LIFE PASTORALP

LIFE16 CCA/IT/000060

Pastures vulnerability and adaptation strategies to climate change impacts in the Alps

C.6

Feasible adaptation strategies

March, 2023

Acknowledgements

This report was produced under co-finance of the EC LIFE program for the Environment and Climate Action (2014-2020), in the framework of Action E.1 “Information and awareness to general public and stakeholders” of the project LIFE PASTORALP (LIFE16 CCA/IT/000060) “Pastures vulnerability and adaptation strategies to climate change impacts in the Alps”.

The project is being implemented by the following beneficiaries:

	**University of Florence - UNIFI**
	**Agenzia Regionale Protezione Ambiente - Valle d'Aosta - ARPA VDA**
	**Centre National de la Recherche Scientifique - CNRS**
	**Institut Agricole Régional – IAR**
	**Institut National de Recherche pour l'Agriculture l'alimentation et l'Environnement – INRAE**
	**Parc National des Ecrins – PNE**
	**Ente Parco Nazionale Gran Paradiso – PNGP**

Contents

1 Executive summary

The C6 action was rich and diverse. It concerned different monitorings and surveys in several fields and allowed to investigate pastoral practices, monitoring of plant and animal biodiversity, to test adaptation strategies and elaborate pastoral management plans (Park National des Ecrin, PNE, and Gran Paradiso National Park, GPNP).

All these works on C6 action and works on vulnerability led to elaborate adaptation strategies which are divided in technical measures which are organized depending on climate hazards and policy recommandations to facilitate adaptation measures adoption and to propose guidelines to keep sustainable agriculture and pastoralism in the two national parks under the pressure of climate changes.

2 Aim of the Action

The aims of this action was to testing adaptation strategies in a set of test sites in GPNP and PNE, in order to define feasible adaptation strategies (FAS) as derived from A.2. Test wills be run during 4 years of vegetative seasons. FAS will be progressively refined based on C1, C4, C5 and stakeholders feedbacks (E2) through a reiterative approach.

This action was composed of two parts :

- a part dedicated to the test sites with monitoring on various items for studying the impact of climate change and practices on biodiversity, in order to test feasible adaptation strategies and refining them during the project life-time.

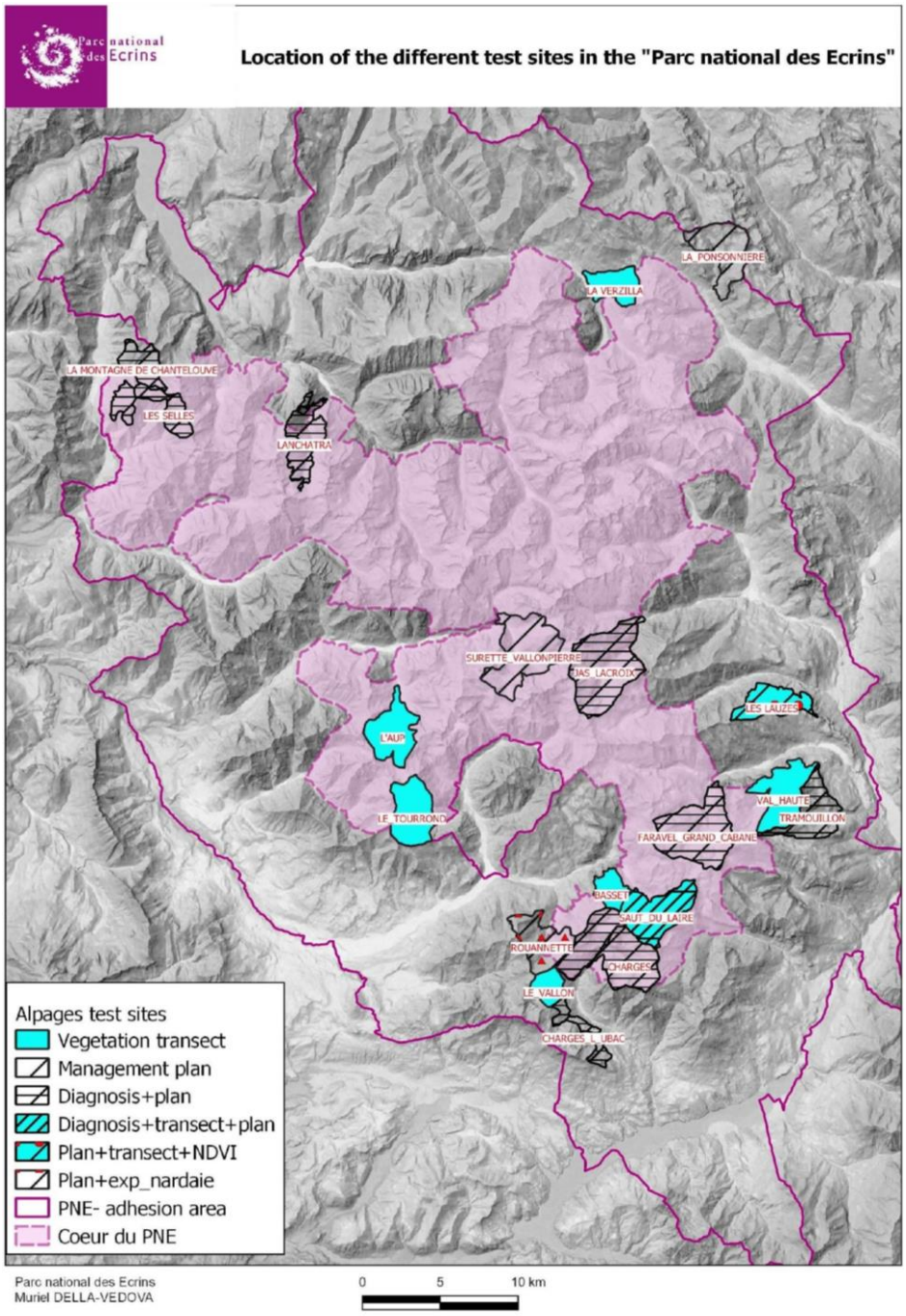
- a part dedicated to the identification of feasible adaptations with the realization of vulnerability pastoral diagnosis and management plans and the construction of a table on adaptation strategies.

3 The test sites

3.1 - Test sites in PNE and results

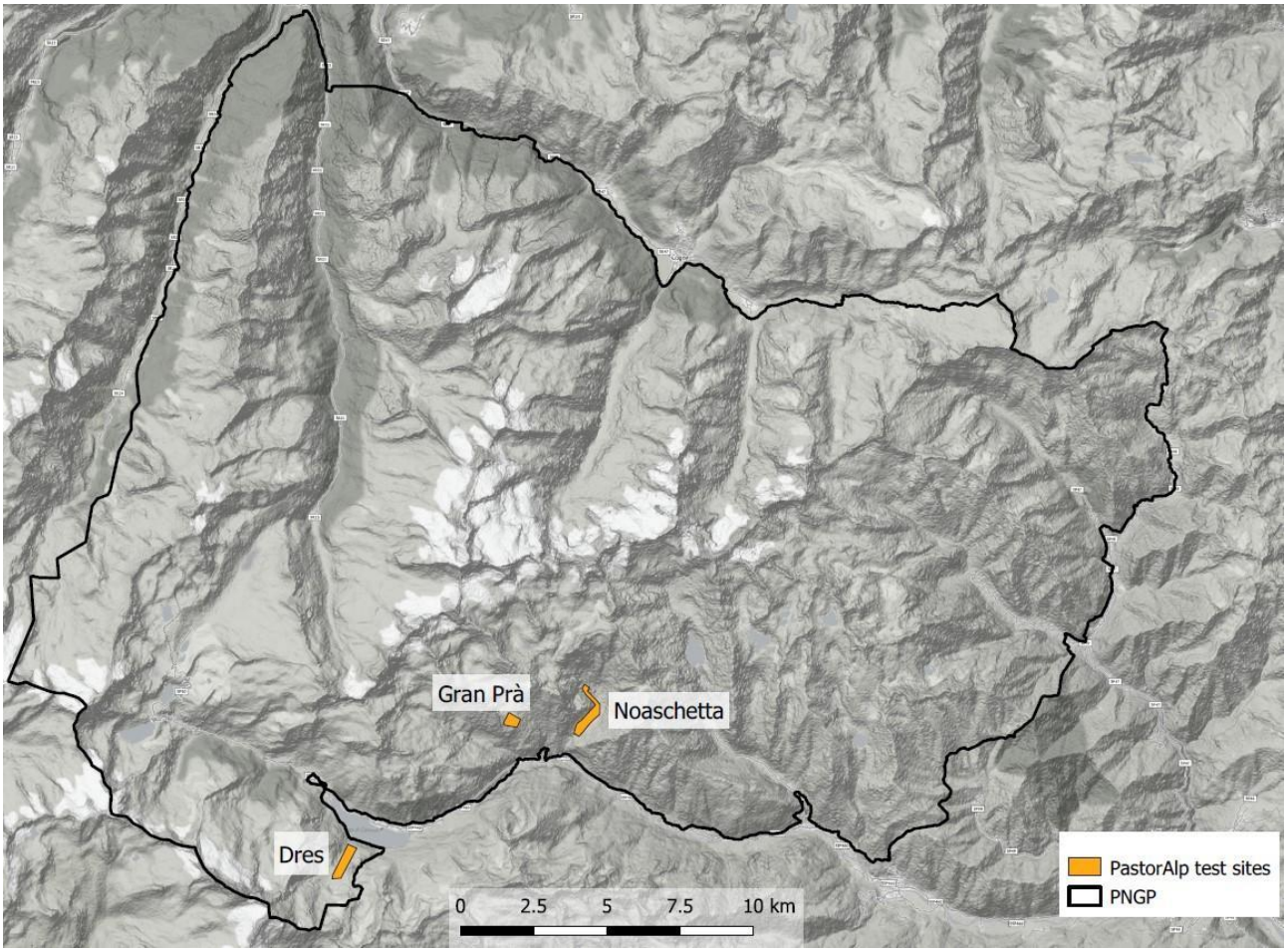
In PNE, the test sites were chosen to test methods and to do monitoring on various items.

At the end of the project, Pastoralp stepped in 22 “alpages”.



3.2 - Test sites in GPNP and results

In GPNP, three test sites (Dres, Gran Prà, Noaschetta) were chosen. Here, different vegetational and faunal components were monitored.



Location of the test sites in GPNP

3.3 – Biodiversity monitoring

3.3.1- Vegetation monitoring (Partner : PNE)

a – Method

The method is based on a classical sampling through 100 contact-points along a transect of 25 or 20 meters. Both ends of each transect are perennial (marked by fixed markers).

For more details, see Accompanying documents "V1_note_méthodologique_transects_végétation (FR)"

b – Realization

This monitoring was carried out over 20 vegetation transects distributed in ten mountain pastures.

In 2019, the ten monitored sites were:
(i) Transect 111 (Maison Blanche) – Alpine pasture of Crouzet-les-Lauzes
(ii) Transect 112 (La Gueillette) – Alpine pasture of Crouzet-les-Lauzes
(iii) Transect 121 (La Folie) – Alpine pasture of Grande Cabane
(iv) Transect 122 (Dessus la Balme) - Alpine pasture of Grand Cabane
(v) Transect 611 (Aulnaie de Basset) – Alpine pasture of Basset
(vi) Transect 621 (Parcs cabane) – Alpine pasture of Saut-du-Laire
(vii) Transect 622 (Rougnous station météo) – Alpine pasture of Saut-du-Laire
(viii) Transect 623 (Rougnous ancien défens) – Alpine pasture of Saut-du-Laire
(ix) Transect 711 (Premier quartier) – Alpine pasture of Distroit
(x) Transect 712 (Entre les cabanes) – Alpine pasture of Distroit

In 2020, the ten remaining monitored sites were:
(i) Transect 131 (L'Eygline) – Alpine pasture of Val Haute
(ii) Transect 132 (Le Lauzet) – Alpine pasture of Val Haute
(iii) Transect 211 (La Verzilla) – Alpine pasture of Laurichard
(iv) Transect 212 (Gatiupel) – Alpine pasture of Laurichard
(v) Transect 511 (Côte de la Cabane) – Alpine pasture of l'Aup
(vi) Transect 641 (Clot la Selle) – Alpine pasture of Tourond
(vii) Transect 642 (Muande) – Alpine pasture of Tourond
(viii) Transect 721 (Cébière aval) – Alpine pasture of Vallon
(ix) Transect 722 (Cébière amont) – Alpine pasture of Vallon
(x) Transect 723 (L'Envers) – Alpine pasture of Vallon

For more details, see Accompanying document V2_CR_lignes_2019_PASTORLAP (FR) and Accompanying document V3_CR_lignes_2020_PASTORLAP (FR).

c - Results and discussion

The main results rely on two vegetation trajectories under climate warming: (1) the extension of mat-grass (*Nardus stricta*) grasslands and (2) the strong regression of snowbed community species, specialized in cold conditions. Both trajectories are linked: as global warming impact snowbed communities, nardus stricta swards take the advantage of these changing ecological conditions to spread over "cold adapted" species (*Alchemilla pentaphyllea*, *Omalotheca supina*, *Trifolium thalii*).

For more details, see Accompanying document V2_CR_lignes_2019_PASTORLAP (FR) and Accompanying document V3_CR_lignes_2020_PASTORLAP (FR).

 This subaction was made by external assistance (Olivier SENN) and personnel of the park.

d - The experimentation on mat-grass grasslands

Because of the dominance of mat-grass grasslands in alpine habitats and the increasing occupancy of mat-grass (*Nardus stricta*) due to climate and pasture changes, the PNE has undertaken an experiment on pasture practices on this kind of grassland (see Appendix V4_protocole_suivi_nardaie_PNE (FR) for detailed protocol).

The main results are a relevant stability of plant species diversity whatever the grazing pressures. Nonetheless, this stability may probably be due to the alpine grassland resilience, i.e. the observation of a possible evolution would require monitoring over a longer period.

For more details, see Accompanying document_V5_pression_pastorale_nardaie_PNE (FR).

 This subaction was made by external assistance (CERPAM) and personnel of the park.

3.3.2- Vegetation monitoring (Partner : GPNP)

In the test site of Noaschetta Valley several surveys on vegetation were carried out. In particular were combined phytosociological surveys (Braun Blanquet 1932) on pastures outside (grazed) and inside exclusion fence together with six different physiognomic transects for the detection of change of vegetation structure with time. The vegetation structure was also investigated through cartographic analyses based on a UAS flight (RGB and DTM) performed on the low Noaschetta Valley and also in the Varda-Muracce area (Gran Pra pastoral district).

For further details *see Accompanying document AD_PNGP_1*.

3.3.3 - The remote sensor monitoring : NDVI and time-lapse images (PNE)

a – Method

The method uses NDVI sensors and time-lapse cameras to collect phenology datas in permanent grasslands. The project allowed to set up automatic data transmission from remote study sites.

b – Realization

NDVI and image sensors were installed in three sites in two pastures (Crouzet and Surette). Data transmission was set up in Crouzet pasture. It could not be set up in Surette pasture because of lack of data transmission network.

c - Results and discussion

Data transmission is fully operational for NDVI when data transmission network is present. It is therefore replicable in any site with data transmission network. Data transmission for images is technically much harder due to data volume and does not seem replicable. Data transmission, when possible, secures dramatically data collection.

Data collected show strong differences in grasslands phenology between years in Crouzet sites (snow melting). In Surette, we did not observe the same patterns.

Sensors will stay after the project for a long-term monitoring and thorough analysis will be performed as soon as the data volume allows it.

3.3.4 - The monitoring of fauna (Partner: GPNP) :

Since the beginning of the LIFE project, we have monitored different components of animal biodiversity in order to observe the effects of pastoral activities on biodiversity.

a - Wetland ecosystems

Methods and realization

The sampling was focused on pollinators (butterflies, bumblebees, hoverflies), water beetles and black grouse. We monitored three plots using different methods depending on the taxa: linear transects (200m length) with monthly repetition from July to September for pollinators, the mark-release-recapture method for water beetles and the annual census activities for the black grouse (performed by the park wardens).

Results and discussion

These monitoring activities allowed us to:
- underline the important conservation concern of this area, characterised by a mosaic of shrubs, woodlands and ponds;
- identify the most important sub-areas, which should be preserved even from light grazing;
- create an important baseline for standardised monitoring against which to identify future changes;
- highlight the strong vulnerability of the area to drought and water scarcity.

For more details and further results, see Accompanying document AD_GPNP_1

b - Alpine pastures

Methods and realization

The sampling was focused mainly on pollinators (butterflies, bumblebees and hoverflies) and grasshoppers. We used the linear transect method (length 200 m) in four plots, characterised by different grazing pressure, every 15 days from the end of June until the beginning of September.

Results and discussion

The abundance and species richness appear to be higher in the plot characterised by medium intensity grazing in August for butterflies and hoverflies. Bumblebees showed the same pattern for abundance while grasshoppers had quite different responses. For this taxa species richness was similar among grazing levels and the highest values were found in the most grazed area. However, as for the other taxa, the highest abundance was found in the plot grazed in August, but, once again, differences are not marked, in particular with the most grazed plot.

For more details and further results, see Accompanying document AD_PNGP_1

c - Subalpine pastures

Methods and realization

The biodiversity was monitored both at community level (butterflies, bumblebees, hoverflies) and to consider differences in grazed and ungrazed areas (bumblebees, hoverflies, surface active macro-invertebrates and grasshoppers). Different taxa were monitored as follow:

- *Surface-active macro-invertebrates*: 3 pitfall traps in the ungrazed patches and 3 traps in the grazed ones. We collected them every 15 days, from July to September.

- *Bumblebees*: one monthly opportunistic linear transect (200 m length) for each area to study the community. Two opportunistic transects per selected area, one in the grazed and one in the ungrazed patches (lasting 10 minutes each) to investigate the habitat use. We collected data from July to September.

- *Butterflies*: linear transect (200 m), every 15 days, from the middle of June to the beginning of September.

- *Hoverflies*: once a month, linear transect (200 m) to get an idea of the community. Every 15 days, two opportunistic transects per selected areas, one in the grazed and one in the ungrazed patches in order to investigate the adults' use of the habitat. Moreover, two emergency traps were set in each study areas, one in the managed patch and one inside the exclusion fence.

- *Grasshopper and crickets*: every 15 days, from the end of July to mid September. Ring counts method, placing the cylinder on the ground 10 times, alternating random and opportunistic attempts, both in the managed and in the unmanaged patches.

Results and discussion

Adult bumblebees and adult hoverflies seem to be more abundant in the ungrazed patches while potential pollinators sampled with emergency traps were more abundant in the grazed ones.

The other monitored taxa didn't show significant differences but the different responses underline the importance of maintaining ungrazed patches as nectar sources for adult pollinators and refuges for other invertebrates.

For more details and further results, see *Accompanying document AD_PNGP_1*

 All the subactions realized by GPNP were made by external assistance and personnel of the park.

3.4 - Social impacts

3.4.1 - Methods

PNE (Partner : INRAe /ex IRSTEA)

INRAE LESSEM conducted a series of interviews with pastoral experts, farmers and shepherds. The informants were asked about their professional activities, grazing practices (farmers and shepherds), their perception of climate change and its impact on their practices and on mountain ecosystems. They were also asked whether they had already implemented or were considering implementing adaptation or mitigation measures and, if so, how these measures impacted their activities.

In contrast to pastoralists, farmers and shepherds tended to see climate change as having relatively little impact compared to other processes such as the Common Agricultural Policy or wolf predation. Although they did not consider climate change to be a key factor at the time of the interviews (i.e. before 2022), informants identified several impacts of climate change on their activities, as well as a variety of coping and adaptation responses to climate change.

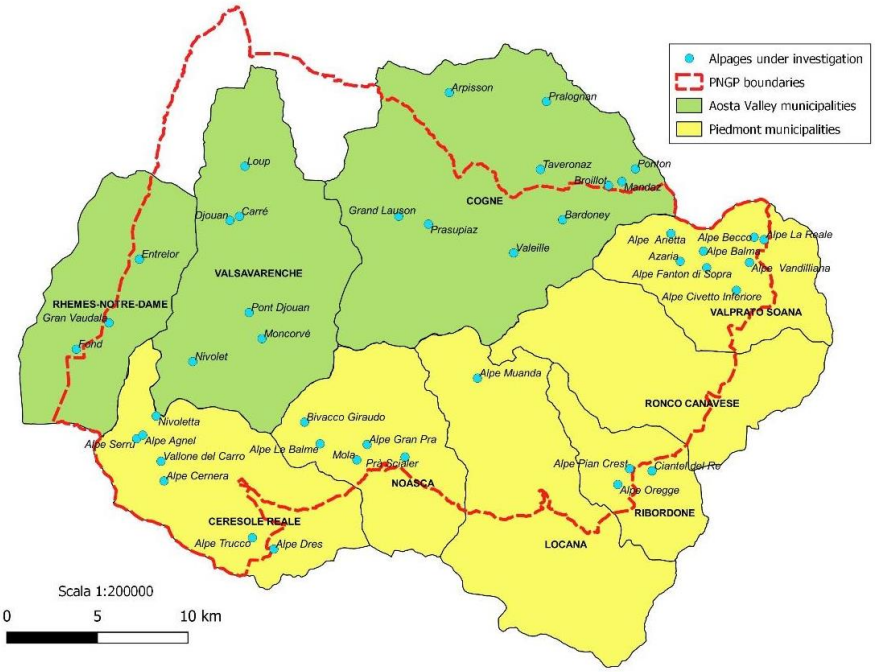
For more details, see Accompanying document PASTORALP- Deliverable C6 - 21 Feb 2022_IRSTEA.

 This sub-action was realized by personnel of IRSTEA/INRAe.

GPNP (Partner : IAR)

During the summer seasons 2019 and 2020, all the breeders or shepherds who regularly utilize the *alpages* of the Gran Paradiso National Park were interviewed by a consultant of Institut Agricole Régional, following a 25-item questionnaire, in order to deepen the main topics related to PASTORALP (perception of climate change and its effects on animals and vegetation), but also other socio-economic aspects and problems specific to these alpine areas.

Forty-five alpine *alpages* currently in use were identified, 21 in Aosta Valley and 24 in Piedmont.



Map of the GPNP territory and *alpages* under investigation.

From a general analysis of all data, it comes out that all people interviewed had big difficulties in having an overall view of the themes considered in this research. Many answers were deeply influenced by the general situation when they were gathered, both about general problems and opinions about climate. In summer 2020 there were also the side-effects of the Covid-19 pandemic that had a negative influence on all breeders whether at economic, or organisational or psychological level.

From the interviews it is evident that climate change is not the main worry for the breeders, even if in the last few years they have already had to face extreme weather conditions or recurring long periods of drought.

The **main problems** related to life and work in *alpage* reported by the farmers are presented in the table below. The first three are: i) coexistence with wildlife (e.g. wild boars and wolves); ii) infrastructure deficiencies and lack of roads; iii) bureaucracy.

1st place	2nd place	3rd place	Others
Wolves (14)	Lack of buildings and roads (9)	Wild boars (6)	Wolves (5)
Crumbling buildings and lack of roads (10)	Wolves (7)	Bureaucracy (4)	Relations with the Park (2)
Wild boars (8)	Relations with the Park (4)	Wolves (3)	Coexistence with tourists (2)
Bureaucracy (6)	Wild boars (3)	Low economic value of the products (3)	Lack of buildings and roads, bad maintenance of paths (2)
Bad weather (1)	Bureaucracy (3)	Coexistence with tourists (2)	Low economic yield of the products (1)
Others (2)	Coexistence with tourists (3)	Unsuitable buildings and lack of roads (3)	Bureaucracy (1)
	Qualified workers are hard to find (2)	Relations with the Park (2)	
	Speculations (1)	Qualified workers are hard to find (1)	
	Few pastures available(1)		
	Low economic value of the products (1)		

Table 1: Current problems in *alpage* reported by GPNP farmers.

Regarding **climate change perception**, all breeders generally agree in stating that in the last years climatic conditions have been abnormal, but at the same time they declare that it could happen even in the past, especially at high altitudes, with intense rainfalls, snow falls also in the months of July and August, severe thunderstorms, flood phenomena. The current perception concerns:

1st element	2nd element	3rd element	Others
Extreme weather conditions	Long term drought	High temperatures on the mountains	Lack of snow in winter
Drought	Abnormal heat	Strong temperature changes	Hail
High temperatures on the mountains for long periods	Extreme weather conditions (storms, wind storms)	Big changes from one year to the other	Retreat of glaciers
		Weather unpredictability	Always less snow during summer
		More consequent years with long dry periods	More frequent floodings
		Rain periods less divided into different seasons	Frost in warmer months
			Damages due to drought both on the mountains and on the valley floor

Table 2: Perception of climate change in order of importance.

Climate issues have generated different responses depending on the territory: the *alpages* on the Piedmont side have generally suffered less from dry periods, which, on the contrary, have caused big difficulties on the side of Aosta Valley, especially in some valleys.

The most worrying aspect is drought, which affects activities throughout the year in various ways: direct effects on pastures, but also on hay meadows, drinking water for the animals, possibility of watering meadows and pastures, functioning of micro-hydroelectric power stations that supply electricity to the *alpages*.

All different climate conditions have a different influence on livestock sector: the dates of the arrival and descent from the *alpages*, which depend on the availability of grass for the animals (snow-free soil and vegetation at a sufficiently advanced stage to ensure proper grazing at the beginning of the season, first snowfall or depletion of pastures resources in autumn), and the longer outdoor grazing season in November/December on the meadows around the stables have already been mentioned. But it is also haymaking in summer that is strictly connected with climate conditions.

Considering as a whole the problems previously listed and climate change effects, the breeders were asked to suggest the **feasible solutions**. Their answers are reported in Table 3:

Suggested solutions for climate-related problems	**Suggested solutions for other problems**
Reduce the number of animals grazing in the *alpage*	Hunting/controlling interventions on wild animals if they might damage the pastures or attack the herd
Improve/renovate the watering systems	Improve/renovate the existing buildings
	Making new paths and roads to the *alpages* and renovating the existing ones
	Reduce bureaucracy for works on *alpages* structures (permissions, etc.)
	Information/awareness campaigns for tourists going to the mountains
	Better protection for shepherds working with livestock guardian dogs
	Twinings with schools (even abroad) training new specialised *alpage*-workers

Table 3: Suggested solutions to *alpage* problems by GPNP farmers and shepherds.

Territorial differences influenced the answers of the interviewees in Piedmont and Aosta Valley: there are diversities in morphology and climate, but also strong social, historical and economic differences that affect the current management of the *alpages* and the future vision of this activity.

The study about the *alpages* of the Gran Paradiso National Park has provided a general overview on the management of the *alpages* by farmers, their problems, their perception of climate change and of its effects.

Climate risks and possible and proposed adaptation solutions have certainly been taken into account in the elaboration of climate change adaptation strategies.

For more details, see Accompanying document Report_Participatory social analysis in the PNGP_compressed

The full report of the social and participatory analysis is available in Italian and English on the project website (https://www.pastoralp.eu/other-products/).

 This sub-action was realized by personnel of IAR.

4 Identification of feasible adaptation strategies

4.1 - Pastoral diagnosis of climatic vulnerability

4.1.1 - Method

Pastoralp has made it possible to test the method of pastoral diagnosis of climate vulnerability. This method was developed in the context of Alpages sentinelles and had not been applied before Pastoralp. This method studies for a mountain pasture :

- The exposure of the mountain pastures to climatic hazards,

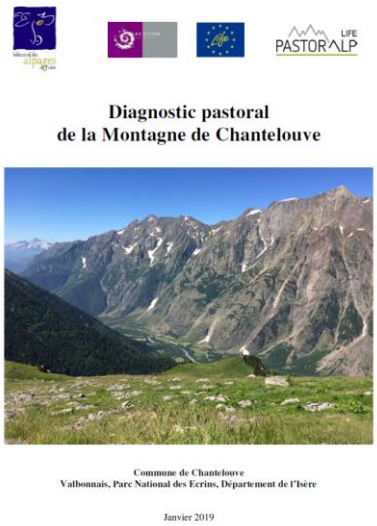
- the sensitivity of the vegetation of each pasture to these hazards,

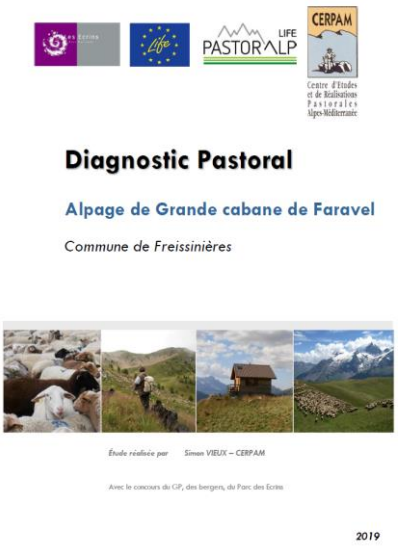
- the margins of manoeuvre that can potentially be mobilised by each pastoral system according to its own characteristics.

For each mountain pasture, field studies are carried out to map the type of vegetation, the shepherd records the movements of the herd, the number of animals during the season, and the various characteristics of the mountain pasture and the herd are studied. The components of biodiversity are also reported. Once all this information has been studied and cross-referenced, a diagnosis is drawn up and proposals for adaptation are made to breeders and shepherds.

4.1.2 - Results

Nine diagnoses were carried out in 2018, 2019 and 2020 in Pastoralp program on mountain pastures of : Faravel, Tramouillon, Chargès and l'Ubac, la Vieille Selle, Jas Lacroix, la Montagne de Chantelouve, les Selles, le Saut du Laire and Lanchatra.





These diagnoses were the subject of a feedback meeting with the municipality that owns the land, with the shepherds and the breeders and with rangers concerned.

The different strategies proposed in these diagnoses were used to build the technical strategies. INRAe LESSEM summarised these strategies in a report that can be found in deliverables.

 These diagnoses was done by CERPAM (Centre de Réalisations Pastorales Alpes-Méditerranée) and FAI (Fédération des Alpages de l'Isère) in the framework of external assistance with a public procurement procedure.

The personnel of PNE participated for the ecological part of these studies.

All the diagnoses were the subject of a feedback to the stakeholders.

For more detail, see all the pastoral diagnoses in Accompanying documents _ AD_Pastoral_diagnoses.

4.2 – The management plans

4.2.1 – In GPNP

Five technical documents were produced in the GPNP to define guidelines for the management of pastures in three test sites of the Piedmont region (districts: Noaschetta, Dres and Gran Prà) and two in Aosta Valley Autonomous Region (pasture district of Fos-Fond in Rhêmes-Notre-Dame and pasture district of Goilles-Etzelley-Bardoney in Cogne) and two in Aosta Valley Autonomous Region (pasture district of Fos-Fond in Rhêmes-Notre-Dame and pasture district of Goilles-Etzelley-Bardoney in Cogne). These guidelines address all the main topics that are important to arrive at a rational pasture management that considers the effects of climate change and provide specific adaptation strategies. For details see Annexe I_PNGP and Annexes II-III-IV_PNGP.

Pilot sites in Cogne (*alpage* of Goilles-Etzelley-Bardoney) and Rhêmes-Notre-Dame (*alpage* of Fos-Fond)

In the pilot sites of Cogne and Rhêmes Notre-Dame, a collaboration between Institut Agricole Régional and the farmers managing the two mountain pastures was established during the years from 2019 to 2022 in order to:

- monitor and note livestock and pasture management in summer;

- record livestock grazing areas twice a day on a map;

- interview livestock farmers regularly during the summer grazing season to highlight abnormal weather events, their consequences on pastures and animals, and any adaptation management practices applied;

- jointly analysing management choices and finding possible adaptation strategies to climate change and beyond.

This collaboration has enabled researchers to discuss all aspects of *alpage* management on a continuous and lasting basis and to involve the two breeders in several Pastoralp project activities (e.g. alpine pasture vegetation surveys, interviews, technical meetings, consultation and validation workshops, field visits with Pastoralp partners).

In particular, the knowledge exchange made it possible to contribute to the elaboration of technical adaptation measures and policy recommendations and to assess their feasibility and effectiveness.

Finally, management guidelines for the two summer alpine pastures were produced and are available on the website.

Figure 1: On the left, *alpage* of Bardoney in Cogne (Aosta Valley, GPNP) and on the right, *alpage* of Fond in Rhêmes Notre-Dame (Aosta Valley, GPNP).

For more detail, see the management plans in Accompanying documents _ AD_PNGP_Management_plans.

 This sub-action was realized by IAR and GPNP : For IAR by personnel of IAR and for GPNP by external assistance and personnel of the park .

4.2.2 – In PNE

Sixteen management plans have been made in PNE. The management plans contain a diagnosis with a pastoral component, an ecological component and a management plan with management recommendations. The recommendations are divided into two tables : a table with recommendations for specific practices to protect species or habitats and a table with adaptation strategies to climate change. These plans will be implemented with the agri-environmental measures of the CAP in 2023 or 2024.

Figure 2: On the left, *alpage* of Distoit in Châteauroux-Les-Alpes (PNE) and on the right, *alpage* of Saut du Laire (PNE).

 These plans was made by personnel of PNE, CERPAM (Centre de Réalisations Pastorales Alpes-Méditerranée) and FAI (Fédération des Alpages de l'Isère).

These plans will be applied in the context of CAP _ MAEC (Mesures Agro-Environnementales et Climatiques). The PNE carries an agro-environmental and climatic project. This allows it to request funding and measures to implement these management plans.

For more detail, see all the pastoral diagnoses in Accompanying documents _ AD_Management_plans.

5 The final strategies

Based on the expected future impacts of climate change and the vulnerability analysis, effective policies and adaptation measures were developed to cope with socio-economic and climate changes in the two study areas (Écrins National Park-FR, Gran Paradiso National Park-IT). In order to define the major climatic risks of the two territories and possible solutions, current regional, national and European policies were analysed and then participatory processes were launched with stakeholders, such as farmers, technicians, agricultural actors and local institution officials. Consultation workshops, interviews and round tables were held in the two parks to: i) gather opinions on perception of CC and its effects on pastures production and animals' performances; ii) discuss current management and criticalities of mountain livestock farming and key drivers of socio-economic change; ii) record adaptation measures already implemented in the project areas; and iii) collect suggestions from stakeholders. At the end of the participatory process, the identified strategies were assessed by stakeholders in terms of feasibility in mountain context, contribution to CC adaptation and economic viability. These strategies encompass both technical measures and adaptation policies and recommendations.

5.1 – Technical measures

In addition to the work of Action C6, other studies have been carried out to initiate this reflection. We can mention the work on alpine pastures, Baptiste NETTIER's thesis and Pascaline BRIEN's internship report (action C1). Many workshops were held during Pastoralp to achieve this result. Some workshops gathered technical partners, others gathered shepherds and breeders and others were organised only with Pastoralp partners. All the work done has led to build a table showing the different feasible strategies on the mountain pastures in GPNP and PNE. The measures are proposed in response to different climatic events.For each climate hazard, suitable adaptation measures were identified, taking into account their potential impacts on the natural environment and the pastoral system. Particular attention was focused on technical difficulties, factors of failure or success, management aspects on the side of the farmer and the shepherd, and finally the conservation of floristic and faunal biodiversity. The proposed adaptations mainly concern the forage and water resources, pastoral management practices or structural adjustments.

Table 4 shows the main suitable adaptation measures for each climate hazard, taking into account their potential impacts on the natural environment and the pastoral system.

Climatic hazards	Consequences for the natural environment and pastoral system	Adaptation measures
Lack of snow, very dry winter or early snowmelt followed by spring frost or late or cold spring	Poor grass production and/or decline of pasture quality	Increasing grazing of coarse vegetation or shrubs
		Reducing herd size or delaying the first grazing date
		Searching for additional pastures (brush clearing, improving barns and trails) on the lower areas of the *alpage* or outside
		Recovery or construction of buildings and infrastructure for underutilized grazing areas
		Permanently modifying the first grazing dates
		Early *démontagnage* at the end of the *alpage* season
		Modifying yeaning dates
		Changing livestock category, breed or species
Early spring	Very advanced plant phenology	Tightening herding in productive grasslands
		Anticipating the grazing period
Spring drought and shallow snowpack	Poor biomass in pastures at low-altitude pastures (scarce water stock)	Reducing grazing pressure of the lowest grasslands
		Grazing on low-lying wooded areas
		Delayed or slower *amontagnage*
Very marked drought in early summer	Quick grass drying	Withdrawing part of livestock from summer mountain pastures
		Reducing herd size
	Poor grass production	Exploring new pasture areas, including wooded or shrubby areas
		Searching for additional grazing areas, such as wooded or shrubby ones
		Stocking reserves in winter farm by haymaking or hay purchasing
		Supplying fodder in summer mountain pastures
		Pastoral utilization of fodder trees
	Necessity to restore complementary areas	Restoring pastures or building *alpage* facilities in new grazing areas
		Restoring mid-mountain pastures (*mayen*)
Heatwave and wind in June	Contemporaneity of grass maturity	Tightening herding in productive grasslands
		Démontagnage of a part of livestock during the season or early *démontagnage* of all livestock
Very hot and dry summer, heatwave and drought	Source dry out (watering and irrigation problems)	Adapting pasture routes for watering animals
		Rationally managing water points in pastures
		Searching for long-lasting supply solutions (*e.g.* catchments, reservoirs)
		Restoring traditional irrigation systems and improving irrigation efficiency
		Abandoning a grazing area or early *démontagnage*
	Quick grass drying	Increasing grazing of coarse vegetation or shrubs
	Modification of pasture density and flora	Improving grazing efficiency (rotational grazing) and pasture management (*e.g.* manuring, weeding)
	Poor forage resource at the end of summer	Preserving late-growing grasslands for the end of the grazing season
		Increasing grazing of coarse vegetation at the end of the season
		Exceptional early ending the summer grazing season
	Adverse effects of heat stress on animals	Changing grazing times (earlier, later, night grazing)
		Including and conserving shaded areas in low-lying pastures
Rainy summer	Onset of paw diseases	Preparing animals for the grazing season (hooves cutting, footbathing)
Heavy rainfall	Damage to pastures (run-off, soil loss)	Continuous and careful maintenance of the drainage channels and the road network (paths, tracks,...)
Very mild autumn	Good pasture conditions	Late *démontagnage*

A comprehensive list of the identified strategies, their applicability, their impact on biodiversity, success factors and technical difficulties are included in the PASTORALP web platform and are provided in a booklet (http://www.pastoralp.eu/tools). The booklet was also printed and distributed to stakeholders at the scientific conference and will be disseminated at future after-life communication events.

For more detail, see all the technical strategies in Accompanying documents _ AD_Adaptation_strategies.

5.2 – Political strategies

During the work on technical measures, some political issues emerged, so the group decided to draw up some specific proposals that could facilitate the implementation of technical measures or improve life in the mountains and the work of shepherds in the context of climate change.

A table was therefore drawn up with strategies relating to
- the implementation of technical measures;
- pastoralism in forest;
- water management;
- multi-use and coexistence between pastoralism and tourism;
- training and cooperation;
- biodiversity and ecology.

Scope	Issue	Adaptation policies
Alpage management	Adaptation of the pastoral system to CC	Discussing CAP (Common Agricultural Policy) measures to make the use of mountain pastures more flexible
		Prioritizing an approach based on expected agro-environmental results, not using rigid parameters such as stocking rates
		Supporting adaptation
		Allowing an extension of the grazing areas
	Promotion of a sustainable grazing management	Promoting an eco-pastoral approach
	Optimization of pastoral management	Funding structural/infrastructural upgrades (watering, tracks, edifices)
		Mitigating the negative effects of the race for entitlements
		Encouraging collective approaches
		Supporting the implementation and use of management plans
Silvo-pastoral management	Inclusion of wooded areas suitable for grazing	Making grazing feasible in suitable forests and applying integrated forestry-pastoral management
	Availability of more pasture areas in marginal zones	Promoting the recovery of pastoral areas covered with shrub and tree vegetation
Water management	Increased pasture production	Promoting infrastructural improvements to ensure storage, reduce consumption and improve water supply
		Preserving the historical irrigation network in the mountains
	Reduction of conflicts related to water use	Promoting watershed management including all stakeholders
Multi-functionality	Development of local mountain economy	Improving living and working conditions in *alpage*
		Enhancing *alpage* production
		Raising farmers' incomes with other agricultural or tourist revenues
	Mutual understanding between the different actors	Improving cohabitation between residents, farmers and tourists
Cooperation and training	Skills of pastoralists	Promoting the organization of training courses
	Capacity building	Implementing cooperation measures between farmers and other actors
	Collaboration between farmers, citizens and institutions	Integrating agricultural agents in local administrations and protected areas
Biodiversity and agro-ecology	Preserving biodiversity	Developing eco-pastoral management for target species, habitats and HNV (High Nature Value) areas
		Promoting payments for environmental benefits by pastoralists
		Preserving biodiversity hotspots and agro-ecological networks
	Fostering coexistence between wildlife and pastoral activities	Promoting knowledge of species and interactions with human activities

The policy guidelines summarised in Table 5 aim to improve, at regional, national and international policy levels, the effectiveness of decision-making in pasture management.

A comprehensive list of the adaptation policies, their applicability, their impact on biodiversity, success factors and technical difficulties are included in the PASTORALP web platform (http://www.pastoralp.eu/tools). The policy recommendations booklet is provided on the website; was also printed and distributed to stakeholders at the scientific conference and will be disseminated at future after-life communication events.

6 Annex: Accompanying documents

AD_Social impacts

- Report_Participatory social analysis in the PNGP
- PASTORALP - Deliverable C6

AD_PNGP_Management plans

- Linee guida PP Noaschetta
- Linee guida PP Dres
- Linee guida PP Ciamosseretto

AD_PNE_Vegetation monitoring

- V1 Méthodologie de l'enregistrement des données sur les lignes permanentes
- V2 Évolution de la végétation sur des lignes permanentes_2019
  - V2 Lignes_data_2019
- V3 Évolution de la végétation sur des lignes permanentes_2020
  - V3 Lignes_data_2020
- V4 Protocole suivi nardaie
- V5 Analyse des pressions pastorales sur les pelouses à nard

AD_PNE_Pastoral_diagnoses

- Pastoral Diagnosis Lanchatra
- Pastoral Diagnosis Les Selles
- Pastoral Diagnosis Tramouillon
- Pastoral Diagnosis Faravel
- Pastoral Diagnosis Chargés Ubac
- Pastoral Diagnosis Jaslacroix
- Pastoral Diagnosis Saut du Laire
- Pastoral Diagnosis Vieille Selle
- Pastoral Diagnosis Montagne de Chantelouve

AD_PNE_Management plans

- MP Surette
- MP Saut du Laire
- MP Rouannette
- MP Lanchatra

MP Les Selles

MP Tramouillon

MP Faravel

MP Chargés Ubac

MP Jas Lacroix

MP Saut du Laire

MP Vieille Selle

MP Montagne de Chantelouve

MP Grande Cabane

MP Distroit

MP Crouzet

MP Chaillon

MP Ponsonniére

AD_Adaptation strategies

Tab technique (Italian, English, French)

Tab policy (Italian, English, French)

AD_PNGP_Fauna_vegetation_monitoring

AD PNGP