LIFE PASTORALP

LIFE16 CCA/IT/000060

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

Deliverable A.2

Report on the review and assessment of national and European legislation, guidelines, plans and best available techniques

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1 EXECUTIVE SUMMARY

This document establishes the Deliverable A.2 "**Report on the review and assessment of national and European legislation, guidelines, plans and best available techniques**" for the LIFE PASTORALP project and it is meant to underline the state of the art concerning climate change adaptation actions in the framework of pastoral activities and pasture management as well as practices related to montane agriculture and biodiversity conservation.

More than 130 scientific works and technical reports have been reviewed, selected among the regional, national and international policies developed during the last decades and among the proposals derived from many research projects applied in the European Alps.

As a main output of the present work, we developed a dynamic database with the purpose of collecting all strategies currently available for the climate change adaptation of montane pastoral activities. For each strategy, we derived from the reviewed documents a list of information useful to estimate the feasibility and the effectiveness of the implemented actions. Finally, we developed and tested a questionnaire to: i) analyse the awareness in the local stakeholders of the climate change effects on pastoral activities; ii) evaluate the willingness of herders and shepherds to apply the identified strategies; iii) stimulate local stakeholders in proposing new feasible and effective adaptation strategies.

2 INTRODUCTION

This report has been elaborated in the framework of the Action A.2: *Review and assessment of the national and European policy framework on pastures and evaluation of the available adaptation options* aiming at reviewing and assessing national and European framework with respect to pastures. In the specific, a detailed analysis on Common Agricultural Policy and its enforcement through the Rural Development Programmes with respect to the pastoral sector in the regions where the two protected areas lie (Piedmont and Aosta Valley, for the Parco Nazionale Gran Paradiso; Auvergne-Rhône-Alpes and Provence-Alpes-Côte d'Azur, for the Parc National des Ecrins) with respect to the pastoral sector has been performed. Furthermore, other plans regulations (Habitats and Birds Directives, Conservation measures for Natura 2000 Sites etc.) that directly and indirectly refer to pastures management and High Nature Value areas protection, were also reviewed. The final goal of this action was to investigate the commitments, priorities and opportunities set in the above mentioned documents during the development of the adaptation strategy in permanent pastures (as foreseen in Action C6), to identify their strengths and weaknesses, to incorporate climate change adaptation considerations and to explore options for integrating climate change adaptation and rural management under policy action

During this Action the best available techniques and methods implemented worldwide for the adaptation of the pastoral resources to climate change were evaluated. The review was focused on the reports of European and international organizations providing guidance on the adaptation of the pastures to climate change. In addition, the ways the pastoral resources of the project areas currently address climate change impacts via adaptation actions as well as via other policies which may not have been developed for this purpose per se, but are indirectly contributing to the reduction of vulnerability and subsequently, to adaptation (e.g. plans, strategies, legislative actions, guidelines, economic incentives, research or awareness raising activities) were investigated. Following, a comparative analysis was also be made between the available adaptation options and those adaptation options already implemented or planned at the project areas. Finally, the most appropriate adaptation options were identified based on their suitability for implementing at the project areas, taking into account their particular characteristics (identified in Actions C2 and C5).

The adaptation options were categorized according to the climate change impact they address and evaluated in terms of their effectiveness, their contribution to climate change adaptation and their economic viability.

The evaluation of the adaptation options were based on an extensive literature review, as well as on expert judgment through questionnaires, distributed to experts and stakeholders engaged in

the field, in order to comment on the measures, to propose additional measures and to evaluate them.

The identified adaptation options were inserted into a database, becoming a database of the "adaptation assessment" function of the PASTORALP platform tools to be developed in Action C7.

2.1 How to read the document

The document consists of 8 sections, where beyond introduction are organized as follows:

- Adaptation policies from global to local level (Section 3);
- Pastoral Programmes/Networks at alpine level and Mediterranean level concerning CC adaptations (Section 4);
- The Pastoralp Data-base (Section 5), where we approach the different adaptation strategies for agriculture (focusing on pastoralism) and biodiversity;
- Adaptation strategies for alpine pastoral community (Section 6);
- Adaptation strategies evaluation (Section 7).

Some preliminary conclusions and a list of references complete this review.

2.2 List of acronyms

Acronym	Definition	Country
ARPA	Agenzia Regionale per la Protezione dell'Ambiente	IT
CAD	Contrats d'Agriculture Durable	FR
CAP	Common Agricultural Policy	EU
CC	Climate Change	Internat.
CESE	Comitato Economico e Sociale Europeo (European Economical and Social Commettee)	EU
CIPRA	Commisione Internazionale per la Protezione delle Alpi (International Commission for Alpine Protection)	Internat.
CMCC	Centro Euro-Mediterraneo sui Cambiamenti Climatici (Euro-Mediterranean Centre on Climate Change)	EU
CSPNB	Conseil Scientifique pour la Protection de la Nature et de la Biodiversité	FR
CTE	Contrat Territorial d'Exploitation	FR
EbA	Ecosystem based Adaptation	Internat.
EEA	European Environmental Agency	EU

Acronym	Definition	Country
EIP-AGRI	European Innovation Partnership for agricultural Productivity and Sustainability	EU
EPCI	Etablissements Publics de Cooperation Intercomunale	FR
ETP	Potential Evapo-Transpiration	Internat.
GIEC	Groupe Intergouvernemental d'Experts sur l'Evolution du Climat	FR
HNV	High Natural Value (Agriculture)	Internat.
IPCC	Intergovernmental Panel on Climate Change	Internat.
IUCN	International Union for Nature Conservation	Internat.
MAE	Mesures Agro-Environnementales	FR
MATTM	Ministero dell'Ambiente e della Tutela el Territorio e del Mare	IT
OGAF	Opération Groupée d'Aménagement Foncier	FR
ONERC	Observatoire National sur les Effets du Réchauffement Climatique	FR
PACA	Provence-Alpes-Côte d'Azur	FR
PCET	Plan Climat Energie Territorial	FR
PLU	Plan Local d'Urbanisme	FR
PDRN	Plan de Développement Rural National	FR
PDRR	Plan de Développement Rural Régional	FR
PIF	Piani Integrati di Filiera	IT
PNACC	Plan National d'Adaptation au Changement Climatique	FR
PNE	Parc National des Ecrins	FR
PNGP	Parco Nazionale del Gran Paradiso	IT
PSR	Piano di Sviluppo Rurale	IT
RMC	Rhône-Méditerranée-Corse (concerning French water agencies)	FR
SCOT	Schéma de Cohérence Territoriale	FR
SNAC	Strategia Nazionale per l'Adattamento Climatico	IT
TVB	Trames Vertes et Bleues (ecological network)	FR

2.3 Evolution of agro-pastoral activities and land use in the Alps

Human being has shaped and modified the mountain environment under the activity of herders for about 6000 years. Mountain pastures are thus the result both of mowing and also the direct pressure of grazing (GUSMEROLI et al. 2005).

In the last 30 years the intense human population decline occurred in the Italian Alps has led to the collapse of mountain socio-economy (PASAKARMIS & MALIENE 2009, GARCÍA-RUIZ & LANA-RENAULT 2011, LASANTA et al. 2015), associated with the development of industrial economy located in the lowlands and valleys. Also French and Swiss Alps have experienced a profound abandonment of the traditional agro-pastoral systems (MOTTET et al. 2006, GELLRICH et al. 2007, FASSIO et al. 2014). These changes have led to a progressive decline of pastoral resources associated with a natural encroachment of forests and shrubs (MACDONALD et al. 2000). Concurrently, some Alpine pastoral areas have experienced an overexploitation of grasslands, leading to an accumulation of manure on the soil, soil compaction and encroachment of invasive species (often nitrophilous, unpalatable species). On the contrary, a well-managed pasture ensures endemic plant diversity, favouring seed germination (OLFF & RITCHIE 1998, OSEM et al. 2002).

Land abandonment in mountainous areas is not a linear phenomenon affecting in the same way all areas; this process is strongly affected by local topography, as well as by ecosystem and climatic conditions (TARGETTI et al. 2010). Nevertheless, land abandonment is nowadays a general and widespread phenomenon which all European mountain areas are heavily experiencing (TESSER et al. 2007, LASANTA et al. 2015, ZETHOF et al. 2016).

2.4 Land use and Climate Change (CC)

Beyond land use change, Climate Change (CC) is acknowledged as a main driving force affecting biodiversity dynamics, especially in marginal ecosystems such as mountain areas (BENNET & SAUNDERS 2010, LOVEJOY 2010, DAWSON et al. 2011). Although it is evidence-based that projected climatic changes are expected to deeply impact habitats in terms of risk of extinction of endemic species and changes in species composition, disentangling the primary causes of habitat loss from climatic drivers and land use changes is still challenging (WARREN et al. 2001, CLAVERO et al. 2011, MANTYKA-PRINGLE et al. 2012, OLIVER & MORECROFT 2014).

Certainly, the effect of CC on biodiversity can be disentangled more clearly in environments characterized by extreme climates (i.e. mountain areas) (BRUNETTI et al. 2009, ACQUAROTTA et al. 2014). However, socio-economic drivers (i.e. land use changes) may bias the direct impact of global warming on marginal ecosystems.

Nevertheless, there are many studies reporting the direct effects of climate change on species composition and distribution. PARMESAN & YOHE (2003) demonstrated that climate warming directly affects the shifts of species' phenology in spring, as well as latitudinal/altitudinal distribution and abundance, whereas other studies showed how increases in air temperatures alter richness of common and generalist species (THOMAS 2010), often replaced by more specialized species. A long-term study (about 200 years) on butterfly communities in Germany, pointed out three frequent phenomena under climate change: loss in the species number, changes in beta-diversity and a gradual transformation of species communities (HABEL et al. 2016). These negative trends were probably due to a combination of large-global and small-scale effects, such as climate change and land use changes.

Thus, long-term studies on the effects of temperature variation and the ecosystem responses should be boosted so as to project impacts of climate change on biodiversity.

2.5 Socio-economic framework

Montane, subalpine and alpine semi-natural open areas (meadows, pastures, different typologies of grasslands) need an appropriate management not only to maintain animal and plant biodiversity, but also to ensure sustainability while improving human life quality. Indeed, taking into account socio-economical aspects is fundamental to perceive long term conservation goals (e.g. LAIOLO et al. 2004). A multi-disciplinary approach, which considers social, political, environmental (related to land cover and climate) factors associated with economic issues might be considered as a fundamental starting point. In this framework, particularly meaningful is the assessment of what people are perceiving about environmental changes (related to both land use and climate) and what they expect in terms of interventions of governance and policies. It is furthermore important to consider that different stakeholders, experts and people coming from different educational backgrounds could have different, yet contrasting perception of the same issue (e.g. HÖCHTL et al. 2005). To this, managers are demanded to be aware that the same problem (i.e. climate change impacts) can be handled in different ways (according to different stakeholders) so as to ensure effective results in terms of sustainability and biodiversity conservation, as well as human well-being.

One promising option might be the maintenance of traditional grazing activities so as to ensure the related ecosystems services. At the same time, it is fundamental to identify the key elements of the traditional systems, which should be certainly maintained and promoted in line with the expected future land use (PLIENINGER et al. 2006).

Currently, some strategies are suggested to integrate traditional farmers' income ensuring long term sustainability of resources with limited environmental impacts. Two important examples

are represented by rural tourism and the production of traditional products (e.g. PDO *"Protected Designation of Origin"* products).

However, in most cases, a financial public support for farmers is needed. Financial subsidies are one of the main tools to assist integrated agriculture with nature conservation (e.g. BENAYAS et al. 2007; MILLS et al. 2007).

Proposed measures range from focused agro-environmental schemes to generalised approaches such as the "Greening" encompassed by Common Agricultural Policy (CAP). A third possible way is represented by identifying effective and biodiversity-friendly agricultural systems so as to promote them under common policies and incentives. However, this third promising way has a potentially important limit, i.e. the identification of these systems could be work-consuming (RIBEIRO et al. 2016).

The Common Agricultural Policy (CAP) is a common policy mainstreamed and funded for all member states of the European Union. The CAP second pillar, the EU's rural development policy, is designed to maintain and support rural areas and landscapes across the EU. A higher degree of flexibility (in comparison with the first pillar) enables regional, national and local authorities to formulate their individual seven-year rural development programmes based on a European 'list of measures'. The first pillar is entirely financed by the EC, the second one is co-financed by regional, national or local funds.

The last CAP reform (2013) serves as an answer of EC climate change adaptation challenges so as to promote, with subsides, the sustainable use of natural resources, safeguarding rural areas and supporting their economy (EUROPEAN COMMISSION 2017).

Currently, the CAP policy refers to the period 2014-2020. A high part of the CAP budget (95%) is devoted to the second pillar (EUROPEAN COMMISSION 2013). The objectives of the second pillar are translated into national and regional Rural Development Programmes (RDPs): for this period, 118 programmes have been approved (*https://ec.europa.eu/agriculture/rural-development-2014-2020_en*). Seven kinds of direct payment have been established, of which only five have been activated in Italy. Their main purposes are to sustain income, without considering productivity, and strengthening the environmental effectiveness of the CAP. The RDPs are composed by different measures (25 defined at European level), framed in sub-measures.

During the last years, there has been a wide awareness that climate change's consequences are increasingly impacting European agriculture. Consequently, the CAP has recognized this issue focusing more on environmental and climatic issues than ever before. RDPs play also an important role in terms of tackling climate change impacts, such as promoting resource efficiency and supporting the shift toward a low-carbon and climate-resilient economy in agriculture, food and forestry sectors (*https://ec.europa.eu/info/news/future-cap-climate-change-your-plate_en*).

In the next sections, a review of climate change adaptation policies (Section 2), focussed on pastoral ecosystems (Section 3) is provided, then specific adaptation strategies for the Alpine pastoral community are reported along with their evaluation/implementation (Sections 5, 6, 7).

3 ADAPTATION POLICIES FROM GLOBAL TO LOCAL LEVEL

3.1 Adaptation policies at international and European level

The United Nation CC policy is developed by the IPCC (Intergovernmental Panel on Climate Change) report, a science-based assessment of climate change issues. The IPCC was established by the United Nations Environment Programme and the World Meteorological Organization in 1988 to provide policymakers with regular scientific-based assessments concerning climate change, its implications and risks, as well as to put forward adaptation and mitigation strategies. In particular Working Group II is responsible for impacts, adaptation and vulnerability analysis delivering official reports (fifth Assessment Report (AR5) released in 2014, IPCC, 2014). The outline of the Synthesis Report, the final version of AR6, will be published in 2019. The Synthesis Report will integrate the three working group contributions and the Special Reports produced during the AR6 cycle. The comprehensive report will be finalized in April 2022.

After the Cancun Adaptation Framework (2010), the Paris 2015 Climate Change Agreement shall pursue the goal of increasing the adaptation capacity to CC impacts and promote resilience and low-emission development. The relevance of a multi-level governance is highlighted: adaptation plans and strategies must range from international to local scales.

In Europe, beyond the Green Paper "Adapting to climate change in Europe - options for EU action" (2007) and the White Paper “Adapting to climate change: towards a European framework for action” (2009), a EU strategy is operative from 2013 and a EU platform (Climate-Adapt conceived by the European Environmental Agency), is available from 2012. The main objectives of the European strategy are:

- to promote and support action plans by member states;
- to promote adaptation in the most vulnerable sectors;
- to assure a higher structural resilience (with involvement of private sector too);
- to assure most informed decisional processes (web platform “Climate-ADAPT”).

3.2 Adaptation policies at national level

In this section, we collected information on adaptation strategies to tackle CC for Italy and France. Details on adaptation strategies for pasturelands (the main focus of LIFE PASTORALP) are reported in Section 6.

In ***Italy*** a national strategy for CC adaptation (SNAC) was adopted in 2015. The SNAC consists in 3 main documents:

- a “state of the art report”, with a climate variability analysis (past, present and future) and impact/vulnerability evaluation at national level;

- a normative review concerning impacts, vulnerability and adaptation policies at European and national level;
- strategic objectives and some actions to mitigate impacts.

The Italian Ministry of Environment (MATTM) established a National Observatory to detect territorial priorities and monitoring the effectiveness of adaptation actions. Finally, the first version of the National Adaptation Plan (PNACC) was drafted in 2017 (CMCC, 2017).

In ***France*** the first national adaptation plan was formally drafted in 2011 (for 2011-2015 period); a new plan for 2017-2021 is under development (ONERC, 2016). The French PNACC 2011-2015 stresses four main challenges:

- to take action for human security and health;
- to reduce inequalities which could arise from risks;
- to reduce costs and take advantage from potential benefits;
- to preserve the natural heritage.

The French PNACC 2011-2015, is composed by 20 thematic issues, 84 actions and 242 measures: an integration of CC adaptation measures is planned in mountain regions conventions and management frameworks. However, the "Conseil Scientifique pour la Protection de la Nature et de la Biovidersité (CSPNB, 2015, in ONERC, 2016) declares that the French PNACC does not take enough into account biodiversity and the complexity of interactions between biodiversity and climate.

Another French convention, the "Conseil Économique Social et Environnemental", according to the GIEC group ("Groupe Inter-gouvernemental d'Experts sur l'Évolution du Climat") recommends a better shared vision of climate actions and the establishment of CC adaptation services (CESE, 2014); most prescriptive territorial plans should be conceived too. On a final note the national observatory on the effects of climatic heating (ONERC, 2016) gives 2017-2021 PNACC a boost for some new proposals and tools:

- to conceive vulnerability maps;
- to develop perspective economic studies;
- to produce decision support tools;
- to consider production chain actions;
- to deliver a trademark for adaptation actions;
- to understand "brakes" in adaptation practices.

3.3 Adaptation policies at regional and local level

In the alpine territory (Austria, Germany, France, Italy, Liechtenstein, Monaco, Slovenia, and Switzerland), the ***Alpine Convention*** is an international territorial treaty for the sustainable development of the Alps. The objective of the Alpine Convention is to protect the natural environment of the Alps while promoting its development. An "Action Plan on Climate Change in the Alps" (without any binding legal value) was adopted in March 2009. The Climate Portal (http://www.alpconv.org/en/ClimatePortal/default.html) collects best practices, relevant publications and reports concerning CC mitigation and adaptation. Two guidelines on local CC adaptations in the Alps are available with a policy guidance for the development and implementation of sub-national Adaptation Strategies in the Alps; 10 specific sectors are explored and key factors to ensure success are analyzed (with special focus on participation, communication and financing). Mountain agriculture and livestock farming (chap. 2.2.5) and Biodiversity and Ecosystems (chap. 2.2.9) are two topics with an important number of interesting suggestions.

Alpine Convention guidelines represent a very important tool to manage and assess an adaptation program at regional or local scale including methodological information to assess Adaptive Capacity and Adaptation Objectives.

Concerning the alpine Italian territory, ***Piedmont Region*** has still not adopted a regional adaptation plan, but in 2018 an interdisciplinary working group under the supervision of the Environment Direction has been designated aiming at establishing the Regional Climate Change Mitigation and Adaptation Strategy. ARPA Piedmont (the Regional Environment Protection Agency) has cooperated in this issues concerning biodiversity climate change monitoring (RIVELLA et al. 2012). A special survey in pastoral CC adaptation is the "Xerograzing" LIFE program in lower Susa valley. The 2017 summer and autumn wildfires pushed regional and local authorities to accelerate adaptation measures to prevent wildfires in the future (the LIFE Program "Xerograzing" is situated in one of these wildfire core areas and is also networking with PASTORALP project).

The ***Aosta Valley Region***, despite of advanced studies on CC impacts and some adaptation reports in agriculture (mainly viticulture and fruit cultivation) has not yet developed and/or adopted an effective regional adaptation scheme or plan.

The ***Lombardy Region*** has developed in 2012 regional guidelines concerning climate change adaptation and regional strategies. Concerning "Agriculture and Biodiversity", Lombardy region developed a specific action plan in 2016 (*Documento di Azione Regionale per l'Adattamento al Cambiamento Climatico*), with a bibliographical analysis of the impacts on forage systems and livestock management. Some strategic objectives have been identified (REGIONE LOMBARDIA-

FLA, 2016), but specific adaptation measures for pastoral activities in the Alps are still undergoing. The plan provides only general guidelines and it is not binding a legal value with respect to the regional planning.

The ***Emilia Romagna Region*** (with Apennine mountain zones) has approved its regional adaptation plan in 2018, but the documentation was not yet available for this review.

For other Italian alpine regions (i.e. Veneto, Trentino--Alto Adige, Friuli-Venezia Giulia), we reviewed only RDP or adaptation strategies and actions concerning pastoralism (see Section 5).

In the Alpine French regions like ***PACA*** (Provence-Alpes-Côte d'Azur) and ***Auvergne-Rhône-Alpes***, a large documentation concerning CC adaptation exists: for instance, with the label COP21 of Paris 2015, a Green Book was produced by some associations, public entities and private companies (AAVV, 2015) so as to provide shared information among different typologies of mountain stakeholders, in particular tourists, hikers or climbers. In the Green Book, 21 actions are specifically referred to CC context. Moreover, a list is given of the best exploitation of adaptation skills that should be undertaken/promoted by inhabitants or practitioners. Furthermore, cooperation between stakeholders and capacity building actions are also promoted in the document.

At department level, the Climate white book of Savoy ("Livre blanc du Climat en Savoie", 2010) represents a reference document for what regards adaptation strategies for water resources (see later), tourism, agriculture, forestry and biodiversity. This report develops a very interesting analysis of tourism adaptation strategies in agreement with others activities and sectors, in particular in the context of winter tourism (artificial snow production, ski activities, urban development). Some reference to agriculture and connection with tourism, landscape conservation and biodiversity are also highlighted.

Also CC and urbanism and water resource management (indirectly related to pastoral activities) is hereby summarized, as reported by some sectorial plans concerning CC adaptation in the French Alps.

Concerning urbanism, in the "Loi Grenelle 1" (03-08-2009) an article (L110) of Urbanism Code stresses how local communities' actions in the urban context might contribute to CC mitigation and adaptation. In some French contexts, a PCET ("Plan Climat Énergie Territorial") exists for local urbanistic plans (PLU or SCOT) exists. These plans should have become mandatory for inter-communal aggregations (EPCI) like municipal communities before 01-01-2017 for EPCI with > 50.000 inhabitants and before 31-12-2018 for EPCI with > 20.000 inhabitants. The challenges identified in the PCET plans are:

- to provide vulnerability studies in urbanistic documents;
- to manage the connectivity approach in landscape management ("Trame verte et bleue") and ensure quiet zones for biodiversity;

- to contend with soil sealing;
- to plan an urban restoration and promote sustainable architecture;
- to ensure water resource and adapt to natural risks.

Concerning water resources management, the RMC Water Agency ("Agence de l'Eau Rhône-Méditerranée-Corse") deployed an adaptation plan for CC in its territory (AGENCE-EAU-RMC, 2012). Since the territory of interest is wide and diverse, only general strategies are proposed in the report. However, it is stressed how the observed and expected higher-frequent droughts might harm all territories, including those that can rely on abundant water resources. The adaptation concept standing behind this document goes beyond a simple analysis of the trends but provides also recommendations on what should be prioritized so as to achieve water resources' resilient systems.

Detailed measures (and their ranking in terms of priorities) are reported in the Climate white book of Savoie (2010) (Tab. 3.1), considered the lower amplitude of this department in a wet northern Alps context. Before a research of new water reserves, some best practices are underlined (Tab. 3.1).

Tab. 3.1. Adaptation strategies concerning water management.

Adaptation strategies and actions in water management	**priority**
To stabilize or reduce water consumption in its different utilizations	preliminary
To improve the management of drinking water service, the processing of water losses and the restoration of water networks	preliminary
To pursue a global and reasoned water management by focusing on the responsibility of different stakeholders in water exploitation and use	preliminary
To implement an inter-communal and supportive management of water at catchment scale	preliminary
To manage a reasoned storage of water in mountains	subsequent
To avoid the proliferation of little storages in mountains	subsequent
To develop local consultation tools like river contracts ("contrats de rivière")	subsequent
To adopt diversified management procedures adapted to the different environmental and territorial variability	subsequent

4 PASTORAL PROGRAMMES/NETWORKS AT ALPINE AND MEDITERRANEAN LEVEL CONCERNING CLIMATE CHANGE ADAPTATION

The most important pastoral programmes, completed or currently undertaken at European and national level are hereby reviewed. The geographical context concerns specifically the alpine chain and northern Mediterranean regions in a mountainous context; the main sectors of interest are pastoralism, forage production, agro-ecology and biodiversity or landscape conservation. Some programmes are not pastoral tailored but they give an insight on mountain governance issues, like water management, natural risk mitigation or protected areas management. Some European platforms like CLIMATE-ADAPT (EEA) have also been integrated in this analytical review.

From the geographical point of view, this review encompasses the western Alps: most of the information comes from France, while a lower number of specific pastoral adaptation programmes have been found for Italy and Switzerland. Limited material has been found for the Eastern Alps, probably due to a lower impact of droughts on pastoral activities in this area. Since we are not familiar with Slavic languages and having obtained a low number of German and Austrian papers and/or reports, their incorporation will be likely undertaken during the Pastoralp project lifetime. Some other programmes, originating in extra-alpine contexts (Ireland, Spain) have been included due to their pastoral interest for adaptation practices or social participation of farmers and shepherds. The following table (Tab. 4.1) shows the most relevant issues of these programmes, and references concerning web links, years of activity and national/regional locations (research programmes are listed in alphabetical order) are also reported.

Tab. 4.1. List of the most important programs at national level concerning CC adaptations.

Program name	*Web-link*	*Location*	*Years*	*Pastoral issues*	*Biodiversity management*	*Others issues*
ADAPTALP	http://www.alpine-space.org/2007-2013/projects/projects/detail/AdaptAlp/show/index.html	DE-IT-AT-SI-CH-FR	2008-2011	marginally	no	natural risk adaptation
ADAPT MONT-BLANC	http://www.espace-mont-blanc.com/it/adapt-mont-blanc	IT-FR-CH	2017-2020	marginally	yes	adaptation governance
AGRIMONTANA	http://www.agrimontana.ch/	CH	From 2007	yes	no	mount. economy
ALPAGES SENTINELLE	http://m.irstea.fr/linstitut/alpages-sentinelles	Alps (F)	From 2004	yes	yes	social participation
ALPFUTUR	http://www.alpfutur.ch/index.php	CH	2012-2017	yes	yes	mount. economy
ALPWATERSCARCE	www.alpwaterscarce.eu	AT-FR-IT-CH-SI	2008-2011	marginally	no	water resources
BURREN	http://burrenprogramme.com/	Ireland	1990-2018	yes	yes	social participation
CLIMADAPT	http://www.gisalpesjura.fr/-Adaptation-au-changement,302-.html	Savoie, Jura (FR)	2008-2010	yes	no	mount. economy
CLIMAPARKS	https://www.parcodolomitifriulane.it/ente-parco/progetti/climaparks/	NE Italy - Slovenia	2010-2013	no	yes	protected areas management
CLIMATE-ADAPT	https://climate-adapt.eea.europa.eu/	EU platform	From 2012	marginally	yes	adaptation governance
CLIMFOUREL	http://climfourel.agropolis.fr/	SW France	2008-	yes	no	forage

			2011			management
GESTIRE 2020	http://www.naturachevale.it/il-progetto/life-gestire-2020/	Lombardy (IT)	2012-2016	marginally	yes	Natura2000
GICC_ADAMONT	http://m.irstea.fr/linstitut/nos-centres/grenoble/partenariats-et-projets	Alps (FR)	2015-2017	yes	yes	adaptation model
GICC_SECALP	http://www.gip-ecofor.org/gicc/?q=node/312	Alps (FR)	2008-2011	yes	yes	forestry adapt. approach
ISAGE	http://www.isage.eu/	GR, E, UK, IT, FR, SF, TR	2016-2018	yes		sheep and goat farming systems
MASTERADAPT	https://masteradapt.eu/	Italy	2016-2018	no	yes	adaptation governace
MIL'OUV	http://idele.fr/reseaux-et-partenariats/life-milouv.html	SW France	2014-2017	yes	yes	social participation
MONTSERRAT	https://lifemontserrat.eu/en/	Catalunya (Spain)	2014-2018	yes	yes	wildfires prevention
MOUNTLAND	http://www.cces.ethz.ch/projects/sulu/MOUNTLAND	CH Jura, Alps	2008-2012	yes	yes	mount. economy
PRIMALP	www.primalp.ethz.ch/pdf-files/transdis.pdf	CH	1996-1999	marginally	marginally	scientific approach
XEROGRAZING	www.lifexerograzing.eu/	Piedmont (IT)	2013-2018	yes	yes	wildfires prevention

5 THE PASTORALP DATA-BASE

In this report, a review was made on on-line documents published by international organizations, on EU reports and on technical reports of countries and Italian departments belonging to the Alpine biogeographical region. In total, 41 documents were reviewed and a raw list of 428 records were collected.

Selected documents have been deeply analysed and all the measures applicable to pastoral activities identified. These have been archived in a database and classified with all relevant information. In particular, at first, we reported for each measure: the type of document from which it has been extracted; the year of publication; the author; the geographical scale (local, regional, national, international); the country of application, if specified.

For each measure, we extracted data listed in Tab. 5.1, trying to obtain the highest harmonization, regardless of the "implemented actions" described in each document (e.g. we called "mowing action" all the measures related to mowing independently of further indications about modality or execution time). To facilitate archiving and elaboration, we grouped measures in nine macro-typologies of actions ("methodological category") on the basis of common features. In Tab. 5.2 we listed such macro-typologies and described which kind of measures they comprise.

Tab. 5.1. Information relative to each measure.

Extracted variable	Description	Type of variable	Explanation
Measure	Specific name of the measure, as reported in the document under analysis	Free field	
Financeable	The document states whether the measure is subsidised?	Yes	
		No	
Financier	Indication about who is the financier	Free field	
Methodological category	Macro-typology of possible actions	Awareness	Measures to increase herders awareness about adaptation and mitigation strategies
		Breeding/genetic	Measures related to animal breeding (genetic quality, local breed)
		Cooperation	Measures to support cooperation among farmers and different kind of stakeholders or experts, to improve environmental change resistance or resilience
		Diet	Measures related to animal diet
		Health	Measures related to animal health
		Human food	Measures related to food production, transport and consumption

		Landscape enrichment	Measures related to agricultural landscape
		Pasture management	Measures related to pasture and herd management
		Technical tools	Measures related to actions which should be done at political or scientific level
Sub-category	Sub-categories of possible interventions	Identified for each methodological category on the basis of common elements	
Implemented actions	Description of the concrete actions	Free field	
Measure purpose	Description of the main purpose	Free field	
Climatic change	Which climatic factor is the object of the measure	Temperature increase	
		Precipitation reduction	
		Meteorological extremes	
		Other	
Action typology	How the action relates to climate change	Adaptation	Measures which respond to an already underway climate change
		Vulnerability	Measures which prevent climate change effects
		Both	
Climate change mitigation	How the measure influences climate change mitigation	Yes	Yes means that the measure contributes to the greenhouse gases reduction or influence carbon sequestration
		No	
Feasibility	First evaluation about the possibility of realisation in mountain ecosystem	High	
		Medium	
		Low	

Tab. 5.2. Sub-categories, divided per methodological category, and explanation of which kind of measure they comprise.

Awareness	
1) Advisory services	Use of consultation, formation and update services
2) Farmer awareness	Increase farmers awareness of environmental and climatic change
3) Knowledge transfer and information actions	Promote information and knowledge exchange
4) Research and training	Promote research and development of new knowledge about pastoral activities and climate change and training
Breeding/genetic	
5) Breed choice and selection	Selecting the most suitable breeds to local situation
6) Genetic resources conservation	Conservation of genetic pools of different breeds
7) Local breeds	Conservation of local breeds

Cooperation	
8) Cooperation	Measures dedicated to create or increase networks among farmers/herders and other individuals involved in rural development
9) Coordinated environmental projects	Encourage coordinated environmental projects
10) Operative groups of EIP	Use of operational groups of the European Innovation Partnership (EIP) to develop innovative projects
11) Pilot studies	Pilot studies, development of new products , practices, processes and technologies
Diet	
12) Dietary regimes	Measures about animal diets, both concerning an efficient forage production and an improvement of the conversion of the forage in energy
13) Dietary supplement	Use of dietary supplement
Health	
14) Animal welfare	Actions to improve animal welfare
15) Pest and disease management	Medical actions to manage pests and diseases
Human food	
16) Human food	Measures to reduce food loss along the food production chain and to guide consumers' choices
Landscape enrichment	
17) Diversification elements	Measures to maintain landscape elements (e.g. trees, shrubs, bushes) and to create structural elements for wildlife
18) Natural elements of the ecosystem	Measures to maintain natural elements (e.g. wetlands, peat bogs, swamps)
19) Provision of shaded areas in pasture	Measures to give to the animals and to the pasture itself shady places
Pasture management	
20) Animal number and composition	Actions to choose number and composition of grazing animals
21) Electric fences monitoring	Use of electric fences to monitor grazing animals
22) Livestock management	Measures related to livestock management (grazing regime, grazing phenology, …)
23) Manure management	Measures related to manure management
24) Grassland management	Measures related to: technique and time of mowing, grass management, seed selection
25) Pasture management	Measures related to pasture management (e.g. conservation and restoration, weed management, eutrophication, ….)
26) Soil management	Soil management and chemical outputs
27) Water management	Measures to increase efficiency in water management
28) Business management	Changes in business management and its mission (transition from farming to agro-touristic...)
Technical tools	
29) Investments in physical assets	Measures to increase performance and sustainability of farms

30) Policies	Political actions, regulations, subsidiary payments, ….
31) Simulation models and prediction	Development and update of simulation and prediction models

Descriptive analyses have been carried out on these data, in particular to identify in which field the proposed measures are still missing (or are underrepresented) and need further evaluation. This database, better analysed in the next section, is a good starting point to precisely identify the areas of intervention which are currently less explored.

5.1 Some preliminary remarks

In this section, we focused on measures proposed or applied by countries or regions, summarized as explained in the previous paragraph, in order to understand:

- which are the main types of action;
- which are the main subcategories in pastoral management category;
- if measures are financeable or not;
- if they are applicable in mountain habitats;
- which are main climate change effects on pasture;
- if measures contribute to reduction of climate change effects.

The number of actions is summarized in "methodology category" and illustrated in Figure 5.1 We put together all measures collected in our research. The category "pasture management" is the most applied measure gathering about one-third of all actions.

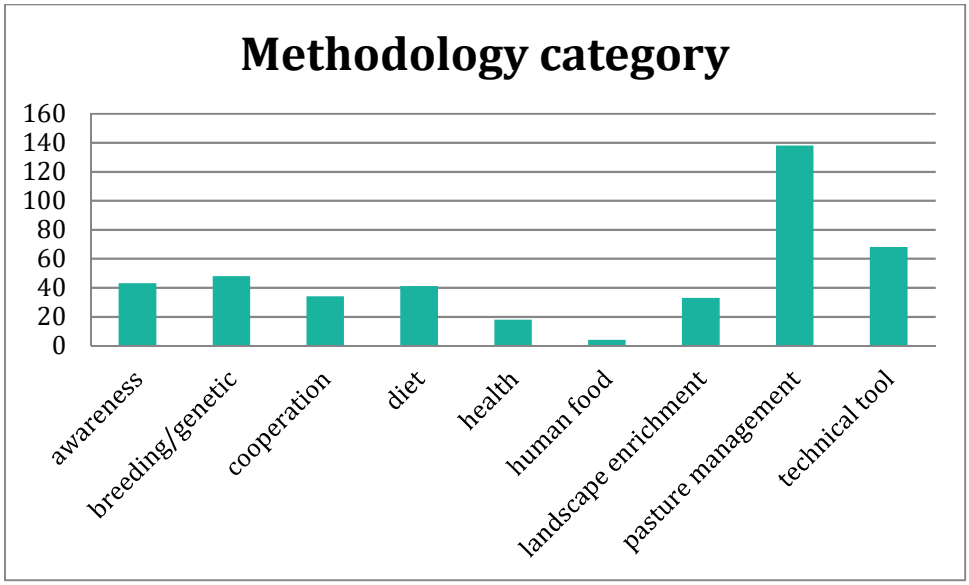

Fig. 5.1. Measure numbers separated in methodology categories.

In Table 5.3 we reported how many measures we found in each sub-category and in the next graphic (Fig. 5.2) we can distinguish which are the proportions among subcategories of "pasture management" category.

Tab. 5.3. List of subcategories in "pasture management" type.

Pasture management	
animal number and composition	15
business management	2
electric fences monitoring	5
grassland management	12
livestock management	10
manure management	8
pasture management	42
soil management	8
water management	29
other	7

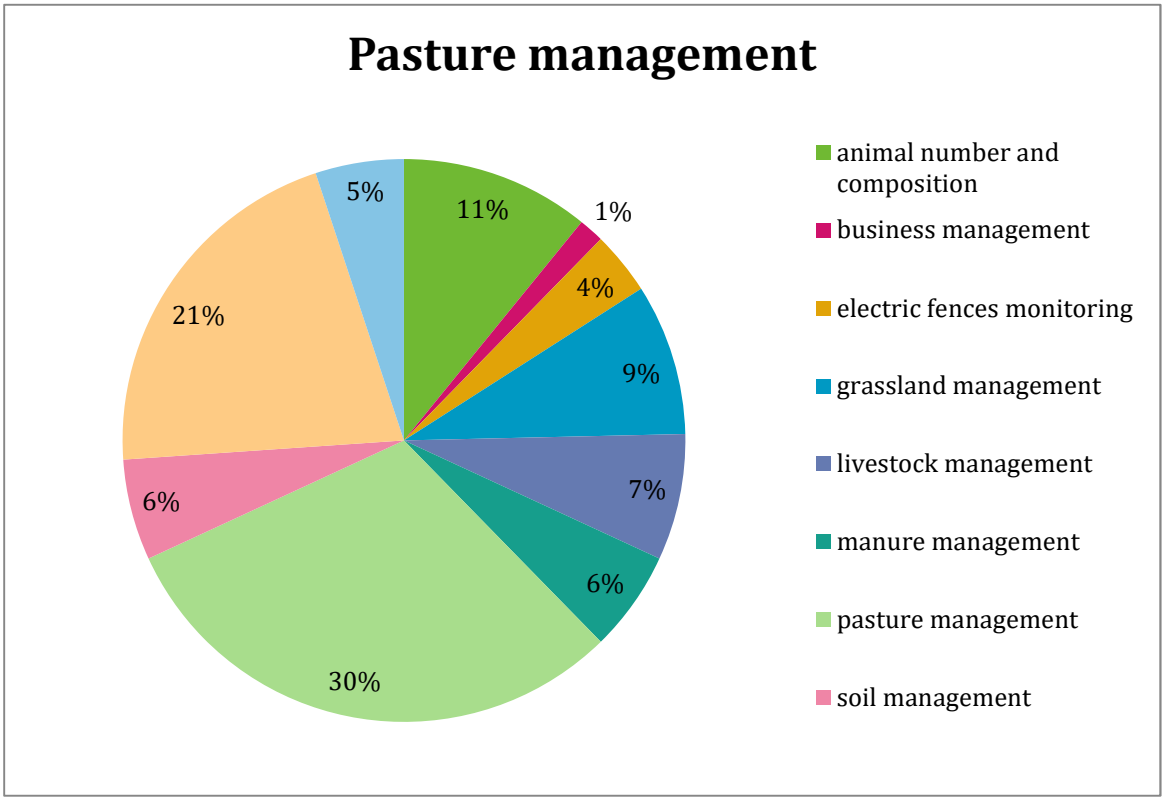

Fig. 5.2. Percentage of pasture management subcategories.

"Water and pasture management" are the most important actions, the latter summarizes some considerable measures concerning mowing, seeding, crop types, fallow lands and so on. We can clearly observe that these two subcategories constitute about 50% of all measures. Interesting is the 11% of "animal number and composition" that often includes measures that reduce the number of grazing animals, i.e. stocking rate on pastures.

In the next table we focused on the financeability of measures (Tab. 5.4 and Fig. 5.3). From some reports we couldn't find financeability information and so we put together columns with no data and no-financeable.

Tab. 5.4. List of methodology categories financeable or not .

Financeability	NO/NA	YES
awareness	11	32
breeding/genetic	28	20
cooperation	4	30
diet	40	1
health	15	2
human food	4	0
landscape enrichment	9	11
pasture management	96	57
technical tool	32	35

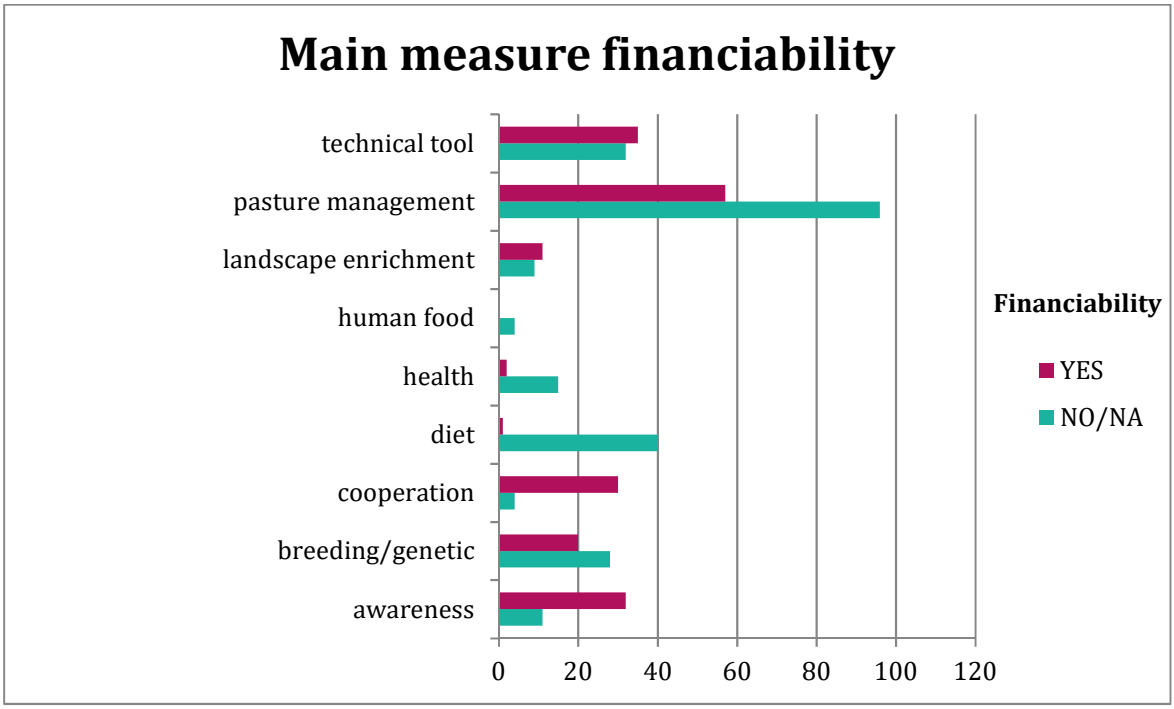

Fig. 5.3. The graphic compares how many measures are financeable. Measures that are not financeable and absent data were put together.

Indeed, our aim was to understand if actions are applicable in mountain habitats or not. This approach is very interesting because often measures are oriented to lowland environments, and their feasibility in mountain contexts is very low (Tab. 5.5 and Fig. 5.4 a, b).

Tab. 5.5. List of methodology categories applicable or not in mountain environment.

	Feasibility in mountain habitat		
Methodology category	**High**	**Medium**	**Low**
awareness	6	36	
breeding/genetic	15	31	2
cooperation	10	24	
diet	11	12	18
health	3	10	4
human_food		4	
landscape_enrichment	3	19	11
pasture_management	46	69	22
technical_tool	12	54	2

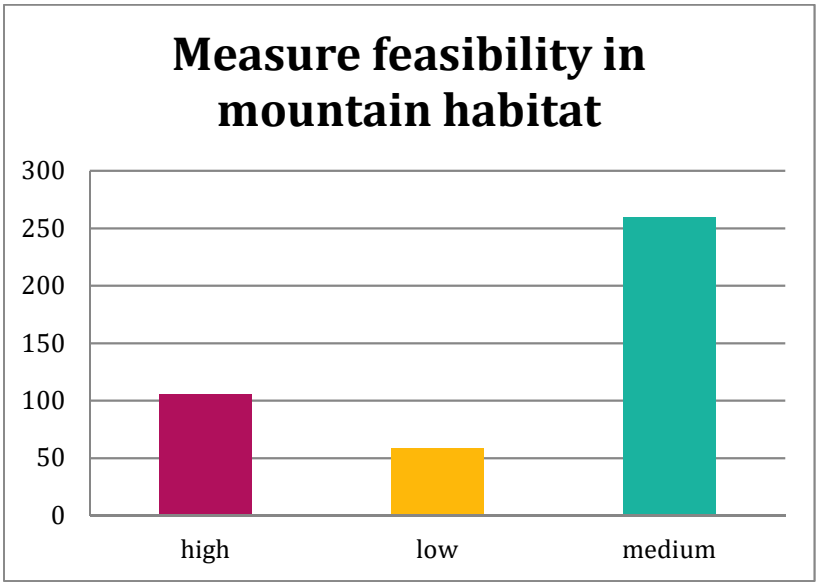

Fig. 5.4 (a). Viability of all measures in mountain areas.

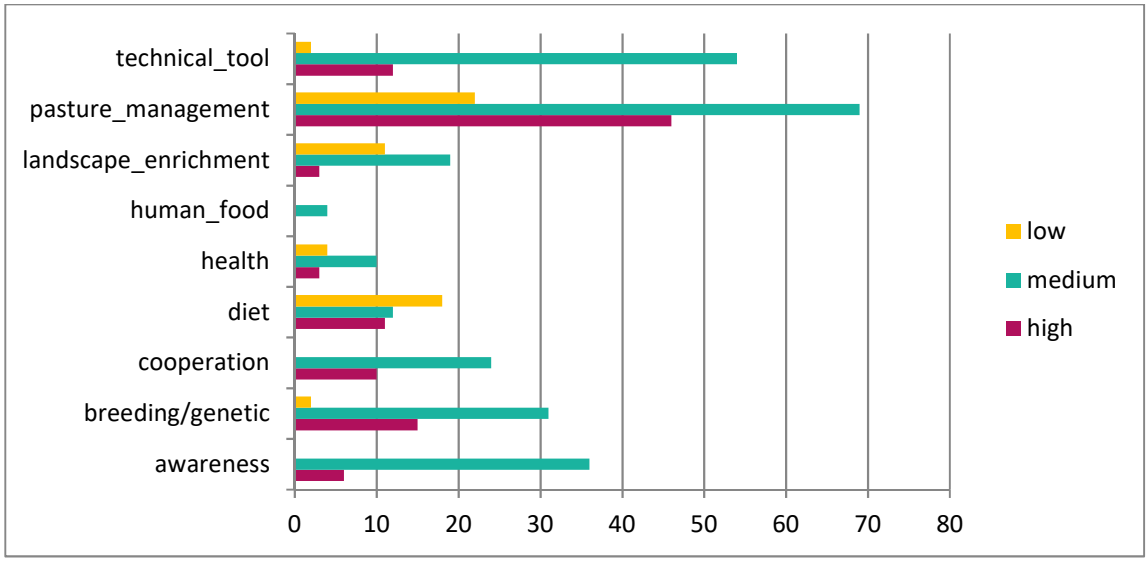

Fig. 5.4 (b). We compare feasibility of each measure (methodology categories) in mountain areas.

In almost all measures, a medium degree of feasibility, in mountain environment, reached the greater percentage than low and high degree. Only changes or supplement in dietary regimes are difficult to adopt in mountain habitat, probably because in these areas moving extra-food in high pastures is very expensive and/or difficult to apply.

We also investigated the effects of climate change on pasture and grazing animals, and results are summarized in Fig. 5.5.

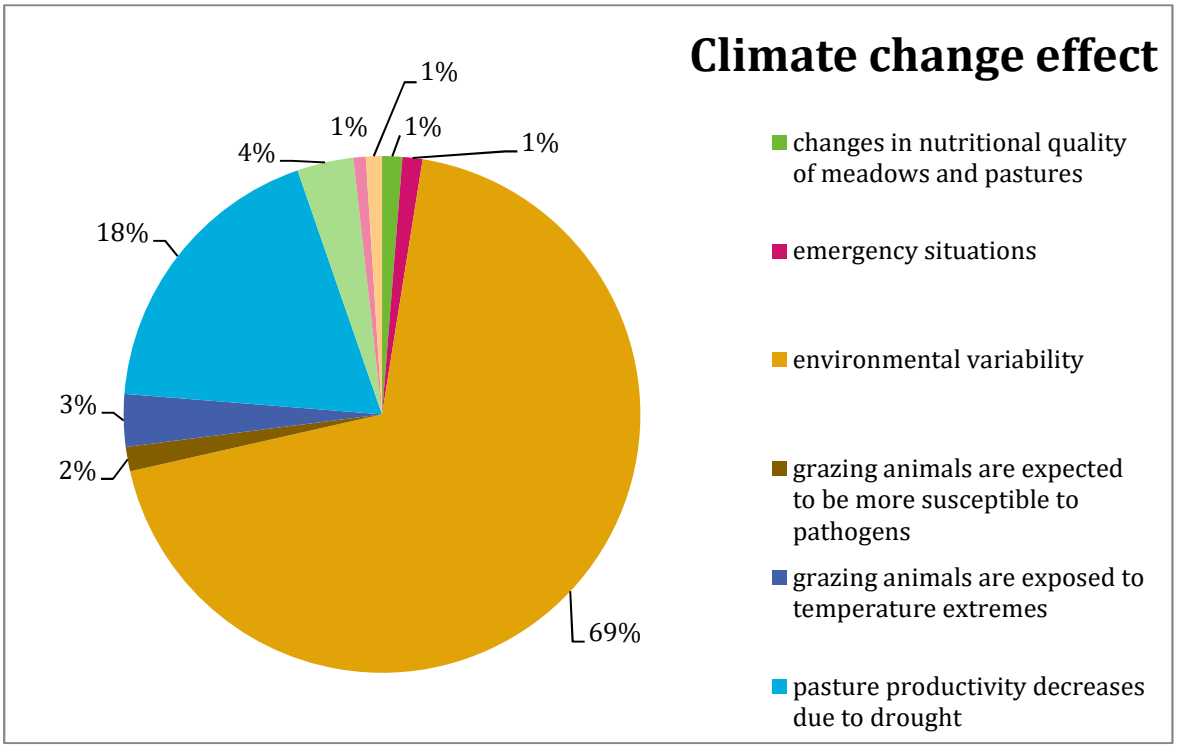

Fig. 5.5. Proportions among different effects of climate change.

The category that represents most of climate change effects on pasture and grazing, is "environmental variability" with about 70%. Notably, "pasture productivity decreases" is represented by 18%, highlighting the negative role of dry seasons (droughts) on grasslands. The productivity decreases due to the combination of droughts and low feasibility of forage supplements which in mountainous contexts is likely difficult.

Finally, analysing our database, we observed how many measures might contribute to mitigate impacts of climate change and to which category they belong (Tab. 5.6 and Fig. 5. 6 a, b).

Tab. 5.6. List of methodology categories that could reduce climate change or not.

	mitigation to climate change impacts	
Methodology category	**no**	**yes**
awareness	27	9
breeding/genetic	30	15
cooperation	21	4
diet	5	20
health	11	1
human food		4
landscape enrichment	23	9
pasture management	41	35
technical tool	50	10

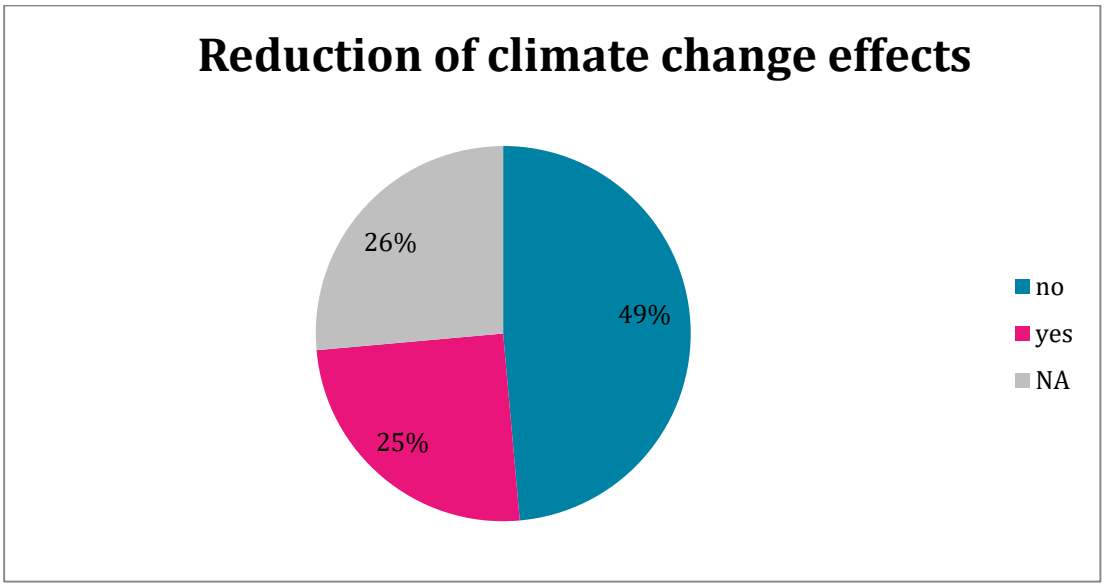

Figure 5.6 (a). Percentage of all measures which have the potential of reducing, or not, climate change impacts (NA is when no data are present in documents).

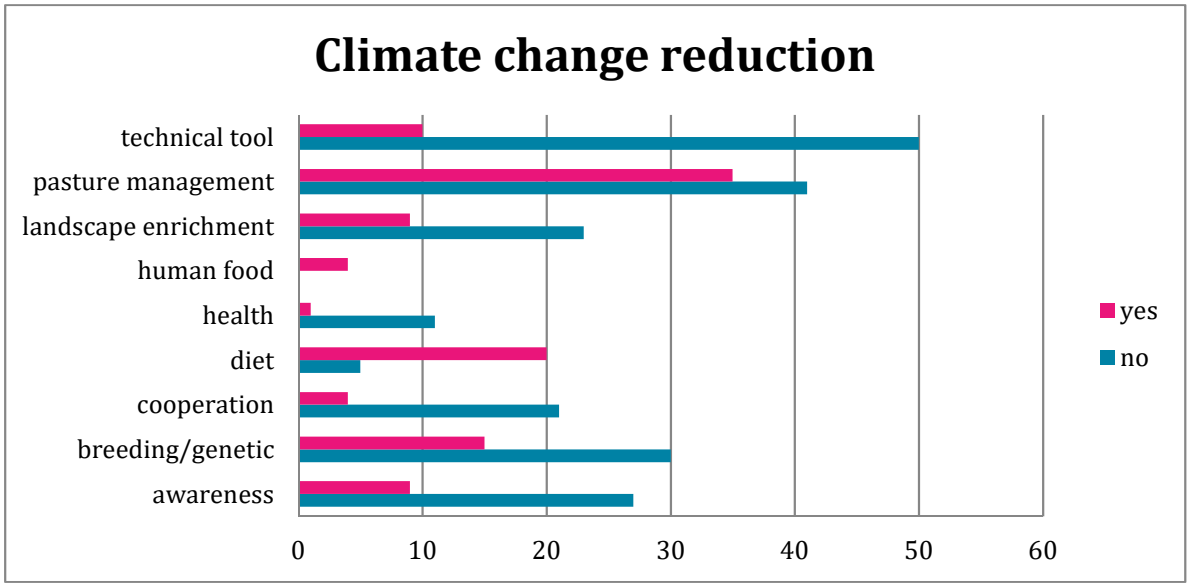

Figure 5.6 (b). Proportions among measures that might reduce, or not, climate change impacts (NA were not represented).

6 ADAPTATION STRATEGIES FOR ALPINE PASTORAL COMMUNITY

After processing > 400 data records and consulting 130 papers and reports, some general remarks can be highlighted. A several number of adaptation measures investigated in the review are cross-cutting actions: this is the case of the majority of CAP measures implemented in Italian PSR and French PDRR at regional level. Only some specific approaches are implemented in CAP M16.5.1 measure for collective establishments ("help to combined actions taken for the purpose of adaptation or mitigation to climate changes effects") and in M10.1 (agri-environment-climate commitments) measures.

Specifically, M10.1 measures are perceived from farmers more like a "payment" than as a "proactive commitment". According to a report of the European Network for Rural Development (RDP analysis, 2015), "climate change is relatively often cited as a general objective for M10 (34 RDPs), but just few objectives seem to be specifically climate-related, and none information is given on how to achieve them. CC-related objective may also be addressed by means of other environmental issues such as soil, water and biodiversity which in turn are able to contribute to climate change mitigation (even if indirectly)".

Similarly, M16.5 was used almost alone to improve water supply by regional policies while the original purpose was wider (EU Commission, 2014):

- joint action undertaken with a view to mitigate or adapt to climate change;
- joint approaches to environmental projects and ongoing environmental practices, including efficient water management, the use of renewable energy and the preservation of agricultural landscapes.

Concerning specific actions the large majority of them are included in special pastoral programmes like ALPAGES SENTINELLE, SECALP, CLIMFOUREL, ADAMONT, MIL'OUV or CLIMADAPT in France, or, to a lesser extent, like MOUNTLAND, ALPFUTUR or AGRIMONTANA in Switzerland. In Italy some results are expected by XEROGRAZING and FAR-CLIMAPP programmes (the latest in Central Apennines). Several measures have already been implemented by farmers and shepherds with an empirical approach or supported by structured researches in cooperation with technicians and researchers. The key measures resulted from this analysis are hereby reported, and described in the corresponding sub-paragraphs:

- circumstantial and structural measures;
- adapting forage resource;
- adapting water resource;
- adapting general pastoral management.

We end this chapter with some biodiversity and landscape implications related to Climate Change adaptation in pastoral landscapes and some considerations concerning collective approach of

adaptation strategies.

6.1 Circumstantial and structural measures

In an usual climate context, shepherds and farmers would rely on the possibility to minimize the negative effects of drought or adverse weather conditions (e.g. long period of rain, late frost, etc.), enabling more flexible forage systems (NETTIER et al. 2012).

Several studies (VITTOZ et al. 2008; LAVOREL et al. 2011; FISCHER et al. 2011; CREMONESE et al. 2017) reported a significant resilience of subalpine pastures towards CC; however, pastoral resilience can decrease in a mountain environment (RUGET et al. 2012; CATORCI et al. 2014). A sustainable pastoralism, i.e. livestock grazing, is able to stabilize and reinforce resilience of grassland against drought events (LAVOREL et al. 2011).

Under extreme climatic events such as consecutive drought years which likely lead to grassland degradation and inadequate fodder resource, emergency adaptation measures cannot be able to tackle the issues.

Adaptation practices can be distinguished in “circumstantial measures”, “structural measures”, “anticipation strategies” and “emergency adaptation measures”. Nettier et al. (2010) showed how an anticipated strategy can be appropriate; anticipating impact of climatic changes with a specific pastoral practice adaptation ensures a sustainable pastoral management. Moreover, Nettier et. al (2013) showed that the original approach, compared to past years, pushes a territory towards collective dynamics after a process of collective learning.

One of the hardest hurdle in adaptation adoption, is the combination of complexity and uncertainties characterizing pastoral activities: predation, increasing stocking rates, precarious living conditions in mountain areas, application of CAP. A programme like “Alpages sentinelle” (DOBREMEZ et al. 2014, CHAIX et al. 2017) can be operated only in a long term perspective, but some results are already evident after about 10 years of activity, in particular with what concerns mutual confidence, knowledge exchanges, collective regulation of over-grazing and access to agro-environmental measures.

Climate change is indisputable, however, it is important to consider and tailor locally different scenarios of climate changes (CHAIX et al. 2017). For example, geographical, socio-economic and ecological contexts vary along ADAMONT (Savoy), MIL’OUV (south Massif Central) or XEROGRAZING (lower Susa Valley in Piedmont) programmes. Consequently, only if we overlap socio-economical and grassland diversity characterizing each territory, with also forage systems and pastoral management, we will be able to have a reliable and specific vulnerability and impacts analysis. However, it is evident that strategies can be adopted only if a societal capacity building and acceptance is forged from the beginning.

6.2 Adapting forage resources

According with of the latest scientific literature and adaptation programmes, pastoral resources can suffer several impacts due to CC:

- anticipation of beginning of vegetative period;
- extension of vegetative period;
- increased potential production of biomass;
- increased risk of early or late frost risk (because of lower snow cover);
- increased risk of summer long droughts periods (with >ETP).

According to Hopkins & Del Prado (2007) the adaptation potential for natural systems is normally low, though these systems contribute to a range of ecosystem services.

Concerning increased potential production of biomass, this unlikely determines benefits as in high altitude mountains mowing cannot be adopted due to the environmental constraints and problematic issues in adopting mechanization (CHAIX et al. 2017). At lower altitude, hay production can increase in spring but decrease in summer (> ETP), specially under Mediterranean-climate influences (southern Alps). In northern Alps, under a more wet climate, biomass production likely increases in meadows under increases in temperatures and longer vegetation period (SÉRÈS 2010; LAUBER et al. 2014; BUTTLER et al. 2012). The possibility to stock hay represents an added value to rely to reserves in critical moments.

A more efficient use of forage resource is underlined by the majority of studies. In particular, rational management of pastures is recommended in Italian and French Alps (LAVOREL et al. 2011; PROBO et al. 2014; PEROTTI et al. 2018). Potentials of exploiting with grazing new generation habitats like woodlands or shrublands should be wider explored (ETIENNE et al. 1994; TCHAKERIAN et al. 2005; LEGEARD 2004; GARDE et al. 2014; PROBO et al. 2016; DELLA MARIANNA et al. 2007; CORTI et al. 2010; CHAIX et al. 2017); use of fodder trees is an ancient practice to recover small and medium livestock and is recommended for the high nutritive value of some leaves like ash or maple (CLIMFOUREL PROJECT 2008).

To sum up, the impacts of CC on pastoral resources in the short term might be quantitative and qualitative, while in the long term, detriments of pastoral resources are likely expected. Table 6.1 resumes the most effective adaptation measures acknowledged in scientific literature (for references see bibliography at the end of this report).

Tab. 6.1. Most common adaptation measures for forage resources.

Adaptation measures	Notes
Purchasing of hay	expensive solution
Fodder supply	expensive solution
Storage of forage resources by increase meadows mowing	for farm owners only
Improve grazing efficiency with a better use of forage resources (turnover in rotational management of pastures)	technical skills required
Pastoral exploration of new grassland sectors	technical skills required
Pastoral exploration of wooden or shrubby landscapes	agreements with owners
Pastoral exploration of crops	at low altitude only
Fodder tree supply	for a small livestock only

6.3 Adapting water resources

An overview of regional and inter-regional policies is reported in Section 3, while in this section, we focus on local measures. In high alpine regions, water scarcity does not represent a limiting factor, except for the following territories:

- Alpine lands influenced by a Mediterranean climate;
- southern Alps, with intra-alpine and sub-Mediterranean zones;
- lowlands in alpine and peri-alpine regions;
- karstic massif, due to a higher water infiltration in subsoil.

However, drought conditions may be ever more frequent in drastic scenarios and extra water supplies can be necessary in agriculture.

It is increasing a general opinion of setting up basin/reservoir buildings also in mountainous and hilly zones for water storage (sectorial basins or multifunctional basins). Some public technical services, like Agence de l'eau RMC-F or Agroscope-CH, wish to limit the spread of little basin while enhancing irrigation efficiency by promoting new sprinkling technologies to save human labor and water resource (MARBOT et al. 2013).

The EAA (2009), in a specific brochure concerning water management adaptation, includes a discussion concerning differences between new technologies and traditional irrigation systems. The restoration and reactivation of these traditional irrigation systems (like Suonen/Bisses in Wallis-CH, Rü in Aosta Valley-I, Bealere in Piedmont-I) are reported by ADAMONT project (PIAZZA-MOREL et al. 2018) as an adaptation option tackling water scarcity in mountain region.

The following table (Tab. 6.2) summarizes the main adaptation measures concerning water management in mountain pastures.

Tab. 6.2. Most common adaptation measures for water resources.

Adaptation measures	Notes
Store water resources in mountain reservoir	
Improve water distribution, management and governance	
Improve irrigation efficiency by sprinkling	especially in CH
Reduce water losses and consumption	
Increase water retention to conserve soil moisture	
Optimise watering hole	
Restore mountain historical irrigation network	

6.4 Adapting pastoral general management

Flexibility in management practices is the main driving factor to guarantee adaptation success in mountain pastures. When we reviewed forage resource adaptation, it emerged the importance of pastoral resources diversity in mountain pastures (different grassland types, rotation grazing management, availability of woodlands and shrubs). Concerning animal health, summer heat waves can exhaust, weaken or stress livestock, especially at lower altitude or southern latitudes (BLACK & NUNN 2009; NARDONE et al. 2010; LACETERA et al. 2013 & 2016; PRIMI 2012; SCOCCO et al. 2016) and outbreaks of parasite vectors may lead to increases in animal diseases. In mountain pastures such risks are likely reduced, but animals may change their behavior during heat waves and move up in altitude, selecting fresher territories (like north expositions), shelter under tree shadow for a longer time, be active earlier in the mornings or later in the evenings (NETTIER et. al. 2017; CHAIX et al. 2017). As a consequence, it is relevant the maintenance of these "safety zones" (GARDE et al., 2014) in the context of mountain pasture while also ensuring animals to move across wide spaces. For example, according to GARDE et al. (2014), ensuring mobility is one of the main adaptation options to tackle climate change for sheep farming systems.

Interaction between adaptation to climate and predation was recently mentioned (Brien 2018) like a potential factor reducing management flexibility. The question is: can adaptation measures towards wolf predation increase vulnerability of pastoral resources? And can CC adaptation measures increase predation risk? On this regard, shepherds of Ecrins National Park (PNE) highly recommended the setting up of permanent cabins ("cabanes perennes") in mountain pastures ensuring lower stresses in livestock and shepherds during long travels to return back to permanent structures for the night.

Another effective adaptation measure is to increase farmers and shepherds' awareness on climate change impacts and lead them to modify some behavior/management along the years: mutual confidence must be pursued and boosted between shepherds and technicians/researchers. On

this regard, reliability of technicians/researchers is the crucial issue, incorporating traditional practices, shepherds'/farmers' requests into innovative and effective livestock management options for climate change adaptation measures adoption (LEGEARD 2004). To this, the aggregation in associative groups (pastoral groups, land associations, collective haymaking organizations), Integrated Production Chains Plans (PIF: CASSIBBA 2015), EIP-AGRI groups, M16 measures of CAP represent relevant strategies to enhance synergies in adaptation practices adoption.

Reduction of stocking rates or changing in breed or species is perceived by farmers as an "extrema ratio" (NETTIER et al. 2012; BRIEN 2018), to put in practice only in case of "shocking" CC scenarios.

The following table (Tab. 6.3) summarizes the most frequent adaptation measures applicable for grazed mountain pastures as reported in literature (for references, see bibliography at the end of this report).

Tab. 6.3. Most common adaptation measures for pasture management

Adaptation measures	**Notes**
Modify pasture period (mounting, descent or permanence)	
Reduce or modify livestock number	
Change livestock species or breed	
Change grazing timetables (earliest, later, night grazing)	
Integrate other farming or touristic activities (multi-functionality)	
Invest in efficient permanent structures (cabins or fences)	several solutions
Change mountain pasture with other with more sustainable activities	
Reinforce flexibility traits of pastoral management	
Improve thermal insulation and ventilation of stables	only in warm lands

6.5 Biodiversity and landscape implications related to CC adaptation

We have already underlined that sub-alpine pastures are relatively resilient to uneven climate, especially if adequately grazed (VITTOZ et al. 2008; LAVOREL et al. 2011; FISCHER et al. 2011; CREMONESE et al. 2017); in case of repeated extreme climate events, ecosystem alterations can occur (LAVOREL et al. 2011; ARTAUX 2011). Pastoral ecosystems have until now overcome two

big droughts like those occurred in 2003 and 2017 (PIAZZA MOREL et al, 2018; DODIER et al., 2018). Multi-specific vegetation communities are more resilient rather than poorest specific communities. In alpine contexts two areas are acknowledged as fragile biotopes:

- snow and peri-glacial communities, with their artic-alpine species;
- not managed open spaces at supra-Mediterranean and mountain level.

Agriculture drop-out and global warming interact to close open spaces by progression of wooden species towards higher altitudes. This likely determines a serious risk of biodiversity loss missing a connectivity approach in landscape management and in the absence of agro-environmental measures allowing connections between supra-Mediterranean, mountain or subalpine grasslands. A more frequent wildfire occurrence induces an expansion of mesoxerophilous and xerophilous species with consequence on landscape diversity.

Connection between Climate Change and connectivity was analyzed by SORDELLO et. al. (2014), and spatial adjustments for fauna were also underlined. A catalogue of measures to improve ecosystems' connectivity was compiled by AlpParc-CIPRA (KOHLER & HEINRICHS 2011): several measures concerning grasslands shall be assessed in a specific territorial context. In the "tramevertebleue.fr" national portal, under the "agriculture" thematic section, no contribute is available.

Other important topics concerning pathways to address adaptation strategies are High Natural Value Agriculture Area (HNV), i.e. the agro-forestry approach and agro-environmental measures. High Natural Value Agriculture (HNV) is a new policy instrument – promoted by the European Innovation Partnership for Agricultural Productivity and Sustainability (EIP-AGRI) – for building a bridge between farmers and researchers in order to boost innovation and pursue practical down-to-earth solutions for an agriculture preserving biodiversity and economic issues. In the activity of EIP-AGRI group some HNV indicators were recently highlighted (EUROPEAN COMMISSION 2017).

The agro-forestry approach, which includes some silvo-pastoral techniques, is considered a key approach to address climate change adaptation and mitigation objectives, often generating significant co-benefits for local ecosystems and biodiversity (MATOCHA et al. 2012). Fodder trees and mixed tree/meadow/grassland open landscapes are managed with agro-forestry techniques, traditional/ancestral practices, coupled with innovative frameworks.

Concerning agro-environmental measures, in France more than two decades of experiences exist: OGAF (from 1994), CAD-CTE (from 1999), MAET (from 2007) and MAEC (from 2015). In alpine pastures at subalpine level, vegetation dynamics are slower and the effectiveness of agro-environmental measures remains uncertain (Mourre 2009); greater interest seems to occur at lower altitude in meadows, mountain steppic grasslands or "parcours". According to NETTIER (2016), MAEC 2015-2016 seems to be a relevant tool for CC mitigation but less for CC adaptation.

Another management tool in French Alps can be the application of the "Plan de Gestion Eco-pastoral" in Natura2000 sites (DELLA VEDOVA-PNE, oral communication): implemented by a farmer, a Natura2000 counselor and a technician of Federation des Alpages de l'Isère, it provides diagnostics for pastoral management and identification of biodiversity hot-spot (like arctic-alpine communities, *Lagopus muta*, special protected species) so as to address biodiversity hot-spot conservation. Moreover, the Agro-environmental measure of MAE H09 implies financing conservation practices adoption in small specific areas.

Finally, all these issues concur to identify "**Ecosystem-based Adaptations**" (EbA). Promoted by IUCN, the EbA set the basis for a "sustainable management, conservation and restoration of ecosystems" adaptation strategy that takes into account the multiple social, economic and cultural co-benefits for local communities". Ecosystem-based adaptation includes biodiversity and ecosystem services (LAVOREL et al. 2013; SCHIRPKE et al. 2017; KOHLER et al. 2016; MAES et al. 2018) as part of an overall adaptation strategy to help people adapting to the adverse effects of climate change (CONVENTION ON BIOLOGICAL DIVERSITY, 2009).

An Ecosystem-based Adaptation Handbook exists (JIMÉNEZ HERNANDEZ 2016): this handbook is meant to step-by-step guide for setting up an EbA intervention. It promotes an integrated approach to EbA with the ultimate goal of "building resilience of socio-ecological systems".

The following table presents a list of the adaptation measures related to biodiversity conservation is presented (Tab. 6.4).

Tab. 6.4. List of adaptation measures concerning biodiversity.

Adaptation measures	**Notes**
Preserve biodiversity hot-spots at regional and sub-regional scale	
Create new biodiversity hot-spots	anticipation measure
Landscape enrichment (wetlands, bogs, green linear structures...)	
Provision of shaded areas in pasture (tree oasis creation)	
Preserve and restore biological corridors and ecological connectivity	
Promote HNV agriculture and agro-ecological practices	
Develop eco-pastoral managements for some target species or endangered habitats	can be financed only on small areas
Promote minimal exploitation (Minimalnutzungsverfahren) in marginal pastoral zones	Agrimontana project
Promote ES (Ecosystem Services) payments for adaptation	

Adaptation measures	Notes
measures in pastoral activities	

6.6 Collective approach of adaptation strategies

We conclude this review with a reference to the collective dimension of adaptation strategies: as shown by Alpages Sentinelle network or LIFE Mil'ouv programme, two steps are basically connected:

- collective learning;
- collective operating.

Co-responsibility of all actors (i.e. farmers, shepherds, technicians of public services, local communities and protected areas and researchers) should lead towards a mutual confidence, common diagnostics and shared aims. Participatory design methods, support modelling, games to support multi-stakeholder decision-making (ARTAUX 2011; BERTHET et al. 2015; DE OLDE & DE BOER 2013; FARRIE et al. 2015) can help the involvement and active participation of different actors. To better address long or medium term changes, an active and joint communication, and interaction with the main stakeholders of pastoral sector is recommended (LAVOREL et al., 2011). Not always climate change impacts or climate threats are the main concerns of farmers or shepherds: in many cases (JURT et al. 2014) the main concerns regard:

- absence or lack of familiar employment;
- heaviest charges of work;
- changes in social or cultural values.

In other contexts, wolf predation is becoming more relevant reducing importance to CC issues (GARDE 2013; MEURET et al. 2017; VERONA et al. 2010, CORTI et al. 2012); to this, and in a perspective to address "wolf-man-climate adaptation" strategies, the establishment of cooperation activities with COADAPHT network is pressing.

7 ADAPTATION STRATEGIES EVALUATION

The objective of this section is to show the methodology developed in order to evaluate the above identified strategies for the adaptation to climate change of mountain pastoral activities. Such an evaluation has been (and will be further) carried out in the French and Italian regions selected as target for the LIFE Project PASTORALP.

By the literature review (both considering technical reports and scientific articles), we did not find much information about the evaluation on the effectiveness of the proposed strategies and methodologies. To this, a public consultation of different target stakeholders was implemented so as to evaluate the proposed strategies in terms of their effectiveness and applicability. Thus, a structured questionnaire (see annex A), characterized by different sections and easy to be filled by different types of stakeholders (less or more experts) has been prepared and shared.

In particular, we identified the following categories of person of interest, whose opinion is fundamental to comment and evaluate the current measures and to propose additional ones:

- local people directly involved in pastoral activities (shepherds; herders; land owners);
- "commercial" stakeholders (local sellers who mainly trade with pasture-derived products; people involved in the development of a local, high quality and sustainable production chain);
- people living and working in the territory; target of the projects (so as to collect opinions from people not directly involved in pasture management but strongly linked to the local territory);
- local politicians (mayors; people involved in the consortium of mountain municipalities and in the local agricultural consortia);
- regional politicians (agricultural management offices of the regions involved in the project);
- technicians (civil servant employed in different local or national bodies, independent worker, staff of agricultural organizations);
- scientists (experts on pastoral activities and managements, climate change, biodiversity conservation).

In summer 2018, a remarkable list of persons was prepared in the Italian territories interested by the project. Most of contacted persons seemed interested in cooperating, they filled the questionnaire and provided also additional information where requested. The questionnaire (Italian version) is presented in annexes A.

We already tested the effectiveness of our questionnaire with 10 stakeholders, which answered all the questions and gave us useful suggestions to improve it. However, autumn-winter 2018-2019 will also be dedicated to spread the questionnaire among other local stakeholders. Indeed, during summer, all the local stakeholders are directly involved and highly busy with their pastoral activities. Moreover, in many cases, they are in the alpine pastures at high altitude, and so very difficult to reach for questionnaire compilation.

It has been developed (and attached) in Italian, then it was also translated in French, since local

stakeholders are unfamiliar with English language.

The questionnaire is organized into 3 sections:

- Section one is focused on characterizing the compiler, so as to have data on compiler's background and the geographical area of activity.
- Section two is dedicated to get an insight on the personal perception of the extent of climate change in mountain ecosystems and its impact on pastoral activities. This is essential to understand the magnitude of CC impacts perception by stakeholders on their activity and organization.
- Section three is directly related to the evaluation of the current adaptation measures and to explore the possibility to develop new ones, more effective and feasible. Indeed, there are structured questions about how each stakeholder uses or evaluate the local Rural Development Programme and open questions allowing the proposal of new measures.

Outcomes from this preliminary survey are still under analysis, and will be performed throughout the project duration, in compliance also with the foreseen consultation workshops (programmed by January – February 2019) and what will derive from modelling outputs.

8 CONCLUSIONS

The present report aimed at assessing European, national and regional strategies for the adaptation of the pastoral sector in mountain ecosystems to climate change.

We at first underlined the important role of traditional agro-pastoral activities in preserving mountain landscapes and biodiversity and how this conservation is currently threatened in particular by land-use and climatic changes. In this framework, local stakeholders should be encouraged to carry out extensive and low impact traditional activities, also through the support of economic subsidies, as well as support farmers and herders to face new climate-related challenges.

Then, an overview of climate change adaptation policies at European, national and local level, was detailed highlighting the strong relevance of a multi-level governance. Indeed, to be effective, adaptation plans and strategies shall be downscaled from international to local scales. Specifically, the report focuses on pastoral programmes concerning climate change adaptation across the Alps (on-line documents published by international organizations, EU reports and technical reports of nations and Italian departments belonging to the Alpine biogeographical region) so as to achieve a detailed and exhaustive state of art on the current measures which could be adopted in traditional mountain pastoral environments. Measures were grouped into methodological categories, on the basis of common features, according to different CC impacts (biodiversity, animal health, production, etc.). These measures were described and strengths and weaknesses in their application analyzed. Suggestions on the development of a methodological framework to evaluate them in the next future was also provided.

This work provides an overview of the possible adaptation strategies that can be applied across the Alps, with regard to protected areas. Moreover, current shortcomings in common policies are also pointed out. The first qualitative and quantitative evaluation of the identified measures is an important step towards the adaptation option assessment and the proposal of new measures, necessary for the development of an adaptation strategy plan and the identification of policy recommendations for climate change adaptations in alpine pastures.

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