REGARDS
REsilience of marginal GrAssland and biodiveRsity
management Decision Support

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General relevance of permanent mountain grassland and present trends

The French alpine mountain range cover around 40 000km2, being 21% of the total area of the alpine mountain range. It spreads on two administrative French regions (Rhône-Alpes and Provence-Alpes-Côte d’Azur) and nine administrative departments in full or partly, for 2 593 000 inhabitants (20% of the total population of the alpine rangeland) (POIA, 2014).

As in Austria, grassland is dominating the French alpine regions. In 2010, the usable agricultural land of alpine areas was composed of 80% of grasslands (Agreste, 2010).

These last 10 years 5% (22 000ha) of the usable agricultural land has been lost in the French Alps, this lost being stronger in the Southern Alps (-7%) than in the Northern Alps (-5%). In the Southern Alps, the decrease of the number of farms has slowed down this last 10 years together with a stabilization of the structure of the farms at medium size. However this trend does not allow the agricultural use of all the agricultural land (Noury & Girard, 2013). At the contrary in the Northern Alps, there has been a strong decrease of the number of farms (mostly due to the strong disappearing of small sized farms) with a global increase of the size of the farms (Noury & Girard, 2013). A paradox of the Northern Alps, as identified by Camacho et al. (2008) in the Abondance valley is that, as mountain sides and alpine pastures are still used, they are becoming increasingly afforested (Camacho et al., 2008). According to a study of Dobremez et al. (2008) in the same valley, this is due to an oversizing of the parcels (at least regarding heifers and summer pastures) as a way to reconcile simplification of the work charge and securing of the pasture (Dobremez et al., 2008). However on a long term scope this appears to threat the renewing of the resource.
Effect of agricultural trends on biodiversity and ecosystem functioning

Although some studies highlight the direct link between distinctive practices (fertilization, mowing, grazing, animal health treatment) and biodiversity (Burel & Garnier, 2008), it seems hardly generalizable and transposable to the field where farming practices trajectories and environmental characteristics are very specifics (Balent et al., 1999).

In the early stages of abandonment, biodiversity is likely to decrease as aggressive pioneer or dominant species invade or predominate grassland. In the medium term as scrub cover develops the spatial degree of biodiversity may increase but then tends to decline as the woodland canopy closes. This process reveals a dynamic pattern of impacts on biological diversity that is not yet fully understood (MacDonald et al., 2000).

Besides global trends, it appears difficult to understand the coupled farming practices and biodiversity dynamics.

Indicating and interpreting changes in biodiversity is problematic because neither the processes involved nor the evaluation of impacts on environmental values are well understood. Temporal and spatial scales play a part in the environmental impacts of the abandonment process. Preliminary ‘models’ from Cernusca et al. (1996) of the effects on biodiversity in the Alps indicate that there is probably temporal variability in the direction of impact where regeneration of natural vegetation follows the abandonment of meadows and fields. In the early stages of abandonment biodiversity is likely to decrease as aggressive pioneer or dominant species invade or predominate grassland. In the medium term as scrub cover develops the spatial degree of biodiversity may increase but then tends to decline as the woodland canopy closes. This process reveals a dynamic pattern of impacts on biological diversity that is not yet fully understood. Indeed, Peco et al. (1998) consider that adequate models of biodiversity and landscape change do not exist (MacDonald et al., 2000).

A study of the impact of practices extensification on two study sites of the French Alps shows a decrease of vegetal diversity along a gradient of extensification in the Lautaret study site (Southern Alps) that fit with observation made regarding permanent grasslands in general and mountain grasslands in particular. However an unchanged vegetal diversity along the gradient of extensification in Les Saisies (northern Alps) study site in accordance with other subalpine grasslands from Northern Alps (dairy farms) (Lavorel et al., 2004) question the “generalizability” of the link between farming practices extensification and biodiversity loss.

These results highlight the complexity of studying the dynamic of biodiversity in response of agricultural practices change as it may be extremely context dependent.

Changes at the landscape level are more easily monitored.

Effect of agricultural trends on landscape

Agricultural land abandonment in the Southern Alps and of its oversizing in the Northern Alps lead to a global trend of shrub encroachment, both in the northern (Camacho et al., 2008) and southern (Moustier, 2006) Alps. In a comparative study of diverse French mountain territories, D. Sheeren et al.
(in press) note a more important dynamic of shrub encroachment in the southern Alps study sites than in the northern Alps, where most important changes appeared to have occurred earlier than the last 30 years (Sheeren et al., in press).

**Societal claims to permanent grassland management**

Societal claims are especially strong regarding summer pasture that supports multiple functions: productive, recreational, environmental... and that belong to municipalities, private but nonagricultural land owners and State, farmers having almost never a dominant right of use through property or land rent. Moreover, summer pastures are often included into environmental zoning such as national and regional parks, conservatories, Natura 2000… The use of these spaces by farmers often needs to be negotiated (Legeard, 2004).

Livestock grazing is often used to meet the challenges of biodiversity. The Natura 2000 sites in the mountains of Southern France are in large part dominated by open and semi-open pastoral environments. The network of natural, regional and national parks is particularly dense in the [alpine] region (Garde et al., 2014).

Environmental science community is comforting the environmental function of grasslands:

Grasslands are increasingly considered not only for their contribution to livestock production but also in their various functions with respect to the environment and the landscape. There is an accumulation of scientific evidence about the environmental functions of grasslands, such as their role in the conservation of biodiversity, in the regulation of physical and chemical fluxes in ecosystems, and the mitigation of pollution. Their role in the maintenance of landscapes of value is also important for reasons of landscape amenity and cultural heritage (Gibon, 2005).

However, in response to the growing interest toward the ecological function of pastoralism, several institutional actors as the French pastoral association have recently felt the need to reaffirme the production function of pastoralism (Pluvinage, 2014), remembering the primary productive role of farmers:

The animal farmer is first and foremost a producer of meat, milk and cheese. Preserving and developing this aspect of his profession is undoubtedly the first strategic challenge facing his future (Garde et al., 2014)

The societal demand towards mountain agriculture comes from an urban vision of mountain area that is challenging local perception of livestock breeding (Richard-Freve, 2012; de Sainte Marie, 2014):

It appears that most farmers are passive adopters of the new set of environmental practices, which they perceive as challenge to the identity and values of their professional community (de Sainte Marie, 2014).

As summarized by L. Garde et al. (2014) hereafter, societal claims may appear controversial to farmers in the tense context of the wolf return, endangering their willingness to implement agri-environmental practices:
It is within its economic, social and environmental position in relation to the expectations of society that pastoral farming can explore the pathways to its future. Broad sectors of the society express their desire for food that is healthy, local, with a low carbon footprint, farm-raised or organic. New expectations have also appeared concerning animal welfare. Pastoral farming in the Southern Alps, like in other mountain ranges, is fully in line with these current societal demands for local, more natural products, vectors of identity and character, associated with a terroir and carrying with them a strong image. However, other societal actors, sometimes even the same ones, strongly express other claims that reveal other values and another project for the future of the region. Their demand is based on a natural wilderness that is widely promoted by certain media and ecological associations. This nature should "rebuild" itself with all of the elements of the ecological pyramid organized around the diversity of big wild hoofed mammals in favorable habitats, crowned by the guild of scavengers and the presence of big predators. This claim, far from being only that of the most committed ecological associations, very precisely corresponds to the European policy of the Habitat Directive that applies to all of its member states, on the one hand, through the implementation of the Natura 2000 network, and on the other, through the obligation at the national level to protect concerned emblematic species. The question therefore arises as to “cohabitation” between the maintenance of livestock activities concerning small ruminants and this global project to rebuild ecological pyramids at the scale of European mountain regions (Garde et al., 2014).

Formal governance instruments

From the mid-19th century to the 1970’s, pastoral activities did not benefit from a specific institutional or juridical support and depended on forest and agricultural governmental policies (Ivanès & Msika, 2000). Poorly known from decision-makers, pastoral populations are marginalized in comparison to other agricultural practitioners.

In the 20th century (especially after the Second World War), the policy of modernization of agriculture increased again the marginalization of mountain communities (mostly relying on pastoralism). Indeed, their extensive characteristics did not seem to be able to enter the modernization process, accelerating rural exodus of mountain areas (Charbonnier, 2012).

Whereas mountain planning met several difficulties linked to the decrease of pastoral activities and the disorganization of land property and with the progressive replacement of foresters by agriculturalists in mountain planning, this new trend grows and pressed the government to develop specific policies for mountain areas. In 1972, the French pastoral law materializes the first step toward a law dedicated to mountain areas and opened a door to revalue pastoral activities (Charbonnier, 2012; Gerbaux, 1993). It was also the first governmental policy specifically dedicated to pastoralism.

It introduced three juridical tools: Landowners Formal Associations, Formal Farmers Group and Formal Land Use Agreement. These tools aimed to address the problem of pastoral land division and to encourage a better organization and a more rational use of grasslands (Ivanès & Msika, 2000).
Shortly thereafter, in 1975, to counterbalance the growing inequalities between regions, the common agricultural policy introduce compensatory payment to offset natural disadvantage, implemented to financially support mountain farming systems (Gerbaux, 1993).

With the emergence of agri-environment\(^1\) in the 1985 and the formulation of the notion of multifonctionnallity of agriculture\(^2\) in the 1990s, pastoralism gained at the same time new environmental and social formal tasks (see previous paragraph). Consistent with this, mountain agriculture rely more on the 2\(^{nd}\) pillar than on the 1\(^{st}\) one (Denat et al., 2013).

Agri-environmental measures complement the common agricultural policy and support environmentally friendly farming practices. Since the 1990s, successive programs have been implemented.

**Brief description of the CAP system**

Agri-environment programmes vary markedly between countries in Europe. The objectives of these programmes usually reflect a combination of the main environmental, ecological and socio-economic problems associated with agriculture, as well as the political situation in each country. In Switzerland, the Netherlands and the United Kingdom, schemes available to farmers concentrate on wildlife and habitat conservation. In Denmark and Germany most schemes offered to farmers aim to reduce agrochemical emissions, while in France the program is geared towards the prevention of land abandonment in agriculturally marginal areas. In Ireland and Austria, the objectives of programs are balanced between environmental protection, biodiversity conservation and landscape maintenance (Keijn & Sutherland, 2003).

In France, national and regional schemes exist alongside ‘local operations’. As regional schemes are the same in each region, both the national and the regional schemes can be considered horizontal whereas the local operations are zonal. Main goal of the AEP is to maintain agricultural activities in areas with a high risk of agricultural land abandonment and rural depopulation (Keijn & Sutherland, 2003).

**Its evolution**

\(^1\) That is “to financially support the farmers that adopt farming practices that contribute to the conservation of « sensitive areas in regards of nature protection » (article 19th of the CEE rules 797/85)” (Deverre & De Sainte-Marie, 2008:86)

\(^2\) Which is "the recognition of the several functions of agriculture, beyond food and fiber production, in the field for example of environmental protection or landscape preservation, rural employment or food security" (Bannal et al., 2012:3)
Mountain agriculture has been concerned by the implementation of several measures that were not specific to mountain farming systems but that was directly concerned by them.

Since 1992, there has been a grassland policy (PMSEE, PHAE, PHAE2) favorable to mountain agriculture. Most of the mountain farms received this financial support that compensates income of extensive grasslands systems. In parallel, in 2000-2006, the implementation of “Land management contracts” (Contrats territoriaux d’exploitation) was consistent with the recognition and the payment of the multifunctionality of agriculture, allowing to support the positive role of mountain farming and to reconcile production and environmental production. However this kind of contract has not been renewed in 2007 and there has been a strong decrease of agri-environmental subsidies in alpine regions. The figure below illustrates it regarding the Savoie northern alpine department (Noury & Poncet, 2013).

The decoupling of direct aid and the balancing of support within the 1st pillar marked an important evolution of the way CAP conceive mountain and/or herbaceous areas. Decoupling appeared not being adapted to mountain areas and coupling of direct aid to sheep and milk production were maintained. Additionally, it highlights the limit of integrating economic support to grassland system within agri-environmental measures. Finally, it marks the first step of a balance of direct aid between both production systems and territories. Noury and Poncet (2013) highlight the great instability of the agricultural policy on long term. The compensatory payment to offset natural disadvantage appears to be the only stable measure in time and thus represent an effective “basis” for mountain farming (Noury & Poncet, 2013).
Finally, J.M. Noury and B. Poncet (2013) highlight as follow the present stakes of alpine agriculture in regards of the CAP:

- In fragile areas of Southern Alps the objective to maintain agriculture has now overtake the objective of maintaining grasslands or practices. Although southern Alp farms receive more subsidies from the CAP than the northern Alps one, this has not been sufficient to stop its declining dynamic, linked to the economic difficulties of sheep farming. They conclude that environmental and “common good” supply supports will not be enough to guaranty the maintenance of agriculture in the most remote areas.

- Dairy farms show very divergent dynamics depending of the areas. Territories of cheese production benefiting geographical indication have maintain and even increase their milk production due to a stabilization and even an increase of the market of quality cheese. At the opposite, alpine territories without geographical indication have seen their number of farms and their production of milk decreasing. They conclude again that direct aid of the CAP cannot solve all the problems and that the evolution of agriculture is strongly linked with the economic dynamics of agricultural sectors.

**2007-2013 programmation**

![Graph showing the amount of direct aid to farms in 2010 (in euros/farms) (translated from Agreste, SUACI Northern Alps ; in Noury & Poncet, 2013)](image)

**First Pillar of The common agricultural policy**

**Suckler-cow premium**
It aims to maintain mother fed calves production by economically supporting farmers that produce sheep for meat production. The table below (table8) shows the amount earn by farmers.

<table>
<thead>
<tr>
<th>Amount of the subsidy (communautary part)</th>
<th>Amount of the subsidy complement for the 40 first females (national part)</th>
<th>Amount of the subsidy complement for the following females (national part)</th>
</tr>
</thead>
<tbody>
<tr>
<td>150 euros</td>
<td>50 euros</td>
<td>25,85 euros</td>
</tr>
</tbody>
</table>

Table 1: Amount of the financial support of the Suckler cow premim (Source: information notice from the French ministry of agriculture, food processing and forest, 2013)

Goat and sheep premium

To receive the subsidy the farmers must respect a ratio of productivity (=number of birth during the year/number of mother the year n-1). This ratio is fixed at the national level at 0.7. Exceptionally it is fixed at 0.6 in the Hautes-Alpes department for 2013. The basic amount of the financial support is 21 euros/heads.

Second pillar of the Common Agricultural Policy

Generalist measures

The compensatory payment to offset natural disadvantage (called Indemnisation compensatoire de handicaps naturels in French) and the agri-environmental grazing subsidy (called Prime herbagère agroenvironnementale in French) are national measures funded from the second pillar of the common agricultural policy. These subsidies are said generalists because all the farmers may apply to it.

Compensatory payment to offset natural disadvantage

It is the most important economic support that may be received by local farmers. Four area types have been defined in France: Mountain and High Mountain areas, Piedmont areas, Simple Disadvantaged Areas and Areas with Specific Handicap.

Based on this classification, the amount of the subsidy is calculated depending of the following table.
Farmers can commit 50 ha maximum of permanent grassland. The financial support is inflated by 50% the first 25 ha (depending of the livestock density on the area). Farmers can not commit more than 50 ha. To farmers whose sheep graze daily between the 15th of June and the 15th of September, and whose the sheep livestock unit is more than the half of the total livestock unit, the subsidies are inflated of 30%. Also, the minimum livestock density must be 0.3UGB/ha, if not the subsidy amount is decreased of 10%.

The general terms to get the subsidy are the following ones:

- The farm buildings, 80% of the usable agricultural land and the main home must be in the disadvantaged area
- At least 3ha of the usable agricultural land must be farmed
- Be aged of more than 18 years old and less than 65.
- Be farmer of pluri-active farmer. The farming revenue should not exceed a certain amount.

**PHAE, Agri-environmental grazing premium**

It aims to promote biodiversity in permanent grassland farming systems and to stabilize the grassland surfaces, particularly in areas of farmland abandonment. Thus the farmer commits himself to respect certain practices during five year in exchange of economic compensation.

The measure leads on limited livestock density, presence of biodiversity components and on a parsimonious input farming management.
The general terms of the measure are the following ones:

- Justify a minimum percentage of grassland in the usable agricultural land (between 50% and 75% of grassland)
- Respect a livestock density between 0.01 livestock unit/ha to 1.4 livestock unit/ha of grassland area (0.01 LU/ha ≤ Grassland livestock unit / grassland surface ≤ 1.4 LU)
- Be aged of more than 18 years old and less than 60.
- Respect at least 66.6% of specialized farming (permanent grassland/usable agricultural land ≥ 66.6%)
- The annual sum of the farmer request must be between 300 euros/year and 7600 euros/year.

Depending of the grassland productivity the amount of the subsidy is different: 76 euros/year for normally productive permanent grassland (>1500 fodder units/ha) and 47 euros / years for not very productive permanent grassland (<1500 fodder units/ha).

Territorial agri-environmental measures (MAET)

It is payments to voluntary farmers located in a targeted area, defined at the national scale (Natura 2000) or at the regional scale for other areas supporting important environmental stakes. It commits farmers to respect environmental friendly specifications for 5 years.

![Figure 4: Areas with an agri-environmental contract – Grasslands systems (2007-2011) (translated from DRAAF Rhône-Alpes)](image-url)
Examples of some commonly used territorialized agri-environmental measure in mountain grasslands:

**MAET H06**: financial support to promote late mowing. As no measure is adapted to financially support existing practices, this measure is used in Lautaret to encourage the farmers, already practicing late mowing, to continue mowing regardless of economic constraints that could lead them to buy their winter fodder instead. The Agricultural Chamber is in charge of the implementation of the measure, with no charge for the farmer.

**MAET H09**: financial support to the inclusion of nature conservation objectives into herd management during the summer season. National Park submits surfaces to eligibility where they have identified environmental stakes. Then the pastoralism advisory association of the French Provence Alpes Cote d’Azur region (called CERPAM) is in charge of the writing of the contract. They put together farming and environmental objectives and organize discussion between stakeholders to set up the specifications of the contract. To write the pastoral management plan, CERPAM is paid by the concerned farmer. Finally the contract is signed between the farmer and the territory head quarter of the Hautes-Alpes department.

**MAET H07**: Maintaining plant diversity in permanent grasslands. On each territory a list of around 20 flowering plants, indicators of the locally “healthy” state of biodiversity and easily recognizable is established. Within this list, at least four different plants should be found along each of the three third of the diagonal of the parcels, that the farmers have engaged in a 5 years contract. Thus farmers engage on a result: they have to reach or maintain defined plant diversity within the 5 years contract, without any practices prescription (except what is imposed by the agri-environmental grazing
premium- PHAE- which is compulsorily contracted with this agri-environmental scheme, but the requirement) (Nettier et al., 2012).

**Geographical indication**

As seen previously geographical indication contribute to the vitality of agriculture in the concerned areas. However, as P. Lamarque and E. Lambin mention it: unlike eco-certification, GIs do not explicitly require a sustainable management of ecosystem and their services in the product specification.

In a study they lead in the Bauges mountain range (Northern French Alps), they conclude that Geographical indications cannot be considered as a standalone instrument to promote the conservation of extensive land use practices given the strong dependence of European farms in marginal areas on CAP subsidies. However they reaffirm that it is a well-developed formal instrument that promotes economic and social dimensions of sustainable rural development (Lamarque & Lambin, 2014).

**Suggestions for future governance interventions**

**Enhancing agri-environmental schemes efficiency**

As C. de Sainte Marie remind us, recent evaluation of agri-environmental schemes have questioned the effectiveness of using management prescriptions to achieve intended outcomes (de Sainte Marie, 2014). She argues that:

“The switch to a result based approach is a bold innovation as it challenges the convention upon which agri-environmental policies have been built. From the MacSharry reforms onward, the reconciliation of farming with the protection of natural resources has been based on the principle of compensation for income foregone and additional costs compared to conventional farming practices. The rationale behind the flowering meadow measure is totally different in that it allow farmers to adapt their management practices to the vegetation of each plot, and to adjust them according to changing conditions” (de Sainte Marie, 2014)

Comparing the “Flowering meadow” (MAET H07), a result-oriented measure, to the “Pastoral management plan” (MAET H09), a measure essentially based on practices prescriptions (table 3 below), B. Nettier et al. (2012) highlight the highest efficiency of the result oriented measures that guaranty a certain plant diversity while allowing more flexibility to farmers to adapt their practices to local and annual conditions. However the “flowering meadows” measure appears to essentially support already existing practices more than to encourage adopting new ones. Indeed, farmers only engage parcels that results from long-term favorable practices, referring to long-term plants dynamic being not consistent with the 5 years contract delay. This highlight the question of farmers’ exposure to the risk of not achieving the objectives, being the only one penalized. It is thus particularly important to well define
what depends of the farmers ‘practices what does not and find in each case, modalities to make the risk acceptable (Nettier et al., 2012).

<table>
<thead>
<tr>
<th></th>
<th>Flowering meadows</th>
<th>Pastoral management plan</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Principle</strong></td>
<td>On each third of the diagonal of the parcels engaged, we should find at least 4 different plants of a list.</td>
<td>Respect of a management plan established in concertation between territory officer and the operator (farmer, official group of farmers, municipality…)</td>
</tr>
<tr>
<td><strong>Case study</strong></td>
<td>Regional park of the Bauges, Haut-jura and Vercors mountain range</td>
<td>Vercors regional Park</td>
</tr>
<tr>
<td><strong>Implementation</strong></td>
<td>Contract on an easily controllable result. No compulsory or recommended practices</td>
<td>Possibility to contract on a result to achieve or maintain. In the study case however, contract only on means (imposed practices)</td>
</tr>
<tr>
<td><strong>Farmers knowledge</strong></td>
<td>Good knowledge of the farmers towards the practices to implement or to avoid</td>
<td>Arguments on practices to implement to reach the objectives; recommended practices sometimes called into question (practices, zoning)</td>
</tr>
<tr>
<td><strong>Farmers practices</strong></td>
<td>No practices change or marginal change</td>
<td>Limited change of practices in general. Loose of flexibility in case of drastic year (drought)</td>
</tr>
<tr>
<td><strong>Farmers attitude</strong></td>
<td>Environmental sensitivity and adherence of the majority to the environmental stake. Recognition of their know-how and of their role in nature management, no compulsory practices (flexibility in the implementation) and few constraint is appreciated</td>
<td>In general, constraints are perceived as low but potentially limiting flexibility. Compulsory practices sometimes judged as non-adapted and indicating a lack of recognition of their know-how. Compulsory results judged seducing for an efficient action and a flexible management of the summer pasture, but risky and not possible to implement when the stakes does not only depend of farming practices. Engagement on practices better guaranty the subsidy</td>
</tr>
</tbody>
</table>

Table 3: Comparison of MAET H07 “flowering meadows” and MAET H09 “Pastoral management plan” (translated from Nettier et al., 2012)

The increased reference to ecosystem services and to its monetary evaluation may promote “payment-by-results” approach to environmental payment that may encourage the development of result-oriented schemes in the future (de Sainte Marie, 2014).

Scientific contribution to enhance adaptive management

As Johnson (1999) defines it:

The overall goal of adaptive management is not to maintain an optimal condition of the resource, but to develop an optimal management capacity. This is accomplished by maintaining ecological resilience that allows the system to react to inevitable stresses, and generating flexibility in institutions and stakeholders that allows managers to react when conditions change. The result is that, rather than managing for a single, optimal state, we manage within a range of acceptable outcomes while avoiding catastrophes and irreversible negative effects (Johnson, 1999).

In front of socio-environmental change and in the context of climate change, interrogations regarding the way to support farmers toward building resilience of desired system function have raised new questions and new initiatives.
We will here focus on two scientific explorations on the ways to support adaptive mountain grassland management.

**Improving management tools to support farmers toward adaptation**

In her thesis, H. Gross focuses on the adaptation of pastoral management practices to agri-environmental objectives. To do so, she analyses the design of management tools for sustainable pastoral system (cognitive content, management philosophy, organizational model) and how it is adapted to local situations. She explores the ways to adapt management during the course of the action. As she put it in context:

In France, agri-environmental policies encourage managers of natural pasture (pastoral technicians within various organizations: departmental agricultural agencies, national and regional parks, chambers of agriculture…) to manage both the renewal of pastoral resources as well as the conservation of biodiversity threatened by shrub encroachment. However, these managers find it difficult to implement this type of management at the practical level. They explain this by a lack of knowledge concerning the evolution of plant cover under the effect of agricultural practices and the lack of tools adapted to their use context (vegetation, breeding systems, etc.). Beyond pastoral pasture management itself, this issue also raises the general question of the agri-environmental management on natural resources that takes uncertainty into account and that adapts as it goes along, as well as that of tools to be designed to help practitioners with this type of management (Gross, 2011).

Her results show that practitioners adapt existing tools to their contexts by adjusting and/or completing them with their own knowledge. Thus, to be actionable, tools are contextualized, which means that their cognitive content is articulated, in practice, with local and empirical knowledge of practitioners. This result invite designers not only to try conceiving tools closest to situation of use (such as favoring co-conception with practitioners) but to conceive tools that allow a sufficient marge of maneuver to the users and its knowledge to be adapted to its situation (Gross, 2011).

This open new questions regarding the design of management tools able to support the resilience of pastoral social-ecological systems: “supporting learning process to implement a learning system, able to create as it goes along the new knowledge it needs to adjust practices, and thus implement an adaptive management” (Gross, 2011).

**Articulating adaptation services to increase social ability to respond to change**

The adaptation service concept arises from the ecosystem services field of research to explore social adaptation pathways in the context of climate change. It focuses on long-term scopes. As developed by Lavorel *et al.* (2015):

The concept of climate adaptation service can be proposed to complement the ecosystem services approach and help people develop choices for adaptation to climate change. This concept highlight the prospect of substantial ecosystem change and stresses the importance of option and insurance values of services not currently considered important for human wellbeing, but which may prove critical in the future. […] adaptation services are defined as the benefit to people from increased social ability to respond to
change, provided by the capacity of ecosystem to moderate and adapt to climate change and variability (Lavorel et al., 2015).

The development of this concept aims at exploring the potentiality of ecosystems to help society design flexible governance systems that enable adaptive learning and decision making in this uncertain context (Wise et al., in press). To identify ecosystem properties that provide adaptation services and how they are likely to change in response to climate change, S. Lavorel et al. (2015) propose a four steps operational framework (figure 6), that aims to “[identify] adaptation services under different scenarios of climate and management change, based on the current understanding of the ecological mechanisms that underpin the supply of ecosystem services” (Lavorel et al., 2015).

![Figure 6: The operational framework for the identification and quantification of adaptation services. Four steps are identified: (1) characterization of the system and its bundles of ecosystem services, (2) describing climate change direct and indirect impacts, (3) identifying adaptation services and (4) proposing management for adaptation service (Lavorel et al., 2015)](image)

A first attempt to operationalize adaptation service concept has been lead regarding biophysical knowledge that underpin it, and economic, institutional and social mechanism still need to be considered (Lavorel et al., 2015).
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