, NGOs, research institutes and universities
Sustainable solutions for regenerating mountain meadows
SOLUTION STRENGTHS: improving and conserving biodiversity **SOLUTION WEAKNESSES:** limited effectiveness **SOLUTION IMPLEMENTATION STAGES:** field analysis, vegetation, elaboration and selection of solutions, implementation, evaluation **OUTCOMES:** improving environmental quality (soil, biodiversity, productivity) **INDICATORS:** production (quantity, quality, number of animals), spore, area, number of farmers applying the solution, etc.) **FINANCINC AND COSTS:** APIA subsidies, own sources, projects **ACTORS INVOLVED:** pastors, local authorities, service providers, NGOs, research institutes and universities Note: participants proposed a stage of workshops/dissemination, which should be noted, and additionally highlighted that some activities are repeated annually, and this must be considered in the implementation phases.

5.5.5. Tyrol

5.5.5.1. REGIONAL DEMONSTRATORS' PARTNERS

A participative process is fundamental for the success of CC adaptations, because a collaboration with local authorities and stakeholders is needed to correctly implement NbS and let them to be accepted by the population. This chapter resumes and analyses regional demonstrators' partners exercises, condensing Factsheet outcomes and underlining the main aspects (negative or positive) that came out from the validation process made up by Local Councils.

Preparing the ground for the adaptation

Table 33. Outputs from Exercise 1 (a) – Tyrol Regional Demonstrator Partners Factsheet (UMIL, 2024)

BACKGROUND	CHALLENGES	NEEDS
BUILDINGS & HEAT		
Climate Hazard: temperature increase, heat waves, extreme weather events (heavy rainfalls, drought, storm events, debris flows, avalanches), flood events, urban heat islands effect especially the health of vulnerable groups.	Heat waves are becoming more frequent and longer, exacerbating overheating problems in settlement areas and indoor spaces. This has an impact on people's health, especially that of vulnerable groups.	Cooler settlement areas and indoor spaces. Cool areas as retreats where people can stay freely during heat waves.
NATURE TOURISM		
Climate: increasing temperature, shorter snow cover duration, rain-on-snow events, ascend of snowline, earlier snowmelt. Tourism: winter sports are a cornerstone of the local economy and livelihoods.	The tourism sector in Tyrol is economically vulnerable due to its strong reliance on nature-based activities, making it highly sensitive to Climate Changes, particularly in precipitation and temperatures. Some mountain resorts already struggle and depend on technical snow.	Tourist resorts need solutions that preserve the region's natural landscapes while ensuring their sustainable development. Thus, place-based approaches that involve all stakeholders and take a systemic view is needed.

Table 34. Outputs from Exercise 1 (b) – Tyrol Regional Demonstrator Partners Factsheet (UMIL, 2024)

HAZARDS	IMPACTS	RISKS → CHALLENGES	VULNERABILITIES
BUILDINGS & HEAT			
• *Heat waves* • *Increased solar radiation* • *Rising temperatures*	• *Urban heat islands* • *Overheating of buildings*	• *Intensification of social inequality* • *Infrastructure strain* • *Health impacts because of heat stress on population*	• *People working/ studying/ going to school in uninsulated houses* • *Elderlies and children* • *People living in poorly insulated housings*

• *Decrease in participation*		• *High energy demand and consumption*	• *Areas with no or insufficient green and blue infrastructures*
NATURE TOURISM			
• *Change in precipitation patterns* • *Rising temperature* • *Extreme weather events/natural hazards* • *Increase in extreme wind events*	• *Upward shift of snow and zero-degree line* • *Decrease in Snow reliability* • *Fuzziness/blurring of seasons* • *Increase of rain on snow events*	• *Financial loss, loss of jobs, increased cost* • *Loss of sensitive ecosystems, loss of biodiversity* • *Damages to buildings and infrastructure*	• *Local economies depending on tourism* • *Ski resorts at low altitude* • *Environmental sensitive ecosystems* • *Emotional connection to snow and the connected*

Identifying adaptation options

Table 35. Outputs from Exercise 2 – Tyrol Regional Demonstrator Partners Factsheet (UMIL, 2024)

SOURCE	MAIN CHALLENGES	SOLUTIONS	EXPECTED IMPACTS	RELEVANT INFORMATION
BUILDINGS & HEAT				
Project: Nature Based Urban Innovation	Balancing environmental quality and economic regulation	A step-change in the use of NbS for urban sustainability	Impacts on governance; business models. Ecosystem restoration	Integration of science, social science and humanities and practical expertise and experience to achieve a step-change in the use of NbS for urban sustainability
Project: Implementation of a forecasting system for urban heat Island effect for the development of urban adaptation strategies	Urban heat islands	Urban green infrastructures; innovative technological platform to monitor them	Better predictions; heat mitigation; livelihood; city management	The project will contribute towards the Greek Climate Change Adaption Strategy of 2016 along with the ministerial decision of 2017 on the regional plans for Climate Change adaptation.
Article: Passive mitigation of overheating in Finnish apartments under current and future climates	Heat islands	House cooling systems (passive and structural mitigation); sustainable houses; simulations	Natural ventilation; temperature decrease; energy save; human health	The study examines how individual, and a combination of passive adaptations, can reduce overheating in three modern structural timber case study apartments
Article: Stakeholders' perceptions of appropriate nature-based solutions in the urban context	Flooding; Heatwaves	Pocket parks; community gardens; trees; green roofs; natural water	Disaster-risk reduction; urban resilience; rural areas development	This study aims to identify stakeholders' perceptions of the most critical urban challenges, the priority interventions, the preferred NbSs and the benefits of the

		retention; sustainable drainage		NbSs, and to identify the determinants of these perceptions.
Article: Multi-Level Toolset for Steering Urban Green Infrastructure to support the Development of Climat-Proofed Cities	Heatwaves; Wind	Urban Green and buildings work	More green areas; cooling building; wellbeing; more trees; carbon sequestration	This article demonstrates how climate simulation tools can be used across different planning levels if they are standardized.
Article: Decreasing the energy demand in public buildings using nature-based solutions: case studies from Novi Sad (Republic of Serbia) and Osijek (Republic of Croatia)	Heatwaves	Urban greenery	Monitoring practice, urban greenery; city restoration; wellbeing; more trees; cooling effect	NbS have positive effects on diverse aspects of urban environments and building energy savings, which are particularly evident in extreme seasons, both summer and winter.
Article: Urban heat mitigation by green and blue infrastructure: Drivers, effectiveness, and future needs	Heatwaves; flooding	List of cooling green and water infrastructures	More green areas; cooling building; wellbeing; more trees; carbon sequestration; storm weather management	Given the importance of multiple services, it is crucial to balance their functionality, cooling performance, and other related co-benefits when planning for the future GBGI.
NATURE TOURISM				
Project: Quality and value creation mission statement Oberstdorf Kleinwalsertal	Increasing the attractiveness of common natural and cultural heritage	Create and implement a unified performance model enhancing sustainable tourism development by aligning service providers' strategies to meet guest requirements.	Research; policy making; tourism management; long-term profitability and customer satisfaction.	Good practice model for a transformation process
Project: Conservation of Ylläs-Aakenus Western Taiga Forest Area in Lapland	Lapland's nature is vulnerable and should not be subjected to excessive wear	Management plan aimed at channeling nature tourism.	Management plan for nature tourism; stakeholder collaboration; habitat types and species inventory; reindeer herding upgrade; nature trails and signposts; public awareness; environmental education; growth of national parks and government-owned lands	\

Article: Managing cross-country skiing destinations under the conditions of Climate Change Scenarios for destinations in Austria and Finland	Skiers' destination changes skiers' perceptions	Tourism strategies; technical solutions; destination evaluation; questionnaires	More data and evaluations on people approach to ski and their wishes. A cost and investment evaluation	Relevant for transforming mountain resorts
Article: Climate change adaptation in the ski industry	CC on ski industry	Many technical and management solutions (snow creation, tree, slope, indoor skiing...); resorts conglomerate; government inputs & policy	Technical improvement; more knowledge and prepared operators; tree plantation and slope management; ski season correct management	Only technical solutions are not enough
Article: From nature experience to visitors' pro-environmental behaviour: the role of perceived restrictiveness and well-being	Wellbeing	Questionnaire (Strong relation between Pub and SWB)	Promote environmental behaviour; decision-making process; promote green areas	Fostering pro-environmental behaviours is essential for nature-based tourism offers and to legitimize transformative adaptation measures

Assessing and selecting adaptation options

Table 36. Outputs from Exercise 3 – Tyrol Regional Demonstrator Partners Factsheet (UMIL, 2024)

	NBS LIST	CRITERIA RELEVANCE: Effectiveness	Failure risk	Policy boost	Secondary beneficials	Benefit distributions	Solution Urgency	Realization cost	Maintenance cost	Community acceptability	Level of the changes	Adverse forces/Barriers
DRIVING CRITERIA				●							●	●
BUILDINGS & HEAT	Innovative solutions for adaptation - Changes in the buildings and settlements; Avoidance of overheating through active and passive measures	4	3	1	2	3	4	3	2	3	3	3
	Passive mitigation of overheating (free cooling, shading …)	4	3	1	3	1	3	2	1	4	2	2
	Blue and green infrastructure in urban areas	4	2	1	1	3	3	5	4	4	3	5

DRIVING CRITERIA												
NATURE & TOURISM	Transformation process for the mountain resort	4	4	5	3	4	3	4	3	2	5	5
	Unified performance model with adaptation focus	4	2	3	4	4	2	4	3	3	3	4
	Management plan aimed at channelling nature tourism.	4	3	2	2	3	3	2	1	2	1	3

Driving criteria were Policy boost, Community acceptability, Level of the changes and Adverse forces/Barriers.

Implementing adaptation actions

SUGGESTED SOLUTION: Innovative solutions for adaptation - Changes in the buildings and settlements; Avoidance of overheating through active and passive measures

Table 37. Outputs from Exercise 4 (a) – Tyrol Regional Demonstrator Partners Factsheet (UMIL, 2024)

IMPLEMENTATION STAGES	SET-UP TIME	PROJECT PHASE	COSTS	MAIN ACTORS
Collecting data on which buildings are affected by overheating problems and the cause	3 months	Beginning	\	Project partners, municipalities, house owners
Simulation of the building and derivation of measures	2 weeks each	Implementation phase	Medium, costs for the simulation software	Project partners
Support in the implementation of the measures and implementation of the measuring points for monitoring	3 months	Implementation phase	Medium, costs for the measuring instruments	Project partners, municipalities, house owners
Derivation of the results and development of counselling services and information material	Implementation phase	Implementation phase	high (print, advertising agency)	Project Partners, advertising agency
OUTCOMES	Information material and knowledge around “Preventing buildings from overheating”			

INDICATORS	Number of consultations; number of requests; number of presentations
FUNDING & FINANCING	\

SUGGESTED SOLUTION: Transformation process for the mountain resort

Table 38. Outputs from Exercise 4 (b) – Tyrol Regional Demonstrator Partners Factsheet (UMIL, 2024)

IMPLEMENTATION STAGES	SET-UP TIME	PROJECT PHASE	COSTS	MAIN ACTORS
Case study selection	2 months	Preparation	\	Workshops, travel, maybe external analysis/ data
Understanding the social-ecological context (stakeholder, tourism patterns, existing offers, vulnerabilities, needs etc.)	2 months	Early stage	Low (travel, print, data)	UIBK, SAT, case study organisations, tourism associations
Development of place-based adaptation measures and/ or future scenarios	1 month	Implementation	Workshops, travel, maybe external analysis/ data	UIBK, SAT, case study organisations, Stakeholders,
Implementation and monitoring concept	6 months	Implementation	Workshops, travel, maybe external analysis/ data	UIBK, SAT, case study organisations
OUTCOMES	Transformative tourism development strategies, nature-based adaptation measures for ski resorts, nature-based offers			
INDICATORS	Number development strategies; n° of adaptation measures; n° of nature-based offers, n° of workshops; ration between summer/ winter revenue, n° of year-round jobs			
FUNDING & FINANCING	EU Horizon; Tyrolean Government funding; private capital			

5.5.5.2. REGIONAL STAKEHOLDERS

A participative process is fundamental for the success of CC adaptations, because a collaboration with local authorities and stakeholders is needed to correctly implement NbS and let them to be accepted by the population. This chapter resumes and analyses regional stakeholders' exercises, condensing Factsheet outcomes and underlining the main aspects (negative or positive) that came out from the validation process made up by Local Councils.

Assessing Climate Risks

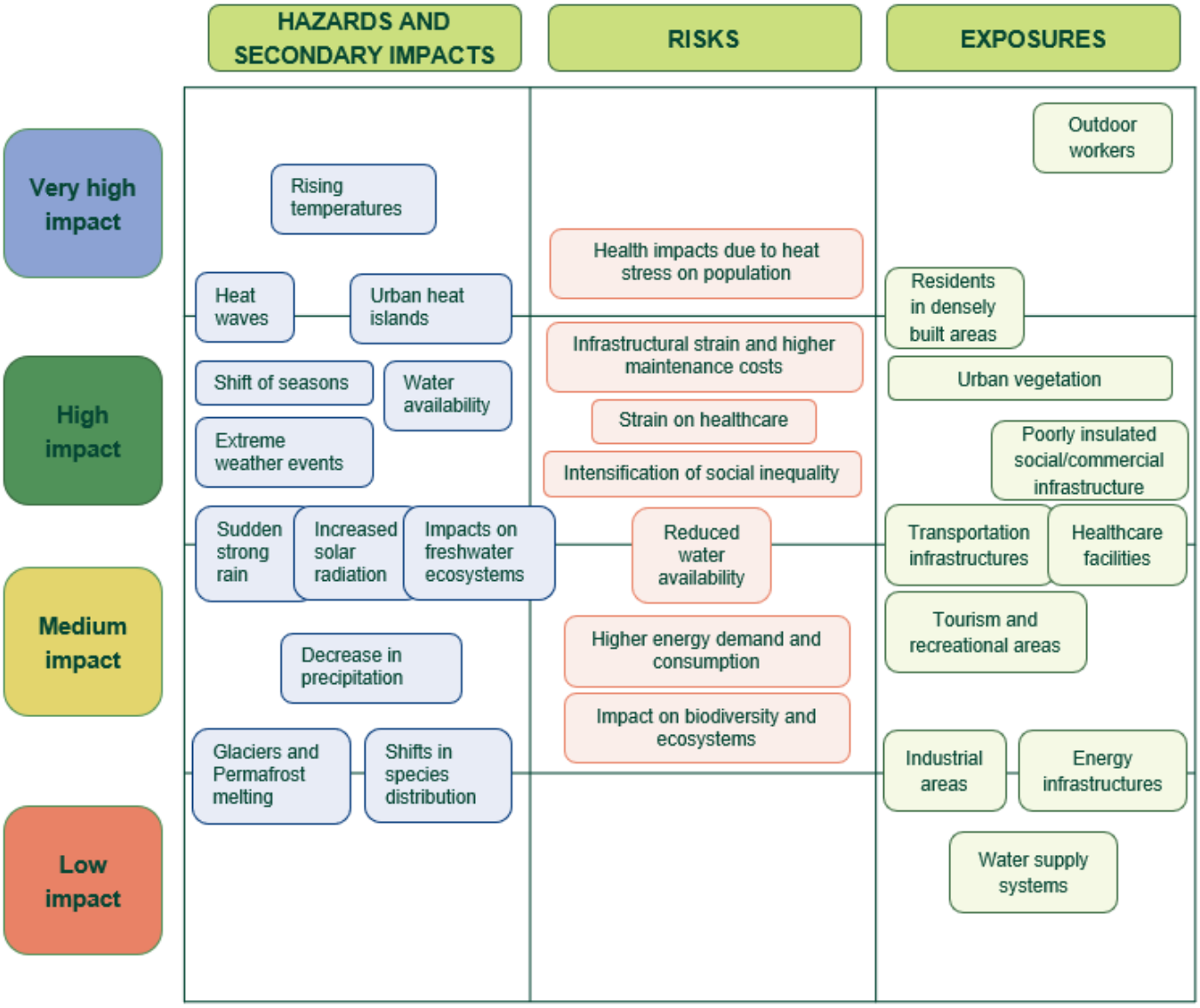


Figure 63. Outputs from Exercise 1 (Buildings & Heat) – Tyrol Stakeholders Factsheet (UMIL, 2024)

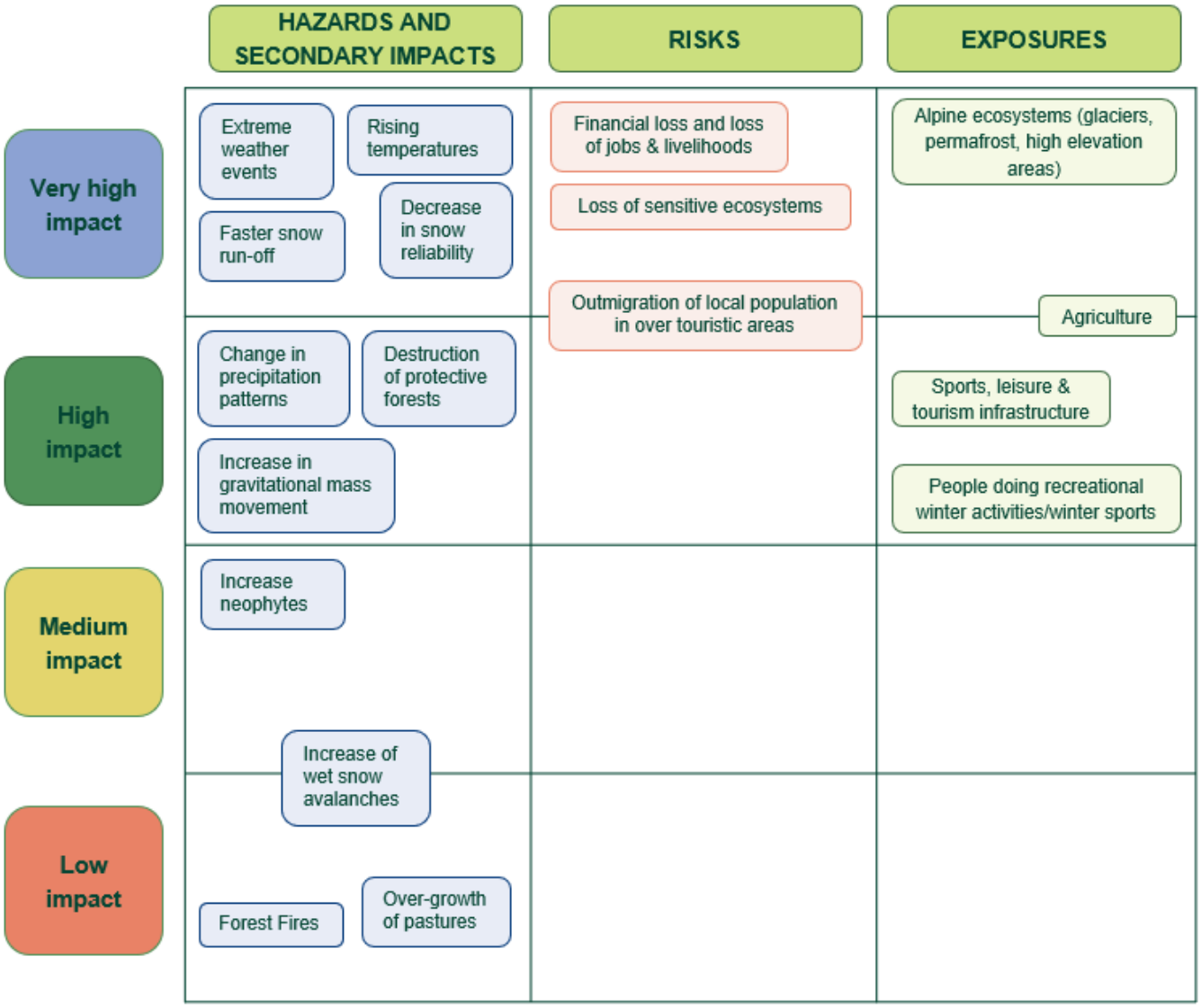


Figure 64. Outputs from Exercise 1 (Nature & Tourism) – Tyrol Stakeholders Factsheet (UMIL, 2024)

Table 39. Outputs from Exercise 2A – Tyrol Stakeholders Factsheet (UMIL, 2024)

ARTICLE/PROJECT	SOLUTION	CHALLENGES	BENEFICIAL IMPACTS
BUILDINGS & HEAT			
Article: Passive mitigation of overheating in Finnish apartments under current and future climates	House cooling system	Heat island	Natural ventilation, energy save
Project: Implementation of a forecasting System for urban heat Island effect for the development of urban adaptation strategies	Urban green areas (UGAs) and infrastructures: innovative technological platform to monitoring them	Urban heat islands	Better predictions, heat mitigation, livelihood, city management
Article: Guidelines to reduce the effects of urban heat in a changing climate: green infrastructures and design measures	Water and green infrastructures (planning)	Heatwaves	Urban greenery, city restoration, wellbeing, more trees, cooling effect, flooding
Participant suggestion: Comparison and evaluation of various measures against summer overheating indoors	Digital Twin of Buildings and Cities	Overheating indoors	Better understanding and communication (visualization) of efficiency for different measures, weakness: high effort
Participant suggestion	Installation of citizens councils	\	\
Project: Accelerating and upscaling transformational adaptation in Europe: demonstration of water-related innovation packages	Adaptive process based on open innovation, user-friendly and accessible climate data services, actionable solutions and large-scale experimentation. This will be supported by the implementation of Innovation Packages built to increase communities' social and climate resilience.	Necessity of climate and social resilience to achieve rapid and far-reaching transformational adaptation	Mitigation and adaptation to many CC challenges; transformative adaptation; better governance; research processes
Participant suggestion	Sustainable Regenerative Strategies for the Inner Areas: An Example of "Civic Design" in Marradi (Tuscany)	Depopulation	Exploit the peculiarities of the territory; appropriate green and grey areas; more tourism; people livelihood opportunities
Participant suggestion: Passive cooling strategies (shading, night-ventilation) and active cooling in combination with renewable energy	Improve infrastructure; passive cooling strategies (shading, night-ventilation) and active cooling in combination with renewable energy; weakness: high effort	Overheating indoors	Weakness: high effort
Participant suggestion	Intensification of green areas (trees etc)	Urban heat islands	Natural cooling
Project: Integrated Environmental Management for Sustainable Development in the alpine region Grosses Walser Tal - Austria	Provide an integrated platform for existing and future measures and model components. Developed sustainability criteria for economic, social and cultural issues in the regions, tourism support	Lack of overarching Integrated environmental management system, unsustainable tourism	Environmental management system; promoting ecologically sustainable tourism in the region
Participant suggestion	Renaturing cities using a regionally focused biodiversity-led multifunctional benefits approach to urban green infrastructure	Heatwaves, flooding	Greening, nature restoration, green areas informed decision-making

Article: Nature-Based Solutions in the EU: Innovating with nature to address social, economic and environmental challenges	Pocket parks; community gardens; trees; green roofs; natural water retention; sustainable drainage	Flooding, heatwaves	Disaster-risk reduction, urban resilience, rural areas development
Participant suggestion: Greening cities and reducing car traffic	Green cities, abandon private cars in cities, increase public/shared transport, convert parking places into green parks	\	\
Participant suggestion	Autoactivation of non-motorized city infrastructure (bike areas, on foot shortcuts...)	\	\
NATURE & TOURISM			
Project: Integration of climate change adaptation into the work of local authorities	Introduce “climate coaches" in order to improve local policies and decision-making	Hard definition of Climate change priorities; no professional figures	Set appropriate Climate Change adaptation priorities; share and promote knowledge; better decision-making processes
Project: Regional Climate Resilient Development Pathways	Sharing knowledge; stakeholder and citizen engagement	Low-capacity regions impacted by Climate Change	Set appropriate Climate Change adaptation priorities; share and promote knowledge; better decision-making processes
Project: Provision of a prediction system allowing for management and optimization of snow in Alpine ski resorts	Develop an advanced meteorological and climate prediction system tailored for snow management. This system will enhance real-time decision-making and climate adaptation for ski resorts across the Alps, ultimately paving the way for commercial exploitation of the service.	Improving the ski industry’s ability to manage snow resources effectively amidst the unpredictability of weather and climate conditions.	Research; weather forecasting; snow monitoring; snow management; ski slope management
Project: Operandum, GoNaturePositive!	Raise awareness about the benefits of nature-positive practices, share knowledge; multi-governance	Climate change	More sustainable society; community participation; sharing knowledge
Project: Conservation of Ylläs-Aakenus Western Taiga Forest Area in Lapland	Eco-tourism; experience tourism. Involve the local population and tourist businesses in preparing and carrying out a special ecotourism plan	Lapland’s nature is vulnerable and should not be subjected to excessive wear	Management plan for nature tourism; stakeholder collaboration; habitat types and species inventory. Reindeer herding upgrade; nature trails and signposts; public awareness; environmental education; growth of national parks and government owned lands
Project: Combining protection with other forms of land use in the natural boreal forests of the Syöte area	Management plan aimed at channelling nature tourism.	Inadequate regulation of nature tourism to preserve the area’s ecological value	Stakeholders and citizen engagement; business development; all-year tourism; nature conservation; sustainable livelihoods
Participant suggestion	Climate-resilient alpine pasture management Community stables to relieve the farmers, "ÖPUL"- managed agriculture to keep the biodiversity change of agricultural subventions to more respect of biodiversity	Biodiversity	Promote mixed forests to minimize the risk of bark beetles and thus prevent mudslides, avalanches and landslides

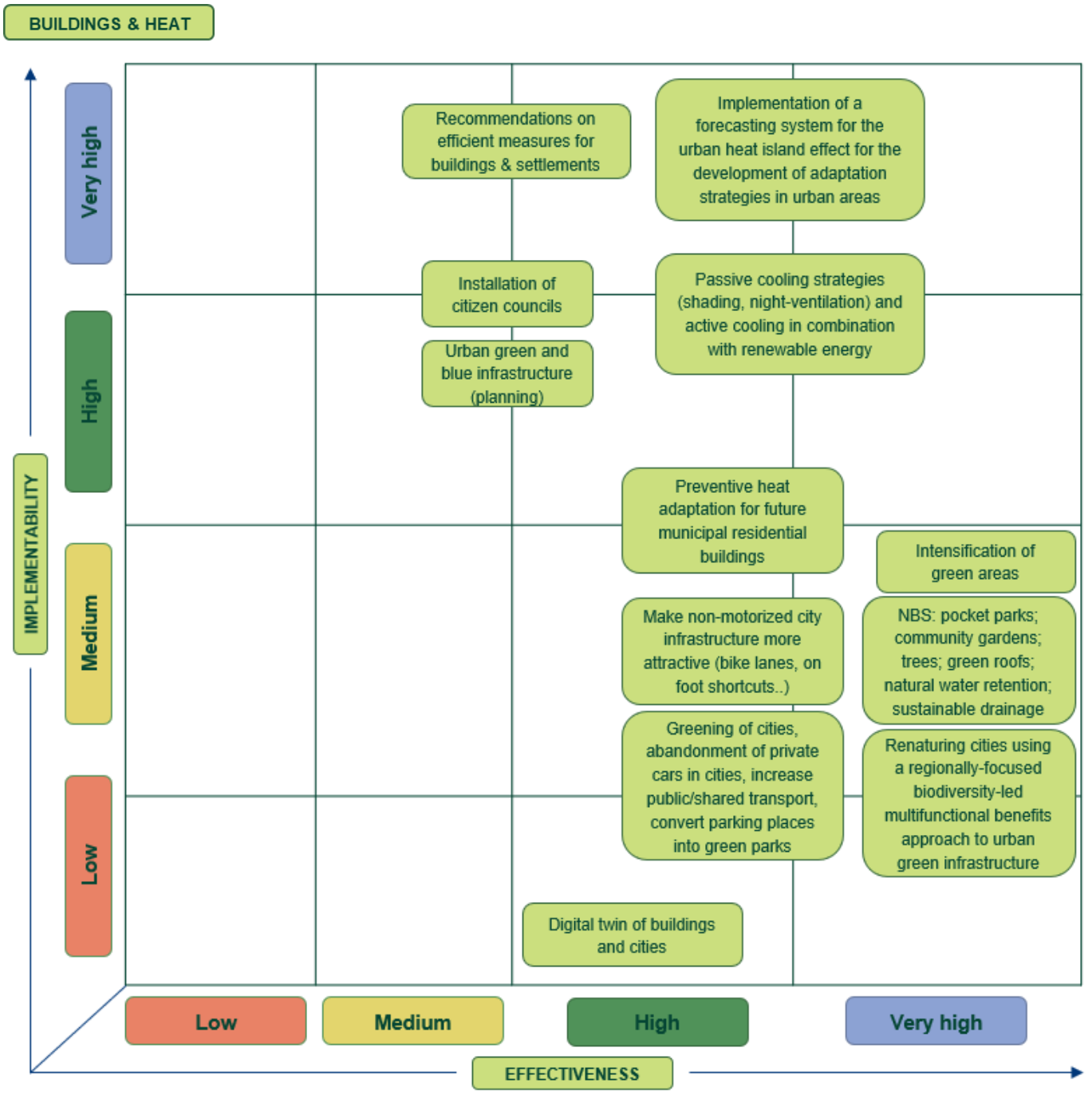


Figure 65. Outputs from Exercise 2B (Building & Heat) – Tyrol Stakeholders Factsheet (UMIL, 2024)

NATURE & TOURISM

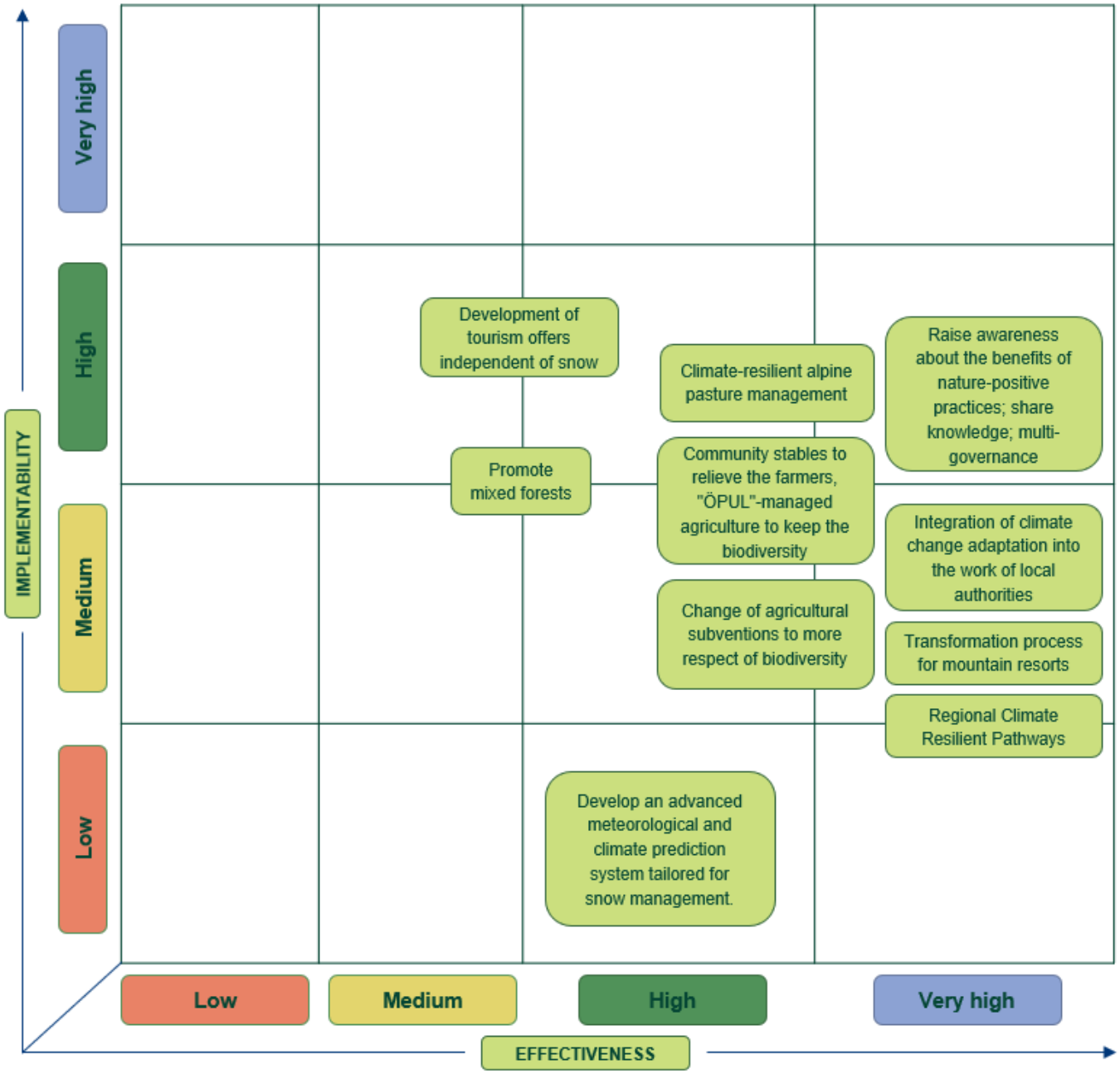


Figure 66. Outputs from Exercise 2B (Nature & Tourism) – Tyrol Stakeholders Factsheet (UMIL, 2024)

Implementation suggestions

Table 40. Chosen mitigation and adaptation solution to CC by Stakeholders - Tyrol

Innovative solutions for adaptation (passive & active cooling solutions, technical solution and behavioural change)
SOLUTION STRENGTHS: good passive measures prevent overheating, better room quality **SOLUTION WEAKNESSES:** expensive and difficult to implement in existing buildings, positive effect on health **SOLUTION IMPLEMENTATION STAGES:** information, recommendation, counselling, further training, promotion, adapting the legal framework **OUTCOMES:** \ **INDICATORS:** building's temperature **FINANCINC AND COSTS:** the earlier integrated in planning, the more cost efficient, funding **ACTORS INVOLVED:** residents, spatial planning, politics and administration, landowners
Green & blue infrastructure implementation
SOLUTION STRENGTHS: cooling effect, better air quality, better protection during heavy weather events (sponge city principle), improved quality of stay, reduced risk to health due to heat **SOLUTION WEAKNESSES:** high maintenance costs, expensive for the public but not for the individual, drinking water available free of charge **SOLUTION IMPLEMENTATION STAGES:** 1. political will/consensus, 2. concept development with participatory process and consideration that green measures need a lot of time to be effective, 3. examination of legal and infrastructural conditions, 4. implementation of the measures at test locations and evaluation, 5. Large-scale construction measures and maintenance **OUTCOMES:** air and life quality **INDICATORS:** temperature, air quality, frequency of use of squares, number of squares with water access, flow rate in the canal during extreme weather events **FINANCINC AND COSTS:** EU and national fundings **ACTORS INVOLVED:** residents, spatial planning, politics and administration, landowners
Transformation of mountain resorts

SOLUTION STRENGTHS: preserves natural landscapes, promoting sustainable economic development, adapts to changing climate conditions (e.g., snow reliability), attract eco-conscious tourists

SOLUTION WEAKNESSES: too broad concept, could mean anything, potential resistance from traditional tourism operators, long implementation timelines, path dependencies, limited short-term returns

SOLUTION IMPLEMENTATION STAGES: 1. evaluate climate risks and tourism trends, 2. Co-Design – based on data, 3. Pilot Projects – Test smaller-scale initiatives (different in case studies), 4. Roll out sustainable practices and infrastructure across the resorts. 5. Monitoring & Adaptation – continuously performance monitoring and strategies adjustment

OUTCOMES: increased year-round tourism through diversification (e.g., hiking, biking, wellness), enhanced environmental conservation. long-term economic sustainability

INDICATORS: increase in off-season visitor numbers, positive biodiversity impacts (e.g., restored ecosystems)

FINANCINC AND COSTS: initial investment through public-private partnerships

ACTORS INVOLVED: local authorities and mountain resort operators, environmental and tourism NGOs, local communities and businesses, tourists and visitors. financial institutions and investors

Integration of Climate Change adaptation into the work of local authorities

OLUTION STRENGTHS: broad reach, high impact

SOLUTION WEAKNESSES: system is sluggish and difficult to change; holistic thinking is lacking; dependent on decision-makers

SOLUTION IMPLEMENTATION STAGES: 1) Introduce committees, 2) Conduct risk and vulnerability assessments; 3) Orientate on KLAR programmes; 4) Training and communication for administrative staff; 5) Public engagement and awareness campaigns; 6) Adapt subsidies; 7) Involve insurance companies in development; 8) Monitoring and evaluation

OUTCOMES: sustainable Tourism Practices (Promote eco-friendly tourism activities, protect ecosystems, and support sustainable infrastructures); resilience of natural attractions (protect natural sites from climate impacts, e.g., erosion, flooding, and ensuring long-term tourism viability); enhanced Visitor Experiences (improve infrastructure for tourist safety and comfort, even in changing climate conditions); increased local engagement and awareness (engage tourists and communities in climate adaptation/conservation efforts, fostering awareness and responsible tourism).

INDICATORS: reflected in laws and regulations; implemented projects

FINANCINC AND COSTS: \

ACTORS INVOLVED: municipalities, regions, administration, tourism association

5.5.6. Valais

5.5.6.1. REGIONAL DEMONSTRATORS' PARTNERS

A participative process is fundamental for the success of CC adaptations, because a collaboration with local authorities and stakeholders is needed to correctly implement NbS and let them to be accepted by the population. This chapter resumes and analyses regional demonstrators' partners exercises, condensing Factsheet outcomes and underlining the main aspects (negative or positive) that came out from the validation process made up by Local Councils.

Preparing the ground for the adaptation

Table 41. Outputs from Exercise 1 (a) – Valais Regional Demonstrator Partners Factsheet (UMIL, 2024)

BACKGROUND	CHALLENGES	NEEDS
Valais is the third largest canton in Switzerland, located in the southwest, with a population of 348,503. The region is characterized by the Rhône River and surrounding Alps, making the valleys among the driest areas in Switzerland with a mountainous climate. The economy relies on tourism (especially skiing), agriculture, hydropower, and residential areas.	Water management is a major challenge due to variable precipitation, rising temperatures, glacier melting, and Climate Change impacts. Water quality issues and the decline of traditional agricultural practices are also concerning.	There is an urgent need for integrated and sustainable water management strategies, technological innovations for water quality monitoring, and community engagement and awareness. Stakeholder acceptance, adoption and behavioural changes are core to success. Ecosystem restoration is essential to enhance climate resilience.

Table 42. Outputs from Exercise 1 (b) – Valais Regional Demonstrator Partners Factsheet (UMIL, 2024)

HAZARDS	IMPACTS	RISKS → CHALLENGES	VULNERABILITIES
• *Glacial melt* • *Precipitation pattern variations* • *Pollution of water* • *Extreme weather events* • *Decreasing Snowfall*	• *Water shortages* • *Reduced water supply* • *Contamination* • *Damage to infrastructures*	• *Access to drinkable water* • *Regulating agricultural runoff and urban waste* • *Flooding and destruction of farmlands & transportation infrastructures* • *Preservation of economic activities: industry and tourism*	• *Irrigation system* • *Water quality monitoring, human health and biodiversity* • *Infrastructure vulnerability to extreme weather* • *Democratic process and water users' behaviour*

Identifying adaptation options

Table 43. Outputs from Exercise 2 – Valais Regional Demonstrator Partners Factsheet (UMIL, 2024)

SOURCE	MAIN CHALLENGES	SOLUTIONS	EXPECTED IMPACTS	RELEVANT INFORMATION
EU Horizon 2020 Project: "CIRCULAR"	Decreasing water availability due to Climate Change	Implementing green infrastructure, such as rain gardens, wetlands, and permeable surfaces to manage stormwater	Improved water management and quality, reduced flooding	Demonstrated success in improving urban water scenarios
EU Project: "LIFE RE-WATER"	Soil erosion and sedimentation	Implementing agroecological practices and cover cropping	Improved soil health and water retention, reduced erosion	Integrates traditional practices with modern agroecology
Article: "Nature-Based Solutions for Water Management"	Pollution from agricultural runoff	Restoring riparian buffers and wetlands alongside rivers	Enhanced water filtration, improved biodiversity, reduced nutrient runoff	Focused on riparian zones' role in water quality improvement
Article: "The Role of Forests in Water Quality"	Increased temperatures affecting aquatic ecosystem	Reforestation and afforestation along watersheds	Enhanced water quality, increased shade for streams, improved biodiversity	Supports the idea that forest cover can mitigate warming impacts
EU INTERREG Project: "RESTORE"	Loss of traditional irrigation methods	Monitoring resources with modern technology.	Sustainable water management practices, recovery of lost knowledge	Combines modern technology with traditional practices

Assessing and selecting adaptation options

Table 44. Outputs from Exercise 3 – Valais Regional Demonstrator Partners Factsheet (UMIL, 2024)

NBS LIST	CRITERIA RELEVANCE: Effectiveness	Failure risk	Policy boost	Secondary beneficials	Benefit distributions	Solution Urgency	Realization cost	Maintenance cost	Community acceptability	Level of the changes	Adverse forces/Barriers
DRIVING CRITERIA	●		●		●	●			●	●	
In watershed quantitative and qualitative monitoring - Transformation of data into inclusive digital interface for an informed decision-making process.	5	2	4	4	5	5	3	2	5	3	3

Integrating water management systems from rivers and lakes into agricultural lands to improve the sustainability of water resources.	4	3	4	3	4	4	4	3	4	4	3
Creating or restoring vegetation along rivers to reduce runoff, filter pollutants, and provide habitat for wildlife.	5	2	4	5	4	5	3	3	4	4	2
Planting trees in watersheds to improve water quality, reduce erosion, and promote biodiversity.	5	2	4	4	4	5	3	2	4	4	2
Utilizing sustainable agriculture techniques such as cover cropping and crop rotation to enhance soil health and water management.	4	3	4	5	4	4	4	3	4	4	3
Implementing green infrastructure such as rain gardens, green roofs, and permeable surfaces to manage stormwater in urban areas.	4	3	4	3	4	4	3	2	4	3	3
Restoring wetland ecosystems to improve water filtration, enhance water retention, and increase biodiversity.	4	2	4	5	5	4	4	3	4	3	3
Protecting and managing natural areas to preserve critical ecosystems and their ability to regulate water quality and quantity.	3	3	3	5	3	3	4	3	3	3	4

Driving criteria selected were Effectiveness, Policy boost, Benefit Distributions, Solution Urgency, Community acceptability and Level of the changes.

Implementing adaptation actions

SUGGESTED SOLUTION: In watershed quantitative and qualitative monitoring - Transformation of data into inclusive digital interface for an informed decision-making process.

Table 45. Outputs from Exercise 4 (a) – Valais Regional Demonstrator Partners Factsheet (UMIL, 2024)

IMPLEMENTATION STAGES	SET-UP TIME	PROJECT PHASE	COSTS	MAIN ACTORS

Planning and preparation	6 months	Early	30k euro	Local government agencies; community stakeholders
Design and Approvals	3 - 6 months	Early	20k euro	Environmental engineers
Implementation of improved decision-making system	12 - 18 months	Middle	250k euro	Contractors specializing in environmental monitoring and IT; decision-making methodology with stakeholders; citizen information sharing
Implementation of ecosystem service modification towards NbS	3 months – 10 years	Middle	Highly variable	Local, regional and national government stakeholders; citizen (voting and behavioural change)
Monitoring and Maintenance	5 years (first review after 1 years)	Early - Late	30k euro annually	Local government and monitoring teams; stakeholders for decision making; citizen information to drive human adoption
OUTCOMES	Improved water quality in the watershed due to enhanced filtration and reduced runoff; increased biodiversity, with healthier aquatic and terrestrial ecosystems; greater community engagement and awareness of watershed management practices; creation of recreational and educational opportunities for local communities			
INDICATORS	Measure the variety and abundance of species (flora and fauna) in the restored areas compared to baseline data; monitor key water quality indicators such as: nutrient concentrations (e.g., nitrogen, phosphorus), pH level, turbidity, dissolved oxygen levels; measure changes in hydrological patterns within the watershed, including flow rates pre- and post-restoration.			
FUNDING & FINANCING	Local government budgets; state and federal environmental grants; private foundations; community fundraising initiatives.			

5.5.6.2. REGIONAL STAKEHOLDERS

A participative process is fundamental for the success of CC adaptations, because a collaboration with local authorities and stakeholders is needed to correctly implement NbS and let them to be accepted by the population. This chapter resumes and analyses regional stakeholders' exercises, condensing Factsheet outcomes and underlining the main aspects (negative or positive) that came out from the validation process made up by Local Councils.

Assessing Climate Risks

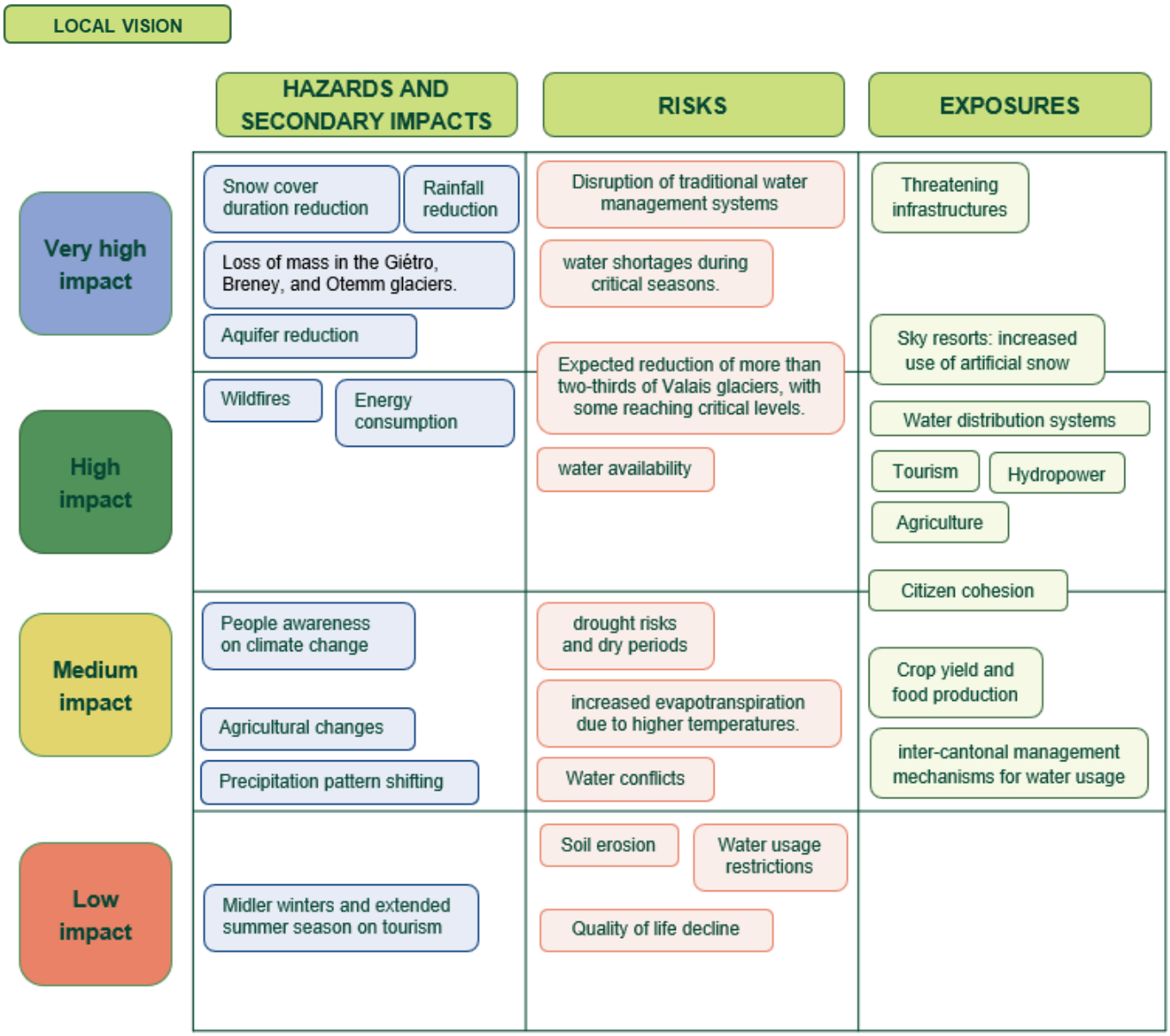


Figure 67. Outputs from Exercise 1 (Local Vision) – Valais Stakeholders Factsheet (UMIL, 2024)

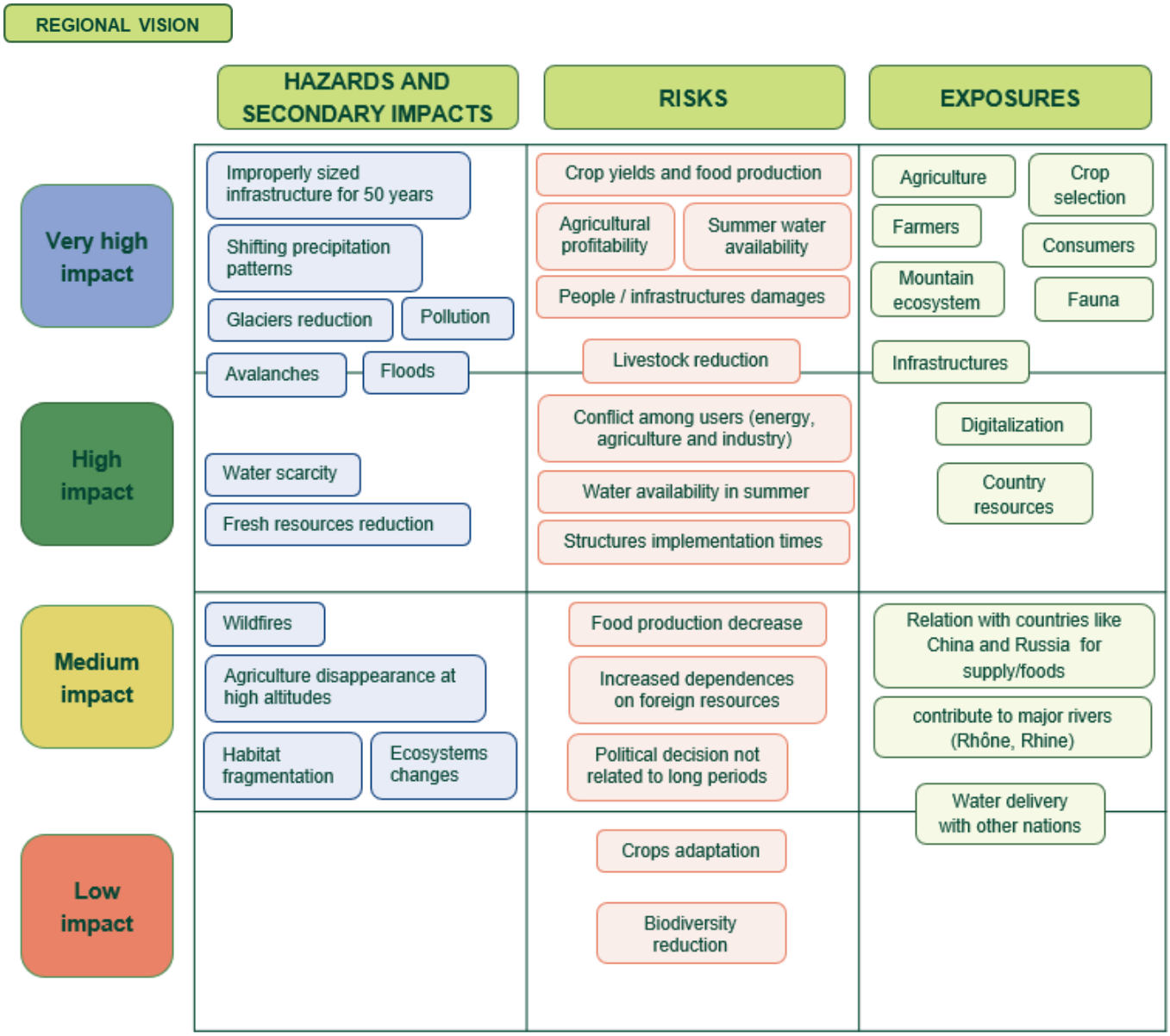


Figure 68. Outputs from Exercise 1 (Regional vision) – Valais Stakeholders Factsheet (UMIL, 2024)

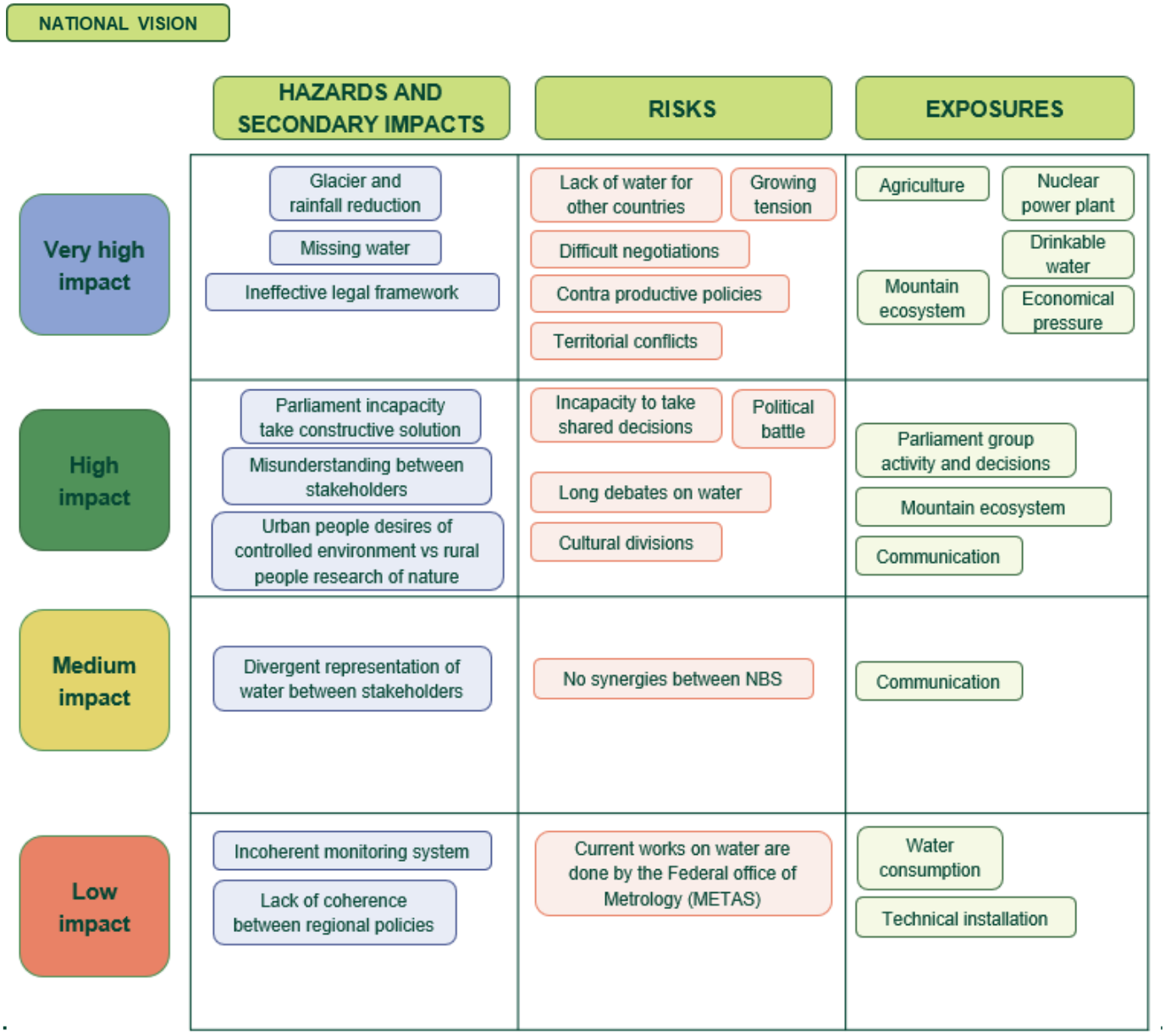


Figure 69. Outputs from Exercise 1 (National vision) – Valais Stakeholders Factsheet (UMIL, 2024)

Determine existing solution

Table 46. Outputs from Exercise 2A – Valais Stakeholders Factsheet (UMIL, 2024)

LOCAL VISION

ARTICLE/PROJECT	SOLUTION	CHALLENGES	BENEFICIAL IMPACTS
Glacier melt and water quality monitoring project in Valais.	Introduction of advanced monitoring technologies to track glacier melt and water quality	High costs of implementation and the need for qualified personnel for maintenance and data analysis	Improvement of water resource management, prevention of shortages, and support for environmental sustainability
Pilot project for the transition to sustainable agriculture in Valais	Implementation of sustainable agricultural practices for efficient water use	Change in farmers' behaviour, with high initial investments needed for more efficient irrigation infrastructure	Conservation of water resources, protection of soils and biodiversity, and resilience to Climate Change
Energy transition project towards renewable energies in Valais	Promotion of renewable energy sources to reduce dependence on hydropower	Need for renewable energy production and distribution infrastructure, along with resistance to changes in the energy sector	Diversification of energy sources, reduction of greenhouse gas emissions, and enhancement of energy resilience
Participant suggestion	Development of an integrated water resource management program using artificial intelligence for continuous monitoring and accurate forecasting of hydrological conditions in Valais	Water lacks; water control; water management	Better information and data on water
Participant suggestion	Stop discussing sustainable tourism and focus on its impact. Promote positive behaviours, establish governance, and demonstrate political courage.	If the community wants to thrive, limit tourism to reduce its impact.	Reduction of CO2 emissions and decreased tourist pressure on the region
Participant suggestion	Have motivated project leaders. This depends on the current leadership. It all comes back to the human element	System inertia makes it very difficult to change laws and political structures	Involvement of individuals from citizens to policymakers
Participant suggestion	Reconnected people	Community-oriented	Improve social relationships among people
Participant suggestion	Have a mobility plan and reduce traffic	Mobility: decarbonizing the region	Facilitate pedestrian mobility in the area to enhance quality of life

REGIONAL VISION

ARTICLE/PROJECT	SOLUTION	CHALLENGES	BENEFICIAL IMPACTS
Participant suggestion	Coordinate a national water strategy. Currently, there is no sense of urgency	Politics: anticipate instead of reacting	Better manage water during critical periods
Participant suggestion	Target food production based on water resource needs (not solely on CO2). A protein has a specific water footprint.	Agriculture: adapt by finding the right amount to produce and the appropriate number of livestock in response to Climate Change.	Agriculture must be a good student and make the necessary efforts. Irrigation systems need to change
Participant suggestion	Consider solutions that are feasible and sustainable	The finances	Have projects that are both financially viable and sustainable

Participant suggestion	It's difficult to say "adapt" when we will support you	Structures (businesses, farms, operations) adapt with difficulty	Good coordination of actions and projects
Participant suggestion	Create snow-based water reserves. Annually, the volume of water remains the same, but it shifts throughout the year	Create water reserves through irrigated soils or water storage	Ensure water availability year-round and maintain livestock
Participant suggestion	We are at a turning point, as the infrastructure is aging. Multi-purpose water reserves, infrastructure, and water needs must be prioritized based on who receives the water	Initial investments in more efficient irrigation infrastructure	Reduce water consumption by minimizing leaks and sharing water among users
Participant suggestion	Behaviour will shift towards a more sustainable economy. Provide infrastructure to support this transition	Change in farmers' behaviour	Change in farmers' behaviour
Participant suggestion	Sustainable Natural Resource Management	Combining data from multiple sources (e.g., rivers, reservoirs, meteorological stations) into a unified system can be complex, requiring robust data management frameworks	Continuous monitoring allows for real-time understanding of hydrological conditions, leading to quicker responses to potential issues such as flooding or water shortages
Participant suggestion	Reforestation and Ecosystem Protection	Biodiversity loss; forest suffering	Improved efficiency in the use of water resources, leading to sustainable management practices that can benefit agriculture, industry, and communities in Valais
Participant suggestion	Coordination among local stakeholders	Lack of communication and decision-making process	An integrated program can improve communication and cooperation among local stakeholders, including farmers, municipal authorities, and environmental organizations

NATIONAL VISION

ARTICLE/PROJECT	SOLUTION	CHALLENGES	BENEFICIAL IMPACTS
Participant suggestion: Inspiration of MeteoSuisse, but for water management	Anticipate issue, improve management framework at the national and regional level, provide better understanding of the situation to politics and administrations	Engagement of politics, pragmatic approach	Capacity to manage water resources at the continental level to ensure safety and availability. Constructive collaboration between states, reduced risks of conflicts
Participant suggestion: Association of the preservation of the Geneva Lake created toolkits to involve families and people into water observation (colour, smell, etc.). Physical actions could be linked to digital services	Engage both visiting people and local people in a common awareness of the situation. Bring not only environmental information, but also cultural awareness about the value of water	Very different backgrounds, communication channels, adoption factors.	Allows to create coherent observation, infrastructures, practices and behaviours. Reduces the costs of infrastructures; prevent natural risks
Participant suggestion	Introduce methodology to create safe space of collaborative & creative discussion to get out of the regular dynamic of power	Need to introduce such skills in a context which might not be prepared to work on it	Avoid major blockage and foster effective co-creation of solutions

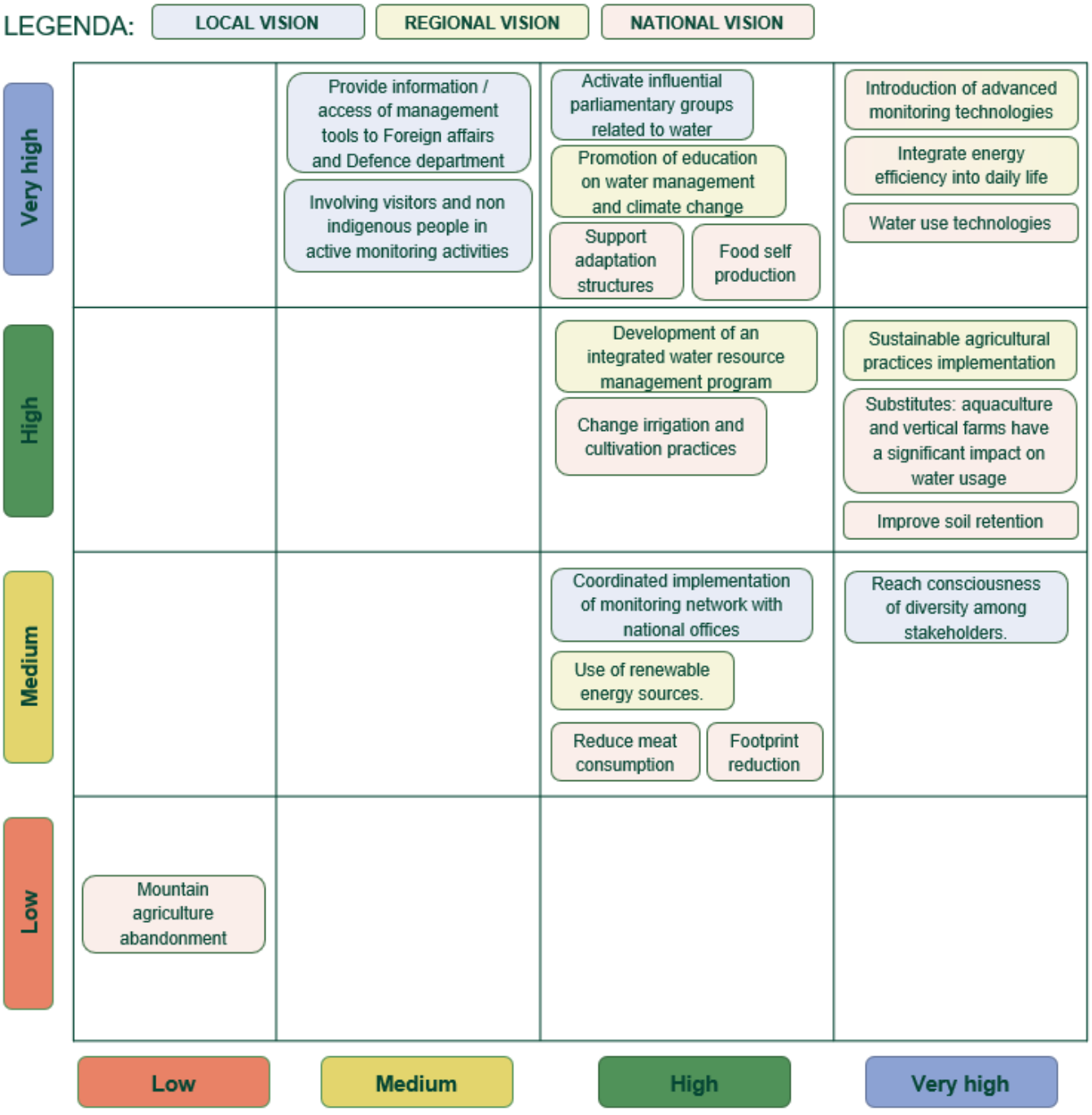


Figure 70. Outputs from Exercise 2B – Valais Stakeholders Factsheet (UMIL, 2024)

Implementation suggestions

Table 47. Chosen mitigation and adaptation solution to CC by Stakeholders - Valais

Regeneration of Humid Area for Integrated management of water resources
SOLUTION STRENGTHS: crucial role of wetlands in regulating water flow and preventing floods; adaptation to water scarcity or excess **SOLUTION WEAKNESSES:** requiring time to become fully operational **SOLUTION IMPLEMENTATION STAGES:** identification of suitable sites, design and planning of the restoration process, implementation of restoration measures, and continuous monitoring of the evolution of the areas; tests have been conducted and demonstrate feasibility. **OUTCOMES:** reduction of flood and drought risks through water flow regulation. **INDICATORS:** groundwater levels and water flow in restored areas **FINANCINC AND COSTS:** fundings through government grants **ACTORS INVOLVED:** local and regional authorities for permits and planning activities
In watershed quantitative and qualitative monitoring
SOLUTION STRENGTHS: enhanced qualitative and quantitative monitoring of watersheds through riparian vegetation **SOLUTION WEAKNESSES:** requiring long-term commitment **SOLUTION IMPLEMENTATION STAGES:** identification of suitable sites, design and planning of the restoration process, implementation of restoration measures, and continuous monitoring of the evolution of the areas **OUTCOMES:** reliable monitoring of quantitative parameters (water levels, flow rates) and qualitative parameters (water quality) in watersheds **INDICATORS:** quantitative measurements of water flow and water levels in areas with riparian vegetation **FINANCINC AND COSTS:** funding through environmental grants **ACTORS INVOLVED:** Local authorities for project approval and coordination.

5.5.7. Catalonia

5.5.7.1. REGIONAL REPLICATORS' PARTNERS

A participative process is fundamental for the success of CC adaptations, because a collaboration with local authorities and stakeholders is needed to correctly implement NbS and let them to be accepted by the population. This chapter resumes and analyses regional replicator's partners exercises, condensing Factsheet outcomes and underlining their main aspects (negative or positive). No validation process was made up in this case because regional replicators were not supposed to define Local Councils for that phase.

Assessing Climate Risks

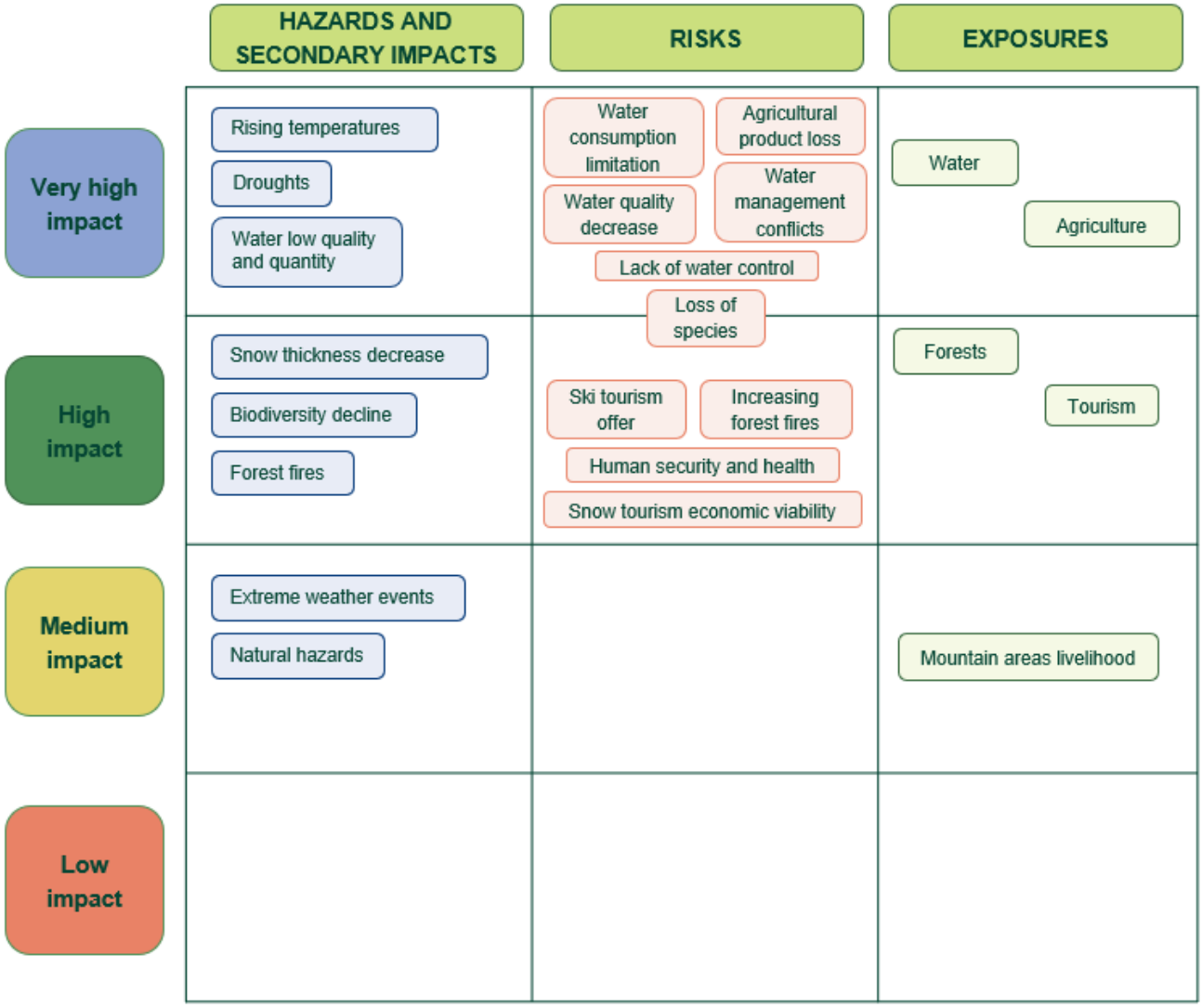


Figure 71. Outputs from Exercise 1 – Catalonia Replicators Factsheet (UMIL, 2024)

Determine existing solution

Table 48. Outputs from Exercise 2A – Catalonia Replicators Factsheet (UMIL, 2024)

ARTICLE/PROJECT	SOLUTION	CHALLENGES	BENEFICIAL IMPACTS
Project: OPEn-air laboratories for Nature based solutions to Manage hydro-meteo risks	Multi-dimensional open and flexible platform enabling stakeholders and end users to improve knowledge in NbS to mitigate Climate Change as well as ways to promote and exploit the improved/preserved environment while increasing business opportunities.	Employment of nature-based solutions (NbS) to mitigate the impact of hydro-meteorological phenomena is not adequately demonstrated	Hydro-meteorological; research; extreme events management
Project: Provision of a prediction system allowing for management and optimization of snow in Alpine ski resorts	Develop an advanced meteorological and climate prediction system tailored for snow management. This system will enhance real-time decision-making and climate adaptation for ski resorts across the Alps, ultimately paving the way for commercial exploitation of the service.	Improving the ski industry's ability to manage snow resources effectively amidst the unpredictability of weather and climate conditions.	Research; weather forecasting; snow monitoring; snow management; ski slope management
Project: Development and application of Novel, Integrated Tools for monitoring and managing Catchments	INTCATCH business will facilitate an eco-innovative approach to deliver good quality water bodies across Europe and beyond. This will support green growth; increase resilience to Climate Change and capture greater market-share for Europe's innovative industries.	Monitoring and management of surface water quality	Hydro informatics; business model; sensors; water management; monitoring; engagement
Project: Political and social awareness on Water Environmental challenges	Develop a user-driven Digital Social Platform (DSP) to enhance knowledge sharing and policy creation for water-related issues across EU local authorities, demonstrated in key cities and scaled to follower cities	Share knowledge and experience of water related issues in local authorities	Public policies; flood risk management; water management; hydrology; business model; citizens engagement; transnational collaboration; policy influence; community involvement; effective water management and conservation.
Project: Assessment of Climatic change and impacts on the Quantity and quality of Water	Define good modelling techniques and policy actions	Rapidly rising temperatures, prolonged droughts and extreme precipitation	Climatic change adaptation hazards impact modelling mountain regions policy water resources limnology climatology
Project: Mainstreaming Ecological Restoration of freshwater-related ecosystems in a Landscape context: Innovation, upscaling and transformation	Blueprint for proficient NbS implementation. Unknown freshwater restoration best-practice	Water scarcity and water uncontrolled quality	Water management; water treatment processes; edaphology; sensors; agriculture
Project: Water Management at River Basin Scale	Modelling and monitoring technologies; Integrated Catchment Simulator; stakeholder engagement	Intensive agriculture over-abstraction of groundwater	Improve water quality; monitoring techniques; river; lake; and groundwater quality
Project: Water4All, Water security for the planet	Improve knowledge on preserving, storing and managing this resource	Water scarcity due to Climate Change	Better management of water; expanded knowledge and planning; policy making

Article: Adapting to Climate Change: perceptions of vulnerability of down-hill ski area operators in Southern and Middle Finland	Artificial snow; snow prevision; slope development, operational practices and even cloud seeding, and the latter ski conglomerates, revenue diversification and marketing practices; questionnaire	Low-lying ski areas limited season and maintenance costs	Slope maintenance; season longer; operator adaptability; more data & knowledge
Article: Adaptation in the Tourism and Recreation Sector	Technical solutions (snowmaking; cloud seeding, slope operations; new sky terrains); management solutions; stakeholders' interaction	Limited adaptation of skiing industry due to CC	Slope development; technical improvement
Article: Core principles for successfully implementing and upscaling Nature-based solutions	Standards for successful implementation of NbS	Better efficiency of the NbS implemented	Core principles for successfully implementing and upscaling Nature-based solutions
Article: Framing Nature-Based Solutions	Proof that NbS are efficient compared to other solutions	Bring ecosystems services and social co-benefits	Framing Nature-Based Solutions
Article: Nature-based Solutions: New influence for environmental management and Research in Europe	Innovative NbS but we should also consider traditional knowledge	NbS could help meet various ethical, intellectual and relational challenges	Possible win-win situations but sometimes must face uncertainties

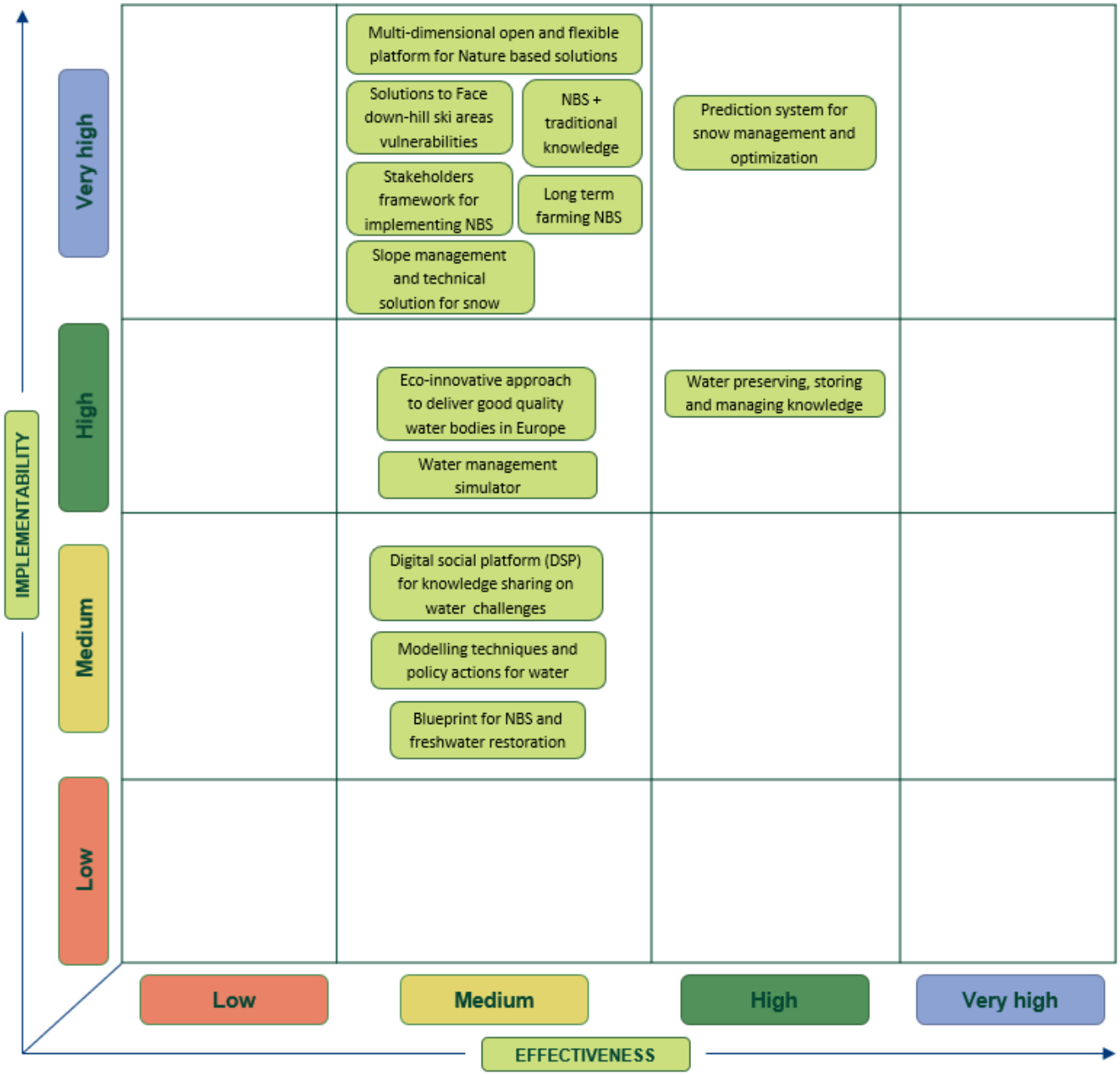


Figure 72. Outputs from Exercise 2B – Catalonia Replicators Factsheet (UMIL, 2024)

5.5.8. Friuli-Venezia Giulia

5.5.8.1. REGIONAL REPLICATORS' PARTNERS

A participative process is fundamental for the success of CC adaptations, because a collaboration with local authorities and stakeholders is needed to correctly implement NbS and let them to be accepted by the population. This chapter resumes and analyses regional replicator's partners exercises, condensing Factsheet outcomes and underlining their main aspects (negative or positive). No validation process was made up in this case because regional replicators were not supposed to define Local Councils for that phase.

Assessing Climate Risks

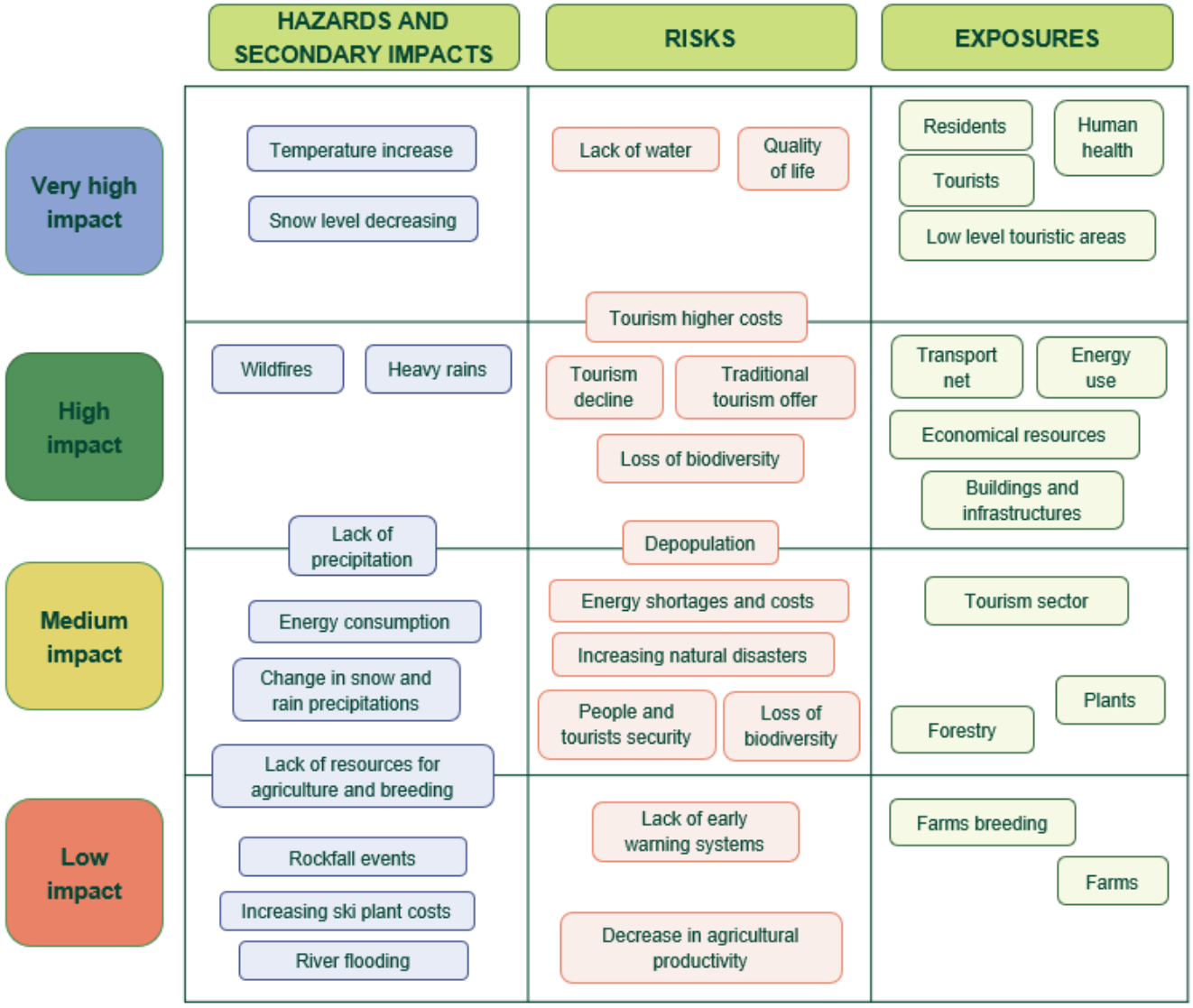


Figure 73. Outputs from Exercise 1 – Friuli-Venezia Giulia Replicators Factsheet (UMIL, 2024)

Determine existing solution

Table 49. Outputs from Exercise 2A – Friuli-Venezia Giulia Replicators Factsheet (UMIL, 2024)

ARTICLE/PROJECT	SOLUTION	CHALLENGES	BENEFICIAL IMPACTS
Participant suggestion	Different kind of tourism: slow and sustainable tourism; improve building characteristics	Environment pollution; smog	Health, sport; decrease the smog; environmental protection (bike/trekking)
Project: Provision of a prediction system allowing for management and optimization of snow in Alpine ski resorts	Develop an advanced meteorological and climate prediction system tailored for snow management, discussion with stakeholders	Health; Tourism; climate adaptation	Climate change adaptation; improving the ski industry's ability to manage snow resources; snow monitoring and ski slope management
Project: Water against Climate Change. Sustainable water management in urban areas	Workshop/meeting about the environment for children: explain the importance of that through games (i.e., waste recycling – water and plastic etc.)	Climate change; lack of water	Lower water consumption; information campaigns and meeting/workshop
Participant suggestion	Bike/car sharing; E-bike	Environment pollution; smog	Health, sport; decrease in smog; environmental protection
Article: Carrots and sticks for conserving the forest - A Nature-based Solution for Wolong Nature Reserve	Afforestation	Water and soil management	Better forest management; prevent deforestation; reduce flooding and landslides
Project: Overcoming barriers for climate resilient building practices	Improve building energy performance	Energy shortage; people health	Decreased energy consumption
Project: Fostering resilience. Opportunities and challenges of the local economy and society to adapt to Climate Change (LIFE CLINOMICS)	Opportunities and challenges of the local economy and society to adapt to Climate Change, engaging local administrations and employees in the agriculture, silviculture, water management, tourism, energy sectors (participatory approach).	Atmospheric precipitation changing; depopulation of mountain areas; lack of knowledge and awareness about Climate Change adaption; lack of communication and collaboration among diverse stakeholders	People/tourists health; fostering knowledge and awareness; preservation of the landscape and biodiversity
Participant suggestion	School teaching related to Climate Changes	People do not pay attention to the environment	More awareness; better resources management

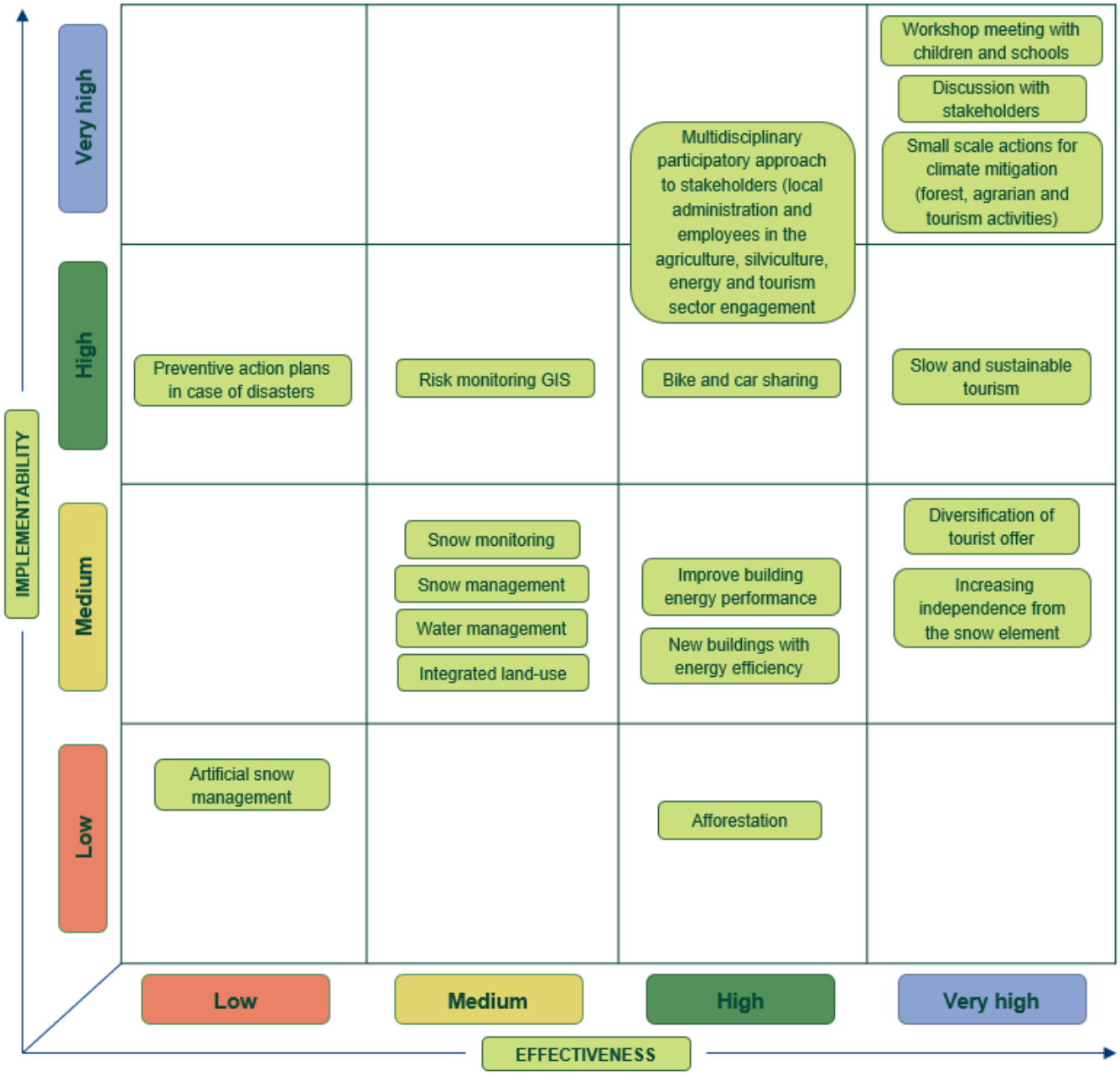


Figure 74. Outputs from Exercise 2B – Friuli-Venezia Giulia Replicators Factsheet (UMIL, 2024)

Implementation suggestions

Table 50. Chosen mitigation and adaptation solution to CC by Stakeholders – Friuli-Venezia Giulia

Meeting and workshop with schools and children
SOLUTION STRENGTHS: low cost; improve the knowledge; people involvement **SOLUTION WEAKNESSES:** no teachers; effective understanding and use **SOLUTION IMPLEMENTATION STAGES:** involve parents, association and forest police; walking into the forest/nature; questionnaires and interviews; the pilot action will be implemented in the pilot territory/territories; one pilot action and one demonstrator partner will be chosen; the analyses will form the basis for determining the draft of the strategy; verification of existing Climate Change vulnerability analyses **OUTCOMES:** children involving; awareness knowledge; list of actions for Climate Change adaptation **INDICATORS:** number of participants; number of children involved **FINANCINC AND COSTS:** already existing analyses, tools/platforms available; for the last step, budget to be identified **ACTORS INVOLVED:** school and family; national and local associations/administrations (municipalities, mountain communities, LAGs); peoples working in forest/nature sectors
Slow and sustainable tourism
SOLUTION STRENGTHS: improve the knowledge; people involvement; sport and health; decrease in smog **SOLUTION WEAKNESSES:** costs, lazy people **SOLUTION IMPLEMENTATION STAGES:** discover the territory without car; create a website; brochure describing the path and the natural environment **OUTCOMES:** awareness knowledge; human health; less pollution **INDICATORS:** numbers. of participants; site visit; number of brochures given/sold, passages on the cycle path or number of bikes rented **FINANCINC AND COSTS:** 20,000 euro for communication (website, brochure, graphic) – 5,000 euro for buy bike – 15,000 euro for trail maintenance and signage **ACTORS INVOLVED:** ASD or sport shops, municipality, region, forest policy, tourist office, tour operator
Multidisciplinary participatory approach to stakeholder (local administration and employees in the agriculture, silviculture, energy and tourism sector) engagement

SOLUTION STRENGTHS: low costs; make involved the stakeholders and let them know the opportunities of nature-based solutions systems

SOLUTION WEAKNESSES: communication between different stakeholders is hard; lack of stakeholder's awareness in the opportunities of nature-based solutions systems

SOLUTION IMPLEMENTATION STAGES: 1) verification of existing Climate Change vulnerability analyses, in order to select the pilot mountain territory/territories; these could be useful as a basis for projects like PNRR Green Communities or for municipalities that have joined the Covenant of Mayors for Climate and Energy initiative 2) determining the draft of strategy and action plan for adaptation to Climate Change for the identified territories; multidisciplinary participatory approach will be adopted towards this plan, engaging public and economic stakeholders from different sectors of the entire regional mountain area via platforms or something similar established under this or other projects; 3) as a result of this participatory approach, one pilot action most suited to the territory will be chosen and consequently also the demonstrator partner will be chosen; 4) the pilot action will be implemented in the pilot territory/territories to demonstrate the long-term environmental and economic benefits of adaptation measures; 5) dissemination days.

OUTCOMES: raised awareness 50% of public and private stakeholders on the opportunities and the competitive advantage of the incorporation of nature-based solutions into their processes; list of actions for Climate Change adaptation.

INDICATORS: numbers of participants; numbers of actions for Climate Change adaption; numbers of refurbished buildings

FINANCINC AND COSTS: use of already existing analyses for the first step; use of tools/platforms made available by the MR project for the second and third step; the multidisciplinary participatory approach could benefit from synergies with other projects; the fourth step managed by the demonstrator partner; for the last step - organization of dissemination days - budget to be identified.

ACTORS INVOLVED: local associations and administrations (municipalities, mountain communities, LAGs), people working in agriculture, silviculture, water management, energy/building and tourism sectors; university; builders' municipalities

5.5.9. Primorje-Gorski Kotar

5.5.9.1. REGIONAL REPLICATORS' PARTNERS

A participative process is fundamental for the success of CC adaptations, because a collaboration with local authorities and stakeholders is needed to correctly implement NbS and let them to be accepted by the population. This chapter resumes and analyses regional replicator's partners exercises, condensing Factsheet outcomes and underlining their main aspects (negative or positive). No validation process was made up in this case because regional replicators were not supposed to define Local Councils for that phase.

Assessing Climate Risks

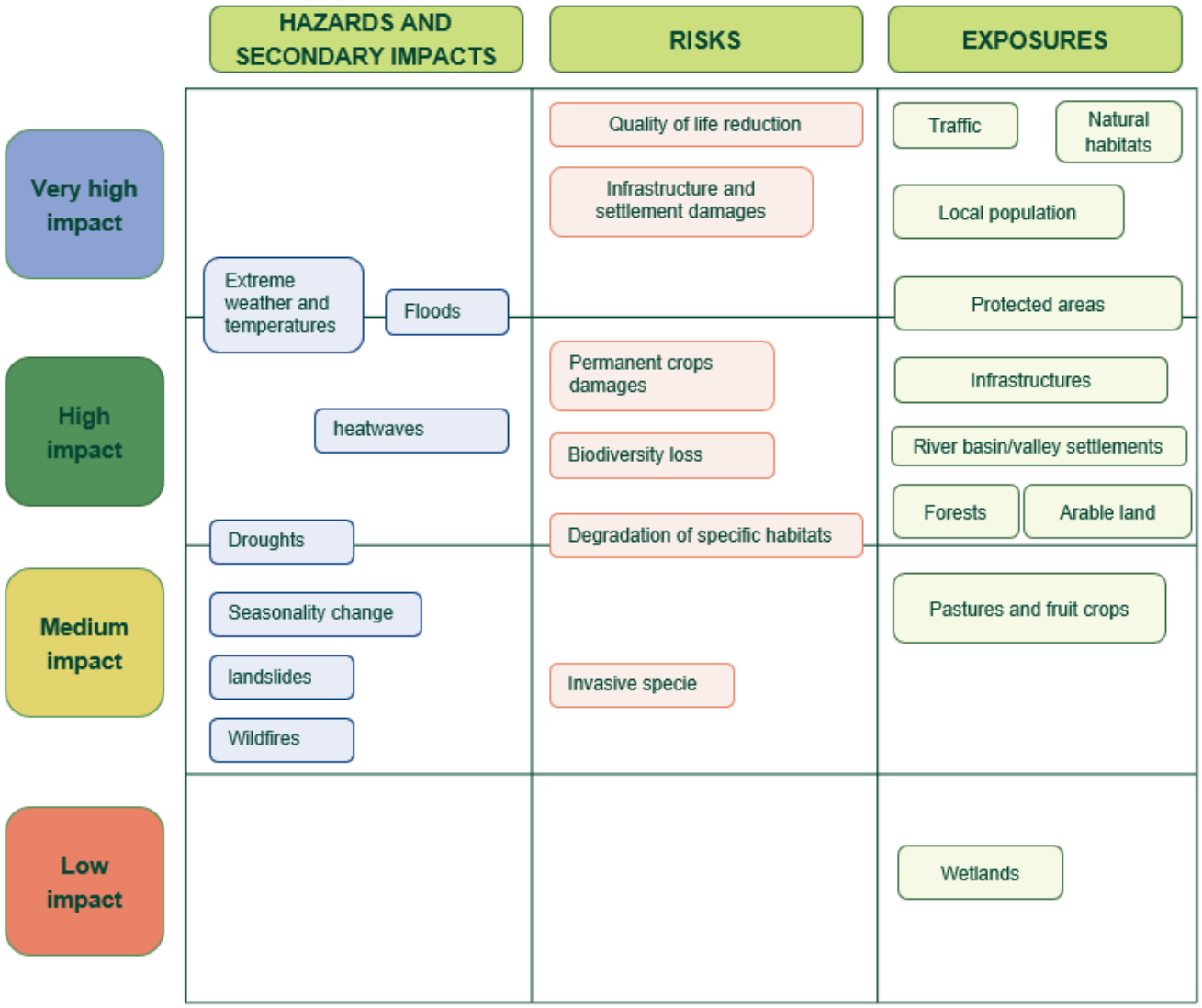


Figure 75. Outputs from Exercise 1 – Primorje-Gorski Kotar Replicators Factsheet (UMIL, 2024)

Determine existing solution

Table 51. Outputs from Exercise 2A – Primorje-Gorski Kotar Factsheet (UMIL, 2024)

ARTICLE/PROJECT	SOLUTION	CHALLENGES	BENEFICIAL IMPACTS
Project: Arctic Impact on Weather and Climate (EU-funded Blue-Action project)	Robust and reliable forecasting that can help meteorological and climate services to better deliver tailored predictions and advice decision-makers	Predicting and monitoring climate and extreme events	Research; observations; weather forecast; modelling; bridging knowledge
Project: Development of a multi-stakeholder dialogue platform and Think tank to promote innovation with Nature based solutions (ThinkNature Platform)	Provide the necessary policy and regulatory tools to solve significant societal challenges such as human well-being, tackling energy poverty, impacts of Climate Change, etc. through continuous dialogue and interaction.	Lack of effective communication and collaboration among diverse stakeholders needed to promote and implement nature-based solutions for societal and environmental issues.	Stakeholder informative platform; knowledge capacity building; stakeholders' engagement; research
Project: Sustainable Hub to Engage into Rural Policies with Actors (EU-funded SHERPA project)	Design future research agendas to fill knowledge gaps and meet the needs of rural actors. Contributing to the formulation of modern, effective rural policies for the 2021-2027 programming period and beyond.	Effectively integrating scientific evidence and local knowledge into policy-making processes for rural areas, ensuring that policies are responsive to the diverse needs of rural communities.	Rural policy; public policy; participatory approach; citizen participation; evidence-based policy; research
Project: Local Initiative Strengthening: how to build up a new Tourism in THE Valleys and among the most vital Centre's OF rural VILLAGES	Increase the competitiveness and the attractiveness of rural marginal territories through the settlement and the implementation of new territorial governance tools and implementing new pilot projects inside the sustainable tourism sector.	For several years rural areas have been suffering from big difficulties and troubles occurred in the competitiveness, the attractiveness and the unemployment field.	Knowledge transfer; workshops; touristic valorisation; engagement; policy making; better governance; showing unexpressed tourist potential
Project: Automation of the modélisation des risques d'inondation dans les eaux d'amont des bassins (INUNDATIO)	Emergency plans based on monitoring. Preventive action plans in case of disasters	Floods; no warning system in place	Prevent floods; Early Warning System; Hydrometeorological Data; Risk Mitigation; Vulnerability Analysis
Project: Assuring water Availability in Agriculture under changing CLIMAte conditions (LIFE ACLIMA)	Innovative technologies, strategies and measures for agricultural and horticultural companies to adapt to declining water availability	Water shortage; floods and droughts	Water recharge and quantity; resource access and usability; optimizing water use and preventing waste; river and lake restoration; landslide control and mitigation; conservation and protection; improved drainage and runoff reduction; food quality and security - reducing pesticides and pollutants; farming and agriculture; landscape value; knowledge sharing; updated

			maps and data; energy efficiency and better use; management and planning
Project: Integrated Research Infrastructure Services for Climate Change risks	Connect natural sciences with social sciences to provide services and share data with stakeholders	Adaptation to Climate Change requires in-depth understanding of Climate Change driven risks, including their determinants.	Appropriate decision-making process and stakeholders' engagement; dissemination.
Project: Assessment of Climatic change and impacts on the Quantity and quality of Water	Define good modelling techniques and policy actions	Rapidly rising temperatures, prolonged droughts and extreme precipitation	Climatic change adaptation hazards impact modelling mountain regions policy water resources limnology climatology
Project: Mainstreaming Ecological Restoration of freshwater-related ecosystems in a Landscape context: Innovation, upscaling and transformation	Blueprint for proficient NbS implementation. Unknown freshwater restoration best-practice	Water scarcity and water uncontrolled quality	Water management; water treatment processes; edaphology; sensors; agriculture
Project: Forest: Climate Change Adaptation	Mobile phone application; methodologies and tools to help decision-making for the forestry-wood sector, incorporating field observations	Climate change has affected the growth and productivity of forests and may worsen many potential threats, such as wildfires, human development or drought	Forestry improvement; stakeholders' engagement; correct evaluation and management; risk reduction; prevent forest dieback; forest resilience; monitoring
Project: Mid-mountain adaptation to Climate Change	Landscape adaptation in marginal mid-mountain areas to improve their environmental and socio-economic resilience	Rural abandonment of mountain slopes which has dramatically reduced the landscapes diversity	Agricultural and forest sustainability; prevent depopulation; citizen engagement; economic improvement; tailored decision-making processes.
Project: Demonstrating cooperative approach for good management of Natura 2000 grasslands at landscape scale in Transylvania	Management techniques, landscape-scale cooperation, well-targeted Regional Development Programme payments (especially Agri-environment payments), and development of new products/better marketing	To encourage continued good management by enlightened Agri-environment and cooperative management schemes, linked also to marketing and economic viability	Improving local knowledge about biodiversity; management of protected grasslands; better soil for farming; food security; stakeholder engagement
Article: Regeneration of Degraded Land with Nature-Based Solutions	Traditional farming techniques (soil dig holes, water bunds) with technology whilst. Communication	Land degradation; water lack; low resources availability	Greening; land restoration; water availability
Article: Challenges and Opportunities of Bio-Circular-Green Economy for Agriculture	Mobile phone application; Potential value chains; circular economy	Crops selling	Resource better use and diffusion, co-operation, circular and bio economy; stakeholders' engagement

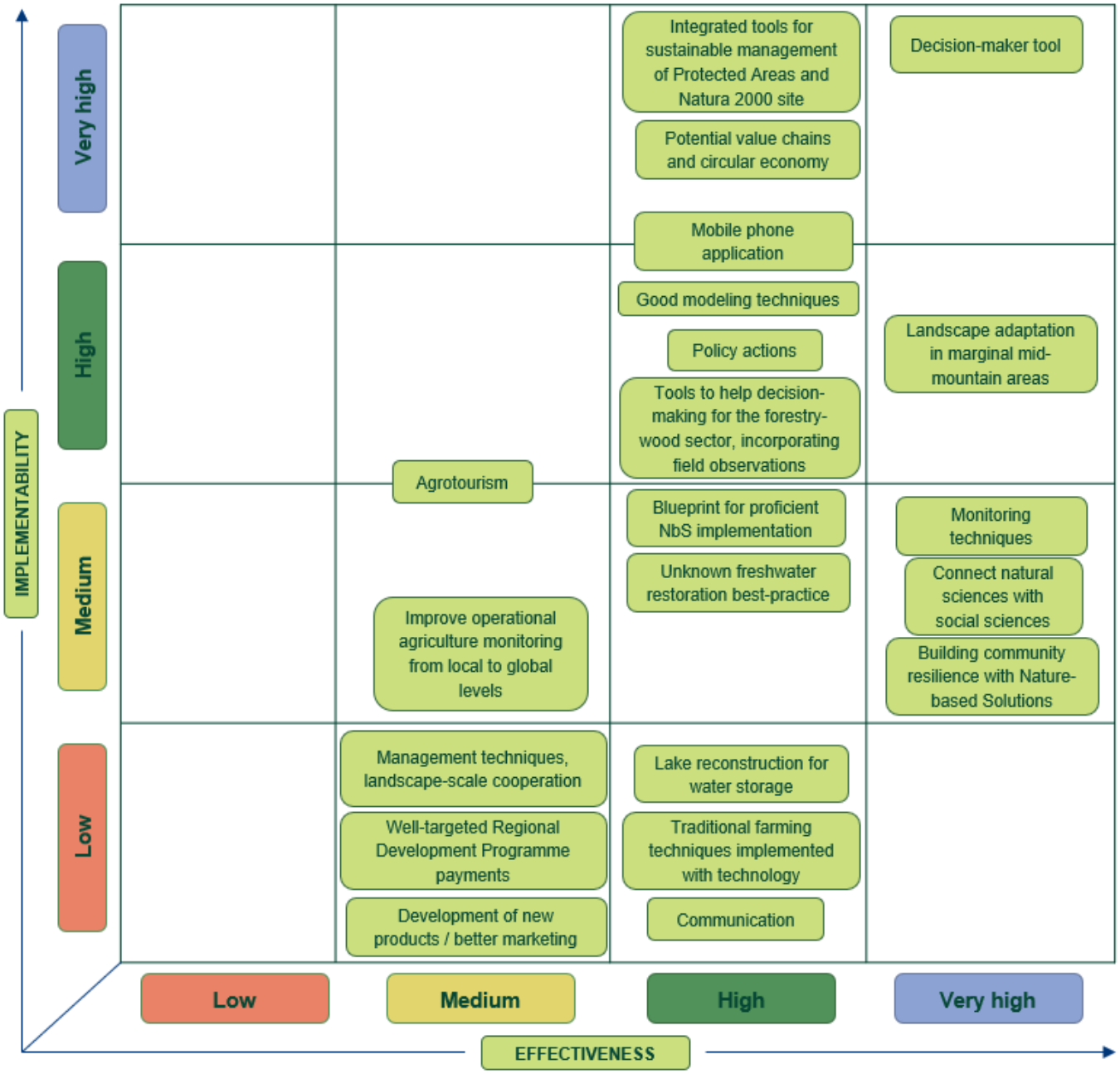


Figure 76. Outputs from Exercise 2B – Primorje-Gorski Kotar Replicators Factsheet (UMIL, 2024)

Implementation suggestions

Table 52. Chosen mitigation and adaptation solution to CC by Stakeholders – Primorje-Gorski Kotar

Landscape adaptation in marginal mid-mountain areas

SOLUTION STRENGTHS: potential boost of sustainable agriculture practices, involvement of motivated new stake holders

SOLUTION WEAKNESSES: convincing current farmers to adapt, difficulty to involve national-level policy makers

SOLUTION IMPLEMENTATION STAGES: contact relevant institutions and stakeholders; analysis; strategy creation; implementation

OUTCOMES: restoration of heterogeneous agro-forest and pastoral land, shared best practices, decreased depopulation of mountain areas

INDICATORS: number of new farmers, amount of land (area) used for sustainable agri-pastoral activities, farmers' annual income, increased the quality of environmental and natural indicators (air, land, water, biodiversity)

FINANCINC AND COSTS: number of new farmers, amount of land (area) used for sustainable agropastoral activities, farmers' annual income, increased quality of environmental and natural indicators (air, land, water, biodiversity)

ACTORS INVOLVED: Primorje-Gorski Kotar County; Regional centre for agriculture and rural development; Ministry of Forestry and Agriculture; universities (Zagreb&Rijeka); local action groups

Assessment of Climatic change and impacts on the quantity and quality of water

SOLUTION STRENGTHS: institutional frameworks will identify vulnerabilities and be used to evaluate a range of policy options

SOLUTION WEAKNESSES: long period of data collection, stakeholders' involvement (different actors)

SOLUTION IMPLEMENTATION STAGES: data collection and analysis; identification of most critical areas; best practices research; design and project phase; implementation strategy; monitoring

OUTCOMES: a clearer picture of possible risks, hazards and exposed areas; all-embracing strategy to deal with Climate Change that causes risks and hazards

INDICATORS: implementation success; decreased risks in exposed areas

FINANCINC AND COSTS: /

ACTORS INVOLVED: Primorje-gorski kotar County; universities (Zagreb&Rijeka); local action groups; Croatian Water Authority (Hrvatske Vode); consultants

Robust and reliable forecasting that can help meteorological and climate services to better deliver tailored predictions and advice decision-makers

SOLUTION STRENGTHS: improved understanding of the climate changing can enhance reliable forecasting and enable tailored predictions and recommendations regarding the weather and climate in particular area

SOLUTION WEAKNESSES: very expensive and not easy to implement, because it needs a lot of education and preparatory investments

SOLUTION IMPLEMENTATION STAGES: preparation of a regulatory framework background; procurement of equipment; education of stakeholders; implementation

OUTCOMES: prediction and monitoring results on a regular basis; early warning system wide utilization

INDICATORS: yearly reports on prediction and monitoring concerning the Climate Change in local area

FINANCINC AND COSTS: /

ACTORS INVOLVED: local self-government, protected areas, regional bodies responsible for different sectors (nature protection, water management, regional development, regional tourism, energy, etc.)

New territorial governance tools for implementing new pilot projects inside the sustainable tourism sector

SOLUTION STRENGTHS: mountain territories are in possession of enormous natural, cultural-historical and local craft wealth; these resources, if properly exploited, could become the real “economic engine” of these areas; increased competitiveness and attractiveness

SOLUTION WEAKNESSES: very hard with this solution to cope with the rural areas’ competitiveness, the attractiveness and the unemployment, as well as depopulation problems and demographical changes due to progressive ageing

SOLUTION IMPLEMENTATION STAGES: preparation of policy framework; preparation of knowledge transfer plan; touristic valorisation; governance improvement plan

OUTCOMES: sustainable business models in touristic sector; competitive and attractive business plans that attract young families for permanent life in rural mountain regions

INDICATORS: number of business models and business plans

FINANCINC AND COSTS: /

ACTORS INVOLVED: local self-governments; regional development agency; regional economy and tourism department; rural mountain area touristic boards

Decision-maker tool

SOLUTION STRENGTHS: systematic approach

SOLUTION WEAKNESSES: potential lack of implementation of proposed measures after developing strategies

SOLUTION IMPLEMENTATION STAGES: participatory processes implementation; risks identification; strategy drafting; measures implementation

OUTCOMES: strategic document developed; decision-making for risk planning enabled

INDICATORS: number of implemented measures

FINANCINC AND COSTS: /

ACTORS INVOLVED: local authorities; PGKC institutions; private sector actors; civil protection sector representatives

Integrated tools for sustainable management of Protected Areas and Natura 2000 site

SOLUTION STRENGTHS: adaptation of participatory planning

SOLUTION WEAKNESSES: difficulty in developing new monitoring systems

SOLUTION IMPLEMENTATION STAGES: existing management and monitoring practices analysis and evaluation; implementing workshops with relevant stakeholders; identification of values, potentials and risks; development of a new tool

OUTCOMES: development and implementation of a new model

INDICATORS: Ha of protected areas and Natura 2000 sites in which new model will be used

FINANCINC AND COSTS: /

ACTORS INVOLVED: Priroda – public institution for protected area management of PGKC; local authorities, PGKC institutions, private and civil sector stakeholders etc.

5.5.10. Subcarpathian Region

5.5.10.1. REGIONAL REPLICATORS' PARTNERS

A participative process is fundamental for the success of CC adaptations, because a collaboration with local authorities and stakeholders is needed to correctly implement NbS and let them to be accepted by the population This chapter resumes and analyses regional replicator's partners exercises, condensing Factsheet outcomes and underlining their main aspects (negative or positive). No validation process was made up in this case because regional replicators were not supposed to define Local Councils for that phase.

Assessing Climate Risks

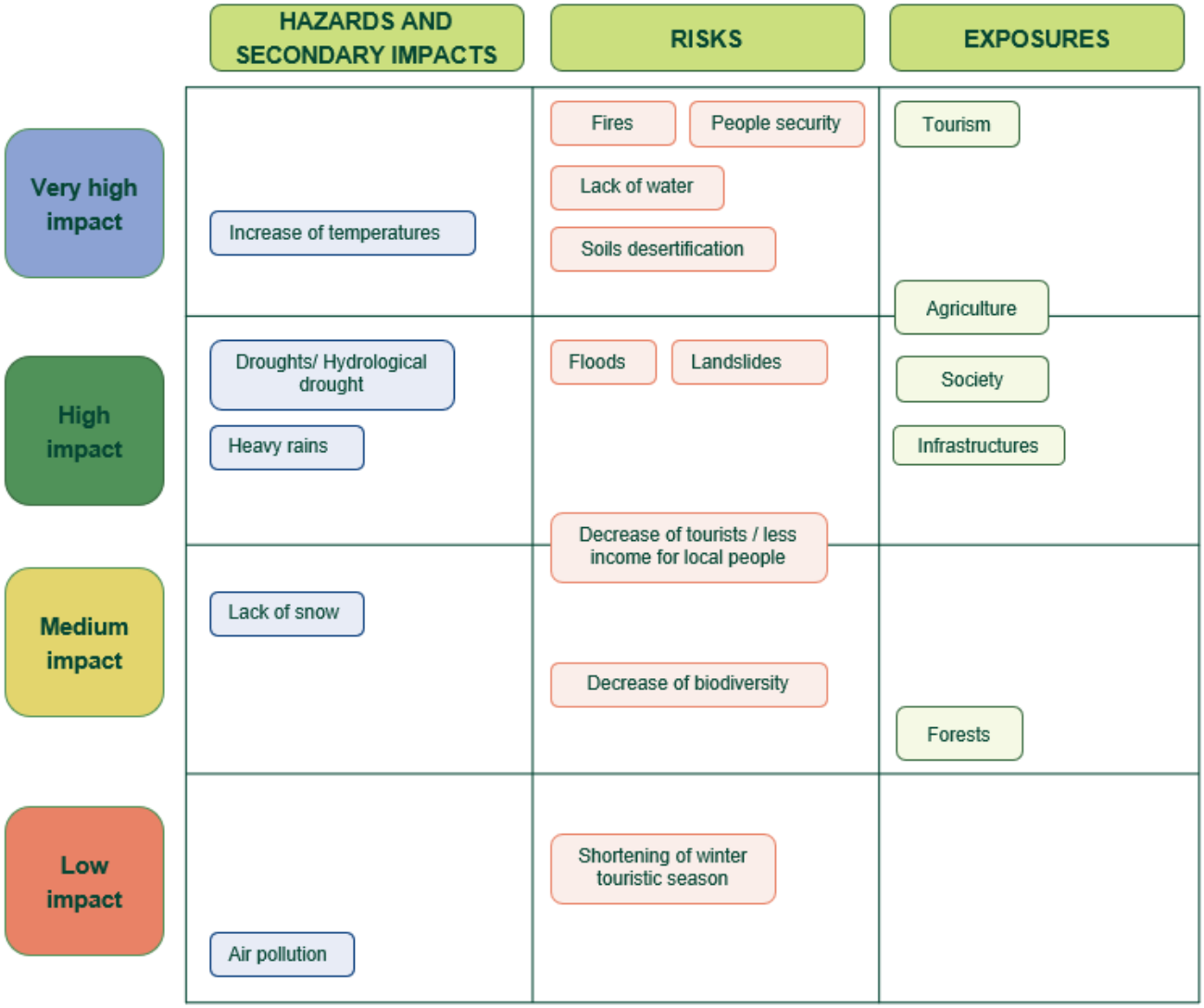


Figure 77. Outputs from Exercise 1 – Subcarpathian Region Replicators Factsheet (UMIL, 2024)

Determine existing solution

Table 53. Outputs from Exercise 2A – Subcarpathian Region Factsheet (UMIL, 2024)

ARTICLE/PROJECT	SOLUTION	CHALLENGES	BENEFICIAL IMPACTS
Project: Mid-mountain adaptation to Climate Change	Landscape adaptation in marginal mid-mountain areas to improve their environmental and socio-economic resilience	Rural abandonment of mountain slopes which has dramatically reduced the landscapes diversity	Agricultural and forest sustainability; prevent depopulation; citizen engagement; economic improvement; tailored decision-making processes
Project: IRRIGAVIT: Irrigazione razionale e gestione del suolo in viticoltura transfrontaliera.	Support of agricultural policies approved by administrative bodies	Increase in drought situations, it is imperative to determine good water management practices based on the principles of sustainability	Viticulture challenges; water management practices; sustainability principles; climate crisis impacts; irrigation strategies; resilience in viticulture; policy implications
Project: Assuring water Availability in Agriculture under changing CLIMAte conditions	Innovative technologies, strategies and measures for agricultural and horticultural companies to adapt to declining water availability	Water shortage; floods and droughts	Water recharge and quantity; resource access and usability; optimizing water use and preventing waste; river and lake restoration; landslide control and mitigation; conservation and protection; improved drainage and runoff reduction; food quality and security - reducing pesticides and pollutants; farming and agriculture; landscape value; knowledge sharing; updated maps and data; energy efficiency and better use; management and planning
Article: Improve the Constructive Design of a Furrow Diking Rotor Aimed at Increasing Water Consumption Efficiency in Sunflower Farming Systems	Furrow diking best designs (technical improvement)	Lack of water	Water availability; soil turning; water consumption efficiency; crops better management; regenerative agriculture
Project: Water4All, Water security for the planet	Improve knowledge on preserving, storing and managing this resource	Water scarcity due to Climate Change	Better management of water; expanded knowledge and planning; policy making
Project: Generate REsiliENt actions agaiNst the HEat islAnd effect on uRban Territory	Green spaces; city vegetation; blue green and blue infrastructure; pollution; air monitoring	Heatwaves; water scarcity and heavy rainfall	Green and blue infrastructure networks; heatwave monitoring
Article: Natural/Small Water Retention Measures: Their Contribution to Ecosystem-Based Concepts	Natural small water retention measures (NSWRM)	Ecological degradation; floods	Large list depending on NbS
Article: Development of Raspberry Pi-Based IoT Landslide Monitoring System	Soil moisture monitoring system	Soil erosion; water regimes changing; water scarcity; landslide	Monitoring practices; water information; risk mitigation

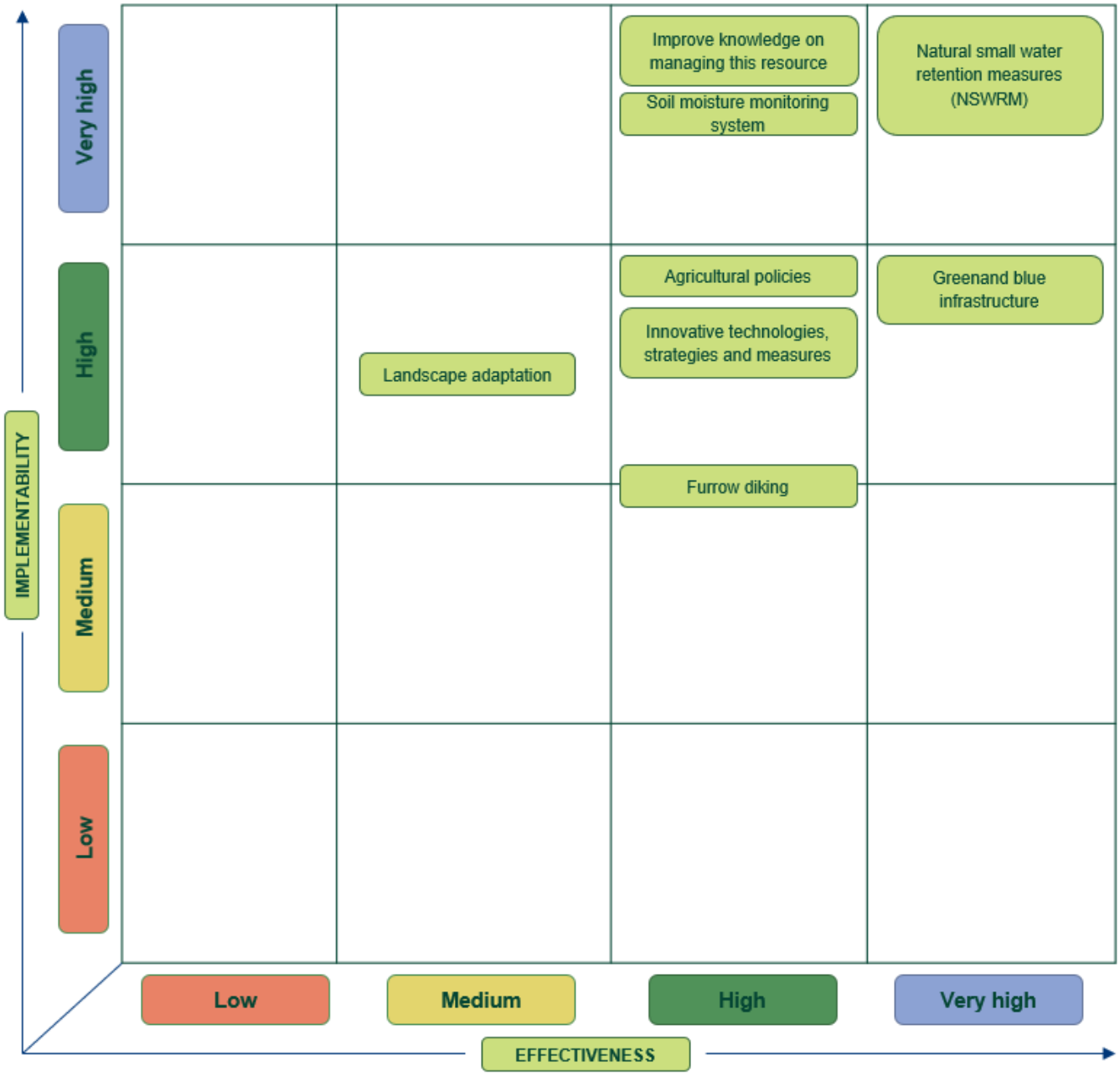


Figure 78. Outputs from Exercise 2B – Subcarpathian Region Replicators Factsheet (UMIL, 2024)

Implementation suggestions

Table 54. Chosen mitigation and adaptation solution to CC by Stakeholders – Subcarpathian Region

Improve the Constructive Design of a Furrow Diking Rotor Aimed at Increasing Water Consumption Efficiency in Farming Systems
SOLUTION STRENGTHS: nature-based solution, flexible, low cost **SOLUTION WEAKNESSES:** lack of funding source **SOLUTION IMPLEMENTATION STAGES:** developing R&D project to construct the design of a furrow diking rotor, estimation of costs, acquiring funds, implementation of project and dissemination of the new system **OUTCOMES:** improved quality and availability of water **INDICATORS:** numbers of municipalities and farmers involved **FINANCINC AND COSTS:** acquiring funding from EU project **ACTORS INVOLVED:** municipality councils, local government, farmers, researchers
Green spaces, blue green and blue infrastructure
SOLUTION STRENGTHS: low cost, providing a couple of impacts **SOLUTION WEAKNESSES:** long time to wait for long term effects **SOLUTION IMPLEMENTATION STAGES:** indicating the areas for creating green spaces, estimation of costs, acquiring funds from national, local programmes or EU programmes/ securing own budget, public procurement, hiring contractor, implementation of project **OUTCOMES:** less heat, shaded areas for citizens, better water retention **INDICATORS:** numbers of municipalities, cities involved **FINANCINC AND COSTS:** acquiring funding from EU project **ACTORS INVOLVED:** municipality and city councils, citizens

6. References

AcegasApsAmga, & DMG-UNITS (2014). *Climate and climate change data for Friuli Venezia Giulia Region (Italy): Report. Available at: http://drinkadria.fgg.uni-lj.si/externalapp/content/climate/LP_CC_FVG_region_Italy.pdf.*

Achermann, S., & Liechti, K. (2012). *Der Wandel in der Landwirtschaft prägt auch die Welterbe-Region. UNESCO-Welterbe Schweizer Alpen Jungfrau-Aletsch (Changes in agriculture also characterise the World Heritage region. Swiss Alps Jungfrau-Aletsch UNESCO World Heritage Site). Available at: https://jungfraualetsch.ch/wp-content/uploads/2021/03/LOW_Landwirtschaft_Einblicke-Ausblicke_2012_def.pdf.*

Adler, C., Wester, P., Bhatt, I., Huggel, C., Insarov, G.E., Morecroft, M.D., Muccione, V., Prakash, A. (2022). *Cross-Chapter Paper 5: Mountains, in: Climate Change 2022 – Impacts, Adaptation and Vulnerability: Working Group II Contribution to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press. https://doi.org/10.1017/9781009325844.*

Agora Est Consulting (2016). *Country report 5.1 Conditionality, Romania: National Risk Assessment – RO RISK. Available at: https://igsu.ro/Resources/COJ/RapoarteStudii/Raport_Final_de_tara%20pt%20Condit%20ex-ante%202016.pdf.*

Alpine convention (2015). *Guidelines for Climate Change Adaptation at the local level in the Alps - ISBN: 9788897500247. Available at: https://www.alpconv.org/fileadmin/user_upload/Publications/AS/AS7_EN.pdf.*

Amt der Tiroler Landesregierung (2023). *Die Wirtschaft in Tirol. Eine Analyse der Leistungs- und Strukturerhebung 2020 (The economy in Tyrol. An analysis of the 2020 performance and structure survey). Available at: https://www.tirol.gv.at/fileadmin/themen/statistik-budget/statistik/downloads/Leistungs-und_Strukturerhebung/lse_2020.pdf.*

ARPA [Regional Environmental Protection Agency] FVG [Friuli-Venezia Giulia] (2018). *RSA 2018 - Report on the state of the environment in Friuli-Venezia Giulia. Available at: https://www.arpa.fvg.it/dati/rapporti-sullo-stato-dellambiente/rsa-2018/ ; last accessed on 29 October 2024.*

ARPA & Piedmont Region (2020). *Guidance Document Toward the Regional Climate Change Strategy Piemonte (2020): Cambimento Climatico.*

Aubin, D. (2011). *Non-owners' success: Confrontations of rules in rivalries between water users in Belgium and Switzerland. Environmental Politics, 20(2), 210–226. https://doi.org/10.1080/09644016.2011.551026*

Austrian Federal Ministry for Sustainability and Tourism (2017). *The Austrian strategy for adaptation to climate change – Vienna, ISBN 978-3-903129-46-7. Available at: https://climate-laws.org/document/the-austrian-strategy-for-adaptation-to-climate-change_f7a6 ; last accessed on 29 October 2024.*

Autonomous Region of Friuli Venezia Giulia (2022). *Supporting energy and climate adaptation policies (SECAP) - L'esperienza del progetto SECAP: Strategie di Mitigazione e Adattamento. Volume 2. Adattamento - ISBN: 9788889405376. Available at: https://2014-2020.ita-slo.eu/sites/default/files/progetti/ATT%2011%20-%20Adaptation%20Strategies.pdf.*

Bioregions Facility (2024). *Bioregions – Forest bioeconomy in action. Available at: https://bioregions.efi.int/bioregions/catalonia/* ; *last accessed on 29 October 2024.*

Bojariu, R., Chitu, Z., Dascalu, S. I., Gothard, M., Velea, L. F., Burcea, R., et al. (2021). *Schimbările climatice – de la bazele fizice la riscuri și adaptare Ediție revăzută și adăugită: (Climate change - from physical basis to risks and adaptation Revised and expanded edition).*

Bulgarian Ministry of Environment and Water (2020). *National Climate Change Adaptation Planning and Strategies. Available at: https://www.moew.government.bg/static/media/ups/articles/attachments/First%20adaptation%20report_ENfd1e22d0ab6ef19a9b2c2762be88011c.pdf.*

Bundesrat (2022). *Report of the Federal Council. Environment Switzerland 2022. Available at: https://www.bafu.admin.ch/bafu/en/home/state/publications-on-the-state-of-the-environment/umwelt-schweiz-2022.html* ; *last accessed on 29 October 2024.*

Buth, M., Kahlenborn, W., Savelsberg, J., et. al. (2015). *Vulnerabilität Deutschlands gegenüber dem Klimawandel. Umweltbundesamt. Available at: https://www.umweltbundesamt.de/sites/default/files/medien/378/publikationen/climate_change_24_2015_vulnerabilitaet_deutschlands_gegenueber_dem_klimawandel_1.pdf.*

CADS [Advisory Council for Sustainable Development of Catalonia] (2016). *The 2030 Agenda: Transform Catalonia, improve the world. Available at: https://ods.cat/wp-content/uploads/2017/07/CADS-Report_3_2016_The-2030-Agenda_Transform-Catalonia_Improve-the-World.pdf.*

Caloiero, T., Cianni, I., & Gaudio, R. (2023). *A rainfall trend analysis for the assessment of climate change in Friuli-Venezia Giulia (north-eastern Italy). Euro-Mediterranean Journal for Environmental Integration, 8(1), 115-127.*

Canton du Valais (2013). *Wasserstrategie des Kantons Wallis. Herausforderungen, Ziele, Stossrichtungen und Massnahmen (Water strategy of the Canton of Valais. Challenges, goals, directions and measures). Available at: https://www.vs.ch/documents/529400/1643440/4.%20Schlussbericht%20der%20%3FSteuerungsgruppe%20Wasser%20Wallis%3F.pdf/82062741-0fcc-4e3c-b983-1094741aa1ed ;*

Canton du Valais (2016). *Das Wallis angesichts des Klimawandels. Auswirkungen und Anpassungsmöglichkeiten in den Bereichen Wasserbewirtschaftung und Naturgefahren (The Valais in the face of climate change. Impacts and adaptation options in the areas of water management and natural hazards). Available at: https://www.bafu.admin.ch/dam/bafu/de/dokumente/klima/externe-studien-berichte/Das%20Wallis%20angesichts%20des%20Klimawandels.pdf.download.pdf/Das_Wallis_angesichts_des_Klimawandels_-_Broschüre.pdf.*

Cardona, O.-D., van Aalst, M. K., Birkmann, J., Fordham, M., McGregor, G., Perez, R., et al. (2012). *Determinants of Risk: Exposure and Vulnerability. In C. B. Field, V. Barros, T. F. Stocker, & Q. Dahe (Eds.), Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation (pp. 65–108). Cambridge University Press. Available at: https://www.researchgate.net/publication/244062037_Determinants_of_risk_exposure_and_vulnerability ; last accessed on 29 October 2024*

Carpathian convention (n.d.). *http://www.carpathianconvention.org/ ; last accessed on 29 October 2024*

Climate-Adapt (n.d.). *Regional Adaptation Support Tool (RAST). (EU Mission on Adaptation to Climate Change). Available at: https://climate-adapt.eea.europa.eu/en/mission/knowledge-and-data/regional-adaptation-support-tool?size=n_10_n&filters%5B0%5D%5Bfield%5D=issued.date&filters%5B0%5D%5Btype%5D=any&filters%5B0%5D%5Bvalues%5D%5B0%5D=All%20time&filters%5B1%5D%5Bfield%5D=language&filters%5B1%5D%5Btype%5D=any&filters%5B1%5D%5Bvalues%5D%5B0%5D=en ; last accessed on 29 October 2024.*

Commune of Râu Sadului (2024). *Primăriei Râu Sadului (Râu Sadului City Hall). Available at: https://riusadului.ro/ ; last accessed on 29 October 2024.*

Corradini, P., Omizzolo, A., Rizzari, M., Corrado, F., Durbiano, E., Bertoldi, G., Tonelli, C., & Pr, V. (n.d.). *Report on the effects of Climate Change on the Alpine Space Snow Tourism Destinations. Available at: https://www.alpine-space.eu/wp-content/uploads/2024/03/Beyondsnow-Report-on-the-effects-of-CC-on-the-AS-Snow-Tourism-Destinations-deliverable-1.1.1-april-2023-DEF.pdf.*

Croatian Ministry of Environment and Energy (2017). *Draft Climate Change Adaptation Strategy in the Republic of Croatia for the period to 2040 with a view to 2070. Available at: https://prilagodba-klimi.hr/wp-content/uploads/docs/Draft%20CC%20Adaptation%20Strategy.pdf.*

Cubon-Bell, V. (2019). *Kent State University. Teaching – Fact Sheets. Kent State University Center for Teaching and Learning. Available at: https://www.kent.edu/ctl/fact-sheets ; last accessed on 29 October 2024.*

Czekaj, F. (2020). *Climate changes and their impact on current and future threats to the Podkarpackie Province. Humanities and Social Sciences, 27(2), 21-29. https://doi.org/10.7862/rz.2020.hss.13.*

EEA [European Environment Agency] (2021). *EEA environmental statement 2021. Publications Office of the European Union, Luxembourg. Available at: https://www.eea.europa.eu/publications/environmental-statement-report ; last accessed on 29 October 2024.*

ESCACC30 [Catalan Strategy for Adaptation to Climate Change for the 2030 horizon] (2023). *Catalan Strategy for Adapting to Climate Change 2021-2030. Available at: https://canviclimatic.gencat.cat/web/.content/03_AMBITS/adaptacio/ESCACC_2021_2030/Resum-Executiu-ESCACC30_Govern_CA_EN.pdf.*

ESTAT [Eurostat] (2004). *Piedmont – Economy. Internationalisation of industry. Available at: https://circabc.europa.eu/webdav/CircaBC/ESTAT/regportraits/Information/itc1_eco.htm ; last accessed on 29 October 2024.*

Estoque, R.C., Ooba, M., Togawa, T. et al. (2022). *Climate impact chains for envisaging climate risks, vulnerabilities, and adaptation issues. Reg Environ Change 22*, 133*. https://doi.org/10.1007/s10113-022-01982-4.*

Eurostat (2006). *LUCAS [Land Use and Cover Area frame Survey]. Available at: https://ec.europa.eu/eurostat/cache/metadata/en/lan_esms.htm ; last accessed on 28 October 2024.*

Eurostat (2022). *Regions in Europe. 2023 Edition*. Available at: *https://ec.europa.eu/eurostat/web/interactive-publications/regions-2023#people-and-society ; last accessed on 29 October 2024.*

Fankhauser, S. (2017). *Adaptation to Climate Change. Annual Review of Resource Economics, 9(1), 209–230. Available at: https://www.annualreviews.org/content/journals/10.1146/annurev-resource-100516-033554 ; last accessed on 29 October 2024*

Fedele, G., Donatti, C. I., Harvey, C. A., Hannah, L., & Hole, D. G. (2019). *Transformative adaptation to climate change for sustainable social-ecological systems. Environmental Science & Policy, 101, 116–125. https://doi.org/10.1016/j.envsci.2019.07.001.*

Field, C.B., Barros, V.R., Dokken, D.J., Mach, K.J., Mastrandrea, M.D. (Eds.), (2014). *Emergent Risks and Key Vulnerabilities, in: Climate Change 2014 Impacts, Adaptation, and Vulnerability. Cambridge University Press, Cambridge, pp. 1039–1100. https://doi.org/10.1017/CBO9781107415379.024.*

Flaminio, S., & Reynard, E. (2023). *Multipurpose Use of Hydropower Reservoirs: Imaginaries of Swiss Reservoirs in the Context of Climate Change and Dam Relicensing. Water Alternatives, 16. Available at: https://www.water-alternatives.org/index.php/alldoc/articles/vol16/v16issue2/701-a16-2-4/file.*

Fuchs, S., Wenk, M., & Keiler, M. (2022). *Geomorphic Hazards in Austria. In C. Embleton-Hamann (Ed.), Landscapes and Landforms of Austria (pp. 105–117). Springer International Publishing. https://doi.org/10.1007/978-3-030-92815-5_6.*

Gabrovo Municipality (2020). *Action Plan for promotion of green public procurement implementation during the realization of the Municipal Development Plan of Gabrovo Municipality. Available at: https://projects2014-2020.interregeurope.eu/fileadmin/user_upload/tx_tevprojects/library/file_1607597980.pdf ; last accessed on 29 October 2024.*

GIZ, & EURAC (2017). *Risk Supplement to the Vulnerability Sourcebook. Available at: https://www.adaptationcommunity.net/wp-content/uploads/2017/10/GIZ-2017_Risk-Supplement-to-the-Vulnerability-Sourcebook.pdf.*

Global Market Research and Analysis (2018). *Report On Mediterranean Adventure Tourism - Catalonia - DESTINATION REVIEW FROM A SOCIO-ECONOMIC, POLITICAL AND ENVIRONMENTAL PERSPECTIVE IN ADVENTURE TOURISM (From Project MEDUSA). Available at https://www.enicbcmed.eu/sites/default/files/2024-05/Destination%20Review-Catalonia_EN.pdf.*

Grêt-Regamey, A., Brunner, S.H., Kienast, F. (2012). *Mountain Ecosystem Services: Who Cares? Mt. Res. Dev. 32, S23–S34. https://doi.org/10.1659/MRD-JOURNAL-D-10-00115.S1.*

Hohenwallner-Ries, D., Pachler, B., & Schermer, C. (2020). *Strategie zur Anpassung an den Klimawandel in Innsbruck (Strategy for adapting to climate change in Innsbruck). Available at: https://www.innsbruck.gv.at/_Resources/Persistent/c3bc936235589e41c38d1e133c732508fc0cd889/strategie_zur_anpassung_an_den_klimawandel_gesamt.pdf ; last accessed on 28 October 2024.*

Institute of Catalan Studies and the Government of Catalonia (2017). *Third Report on Climate Change in Catalonia. Climate change in Catalonia: executive summary of the Third report on climate change in Catalonia. – First edition Títol original: El Canvi climàtic a Catalunya: resum executiu del tercer informe sobre el canvi climàtic a Catalunya ISBN 9788439396222 (Generalitat de Catalunya). ISBN 9788499653877 (Institut d'Estudis Catalans). Available at: https://cads.gencat.cat/web/.content/Documents/Publicacions/tercer-informe-sobre-canvi-climatic-catalunya/Resum_executiu_TICCC/RESUM_EXECUT_TICCC_web_EN.pdf.*

Iojâ, I. C., Croitoru, A. E., Vavari, S. A. D., Benedek, J., & Sandu-Giprian, M. (2022). *Best Practice and Awareness Raising Guide on Climate Change Mitigation and Adaptation for the Sibiu County Council, Available at: https://eeagrants.org/archive/2014-2021/projects/RO-ENVIRONMENT-0011 ; last accessed on 29 October 2024*

IPCC [Intergovernmental Panel on Climate Change] (2018). *Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty. in Press*
Available at: https://www.ipcc.ch/sr15/ ; last accessed on 28 October 2024.

IPCC [Intergovernmental Panel on Climate Change] (2022). *Climate Change 2022: Impacts, Adaptation and Vulnerability: IPCC Sixth Assessment Report. Available at: https://report.ipcc.ch/ar6/wg2/IPCC_AR6_WGII_FullReport.pdf.*

Isidoro De Bortoli, Paola Menzardi (2024). *JOINT STRATEGY REPORT - Joint strategy for community-led sustainable development of mountain areas in Central Europe with a special focus on participatory governance (Eurac research). Available at: https://www.interreg-central.eu/wp-content/uploads/2024/03/Central-Mountains-Joint-Strategy-Report.pdf*

Italian Ministry of the Environment (2022a). *PTE - Piano Nazionale di Transizione Ecologica, Available at: https://www.mase.gov.it/pagina/piano-la-transizione-ecologica ; last accessed on 28 October 2024.*

Italian Ministry of the Environment (2022b). *Piano Nazionale di Adattamento ai Cambiamenti Climatici (PNACC). Available at: /https://www.mase.gov.it/sites/default/files/archivio/allegati/clima/PNACC_versione_dicembre2022.pdf.*

IUCN [International Union for Conservation of Nature] (2016). *Resolution 69 on Defining Nature-based Solutions (WCC-2016-Res-069). IUCN Resolutions, Recommendations and Other Decisions 6–10 September 2016. World Conservation Congress Honolulu, Hawaii, USA. Available at: https://portals.iucn.org/library/sites/library/files/resrecfiles/WCC_2016_RES_069_EN.pdf.*

Karpaty.info. *Poland - Subcarpathian region. Available at: https://www.karpaty.info/en/pl/pk/ ; last accessed on 28 October 2024.*

Klein, J.A., Tucker, C.M., Steger, C.E., Nolin, A., Reid, R., Hopping, K.A., Yeh, E.T., Pradhan, M.S., Taber, A., Molden, D., Ghate, R., Choudhury, D., Alcántara-Ayala, I., Lavorel, S., Müller, B., Grêt-Regamey, A., Boone, R.B., Bourgeron, P., Castellanos, E., Chen, X., Dong, S., Keiler, M., Seidl, R., Thorn, J., Yager, K. (2019). *An integrated community and ecosystem-based approach to disaster risk reduction in mountain systems. Environ. Sci. Policy 94, 143–152. https://doi.org/10.1016/j.envsci.2018.12.034.*

Knight, J. (2022). *Scientists' warning of the impacts of climate change on mountains. PeerJ 10, e14253. https://doi.org/10.7717/peerj.14253.*

Kozlica, N., Radunovi, S. & Kovaÿiÿ, M. (2022). *Plan Razvoja Gorskog Kotara 2022-2027. Analiza Stanja (Gorski Kotar Development Plan 2022-2027. State Analysis). Available at: https://prigoda.hr/wp-content/uploads/2022/09/ANALIZA-STANJA-GK_2022.pdf.*

Kundzewicz, Z. W., Piniewski, M., Mezghani, A., Okruszko, T., Pińskwar, I., Kardel, I., Hov, Ø., Szcześniak, M., Szwed, M., Benestad, R. E., Marcinkowski, P., Graczyk, D., Dobler, A., Førland, E. J., O'Keefe, J., Choryński, A., Parding, K. M., & Haugen, J. E. (2018). *Assessment of climate change and associated impact on selected sectors in Poland. Acta Geophysica, 66(6), 1509–1523. https://doi.org/10.1007/s11600-018-0220-4.*

Lapland Ministry of Agriculture and Forestry (2014). *Finland's National Climate Change Adaptation Plan 2022. ISBN 978-952-453-862-6 (Electronic version). ISSN 1797-397X (Electronic version). Available at:*

https://mmm.fi/documents/1410837/0/Finland_s_National_climate_Change_Adaptation_Plan_2022+%281%29.pdf.

Lapland regional council publication (2011). *Lapland Climate Strategy 2030. ISBN 978-951-9244-59-4 Available at: https://primo.uef.fi/discovery/fulldisplay?docid=alma9911220363705966&context=L&vid=358FIN_UOEF:VU1&lang=fi&search_scope=MyInstitution&adaptor=Local%20Search%20Engine&tab=LibraryCatalog&query=sub,exact,ilmastovaikutukset,AND&mode=advanced&offset=50 ; last accessed on 29 October 2024.*

Leitner, M., Dworak, T., Lourenco, T. C., Lexer, W., Prutsch, A., & Vanneuville, W. (2020). *Rationale, approach and added value of Key Type of Measures for adaptation to climate change, Available at: https://www.eionet.europa.eu/etcs/etc-cca/products/etc-cca-reports/rationale-approach-and-added-value-of-key-type-of-measures-for-adaptation-to-climate-change ; last accessed on 29 October 2024.*

Loidi, J. (2017). *The Ebro Basin. In J. Loidi (Ed.), Plant and Vegetation. The vegetation of the Iberian Peninsula (pp. 513–547). New York NY: Springer Berlin Heidelberg.*

McPhearson, T., Cook, E.M., Berbés-Blázquez, M., Cheng, C., Grimm, N.B., Andersson, E., Barbosa, O., Chandler, D.G., Chang, H., Chester, M.V., Childers, D.L., Elser, S.R., Frantzeskaki, N., Grabowski, Z., Groffman, P., Hale, R.L., Iwaniec, D.M., Kabisch, N., Kennedy, C., Markolf, S.A., Matsler, A.M., McPhillips, L.E., Miller, T.R., Muñoz-Erickson, T.A., Rosi, E., Troxler, T.G. (2022). *A social-ecological-technological systems framework for urban ecosystem services. One Earth 5, 505–518. https://doi.org/10.1016/j.oneear.2022.04.007.*

Meri, R., Ronchi, D., Sardonini, L., & Viaggi, D. (2007). *Po Basin Case study status report. AquaMoney. Available at: http://www.aquamoney.ecologic-events.de/sites/download/poit.pdf.*

Meteoblue (n.d.). *Climate Change Gorski Kotar. Available at: https://www.meteoblue.com/en/climate-change/gorski-kotar_croatia_3214579 ; last accessed on 29 October 2024.*

Milano, M., & Reynard, E. (2022). *Prospective integrated modelling of water scarcity risk in western Switzerland: Lessons learned and new challenges for water security assessment. Géocarrefour, 96(1), Article 1. https://doi.org/10.4000/geocarrefour.18618.*

Mortreux, C., O'Neill, S., & Barnett, J. (2020). *Between adaptive capacity and action: new insights into climate change adaptation at the household scale. Environmental Research Letters, 15(7), 74035, Available at: https://iopscience.iop.org/article/10.1088/1748-9326/ab7834/meta ; last accessed on 29 October 2024.*

Mourey, J., Ravanel, L., & Lambiel, C. (2022). *Climate change related processes affecting mountaineering itineraries, mapping and application to the Valais Alps (Switzerland). Geografiska Annaler: Series A, Physical Geography, 104(2), 109–126. https://doi.org/10.1080/04353676.2022.2064651.*

Municipality of Gabrovo (2021). *Sustainable Energy and Climate Action Plan of the Municipality of Gabrovo until 2030*.

National Centre for Climate Services (2021). *Klimawandel im Kanton Wallis. Was geschah bisher und was erwartet uns in Zukunft? (Climate change in the canton of Valais. What has happened so far and what can we expect in the future?). Available at: https://www.nccs.admin.ch/dam/nccs/de/dokumente/website/regionen/kantone/faktenblaetter/Faktenblaetter_Klimawandel_VS_d_2110.pdf.download.pdf/Faktenblaetter_Klimawandel_VS_d_2110.pdf.*

Navarro, D., Lizundia-Loiola, J., Paz, J., Abajo, C., Cantergiani, G., & Feliu, E. (2022). *ESPON-CLIMATE Update 2022. Updating and Integrating CLIMATE Datasets and Maps. Final Report. ESPON EGTC. Available at: https://www.espon.eu/projects/espon-2020/monitoring-and-tools/climate-data-and-maps-update ; last accessed on 29 October 2024.*

OECD [Organisation for Economic Co-operation and Development] (2021). *Regional Innovation in Piedmont, Italy: From Innovation Environment to Innovation Ecosystem. https://doi.org/10.1787/7df50d82-en.*

OECD [Organisation for Economic Co-operation and Development] (2023*). Enhancing international partnership and co-operation in Friuli Venezia Giulia, Italy: OECD Local Economic and Employment Development (LEED) Papers 2023/17. Available at: https://www.oecd.org/content/dam/oecd/en/publications/reports/2023/10/enhancing-international-partnership-and-co-operation-in-friuli-venezia-giulia-italy_3a9fd3ba/61e7fe2a-en.pdf.*

Oedl-Wieser, T. (2017). *Women as Drivers for a Sustainable and Social Inclusive Development in Mountain Regions – The Case of the Austrian Alps. European Countryside, 9(4), 808–821. https://doi.org/10.1515/euco-2017-0045*.

Ollivier, G., Magda, D., Mazé, A., Plumecocq, G., Lamine, C. (2018). *Agroecological Transitions: What Can Sustainability Transition Frameworks Teach Us? An Ontological and Empirical Analysis. Ecol. Soc. 23. https://doi.org/10.5751/ES-09952-230205.*

OPCC [PYRENEAN CLIMATE CHANGE OBSERVATORY] (2023). *Climate change in the Pyrenees: impacts, vulnerability and adaptation: Bases of knowledge for the future adaptation strategy of the Pyrenees. Available at: https://www.opcc-ctp.org/sites/default/files/editor/opcc-resumen-en-print.pdf ; last accessed on 28 October 2024*

Ministry of Agriculture, Food Sovereignty and Forests (2022). *Italy CAP Strategic Plan 2023-2027 - PAC. Available at: https://www.reterurale.it/flex/cm/pages/ServeBLOB.php/L/IT/IDPagina/24037 ; last accessed on 29 October 2024.*

Pagani, L., Zanarotti, M. C., & Habus, A. (2022). *The evaluation of heat vulnerability in Friuli Venezia Giulia. In Book of the short paper (pp. 635-640). Pearson.*

Page M J, McKenzie J E, Bossuyt P M, Boutron I, Hoffmann T C, Mulrow C D et al (2021). *The PRISMA 2020 statement: an updated guideline for reporting systematic reviews BMJ 2021; 372 :n71 doi:10.1136/bmj.n71.*

Permanent Secretariat of the Alpine Convention (2021). *Climate Action Plan 2.0 Sterndruck, Fügen, Austria. Available at: https://alpineclimate2050.org/climate-action-plan-2-0/ ; last accessed on 28 October 2024.*

Piedmont Region (2017). *Zootecnia. Turin: IPLA: Analisi degli scenari di clima regionale del periodo 2011-2100. (Animal husbandry. Turin: IPLA: Analysis of regional climate scenarios for the period).*

Piedmont Region (2020). *Regione Piemonte Annex to Under 2 MOU: General overview and weather conditions information, Available at: https://www.theclimategroup.org/sites/default/files/2020-10/Piedmont-appendix.pdf.*

Piedmont Region (2022). *Regional strategy on climate change* (*La Strategia regionale sul Cambiamento Climatico, primo stralcio). Available at: https://www.regione.piemonte.it/web/temi/ambiente-territorio/cambiamento-climatico/strategia-regionale-sul-cambiamento-climatico ; last accessed on 28 October 2024.*

Phusicos (2019) *Deliverable D5.1 NBS in-depth case study analysis of the characteristics of successful governance models. Work Package 5 – Governance Innovation. Available at: https://pure.iiasa.ac.at/id/eprint/17250/1/D5_1_NBS-in-depth-case-study-analysis_Final.pdf.*

Polish Ministry of the Environment (2023). *Polish National Strategy for Adaptation to Climate Change by 2020 with the perspective by 2030. Available at: https://bip.mos.gov.pl/fileadmin/user_upload/bip/strategie_plany_programy/Strategiczny_plan_adaptacji_2020.pdf .*

Poth, C. N. (Ed.) (2023). *The sage handbook of mixed methods research design. Thousand Oaks: Sage.*

Primorje-Gorski Kotar County (2011) *Razvojna strategija - Development strategy of the Primorje-Gorski Kotar County 2016-2020. Available at: https://prigoda.hr/en/razvojna-strategija-pgz/.*

Reisinger, Andy, Mark Howden, Carolina Vera, et al. (2020). *The Concept of Risk in the IPCC Sixth Assessment Report: A Summary of Cross-Working Group Discussions. Intergovernmental Panel on Climate Change, Geneva, Switzerland. Available at: https://www.ipcc.ch/site/assets/uploads/2021/02/Risk-guidance-FINAL_15Feb2021.pdf.*

Regional Council of Lapland (2017). *Lapland's Tourism Strategy 2020-2023.*

Republic of Bulgaria (2018). *National Climate Change Adaptation Strategy and Action Plan. Available at: https://www.moew.government.bg/static/media/ups/categories/attachments/Strategy%20and%20Action%20Plan%20-%20Full%20Report%20-%20%20ENd3b215dfec16a8be016bfa529bcb6936.pdf.*

Rodriguez, V. (2024). *Catalonia Autonomous Community, Spain. Available at: https://www.britannica.com/place/Catalonia ; last accessed on 28 October 2024.*

Romanian Ministry of Environment, Water and Forests (2017). *Romania's 7th National Communication under the United Nations Framework Convention on climate change, Available at: https://unfccc.int/sites/default/files/resource/0587134_Romania-NC7-1-NC7_ROMANIA.pdf.*

Romanian Ministry of Environment, Water and Forests (2024). *Nas [National Adaptation Strategy] - National strategy to adapt the climate change for the period 2024-2030 with a view to 2050. Available at: https://www.mmediu.ro/categorie/cadrul-national/408 ; last accessed on 28 October 2024.*

Sapino, F., Pérez-Blanco, C. D., Gutiérrez-Martín, C., & Frontuto, V. (2020). *An ensemble experiment of mathematical programming models to assess socio-economic effects of agricultural water pricing reform in the Piedmont Region, Italy. Journal of environmental management, 267, 110645.*

Schneider, J. (Ed.) (2014*). Österreichischer Sachstandsbericht Klimawandel 2014 (Austrian Assessment Report on Climate Change 2014). Verlag der Österreichischen Akademie der Wissenschaften.*

Schneider, F., Bonriposi, M., Graefe, O., Herweg, K., Homewood, C., Huss, M., Kauzlaric, M., Liniger, H., Rey, E., Reynard, E., Rist, S., Schädler, B., & Weingartner, R. (2016). *MontanAqua: Tackling Water Stress in the Alps: Water Management Options in the Crans-Montana-Sierre Region (Valais). GAIA - Ecological Perspectives for Science and Society, 25(3), 191–193. https://doi.org/10.14512/gaia.25.3.11.*

Schneiderbauer, S., Pedoth, L., Zhang, D., & Zebisch, M. (2013). *Assessing adaptive capacity within regional climate change vulnerability studies—an Alpine example. Natural Hazards, 67(3), 1059–1073. DOI: 10.1007/s11069-011-9919-0.*

Seddon, N., Chausson, A., Berry, P., Girardin, C.A.J., Smith, A., Turner, B. (2020). *Understanding the value and limits of nature-based solutions to climate change and other global challenges. Philos. Trans. R. Soc. B Biol. Sci. 375, 20190120. https://doi.org/10.1098/rstb.2019.0120.*

Seddon, N., Smith, A., Smith, P., Key, I., Chausson, A., Girardin, C., House, J., Srivastava, S., Turner, B. (2021). *Getting the message right on nature‐based solutions to climate change. Glob. Change Biol. 27, 1518‐1546. https://doi.org/10.1111/gcb.15513.*

Selkimäki, M., González-Olabarria, J. R., & Pukkala, T. (2012). *Site and stand characteristics related to surface erosion occurrence in forests of Catalonia (Spain). European Journal of Forest Research, 131(3), 727–738.*

Sibiu County Council (2022). *Strategy and Plan for mitigating and adapting to climate change in the Municipality of Sibiu. Action plan for diminishing and measures needed for adaptation in Sibiu County (SC-PAAMA-CJS-2021). Available at: https://eeagrantsmediu.ro/en/atenuarea-schimbarilor-climatice-si-adaptare/strategy-and-plan-for-mitigating-and-adapting-to-climate-change-in-the-municipality-of-sibiu-in-public-consultation/ ; last accessed on 29 October 2024.*

Spanish MITECO [Ministry for the Ecological Transition and the Demographic Challenge] (2020). *National Climate Change Adaptation Plan, Madrid, ISBN: 978-84-18508-32-5. Available at: https://migrationnetwork.un.org/policy-repository/national-adaptation-plan-climate-change-2021-2030-pnacc ; last accessed on 29 October 2024.*

Smit, B., & Pilifosova, O. (2003). *From Adaptation to Adaptive Capacity and Vulnerability Reduction. In J. B. Smith, R. J. T. Klein, & S. Huq (Eds.), Climate Change, Adaptive Capacity and Development (pp. 1-28). London: Imperial College Press. https://doi.org/10.1142/9781860945816_0002.*

Smith, A., Stirling, A. (2010). *The Politics of Social-ecological Resilience and Sustainable Socio-technical Transitions. Ecol. Soc. 15, art11. https://doi.org/10.5751/ES-03218-150111.*

Socio-economic analysis of the Carpathian area (2007). *Carpathian Convention. Available at: http://www.carpathianconvention.org/tl_files/carpathiancon/Downloads/03%20Meetings%20and%20Events/Working%20Groups/Spatial%20Planning/200805_Strategic%20Workshop%20on%20Spatial%20Planning/8SocioEconomicAnalysis.pdf.*

Steiger, R., & Stötter, J. (2013). *Climate Change Impact Assessment of Ski Tourism in Tyrol. Tourism Geographies, 15(4), 577–600. https://doi.org/10.1080/14616688.2012.762539.*

Svein Disch Mathiesen et al. (2023). *Reindeer Husbandry. Resilience in the Changing Arctic, Volume 2. DOI: https://doi.org/10.1007/978-3-031-42289-8. Available at: https://link.springer.com/book/10.1007/978-3-031-42289-8 ; last accessed on 29 October 2024.*

Tebaldi, E., & Gobjila, A. (2018). *Romania Systematic Country Diagnostic - Agriculture, Available at: https://documents1.worldbank.org/curated/en/698251530897736576/pdf/128044-SCD-PUBLIC-P160439-RomaniaSCDBackgroundNoteAgriculture.pdf.*

Tennberg, M., Emelyanova, A., Eriksen, H., Haapala, J., Hannukkala, A., Jaakkola, J.J.K., Jouttijärvi, T., Jylhä, K., et al. (2017). *The Barents area changes – How will Finland adapt? (Barentsin alue muuttuu – miten Suomi sopeutuu?). Prime minister's office - Adaptation Actions for a Changing Arctic (AACA), Publications of the Govenrment´s analysis, assessment and research activities 31/2017, Helsinki, Finland.*

Tiranti, D., & Ronchi, C. (2023). *Climate Change Impacts on Shallow Landslide Events and on the Performance of the Regional Shallow Landslide Early Warning System of Piemonte (Northwestern Italy). GeoHazards, 4(4), 475–496.*

Tirol Werbung (2024). *Überblick: Tirol in Zahlen (Overview: Tyrol in figures). Available at: https://presse.tirol.at/pr1113902-ueberblick-tirol-in-zahlen/89475/ ; last accessed on 28 October 2024.*

TranfrormAr project. *Funded by European Union's Horizon H2020 innovation action programme under grant agreement 101036683. Available at: https://transformar.eu/ ; last accessed on 29 October 2024.*

TransAlp (2022). *Climate Change and Extreme Events in The Alpine Area: How to be Prepared. Trans-Alp. Available at: http://project-transalp.eu/wp-content/uploads/2023/03/Project-TransAlp_ENG_compressed-1.pdf.*

Tourist board Gorski Kotar (2022). *Gorski Kotar Green oasis of Europe. Available at: https://gorskikotar.hr/en/gorski-kotar/* ; *last accessed on 29 October 2024*

Ugarković, I. Tikvić, (2011). *Variation of climate in the region of Gorski Kotar. Available at: https://www.researchgate.net/publication/282717646_Variation_of_climate_in_the_region_of_gorski_kotar ; last accessed on 29 October 2024.*

UNEP [United Nations Environment Programme]*. In Europe's wild Carpathian Mountains, prospect of drought rises. Available at: https://www.unep.org/news-and-stories/story/europes-wild-carpathian-mountains-prospect-drought-rises#:~:text=The%20Carpathian%20region%20has%20been,droughts%2C%20erratic%20rainfall%20and%20floods ; last accessed on 28 October 2024.*

UNEP [United Nations Environment Programme] (2021). *Becoming #GenerationRestoration: Ecosystem restoration for people, nature and climate. Nairobi. Available at: https://www.researchgate.net/profile/Lera-Miles-2/publication/358833835_Becoming_GenerationRestoration_Ecosystem_restoration_for_people_nature_and_climate/links/6217d5a6cf3e20571e1fee5d/Becoming-GenerationRestoration-Ecosystem-restoration-for-people-nature-and-climate.pdf.*

United Nations Framework Convention on Climate Change (2022*). EIGHTH NATIONAL COMMUNICATION ON CLIMATE CHANGE, SOFIA. Available at: https://unfccc.int/sites/default/files/resource/VIII%20NC_Bulgaria%202022.pdf.*

UNNDR [United Nations Office for Disaster Risk Reduction] *Sendai Framework Terminology on Disaster Risk Reduction. Available at: https://www.undrr.org/drr-glossary/terminology ; last accessed on 28 October 2024*

Valente, S.M. (2005). *Evaluation of Innovative Research-Based Fact Sheets. Journal for Nurses in Staff Development, 21 (4), 171-176.*

Visit Rovaniemi (n.d.). *Rovaniemi – The Official Hometown of Santa Claus. Available at: https://www.visitrovaniemi.fi/ ; last accessed on 29 October 2024.*

Višnja, Š. (2019). *Program zaštite zraka, ozonskog sloja, ublažavanja klimatskih promjena I Prilagodbe klimatskim promjenama u primorsko – goranskoj županiji – za razdoblje 2019 - 2022 (Air protection, ozone layer, climate change mitigation and adaptation to climate change program in Primorsko-Goran County – 2019 - 2022). Available at: https://www2.pgz.hr/doc/dza zaštiteokumenti/savjetovanje-s-javnoscu/2019/zrak/Nacrt%20programa.pdf.*

Weiler, R.M. (1998). *Developing Fact Sheets. Journal of Health Education, 29 (1), 46-50.*

Werners, S. E., Wise, R. M., Butler, J. R., Totin, E., & Vincent, K. (2021). Adaptation pathways: A review of approaches and a learning framework. *Environmental Science & Policy, 116*, 266–275. *https://doi.org/10.1016/j.envsci.2020.11.003.*

Wehbe, M., Salmoral, G., Bea, M., López-Gunn, E., Smithers, R.J. (2024). *DIY Manual on Engaging Stakeholders and Citizens in Climate Adaptation (EU Mission on Adaptation to Climate Change). Available at: https://climate-adapt.eea.europa.eu/en/mission/solutions/citizen-engagement-manual ; last accessed on 29 October 2024.*

World Bank Group (2021). *Climate Risk Country Profile—Bulgaria. Available at: https://climateknowledgeportal.worldbank.org/sites/default/files/2021-06/15848-WB_Bulgaria%20Country%20Profile-WEB.pdf.*

World Bank Group (2023). *Romania Country Climate and Development Report. CCDR Series. Washington, DC. Available at: https://openknowledge.worldbank.org/entities/publication/b6dfeaca-c430-4877-9f2c-547885bf9cc1 ; last accessed on 29 October 2024.*

Zimeri, A.M. (2016). *A Flipped Classroom Exercise to Teach Undergraduates to Critically Think Using Primary Scientific Literature. International Journal of Environmental & Science Education, 11 (12), 5396-5403. Available at: https://files.eric.ed.gov/fulltext/EJ1115649.pdf.*