GASL – ACTION NETWORK
"RESTORING VALUE TO GRASSLAND"

Proceeding of the Workshop
Multifunctionality of pastoralism: linking global and local strategies through shared visions and methods

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Proceeding of the Workshop
Multifunctionality of pastoralism:
linking global and local strategies through shared visions and methods

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Foreword

The World Bank, FAO, the Global Agenda for Sustainable Livestock (GASL), the LIFLOD network and TerrAfrica have organized a workshop hold just prior to the start of the 2016 International Rangeland Congress in Canada in Saskatoon, 17-22 July 2016 to share current knowledge on the multifunctionality of pastoral systems and to identify development pathways that better articulate visions and perceptions of pastoralism stakeholders at different scales.

The objective of the workshop was to present the state of the art of international research and development work and how they address the multifunctionality of pastoralism at various scales. The three-half days of workshop were based on:

-case studies presentations dealing with a diversity of situations and contexts at the global level, to display the time and space variability and dynamics of the functions and values associated with pastoral systems, as well as the diversity of stakeholders involved.

- working group sessions helping us identifying needs for new knowledge taking into account the multifunctionality at different scales in pastoral development projects and contributing in building and agreeing on a generic conceptual model. The model integrate the different factors needed to answer the questions linked to livestock sustainable development at the local and global level.

These proceedings gather the articles and the posters abstracts presented during the workshop as well as the mains output of the meeting.

Acknowledgment

We are grateful to the organising committee of the 10th International Rangeland Congress for its help in the organisation of this workshop

SOMMAIRE

INTRODUCTION

Why and how address multifunctionality of pastoral farming systems?

By the Organising Committee of the workshop: *A. Ickowicz, V. Blanfort, S. Forman, B. Hubert, J. Lasseur, C., Marguerat, J.F. Tourrand, G. VelascoGil, L. Wedderburn.*

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RATIONALE

While around one billion people in the world live from livestock farming, rangeland covers one third of the world land. The Livestock-Rangeland couple secures diverse functions for the human population in different livelihood domains including food supply and food security, rural income and savings, food trading and agro-industries, soil fertility and crop fertilizers, production of goods (wool, leather…), tillage and rural transportation, leisure, landscape, social relationship, medicine, etc.

Facing the new environmental challenge defined during the COP21, the Livestock-Rangeland couple has to tackle some impacts, at both the local and global scales, especially regarding greenhouse gases (GHG) emission, biodiversity loss and water pollution, in order to better contribute to sustainable development. (FAO, 2018)

Globally, the new environmental challenge focuses on biodiversity conservation and reducing deforestation, desertification, GHG emissions, pesticide consumption and fossil energy. The contribution of pastoral systems to food security and nutrition challenges is also at stake, considering the world demographic tendencies and the forecast of an increasing demand for animal source food in the emerging and developing countries. At the local scale, the main challenges are to face higher frequency of climatic events (droughts, overflows …), low attractiveness of livestock and rural activity, especially for young people, adaptation to new standards and to a volatile and unpredictable market, and integration of new generic technologies.

However, in this complex global-local context, the impacts and contributions of pastoral and agro-pastoral systems are still poorly qualified and quantified and their perception still varies among different stakeholder groups (Ickowicz et al, 2010). Hence, these are strong limitations to the development and the adaptation of these systems.

The World Bank, the FAO, the Global Agenda for Sustainable Livestock (GASL), the LIFLOD network (with the support of Cirad and Inra) and TerrAfrica organized this workshop just prior to the start of the 2016 International Rangeland Congress in Canada in Saskatoon, 17-22 July 2016 to present and share current knowledge on the multi-functionality of pastoral and agro-pastoral systems in order to identify development pathways that better articulate visions and perceptions of pastoralism stakeholders at different scales.

PURPOSE

The objective of the workshop was to present the state of the art of international research and development work and how they address the multi-functionality of pastoralism at various scales. The workshop aimed at building and approving a generic conceptual model that integrates the different factors needed to answer the questions linked to livestock sustainable development at the local and global level with a special focus on (i) linking international policy debates (Food Security; Climate Change; Biodiversity) to local stakeholders expectations from livestock activities (ii) defining and characterizing the different functions of pastoral systems at different scales and in different agro-ecological and socioeconomic situations (iii) consolidating " "innovation", "knowledge issues" and "efficient support actions" to progress towards sustainable strategies and projects for pastoral systems.

By hypothesis, multifunctionality is built on:

- The agro-ecological, social and historical contexts within which livestock systems have developed;
- Heterogeneous stakeholders having developed diversified knowledge about local ecosystems and having different expectations for livestock activities (economic returns, local product, ecosystem services, cultural symbols…) and for herder's families (viability, security, sustainability…)
- A complex bundle of access and usage rights for natural resources, including land and water
- A specific environmental policy and a body of collective actions

- A complex network of livestock value chains specific to local products, traditional food habits, local commercial circuits or primary products flows oriented towards urban markets or export.

To address these hypothesis and develop a comprehensive state of the art, the workshop which gathered seventy nine colleagues from twenty nine countries around the world coming from different types of institutions (research, professional associations, ministries, environmental institutes, …) was organized in four sessions :

- « Multifunctionality around the world » through presentations of case studies
- « Diverse perceptions of multifunctionality for a shared framework » presenting a database of success stories, films on perceptions of multifunctionality, and a test of a conceptual model on multifunctionality.
- Working groups with the aim to test, discuss and enrich the conceptual model
- A conclusion session with wrap-up and recommendations for future actions.

This workshop is part of the Action Plan of the "Restoring Value to Grassland" Action Network developed within the Multi-stakeholder Partnership "Global Agenda for Sustainable Livestock" (GASL) (http://www.livestockdialogue.org). The GASL platform is supported by FAO. The Global Agenda recognizes that for livestock to be sustainable, the sector needs to respond to the growing demand for livestock products and enhance its contribution to food and nutritional security; provide secure livelihoods and economic opportunities for hundreds of millions of pastoralists and smallholder farmers; use natural resources efficiently, address climate change and mitigate other environmental impacts; and enhance human, animal, and environmental health and welfare. The Global Agenda provides a multi-stakeholder global Partnership, to comprehensively address the sector's multiple challenges towards sustainable development. It facilitates global dialogue to foster local practice and policy change, focusing on innovation, capacity building, and incentive systems and enabling environments.

Focusing on grassland and rangeland livestock systems, the "Restoring Value to Grassland" Action Network of GASL aims **"To maintain, restore and enhance environmental and economic value of grasslands, while promoting their social and cultural functions globally".** The main operational objective of this Action Network is then to promote the multiple functions of grassland livestock systems through developing assessment methods and sharing of information.

This workshop was initiated on behalf of the Global Agenda for Sustainable Livestock (GASL), and the World Bank under the auspices of the Livestock Global Alliance (LGA) and was the 3rd Workshop on Multifunctionality of Pastoralism, organized by the LiFlod Network.

Our first Workshop was held in Hohhot (China) as a side event of the VIIIth IRC in 2008. The second was in Rosario (Argentina) in 2011 linked to the IXth IRC. The proceedings of both workshops were disseminated (see below).

We are grateful to the donors who enabled us to organize this event: Cirad, Inra, Agropolis international, FAO-GASL, the World Bank, the LGA, the French Ministries of Agriculture and of Foreign Affairs.

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METHODOLOGICAL

ASPECTS

Conceptual models of livestock multi-functionality

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Why conceptual modeling

Describing the multi-functionality of livestock is recognizing that a system can be addressed from different perspectives. We are talking about a system as a coherent whole regarding a functioning, a global behavior or dynamics. In our case the livestock is not the system. The system is the set of components: livestock, actors of various kinds, biophysical elements, resources that are necessary to account a given function. But what is a function? Mathematically it is anything transforming something into something. We already mentioned a functioning, i.e. a well defined global dynamics. In our context, it is the service provided to an identified human community. Of course, this service can be more or less valued by the given community. An immediate consequence is that each function brings about (enacts) its own system, different for each function. It is these systems we intend to describe.

But what do we mean by describing? It can extend from oral or written discourse up to mathematical or computer models. Despite our effort to define (all?) the words we are using, and to use the same words consistently throughout our discourse, it is hard to extract from discourses what are the key concepts and capture their supposed relationships unless we are very familiar with the domain, i.e. both with what we are talking about, and the history of the choices made to describe it. On the other hand, mathematical and computer models appear to be very concise, capturing the essential matter. Unfortunately, they could also be hard to understand without a good literacy in mathematics and computer science. Therefore, the question becomes: does it exist a description able to expose the key concepts and their relationships that are neither texts or discourse, nor equations or code, and that could be understood with minimal literacy? We pretend that conceptual models are candidates for such descriptions. It remains to present what are models in general and conceptual models in particular. We will present a graphical representation that appeared usable for such matter as well as a methodology to build such representations. Finally, we will address the question of validation and articulation of the obtained perspectives.

What is a model?

Assuming we want to assess the sustainability of an ecosystem, called A (see figure 1, left). We can hardly manipulate a whole ecosystem to understand how it behaves in response to the variability of various factors (rain, temperature, etc.). If we hypothesize that the dynamics of the biomass is significant with respect to the sustainability of the system, we could try to record the observations over time (see figure 1, middle top). These observations could be fitted by a curve with an equation $y = f(x)$ where y is the quantity of biomass and x is the time. This process of choosing the dynamics to account for and the related kind of equation is called an *abstraction*. Given this equation, the choice of its parameters in order to fit the observed data is called a *calibration*. The calibrated equation becomes the model of the ecosystem through this particular abstraction (it could have been done otherwise). To increase the confidence on the model, we can also *evaluate* it. One way is to calibrate it on a subseries of observed data and

check whether the obtained model fits the other ones (see figure 1, middle bottom). Now, it is possible to manipulate the model like drawing it, building its derivatives, finding its maxima or minima and whether it becomes zero (see figure 1, right). This last property (becoming zero) can be *interpreted* as a breakdown of the ecosystem. Hence, the question of sustainability on the ecosystem becomes the question of becoming 0 on the model. If the model answer “no” (i.e. it never becomes zero), then the ecosystem can be interpreted as sustainable, as far as the evolution of the biomass is the right clue (see figure 1, bottom).

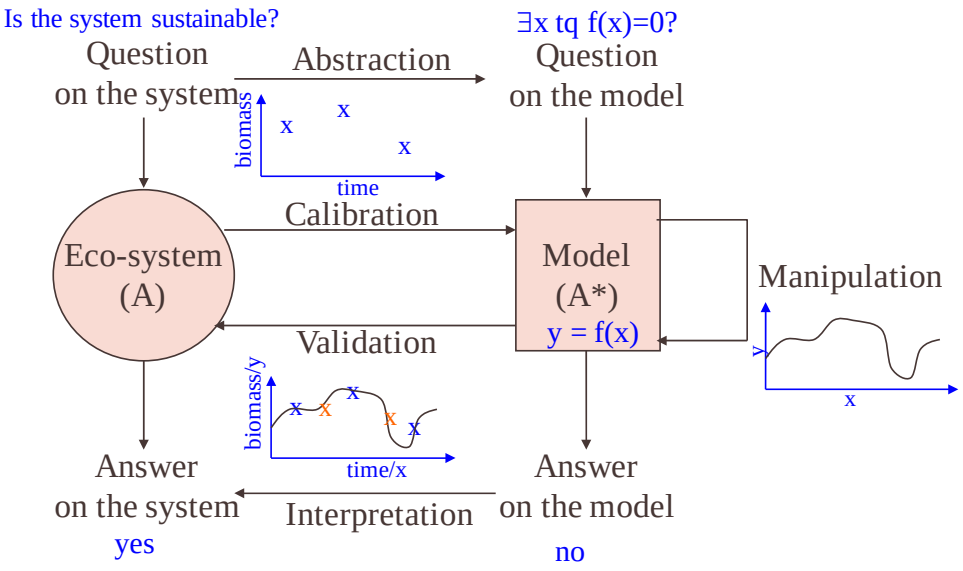

Figure 1. *how to relative a model to a system and conversely*

To sum up and following [Minsky65], any object A* (here the calibrated equation) is a model of a system A (here the ecosystem) if manipulating A* allows to answer some questions Q (is the ecosystem sustainable) asked by an observer X on the system A. It means that the observer X instead of manipulating A to get his answers will use another object A* sufficiently standing for A to provide valuable answers on A. This definition is very general because no hypotheses are made on the nature of the object A*. It can be a living animal (for example the drosophila to understand of laws of genetics), a living plant (like the rice for crop species), a mockup, a mathematical formula (like in our example) or a computer program. The main requested feature is its manipulability. Then, of course, A* is a description in the sense discussed earlier. But A* cannot be simply a text because a text can hardly be manipulated but by the intellectual thinking of the reader. However, it can be a mathematical formula through algebraic manipulation or a piece of computer code through running the program. A* will be called a representation to capture both its standing for something else (the system A) and its manipulability. A* must even be a formal representation, meaning that the manipulation depends on its form (e.g. *(A + B)*C => A*C + A*B*) independently of what it stands for (who knows what *A*, *B* and *C* are!). We can find the zeros of the equation *y = f(x)* even if we do not know that y represents the biomass and x the time. Finally, we expect A* to capture everything that is necessary to answer the questions Q but only what is necessary to answer those questions. This principle of parsimony is very important because an exhaustive description of any system A could potentially be endless (and useless).

What is a conceptual model?

Let us focus on the abstraction going from a system towards a model. In our example, we have first identified the system to model, i.e. the ecosystem. It amounts to identify what is part of the system and what is not part of it, i.e. both its border and its extent. Therefore, talking about a system already is an abstraction. Second, we have chosen how to describe it. We could have enumerated its components and relationships among them and how to describe each component, being heterogeneous or not. Here it was chosen to characterize globally the ecosystem by a quantity. Moreover, sustainability deals with time: past and present because it still is…present, but also the future. Hence, we have the concepts of ecosystem, biomass and its measure of quantity, time, and maybe trajectory. These concepts are the components of the abstraction even before formulating a suitable equation. Because they are concepts, their representation is called a conceptual model.

Figure 2 illustrates that in between *x*, *y* and *f* being part of the model and the system to be modeled, the abstraction process is based on a number of concepts that are of outmost importance both for justifying the model and for interpreting the answers from the model. Moreover, everybody can potentially understand these concepts while not everybody is able to understand an equation or a piece of code. Therefore, the conceptual model appears central for multi-disciplinary understanding. It remains to explain what we mean by concept and how to represent them.

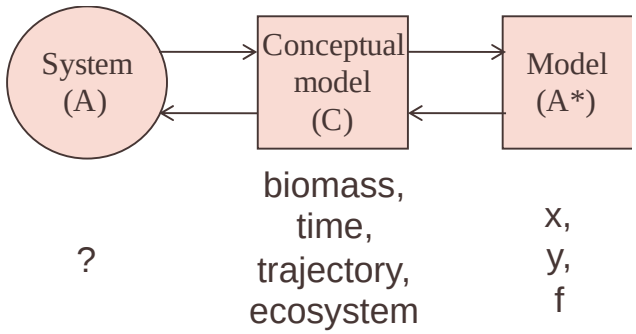

***Figure 2**. The conceptual model between the system and the model.*

What is a concept?

A concept is the idea one have in his mind of something. First of all, the idea is always one's idea. It is personal. This concept can be related to an individual objet: my concept of my car, my concept of the ecosystem I am interested in. It can be related to an immaterial object of thought: my concept of beauty, equity or of what a concept is. Finally, it can be a category, i.e. a way to put objects together: because they have the same size or color, because they are of the same species, etc. These concepts are called categorical concepts. They are the boxes used to classify the world. Of course, an object (or at least his idea) can be in several categories at ones (both big, blue and of a given species). These concepts build how the reality appears to us. One of the important process of everyday knowledge in general, and of science in particular, is first to create a world of distinctions: e.g. the mineral from the vegetal from the animal. And this world of distinction must be operative for making the reality understandable if not predictable.

How to represent a concept?

If a concept is something in one's mind, we have a problem because we are unable to look into one's mind nor do we know what is a mind. Fortunately, they appear through the words we are using. Even if we may not know what it means for someone to be blue, at least we know that he has a category of blue things called "blue things". There are very often labels onto the boxes. Therefore, the terminology is the (only?) entry point into one's mind. But how to be sure about the nature of the objects that are named? Especially, how to be sure that two observers are meaning the same object or category of objects when they use the same word. The only entry points we have are the definitions. A definition relates a word to a set of related other words. If the same word is not related to the same set of related concepts (not just words because they could also use different words for the same concepts), they are related to distinct concepts. Conversely if two different words are related to the same set of related concepts, then they are related to the same concept. Therefore, we obtain a network of related concepts (and associated words) where, additionally, the relations themselves are named (and therefore might be concepts as well). It is this network that we call a conceptual model. One of its property is to be closed, i.e. all the concepts necessary to define the other concepts of the same network are in the network OR the concept is considered atomic, i.e. not necessary to be explained further for our purpose. Therefore, any conceptual network defines its level of granularity, a kind of conceptual scale. For example, it might not be necessary to explain that an animal or plant is made of cells and atoms, nor how we make the distinction between plants and animals for describing an ecosystem. When the concepts are directly related to spatial or temporal concepts, the conceptual scale strictly corresponds to the usual concept (sic!) of scale with an extent and a granularity.

To represent such terminological and/or conceptual networks, a number of formalisms have been proposed like the formal logics or the frame languages, and more recently the description logics (DL), the ontology languages (OWL) and the thesaurus languages (SKOS). We have chosen to use a graphical representation to highlight the graph structure of the conceptual model, using UML (Unified Modeling Language). UML is mainly used by the computer scientists. Although UML does not provide the expressiveness we could expect from such formalisms.

UML introduces a number of diagrams from which the class diagram is the most suitable to graphically represent the

concepts. The concepts are represented by a class made of a box with two parts: an upper part with the concept name (capitalized and singular) and a lower part with the list of attributes. In the figure 5 a), the concept of farmer is represented with three attributes: its name, age and height. The concepts are related to one another with a number of possible arrows:

- The line with a triangular white arrow to represent a generalization/specialization relationship to build taxonomies of concepts (in Figure 5 b), the concept of farmer is a specialization of the concept of person: every farmer is a person, but not the converse);
- The line with a white or black diamond to represent the part-of relationship (in Figure 5 c), a tree is a part of a forest, or a forest is made of trees);
- The simple line (although sometimes with arrows to denote a natural directionality) with a name to represent a relationship. It is annotated with cardinalities, i.e. how many objects of a category can be related to how many objects of the other (in Figure 5 d), there is an ownership relationship (or association) between the concept of farmer and the concept of plot, and a plot is owned by only one farmer (1) and the farmer can have as many plots as he wants (*)).

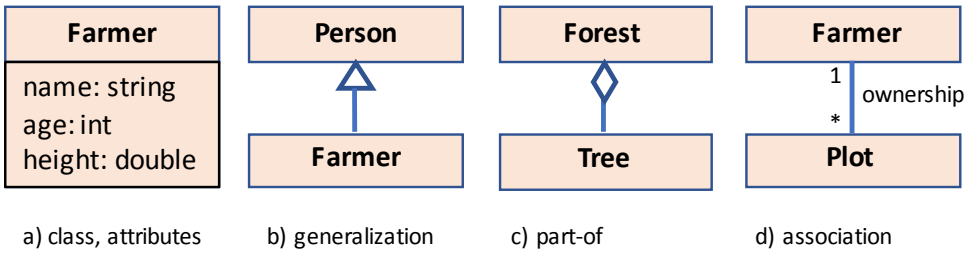

***Figure 3**. Some basic UML representations*

Using UML, a definition can be easily translated into a UML graph. For example, the Collins defines a livestock as being animals kept in a farm. A resulting graph could be as represented in the figure 4. The livestock is made of animals (or animals are part of livestock) and the livestock has a location relationship to the concept of farm (a livestock is only located on one farm that may have many livestocks). This formalism will be used throughout the rest of the chapter.

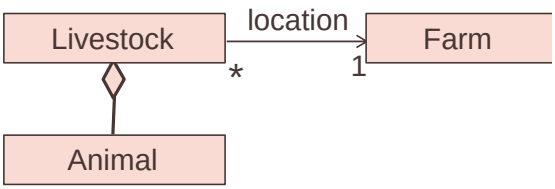

***Figure 4**. UML class diagram for a livestock definition*

Introducing multiple perspectives

The understanding and the modeling of socio-ecosystems organized around the livestock requires to convoke a set of disciplines. Effectively, to account for the biophysical dynamics impacted by the livestock, we need as well hydrography as soil sciences or ecology. And the social practices and dynamics require agronomy, economy, sociology, management sciences, etc. This necessary dialog among the disciplines raises a number of open issues. First, their interactions can raise new questions in each field. For example, classical hydrology, as well as ecology of the populations, are not really equipped with the necessary concepts to account for collecting. Then, in a modeling approach, the various disciplinary fields invest differently in the use of formalisms, especially mathematical ones. Finally, the terminology and the associated concepts are strongly heterogeneous among the disciplines and, sometimes, within a single discipline depending on the school of thought and the questions raised. It possibly (if not always) creates misunderstanding that hinders the construction of an integrated model of socio-ecosystems. This multiplicity of points of view raises the question: “how to represent and to integrate the knowledge of heterogeneous disciplines in the same model?”.
But the social systems we are seeking to model are themselves made of a multiplicity of organization levels (more or less structured social networks, epistemic communities or communities of practice, customary organizations,

associations, state services, administrative units, etc.). The levels themselves induce different points of view that account for the observed behaviors. It is because one view an animal as a livestock that one breeds it. In general, the same object will be viewed differently depending on the envisaged interactions or uses, and named differently. Hence a person will be seen as a citizen from the point of view of the state, an inhabitant by a commune, a member of an association, the father or the mother of the family. Each of the point of view or role is associated with very different expected relations, behaviors, rights and duties. For the objects, a tree can be seen as a protected species for international or national laws, a stock of carbon, the nest of some birds, and providing good construction wood for local communities. In general, an object can be seen as a resource as long as it can possibly be used by someone. It is the same for the space that can be appropriated differently by different groups of people (the so-called territories in the French sense) or other living beings (the so-called habitats) and different uses. It creates a set of superposed mosaics shaping the landscape.
These points of view are different because the disciplinary points of view are points of view on the system, while the others are points of view within the system. However, they are all points of view to be articulated to one another to account for the complexity of the socio-ecosystem under study. Moreover, a discipline exists through a group of people permanently debating about a set of shared concepts to account for their object of science (and debating about what this object of science is). Then, a point of view is always socially built regardless of being outside or inside the system. Finally, a point of view is always a subset of the concepts built by a group (or several groups) of people focused on the objective to be tackled, being practical or scientific.

Methods

There are several methods to obtain a conceptual model:
- By manual or automatic extraction from a text (or corpus);
- By derivation from the formulation of the objective/question originating the point of view;
- By interview with the concerned actor (knowledge engineering);
- By collective animation

Extraction from a text

A text is organized with common nouns, adjectives and verbs articulated by prepositions determining composition (of), and temporal and spatial situations. The proper nouns directly correspond to individual concepts. The verbs of action articulate their subjects (who is performing the action), objects (on what), means (using what), results and spatial and temporal modalities (when and where). The state verbs generally define relations or definitions (to be). The adjectives suggest the attributes of which they are a possible value (the sky is blue => attribute “color” of which one possible value is “blue”).

Manually, underlying each common noun, verbs (distinguishing state and action verbs) and adjectives allows to extract a starting list of words to account for and to organize depending on the sentence structure. One must care of the concepts corresponding to composed words (e.g. flower plant or European union), to consider therefore as a single word!

Automatically, some software exists to extract key-words from texts, more or less correctly (e.g. eliminating the articles, prepositions and structuring words). Of course, it is only a starting base for further work. It is better to choose software that realize a real grammatical analysis of the sentences, possibly generating partial graphs (or even complete graphs).

Derivation from a question

Because we have to represent the concepts used from a particular point of view, we can start from a statement of the problematics/question/objective justifying this point of view. First, one must write down the question in a sentence as complete as possible, and then take each word and define it until we come up with a complete (closed) graph. The advantage is that we obtain a very focused conceptual model. It helps to obtain all that is necessary but only what is necessary to understand and answer the question.

To illustrate this approach, let's take the following question (Müller and Diallo 2012) :
« Given the residential segregation within a town, what is the impact of the student choices, of the strategy of the school directors and the scholar policy on scholar segregation?"
You favor the questions of the form « What is the impact of *X* on *Y*, given *Z* ? » to have the key elements of the question :

- *Z*: the fixed conditions;
- *X*: the drivers and/or possible choices on which the scenarios rely;
- *Y*: the indicators or outcomes we expect.

A possible result from the previous question asked to a geographer is shown in the figure 5.

In the higher part of the figure 5, we have the representation of the question around the asked person. The subgraph can be read: the geographer defines the residential segregation and observes the scholar segregation as a function of the strategies and policies. The rest of the graph defines the terms. For example, residential segregation is defined on a residential space made of zones, themselves made of places, each zone being characterized by its social category: poor, rich or medium. Any subgraph can be read as a similar sentence, revealing the options taken for addressing the question.

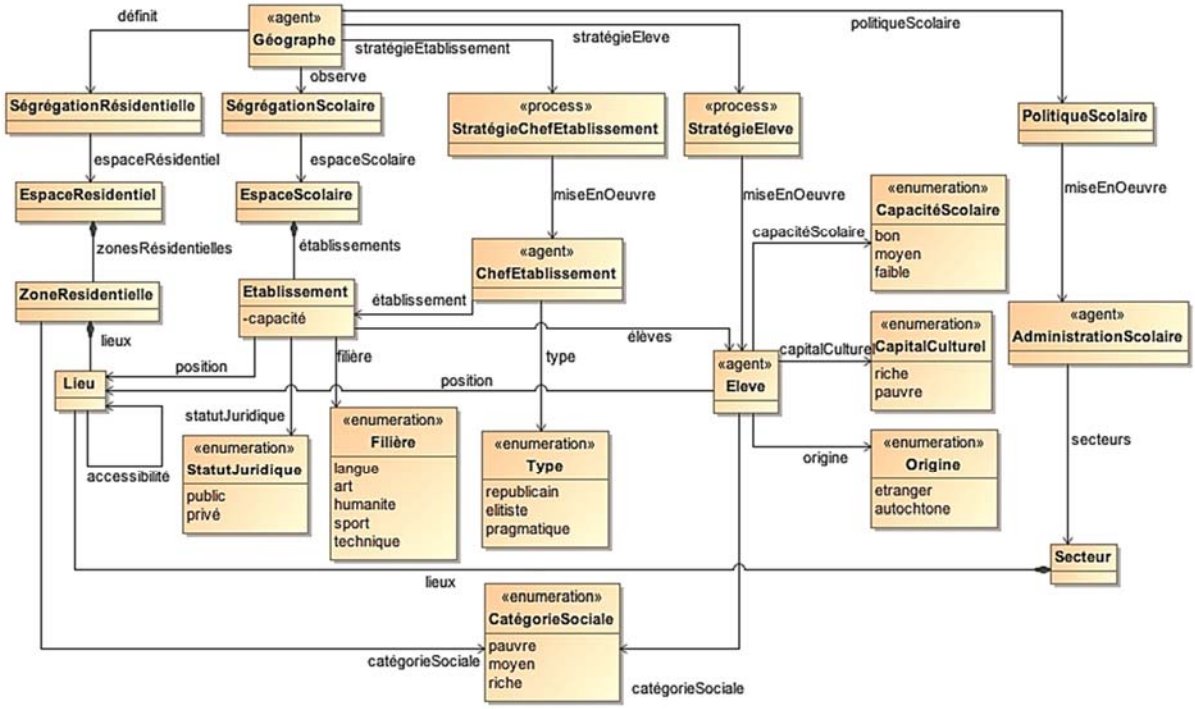

***Figure 5**. UML class diagram for a question on segregation*

Interview

To build a conceptual model from an interview still remains an art but the following questions can be used as a framework:

- Who are you? Disciplinary background and in the related project;
- What is your research question or your aim/objective? This allows to use the previous method with him;
- What is your research object? What are you looking at or managing? This allows to identify the system, i.e. to draw the border between the object of study and the rest (spatial and temporal limits, identity, composition, etc.)
- What are the activities you deploy to answer your question, manage your system? For each activity we must identify what they need (the resources), what they produce (products, knowledge, changes) and what is relevant to specify the activity.
- Are there other actors in your system under study/management or are there actors influencing the system? It

- is the departure point for reiterating the questions on each of those identified actors.

For example, the interview of a geneticist in the framework of domesticating a wild species gave the schema of the figure 6.

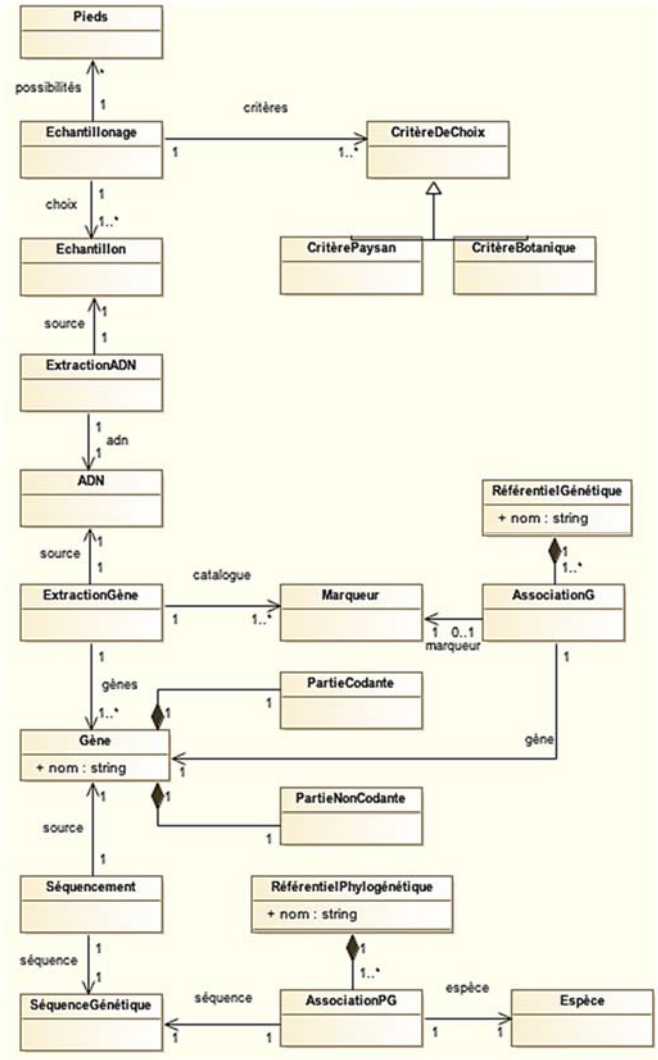

***Figure 5**. The point of view of the geneticist*

This schema represents a process going from sampling plants in the field up to sequencing, identifying the sources of information necessary at each stage (the references for the genetic markers, the species identification, etc.). In this project, the comparison with the points of view of the botanists and biochemists revealed an interesting debate on the relationships among the categories built by the different disciplines: the morphotypes for similar plants, genotypes for similar parts of the genomes, chemotypes for similar organic compositions, and the notion of species. Of course, the notion of similarity is itself different and questionable in each domain and there is no reason to have the various types corresponding to one another, making the very notion of species questionable.

Collective animation

The collective animation consists in deploying the previous approaches in working groups of experts or stakeholders. It can be carried out around a shared schema as illustrated in the figure 6 with drawings or using post-it.

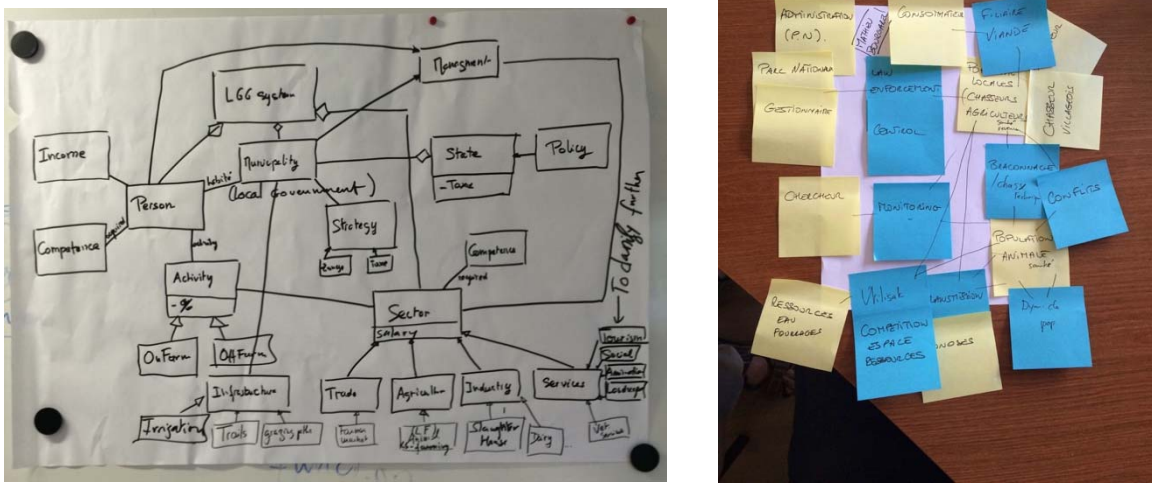

***Figure 6**. Brainstorming around breeding or wild fauna management using various supports*

Validation

The validation of conceptual models raises specific issues that are different from the problem of the validation of quantitative models. For the later, the comparison of the model results with measured quantities on the modeled system has been well formalized. For the conceptual model, it is more problematic. We propose three possible and complementary tracks:

1. Restitution of the obtained schemas to interviewed people or groups;
2. Application to case studies;
3. Simulation.

In the case of interviews and collective, the first proposition is compulsory. The risk is the lack of criteria of completion, possibly inducing an endless process. It is particularly the case if one introduce new actors within the process. The same problematic has been identified with technical drawings in industrial engineering. In fact, a conceptual model can be considered as analogous to technical drawings but in larger disciplinary domains.

The application to case studies consists in selecting one or several descriptions of relevant case studies. These descriptions are texts that can be existing (like monographies, papers, etc.), or can be built from knowledgeable actors. The idea is to account the integrality of the text using the concepts mentioned in the conceptual model, i.e. to put each word or group of words from the text within one of the proposed boxes. This work can result in revising the conceptual model because some words do not enter or not exactly corresponds to the proposed concepts, or some concepts are never used. This validation technics is described in (Provitolo, Müller, and Dubos-Paillard 2009).

Finally, a conceptual model can be the starting point of a complete modeling process up to a running simulation. The advantage of this approach is a double requirement:

- A requirement of precision because the description must be sufficiently complete to be able to explain all the dynamics of the described system. In particular, the conceptual model must be completed with the description of the activities and processes. The conceptual model enumerates what are the processes and activities. We still explain how

- they proceed using additional formalisms (equations, dynamical systems, activity diagram, etc.).
- A requirement of validity by comparing the temporal series produced by the simulation with the actual temporal series observed on the modeled system. Very often, one use a part of the observed temporal series to calibrate the parameters of the model (i.e. to adjust the parameters to reproduce the same series), and another part to validate the model (i.e. to compare the simulated series with the observed ones, (Hervé et al. 2013)).

What the conceptual model is to the technical drawings, the simulation model is to the industrial mockup. However, our approach is applicable to a much wider domain up to the mockup of or virtual socio-ecosystem.

Articulating the points of view

In the case of the livestock, four perspectives where chosen and worked on: the social point of view for the role of livestock on social live (social roles, statutes, access to knowledge and competences, etc.), the production point of view with the technical and economical accounts of livestock and its byproducts (wool, milk, etc.), the local development point of view with the role of livestock within a variety of sectors promoted by the local authorities, and the eco-systemic point of view with the positive and negative interactions of the livestock with the natural resources (water quality, biodiversity, nutrients processes and management, air quality, etc.). These perspectives were elaborated by working groups on two sessions: one in April 2016 in Montpellier (France) and one in Saskatoon (Canada) in July 2016.

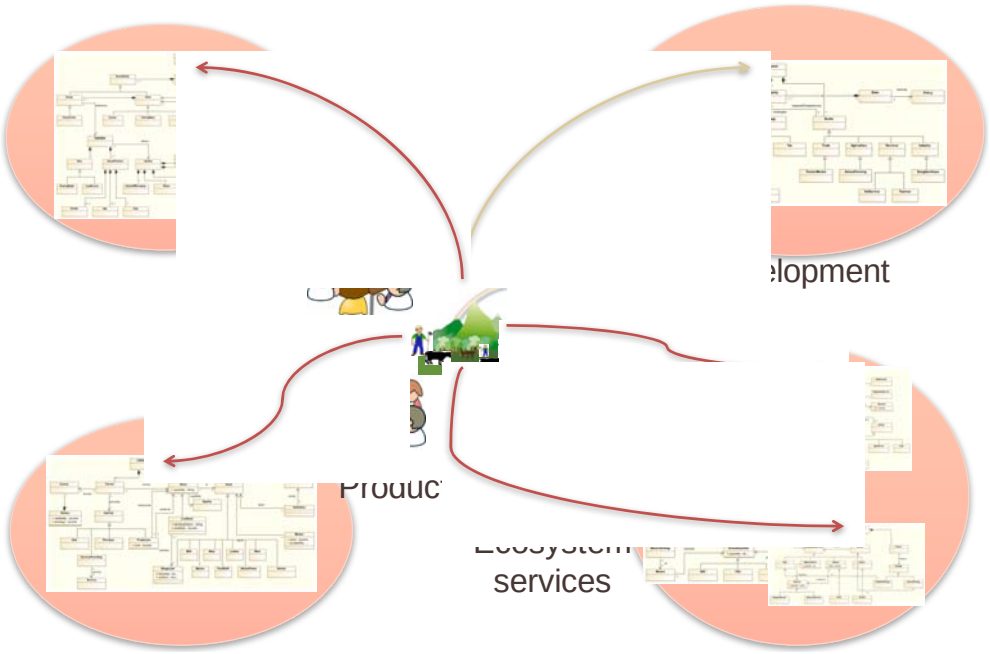

***Figure 7**. The conceptual models from different perspectives*

Each conceptual model has been developed completely independently from one another. But, of course, some words or some concepts appear to be the same, or of the same nature. The next consists in proposing to introduce the discussion on the possible relations between these concepts. For example, concepts related to pieces of land appeared in all conceptual models but with different accounts (see figure 8.) Let's use the concept of landscape as a pivot concept to designate the extent of the eco-system analyzed in different ways depending on the point of view (figure 9):

- From the social perspective, the landscape is seen as a superposition of pieces of land appropriated by different group of actors: the fields by the farmers, the forest by the forest administration, the watershed from the water user association point of view, a field potentially having a part of forest and being situated in a given watershed.
- From the production perspective, the landscape is decomposed into parts having different attributes in terms of available biomass and floristic composition with respect to the productivity of livestock and pathways management.
- From the local development perspective, the landscape is analyzed in terms of zoning, then potential land uses, and its role to favor or not a sector of activity.
- From the eco-systemic perspective, the land is analyzed in habitats for the land cover, and in hydrological components regarding water flow behavior and pollutant diffusion. By the way, the hydrological components are superposed to the habitats, because the fields can themselves be water containers.

As a whole, the landscape appears as an intricate set of superposed mosaics that depends on a variety of concerns and therefore submitted to a variety of decisions and processes interacting with one another. Consequently, it

becomes possible to assess what could be the impact of a decision from one perspective onto all the other perspectives.

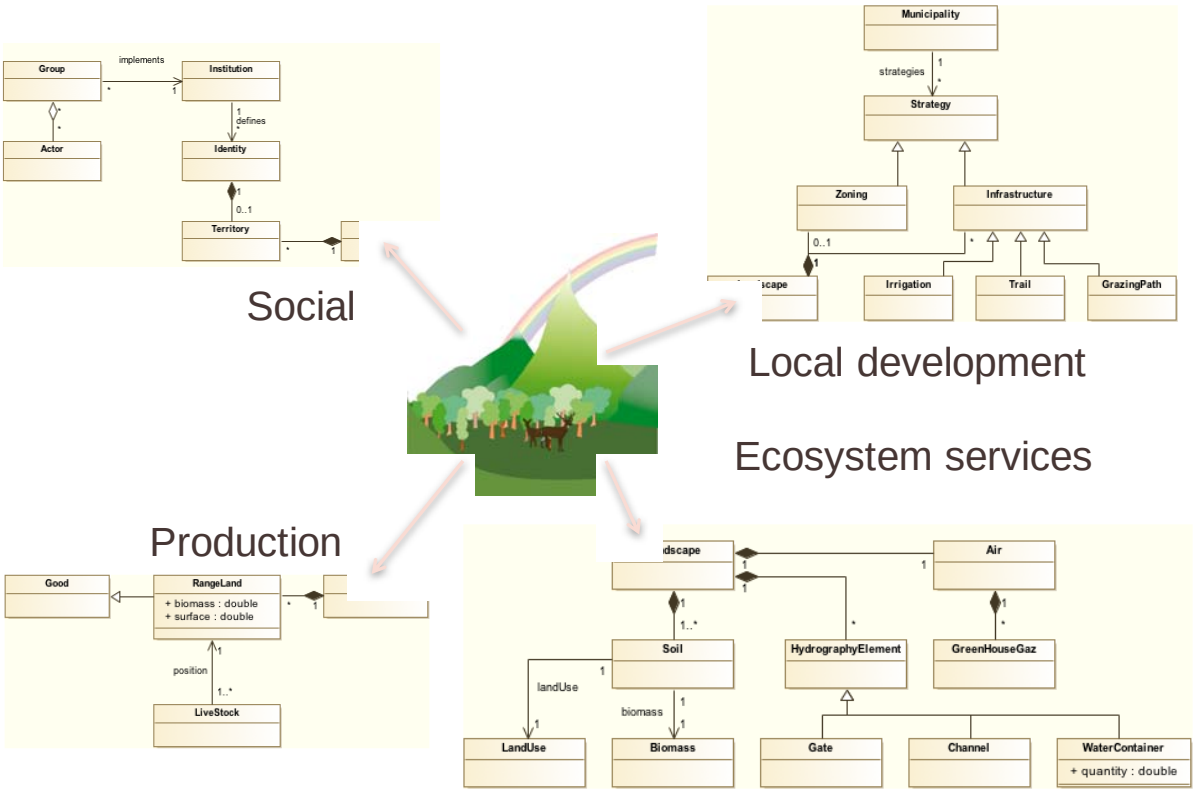

***Figure 8**. The landscape seen from the various perspectives*

Document, standardize and share information on lessons learnt, within the Global Agenda for Sustainable Livestock

(output 1 of the Action Network 2: restoring value to Grasslands)

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GASL

The primary objective of the Global Agenda for Sustainable Livestock is to maintain, restore and enhance environmental and economic value of grasslands, while promoting their social and cultural functions globally. Grasslands are ecosystems generating multiple services. Worldwide, great efforts within field projects to implement ideas on how to improve grassland/pasture management to deliver multiple outcomes are deployed. Much literature is available, but no "library/inventory" with an overview on the most relevant key elements considered/implemented/achieved in different projects/pilot sites.

Within Action Network 2, it was therefore decided at the Workshop in Montpellier 2014 to build an Internet friendly framework, including standardized information on lessons learnt. This information on sustainable grassland management and its multiple outcomes shall include topics as: land tenure, institutional arrangements, sustainability dimensions, etc.

In order to facilitate the standardization of information, a matrix has been elaborated to fill in the information on pilotsites.

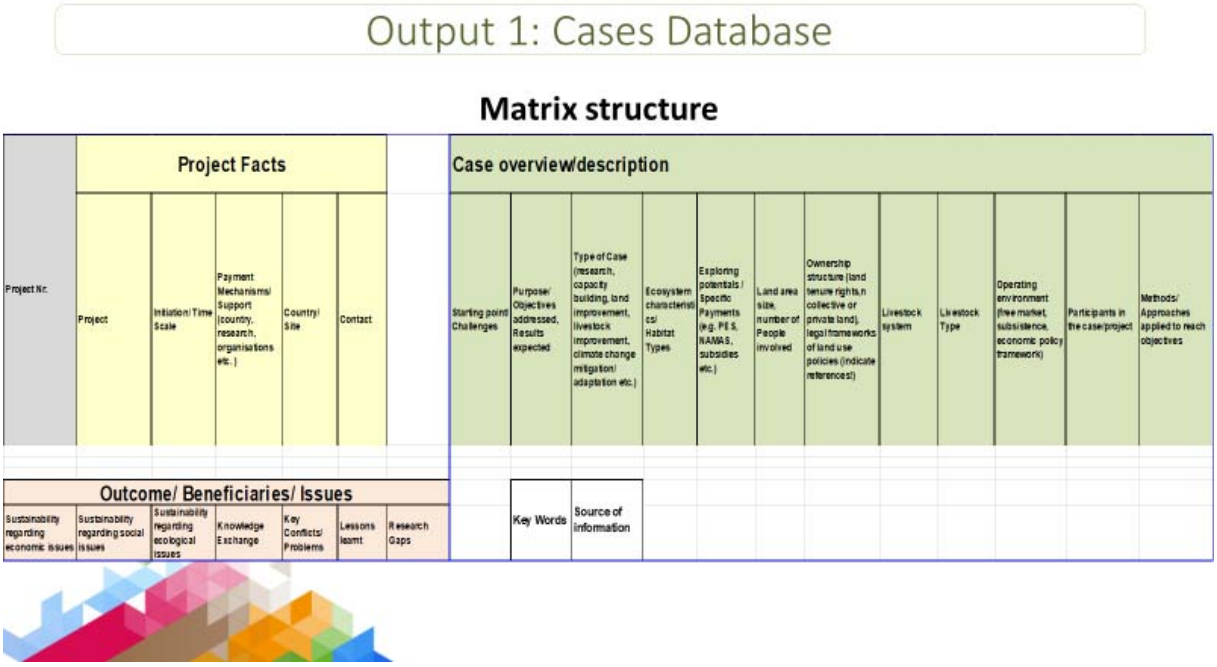


Fig 1*. Extracts of the structure of the matrix (framework) on pilotsites*

The aim of the database is to allow fast dissemination of relevant information regarding restoring value to grassland, facilitate exchange of experiences, catalyze practice change and become a "virtual knowledge center network". In the near future, it should be possible to access relevant information in this database of pilot sites (cases) from all over the world, published on the Global Agenda Web Site. Future targeted groups will be project leaders, researchers, policy makers, NGO's and interested persons. Big effort will have to be put in the dissemination of collected information and its multiplication through the GASL information site.

The framework has been adapted to a WEB friendly format by FAO.

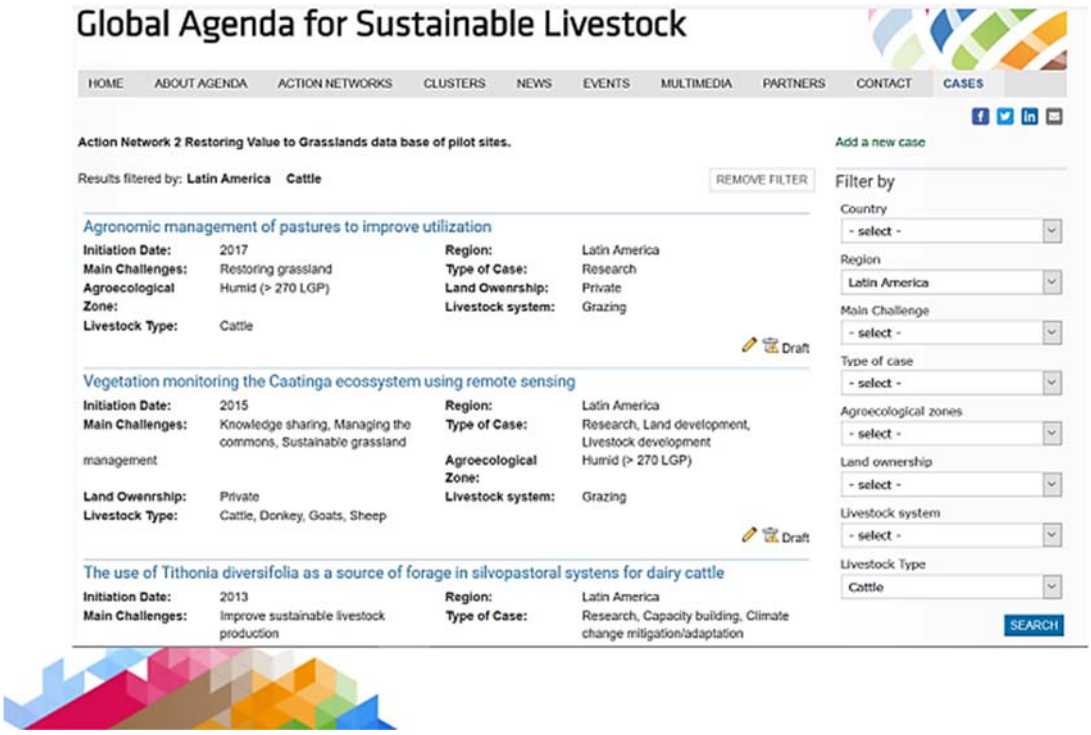


***Fig 2**. Within the database, information can be filtered by different subjects*

Details on cases are given by clicking on the project. The data base gives detailed information on project facts, case overview/description as well as on outcome/beneficiaries' issues.

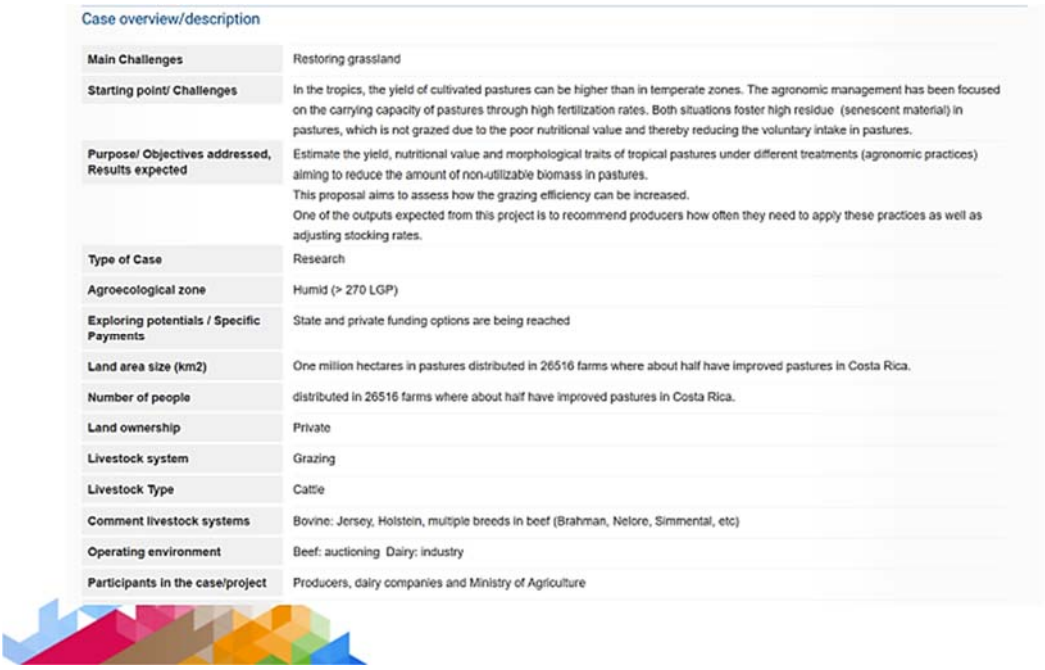
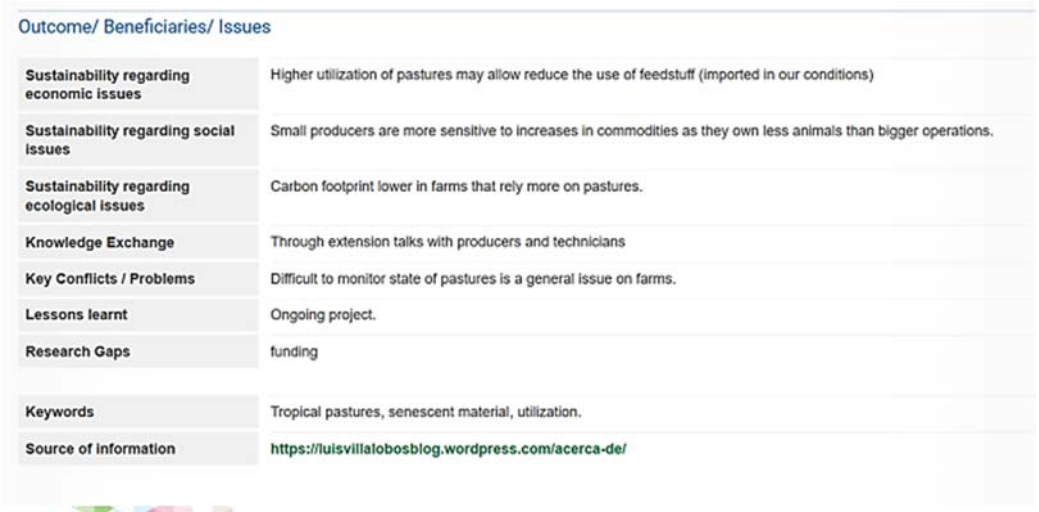


***Fig 3**. Detailed information on case overview/description according to the information given in the matrix*



Outcome/ Beneficiaries/ Issues

Sustainability regarding economic issues	Higher utilization of pastures may allow reduce the use of feedstuff (imported in our conditions)
Sustainability regarding social issues	Small producers are more sensitive to increases in commodities as they own less animals than bigger operations.
Sustainability regarding ecological issues	Carbon footprint lower in farms that rely more on pastures.
Knowledge Exchange	Through extension talks with producers and technicians
Key Conflicts / Problems	Difficult to monitor state of pastures is a general issue on farms.
Lessons learnt	Ongoing project.
Research Gaps	funding
Keywords	Tropical pastures, senescent material, utilization.
Source of information	https://luisvillalobosblog.wordpress.com/acerca-de/

The database has multiple utilities. Results can be filtered and allow extracts by region, type of livestock, type of landscape and of intervention e.g.

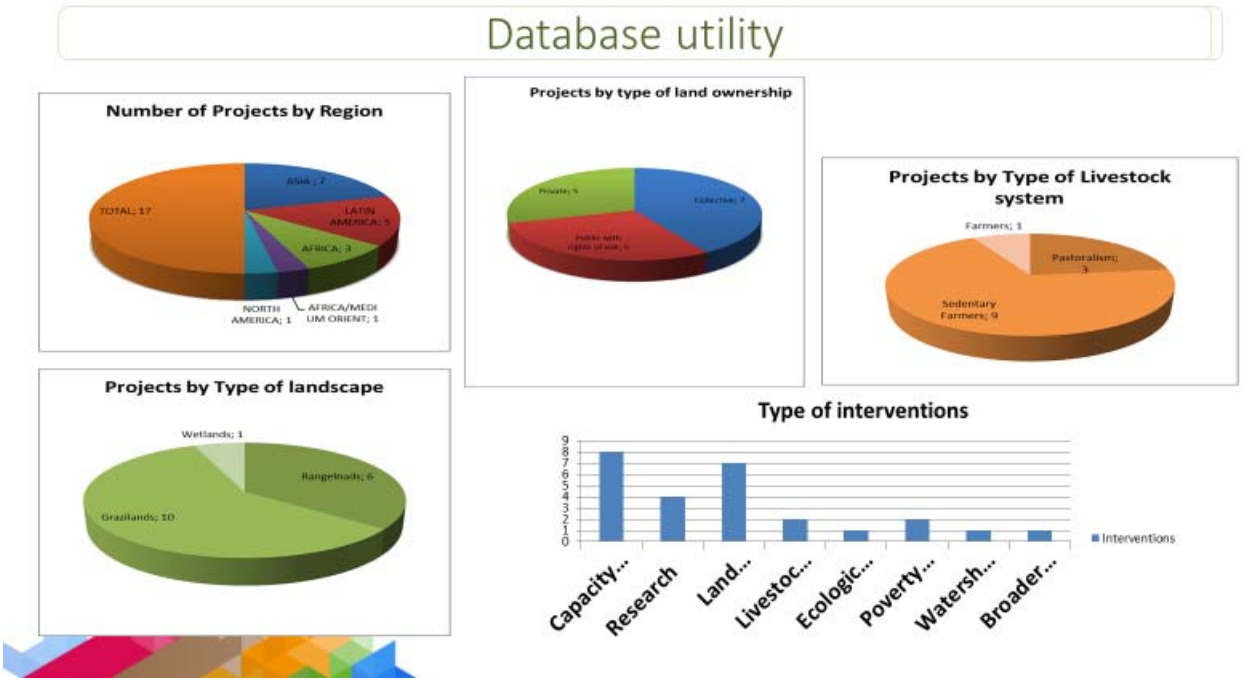


***Fig 5**. Possibilities of extractions for various purposes*

Up till now, 28 cases have been sent in and added to the database. Some more have already been promised. It is a continuous search for new cases, in all stakeholder meetings, in specific working groups, at every event on grasslands as well as through literature and hopefully the GASL homepage will invite project leaders to add their cases to this database.

The biological bases of environmental values of grassland/rangelands

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INTRODUCTION

The livestock sector's relationship with climate change is complex and raises a number of questions. The sector is a major contributor to agricultural greenhouse gas emissions (GHG), but is itself subject to climate change, and must therefore adapt to ensure its survival. Moreover, livestock production contributes to a significant and increasing extent to food systems and to agricultural systems in developing countries (manure, transportation, savings, income). The place of animals must therefore be reconsidered in designing climate-smart farming systems. However, the focus nowadays is on producing more, and improving the productivity of systems. It is nevertheless recognized that this must be done more sustainably, taking climate change into account (in both developing and developed countries) in terms of adaptation and mitigation (Vigne et al., 2016).

The animal production sector's global emissions amount to 7.1 Gt CO_2 equivalent (CO_2-eq), or 14.5 % of anthropogenic emissions (Gerber et al. 2013), mainly in the form of methane (CH4), nitrous oxide (N2O) and CO_2. This estimate is derived from a life cycle assessment approach and includes emissions from ruminant enteric fermentation, manure and feed production, livestock-induced land use change, and from post-farm energy use. Other study estimates lie in the range of 5.6–7.5 Gt CO_2-eq, with the differences deriving from the scope of their analysis (for example, the IPCC, which reports on direct agricultural emissions for the sector). Cattle are the main contributor to the sector's emissions with about 5.0 gigatonnes CO_2-eq (62 %) and grazing systems are responsible for 1.32 Gt CO_2 -eq/yr or 20% of all emissions (Garnett and al., 2017).

These undeniable livestock emissions are gradually being factored into agricultural development policies in developed countries, while in developing countries they are often seen as a lower priority than the fight against hunger, malnutrition, poverty and economic development. On the other hand, grazing land has a very high GHG mitigation potential (4 % of anthropogenic emissions) by sequestering and storing CO_2 in the soil (Lal 2004). Agricultural soil management is therefore essential for controlling carbon flows in the fight against climate change (90 % of the emission reduction potential of the agricultural sector, according to Gerber et al. 2013).

In this article, we focus on the GHG mitigation options provided by potential carbon sequestration in the soil of pastures of the diverse range of grazing systems worldwide. These systems are specific to ruminants and characterized by the fact that more than 90 percent of dry matter fed to ("grassfed") animals comes from natural grasslands (rangelands), semi-natural grasslands and improved grasslands or pastures. And less than 10% of the total value of production comes from non-livestock farming activities (Garnett et al., 2017).

WHAT IS SOIL CARBON IN GRAZING LIVESTOCK SYSTEM?

The sequestration process

Sequestration is the process of removing carbon from the atmosphere, where it is present in the form of CO_2, and drawing it down into the terrestrial pool, via plants growing on the land. Through photosynthesis (which takes place during daytime due to solar energy) some of the CO_2 is converted into a food source, glucose, and then into other compounds to build the biomass of the plants (accompanied by a production of oxygen). During the night plants breathe (in order to survive this period without light), by using oxygen and carbohydrates. During this respiration process, some CO_2 is released back into the atmosphere.

The carbon accumulated during plant growth is found in above-ground biomass (stem, leaves, flowers, seeds), and some in its root structure. When plants die and decay, part of this carbon is emitted back to the atmosphere as CO_2 (mineralization). Another part may be converted into more stable carbon compounds (soil organic matter. Soil organic matter (SOM) comprises a range of organic molecules ranging from small, easily degraded substances such as sugars exuded by plant roots, through to large, complex organic compounds which resist decomposition and can remain in the soils for decades or centuries. This might occur if biomass is buried or otherwise drawn down deep into soils where it is not disturbed, and in the case of roots which are already below ground.

The SOM may increase, or be re-released within a matter of weeks or months. It does not necessarily become converted into a more stable form and thus in the long term the soil carbon content may not in fact increase. The presence of favourable soil and climatic conditions, in conjunction with land use and management, is critical to the formation of soil carbon and the maintenance of its stability. This is what is meant by mitigation in the context of soil carbon. Figure 1 provides a simple illustration of the sequestration process.

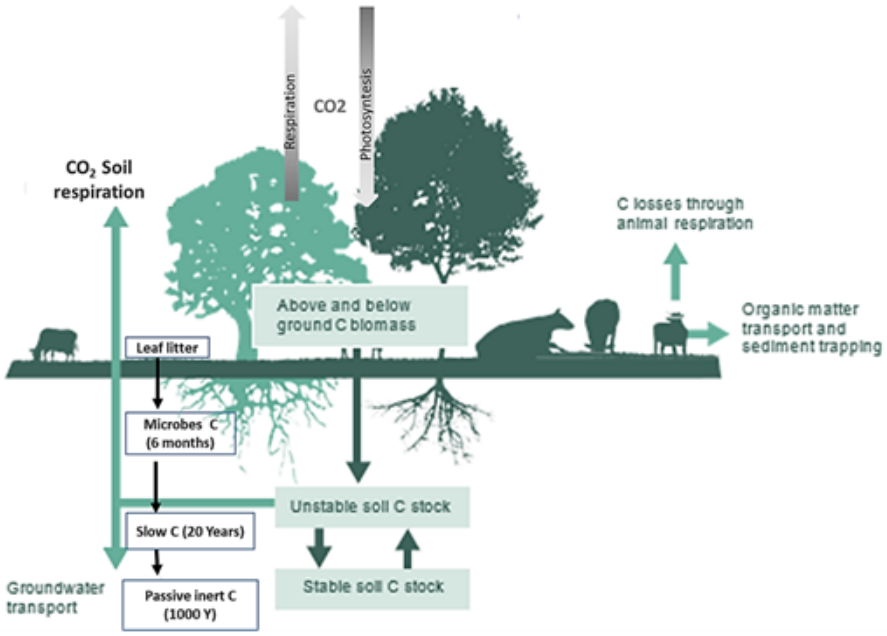

Figure 1. *Diagram of key carbon cycling dynamics in grazing ecosystems (source Garnett and al., 2017).*

In grazing ecosystems, the mechanisms driving the exchange of GHG between soil and water and the atmosphere are complex and knowledge of these ecosystems is lacking (Valentini et al. 2014), especially in tropical environments (IPCC 2013). Under arid to semi-arid conditions, soil moisture is one of the main factor controlling emissions of CO_2 (Kuzyakov and Gavrichkova 2010; Yemadje et al. 2016) and N2O from the soil (Ussiri and Lal 2013), while CH4 emissions occur only in hydromorphic conditions (Serrano-Silva et al.

2014). In pastoral ecosystems, large amounts of manure are produced and deposited, thereby directly or indirectly affecting GHG emissions via modifications of the chemical and physical properties of the soil (Thangarajan et al. 2013). Various processes are involved including microbial processes: (priming, methanogenesis, nitrification/denitrification) and modification of the physical characteristics of the soil (texture and moisture).

Livestock, as a vector of organic matter, also plays an important role in the spatial redistribution of nutrients and carbon. This is particularly true in West African agro-pastoral ecosystems (Manlay et al.2004a; Manlay et al. 2004b; Schlecht et al. 2004) and, due to the high mobility of herds and the importance of ruminants in the functioning of the ecosystem, a similar situation can be envisaged for pastoral ecosystems elsewhere. The resulting heterogeneous distribution of animal excreta in the landscape may affect the heterogeneity of soil properties and spatial variations in available nutrients as well as the distribution of plant roots. These factors significantly affect CO_2, N2O via microbiological processes (Smith et al. 2003).

How are carbon stocks and carbon sequestration rates in soils measured?

To assess the effect of a management practice on soil carbon, the classic approach consists of measuring the soil's organic carbon composition. One way is to use an auger (a type of drill) to take soil samples down to different depths. The soil is then analysed in a laboratory to obtain the C concentration. A more recent (non-destructive, more rapid, reproducible and low-cost) method consists of using near-infrared reflectance spectroscopy in soil analysis. The carbon stock is then calculated by evaluating the concentration of carbon (%) with the depth of the measurement by the soil's bulk density (g/m3). By repeating soil sampling over a range of years the change (loss or gain) in carbon stocks can be estimated. Typically, the top 30 cm of soils is considered as the soil compartment that contains the largest concentration of carbon. Nevertheless, while greater depths contain lower concentrations, they may store a great deal in absolute terms. Far less research has been conducted into these lower depths as measurements are harder to take. Flux measurements by eddy covariance are another way of estimating changes in soil carbon stocks. Eddy covariance is a powerful tool for measuring total ecosystem fluxes of carbon because it is able to detect changes in the net ecosystem exchange (NEE) of carbon at fine temporal resolution, and enables estimates to be made of whether given ecosystems or land management practices result in net sinks or sources of carbon.

These methods are hampered by limitations and uncertainties, in particular concerning our ability to measure soil carbon on a large scale. First, to get an accurate picture of current stocks and future changes, it is necessary to sample widely because of the high spatial heterogeneity of soils. Then, the temporal dynamics must be considered. The soil organic carbon content changes slowly and only marginally from year to year, so change needs to be measured over a long time-frame (more than 10 years). The rate of soil C accumulation can be determined by measuring soil C stocks over time at the same location (diachronic approach) or along a chronosequence that substitutes spatial history differences for time (synchronic approach where samples are taken at the same time from field plots under different land-use or management systems). Chronosequence studies are easier to set up but are often criticized for being "space-for-time" analyses which do not have the same starting point (e.g. soil texture) of measured sites (Stahl and al., 2017).

Any change in carbon is, moreover, being measured against huge background stocks. The 'noise' from the uncertainties in actually measuring the baseline stock can make it hard to measure the relatively small changes (Garnett and al., 2017).
An alternative to measurement methods is to use models. A large number of general computer models are currently being used to predict carbon sequestration in agricultural systems. These models fail to adequately replicate the impacts of different grassland management practices on carbon storage and GHG emissions compared to measurements on plots. Consideration of the mechanisms and processes involved in carbon stabilization and destabilization, particularly in relation to the impact of nitrogen fertilization on soil carbon stabilization, is still rather incomplete in large-scale models. There is therefore a need to advance these models, which for the most part fail to replicate the interactions between primary production and residence time of carbon in soils; both of these processes control the amount of carbon stored in soils.

THE CARBON SEQUESTRATION POTENTIAL OF GRASSLAND AND RANGELAND

What are the issues around grazing areas?

The total stock of SOC on earth (to a depth of 1 metre) is 1,500 GtC – twice the amount of carbon found in terrestrial vegetation, and three times the amount found in the atmosphere, making it a very significant global carbon pool. Peatlands store the most soil carbon per hectare by far, followed by boreal forests and then temperate and tropical grasslands. But because of their larger land area in absolute terms, boreal forests are the largest soil carbon stores, followed by temperate and tropical savannas – the latter hold about a third of total global soil carbon stocks. . Of course, there is also considerable carbon in above-ground vegetation

Ruminants are a major source of GHG emissions, particularly CH4 and N2O, but any soil carbon sequestration arising is small, uncertain, time-limited, reversible and difficult to verify. However, ruminants in well-managed grazing systems can sequester Ruminants are a major source of GHG emissions, particularly CH4 and N2O, but any soil carbon sequestration arising is small, uncertain, time-limited, reversible and difficult to verify. However, ruminants in well-managed grazing systems can sequester carbon in grasslands, so that this sequestration partially or entirely compensates for the CH4 generated by these systems. The landscapes of razing systems can balance the GHG emission by their low level of consumption g of non ‑ renewable energy and positive contribution to carbon sequestration. Grasslands which

account for 30% of the land surface (3,5 billions of ha), store 30% of C soil stock (in the soil organic matter), or nearly 4% of anthropogenic GHG emissions (Lal, 2004). However, the carbon sequestration potential would range from 0 to 4 t C/ha/year depending on the ecological zone, soil characteristics, climatic conditions and agricultural practices (Soussana et al. 2010).

In pastoral ecosystems, the mechanisms driving the exchange of GHG between soil and water and the atmosphere are complex, and knowledge of these ecosystems is lacking (Valentini et al. 2014), especially in tropical environments (IPCC 2013). Garnett and al. (2017) point out the fact that the range in estimates is large. This reflects the uncertainties inherent in the estimation methods, and the differences in management practices, the geographical and agro-ecological context of the studies and data acquisition methods. For example, little information is available about possible long-term carbon sequestration in pastures or their capacity to store C in intermediate (20–50 cm) to deep soil (50–100 cm) layers (Stahl and al., 2017). The sequestration potential can vary from 0 to 150 kg C / ha / year in arid regions and from 100 kg to 1 t C / ha / year on wet and cold regions (VIgne et al., 2016).
A paper by Budiman and al. (2017) surveyed the soil organic carbon (SOC) stock estimates and sequestration potentials from 20 regions in the world, including grassland areas, but most studies on SOC sequestration only consider topsoil (up to 0.3 m depth). In a review. Chang and al. (2004) estimate that the carbon balance of European grassland (including in particular Ghg emissions) is estimated to be a net sink of 150 ± 70 Kg C m-2 yr-1 during 1961-2010, equivalent to a 50-year continental cumulative soil-carbon sequestration of 1 billion ± 0.4 t C. Valentini et al. (2014) estimate the net long-term carbon balance of African ecosystems based on observations (including losses from fire disturbance) gives a sink of the order of 200 millions C /year, albeit with a large uncertainty around this number. Some authors point out the fact that that simply having a grassland does not result is a carbon sink, and it is untenable that grasslands act as a perpetual carbon sink. (Smith , 2014). The author conclude that “high carbon stocks (total storage of carbon in grasslands, mainly in the soils), does not equate to large carbon sinks (the net annual removals of carbon from the atmosphere). On existing grassland, only through improving the grassland can soil C be sequestered, so where grassland management is poor, policy should seek to improve it. Secondly, since there is much more carbon to be lost from grasslands than can be gained, protecting large grassland carbon stocks should be a policy priority.”There as thus good grounds to take into account the potential capacity of pastures to sequester carbon in terms of mitigation, but it is equally essential to consider the risks and limits of this process (see § 3).

Case study: soil carbon stocks after conversion of Amazonian tropical forest to grazed pasture

The livestock farming development trend in the Amazon region clearly illustrates the new challenges of livestock production facing climate change. Livestock development in the Amazonian basin has fueled a lively international debate in recent decades. According to the FAO, approximately 80% of deforested areas were converted into pastures resulting in rapid carbon (C) emissions (~ 733 t CO_2eq. ha-1) (Blanfort et al., 2014). Efforts to curb deforestation should therefore continue to be a priority to preserve C stocks and forest biodiversity. In addition, this also needs to be accompanied by sustainable management of areas that were converted into pastures, including strategies for greenhouse gas (GHG) mitigation. However, little is known about the long-term capacity of tropical pastures to sequester C in different soil layers after deforestation. Deep soil layers are generally not taken into consideration or are underestimated when C storage is calculated.

In French Amazonia, research is being conducted to understand the long-term dynamics of C in deep soil of permanent tropical pastures established (with the grass Brachiaria humidicola) after deforestation from 1970 in French Guiana). A unique combination of a large chronosequence study (figure 2) and eddy covariance measurements (flux tower, figure 3) was set up. We compared this approach with eddy covariance flux measurements on two pastures and one native forest (Stahl et al., 2017). The results showed that pastures stored at least 1.27 ± 0.37 tC ha-1 yr-1 while the nearby native forest stored 3.23 ± 0.65 tC ha-1 yr-1. (figure 1).

The results suggest that in French Amazonia old permanent tropical pastures (≥ 24- year-olds) can restore a part of the C storage observed in native forest with appropriate practices (no fire and no overgrazing, but a mixture of grasses and legumes and a grazing rotation plan. It allows farmers to maintain these pastures in the long- term without the loss of soil fertility often observed in cultivated soils (McGrath et al., 2001). Conservation of soil fertility should help limit the conversion of new fertile areas and consequently, deforestation.

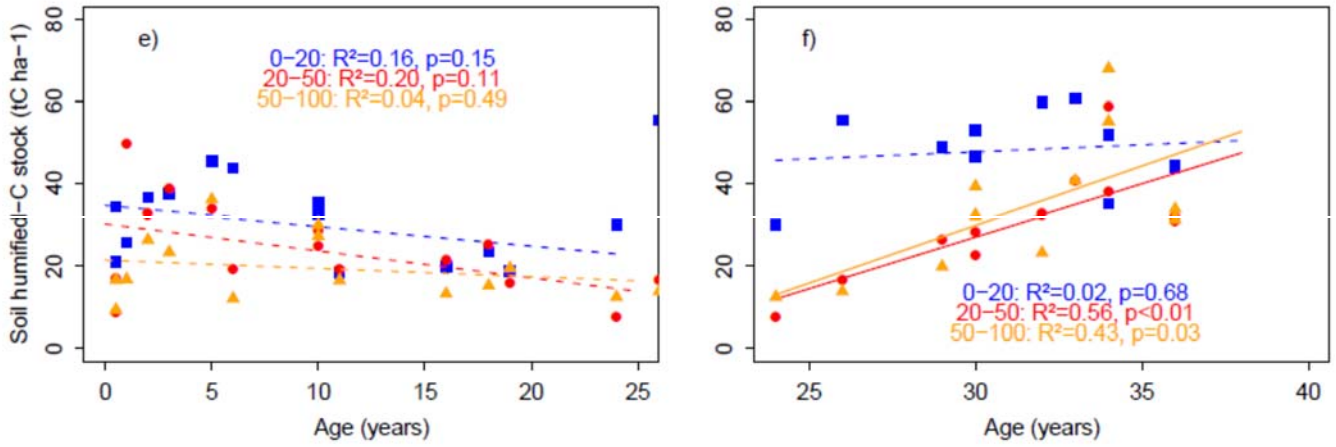

Figure 2 (Stahl and al., 2017). The inventory of soil C and N stocks at a depth of 1 m was conducted in a study of pasture chronosequence including 24 from six months to 36 years and four native forest sites. The figure show the carbon stock changes along the chronoséquence in different soil layers. This carbon is mainly sequestered in the humus of deep soil layers (20-100 cm), whereas no C storage was observed in the top soil (0-20 cm layer). Soil humified C stock in the three soil layers (0–20 cm: blue squares; 20–50 cm: red circles; 50–100 cm: orange triangles) under pastures ≤24 years old and (f) pastures ≥24 years old. Dashed lines mean no significant relationship between soil C stocks and the age of the pasture. Solid lines mean a significant linear relationship was found between soil C stocks and the age of the pasture.

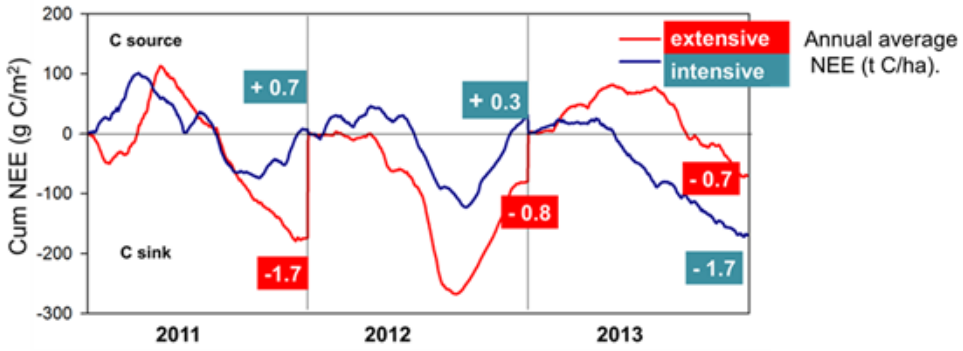

Figure 3. *Eddy covariance flux measurements was realized on 2 pastures show intra-annual variations of net C storage (NEE Net Ecosystem) as an effect of soil water conditions modulated by the management. Extensive management allows a better net C storage for dry years (2012), while during the wet years (2013) intensive grazing seems to be an advantage. Negative values indicate storage of C by ecosystems and positive value indicates release of C. (Blanfort et al., 2014).*

CASE STUDY: GREENHOUSE GAS BALANCE OF A SAHELIAN RANGELAND ECOSYSTEM IN SEMI-ARID WEST AFRICA

In a very different context, the pastoral livestock farming in the Sahel is often accused of harming the environment and contribute to global warming. However a more systemic approach of a pastoral territory indicates much less harmful interactions between animals and their environment (Hassouma et al., 2017). An original recent study integrate the various components of the ecosystem (animals, soil, plants) and consider all components of the GHG balance at the landscape level. Results show that the annual net GHG balance of the ecosystem was -0.01±0.03 tC-eq/ha/year at landscape scale (cf Hassouma et al., 2017 in the chapter "Case studies" of this document).

What management practices to sequester carbon ?

At COP21, France set an international research program, the 4 per mille Soils for Food Security and Climate' of the Lima-Paris Action Agenda. The 4 per mille or 4 per 1000 aspires to increase global soil organic matter stocks by 0.4 percent per year as a compensation for the global emission of greenhouse gases by anthropogenic sources. Since 2015 it has been backed by almost 150 signatories (countries, regions, international agencies, private sectors and NGOs). Stakeholders committed in a voluntary action plan to implementing farming practices that maintain or enhance soil carbon stocks in agricultural soils and to preserve carbon-rich soils. (SOC) sequestration is seen as a possible solution to mitigate climate change, to take atmospheric CO2and convert it into soil carbon which is long-

lived. As soil stores two to three times more carbon than the atmosphere, a relatively small increase in the stocks could play a significant role in mitigating GHG emissions. The annual greenhouse gas emissions from fossil carbon are estimated at 8.9 gigatonnes C (8.9 × 1015 g), and a global estimate of soil C stocks to 2 m of soil depth of 2400 Gt (2400 × 1015 g), while most studies on SOC sequestration only consider topsoil (up to 0.3 m depth), as it is considered to be most affected by management techniques. Taking the ratio of global anthropogenic C emissions and the total SOC stock (8.9/2400), results in the value of or 4‰. Increasing SOC has been proposed to mitigate climate change with the additional benefit of improving soil structure and conditions (Budiman and al., 2017). As grasslands are among the largest ecosystems in the world, between (20-47% of the land area), grazing systems can be considered as a major ecosystem concerned by this initiative. Budiman et al. estimate that on 149 million km2 of the land area of the world, there are on average 161 tonnes of SOC per hectare. So 4 per mille thus equates to an average sequestration rate to offset emissions at 0.6 tonnes of C per hectare per year. This 4 per mille blanket value cannot be applied everywhere as soil varies widely in terms of C storage, which includes desert, peatlands, mountains. Nevertheless, studies across the globe have measured SOC sequestration rates and they suggest that an annual rate of 0.2 to 0.5 t C per hectare is possible, after the adoption of best management practices such as reduced tillage in combination with legume cover crops.

It is not possible within the framework of this synthetic paper to develop in detail the grazing management options favorable to the storage of carbon. However. It seems important to point out just some basic principles. Garnett and al., 2017) underline the point that "Livestock add neither new carbon nor nitrogen into the system. They merely contribute to their accumulation in some compartments (reservoirs) in soils, or in plant and animal biomass". As plants naturally take up carbon from the atmosphere, stimulating the rate of plant growth by using fertilisers, or by co-planting nitrogen- fixing legumes is a first approach to promote sequestration. But not all organic matter that enters the soil is converted into long term, stable soil carbon, since much of it is labile and leaves the system within a period of weeks, months or years . Additional, approach is to introduce deep rooting grasses such as Brachiaria spp. into the pasture (cf § 2.2) , the idea being that the carbon in the dead roots is stored deep underground in .

An other way to contribute to sequestering carbon on grazing lands is to manage the livestock through good grazing management. That means to manage the intensity of grazing by adjusting the stocking rate and the timing of grazing. Light to moderate intensity grazing is more likely to maintain soil carbon stocks and has greater potential to foster sequestration (on lands where this is possible) than continuously heavy grazing, which is usually damaging and reduces soil carbon.

CONCLUSIONS

The interactions between grazing farming activities and climate change, especially in the less developed regions, are complex. On the one hand, the entire livestock sector is a major contributor to the phenomenon in progress, mainly through its greenhouse gases emissions; it is subject on the other hand to climate change constraints to which it must adapt. Breeding has real ability to adapt while also offering significant and multiple mitigation potential. The necessary and obvious contribution to food security of large populations and the response to future demand for animal products necessitate the reconsideration of animals as contributors in designing climate-smart farming systems.

This reconsideration of pasture systems must of course be based on the experience of dairy/stock farmers, ranchers, pastoralists who adapt to climate variations is the basis of their activity. However, the major climatic disturbances already taking place and projected go beyond the climatic variability inherent in agricultural systems. It requires structured discussions between producers, livestock and crop farmers, private companies in the various commodity chains, policy makers and civil society. Research and development institutions are essential in this dynamic process. They must explain the issues and propose technical and institutional solutions that apply to the entire production chain and territory. Research is also involved and in "the North", scientific works now address these issues, but many uncertainties remain. In tropical areas, few references are available and significant work remains to be done to establish the baselines and strategies to support sustainable grazing activity in these regions where global sequestration potential is high, facing the surfaces concerned. Beyond local and regional issues, research can contribute to these questions about the role and challenges of grazed ecosystems in climate change and land use change while maintain/increase the productivity capacities of livestock sector. Livestock certainly remains a major GHG contributor, but it has been proven that the sector can significantly reduce emissions including carbon storage. Livestock could reduce its greenhouse gas emissions by 30% via greater use of better agricultural practices and existing technologies, while maintaining the objectives of doubling production in the South in particular in connection with the increasing demand.

In the context of climate change mitigation, the carbon issue was first addressed by the forest domain identified as the most carbon-storing sector in aboveground biomass. Then, when the storage of carbon in the soil compartment has become a significant additional option, crops agronomy sector has naturally integrated the theme because of a significant history of soil organic matter (SOM is composed of near 50% of C). Livestock's place on climate issues is still largely regarded in terms of contribution to GHG emissions, in particular methane. It is now crucial to highlight the role of grazing land in terms of mitigation. But for the message to be clear, and to be able to generate appropriate actions, ambiguities and uncertainties still need to be assessed. Soil carbon sequestration in grazing systems is not an evidence, but their capacity to contribute to the process is real, and more research is needed (among others) to clarify the conditions of implementation.

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CASE STUDIES

Evolution of the multiple functions of livestock in tropical landscapes: comparison of trends in different observatories of livestock in Africa, Asia and Latin America

(Abstract of the poster presented)

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GASL

BACKGROUND/INTRODUCTION: The multifunctionality of livestock in developing world is widely recognized. Most countries are actually witnessing several changes (population growth, development of animal product markets, climate change, etc.) affecting breeding systems and their functions.

DESCRIPTION/PURPOSE/OBJECTIVES: The compared approach of the evolution of livestock multiple functions is a challenge for research. It helps anticipate changes and future sustainable development of agricultural landscapes. It is based on field knowledge of researchers of the Joint Research nit Selmet observing ongoing developments of livestock in 14 highly contrasted landscapes (9 in West Africa savannah zone :Mali, Burkina Faso, Senegal); 1 in Madagascar (Vakinankaratra), 1 in Egypt (North West coast), 2 in Brazil (Amazon), and 1 in Vietnam (North mountain). The multivariate approach (PCA, HAC) of the "scoring" of changes awarded by the experts allowed to propose evolutionary trends over the last 50 years (1960-2010).

LESSONS LEARNED/RESULTS: Four main trends appear (Fig 1). The first trend (T1 Fig1a; Paragominas Fazendas in Brazil) is characterised by a huge development of economical functions (exports), balanced by a strong environmental degradation and large increases in GHG emissions. The 2nd trend (T2 Fig1b; Fatick in Senegal, Dentiola and Diou in Mali, Marsa Mathrut in Egypt, and Paragominas traditional systems in Brazil), by the emergence of commercial livestock farming activities associated with a degradation of the living environment, erosion of biodiversity, and a rise in competition over natural resources. The 3rd trend (T3 Fig1c: Koumbia in Burkina, orontiéna in Mali, Widou and Kolda in Senegal, Highlands in Madagascar and Son La in Vietnam) by a more moderate evolution with an improvement in economic and social areas and a slight deterioration on environmental functions. The 4th trend (T4 Fig1d: Kanoula in Mali) is more dramatic with a regression of livestock functions in almost all areas.

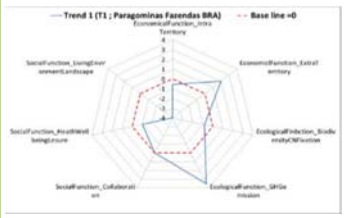

Fig1a

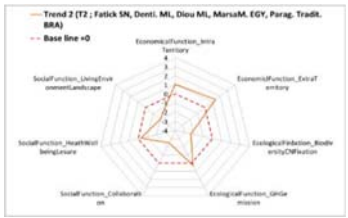

Fig1b

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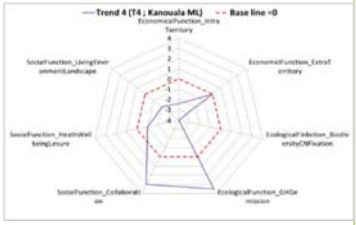

Fig1d

Conclusions/Next steps: This comparative approach of changes in livestock functions on a range of situations distributed in developing countries and over a long period (50 years), highlights a trend of overall improvement of the economic functions of livestock, accompanied by a degradation of functions in environmental and social areas, especially in the landscapes with high level of population density. For the future, the challenge would be to avoid a T3 - T2 - T1 pathway, where economic development propsers at the expense of the environment. The study will undergo detailed quantitative and diachronic analyzes. Such analyzes stress the need for long term livestock observatories to evaluate scenarios for the future of landscapes.

The multi-functionality of extensive cattle livestock and its importance for agricultural systems in northern highlands of Vietnam

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INTRODUCTION

The concept of multifunctionality is used by many authors to stress the non-market dimensions of agriculture. In that respect, multifunctionality comprises the existence of multiple commodity and non-commodity outputs that are jointly produced by agriculture (Caron P. and Le Cotty, 2006). As multifunctionality was progressively adopted by research, three issues emerged as focus points for the scientific debates (Multagri project, 2005) including: (i) the interrelations between functions; (ii) increasing the links between agriculture and society; and (iii) the relation between multifunctionality and sustainability.

The Northern Mountainous Regions account for about 30% of the total surface area in Vietnam, and more than 2000 administrative communes. Around 39% of the communes are located at a medium altitude between 200 and 600 m, and 39% of them are over 600 m. There are different mountains ranges, with some peaks reaching 3000 m or more (Phan Xi Păng, 3143 m.), and several large intermountain basins. Due to this topography, the regions are characterized by a wide range of ecosystems. We differentiate the low mountain zone (around 200 to 300 m of elevation), mid-elevation mountain zone (between 300 and 800 m), and high mountain zone (over 800 m altitude) (Tran Duc Vien, 2006). The regions contain about 15% of the national population. It is characterized with medium population density (100 inhabitants/km²) and high proportion of ethnic minorities in addition to the Kinh population. In the low mountain zone, which is relatively better watered, with higher temperature, and closer to the roads and market infrastructures, the main ethnic minorities are the Muong and the Thai. In the mid-elevation mountain zone, there are mainly ethnic groups, among which might the Dao, the Kho Mu, the Xin Mun, the Ha Nhi and others. In the High mountain zone, which are more remote areas, the main ethnic minorities are the H'Môn, the Lo Lo, and, in some places, the Dao (Tran Duc Vien, 2006).

These regions cope with many difficulties compared to lowland and delta areas in terms of steep slopes, uneven terrain, access difficulties, low soil quality, poor infrastructure, and high poverty rate. Particularly, the pressure on land is strong in the highlands, where a high proportion of unfertile land spots does not favorable for crop production (Minot et al., 2003; Tran Duc Vien, 2006). These regions are considered as a favorable area for ruminant production with the availability of pasture lands. According to Minot et al. (2006), a majority of households in Northern Mountainous Regions can improve their living standard from animal husbandry. Epprecht (2005) calculated that the share of livestock is more than 22% of total household income in the northern uplands.

Cattle are considered as the most important ruminant species. In Northern Mountainous Regions, the majority of cattle are raised in highland extensive mixed farming systems in hilly and mountainous landscapes of high altitude and steep slopes (Dixon et al., 2001). According to Maltsoglou and Rapsomanikis (2005), the highest proportion of households raising cattle is in the Northern highlands (nearly 70%). However, the share of beef in the market from these Regions is lower than the share of draught animals. Therefore, beef cattle still contribute a relatively small share in the total income of households (Epprecht, 2005).

Furthermore, cattle population in the Northern highlands is strongly affected by diseases and high mortality rate in the winter due to poor health care service as well as feed shortage, especially for cattle grazing in the natural pasture in the hill tops (Huyen et al., 2011). Smallholders in the uplands of Vietnam are mostly dependent on natural pastures for cattle feeding. In the high altitude areas, each family usually owns between two and five heads of cattle. Pastoral systems are characterized by multi-functions of livestock that contrast with the vision of commercial firms invested in the development of mono-cropping maize production or pig intensive rearing. These important multi-functions of extensive livestock need to be taken into account for assessing the functions of grasslands in local communities. Free-grazing and tethered grazing are the main feeding systems, in which cattle are generally grazed every day on natural pastures in the forest land far from the homestead with little or no use of crop-by products (Mui, 2003; Huyen et al., 2006; Phung, 2009). However, there is a lack of information on quantitative and qualitative of grass in the pastures. Phong (1995) and Mui (2003) reported that Northern Mountainous Regions and the middle highlands occupy more than half of the total grassland in Vietnam. However, the grazing area is declining due to crop production, re-settlement or reforestation programmes. As a result, available native pastures tend to be overgrazed and there is little formal grazing management until now.

OBJECTIVES

This study analyzed the diversity of the functions of grasslands that are characterized by multi-functions of cattle in the pastoral systems, and their perception by various stakeholders resulting in motivation to (or in low interest for) improving pasture management in Son La province, a mountainous province in the northern highlands Vietnam.

DISCUSSIONS AND LESSON LEARNED

The multiples functions and linkages of livestock, pastures, forest and crop cultivation at farm scale

Son La province is the largest province in the Northern Mountainous Regions. Looking back the historical development in keeping cattle in the province, the availability of natural pasture/ grazing land and land tenure affect the cattle population and structure of cattle herd. According to Huyen et al. (2006), increased keeping cattle in recent years might reflect a recent increase of farmers' prosperity in Son La province. Security of farmers' land tenure through national land allocation policies (1993 and later) and local implementation programs possibly further supported this investment.

In the past, large ruminants were kept for draught and for reproduction and restocking of the herds and occasional sales. As ruminants were grazing freely, losses due to theft were high. High losses were also caused by epidemics, as there was few health controls. The reduction of the number of females between 1990 and 2002 was interpreted as an effect of ever more limited pastures, forcing households to reduce herds in general and females in particular, while maintaining males for draught. Decreasing pastures had also driven farmers to reduce the number of other ruminants. Between 2001 and 2004, most farmers gave up upland rice for the new, high-yielding maize varieties. An increasing share of rice for home consumption had now to be purchased. Maize became a major cash crop and animal feed. Farmers raised cattle and buffaloes still as draught animals, but cows for reproduction became less frequent than before or even rare in some villages (Huyen et al., 2006).

Extensive cattle production plays important roles not only in supplying meat in the beef-cattle marketing value chain, but also in providing draught power for soil preparation and harvest transportation, manure for soil fertilization, household savings, and cultural goods to be used for important social events. In addition, grazing animals involve in forest management and occupation, and in fallow management. Figure 1 summarizes the multiple functions and linkages of grasslands, livestock, forest and crop cultivation at farm level.

The grazing areas are composed of uncovered grasslands, but also of forest lands, fallows and interstitial areas (border of fields, roads..). Pastoral systems are characterized by multi-functions of livestock with strong linkages of livestock, grassland, forest and cropping that contrast with the vision of commercial firms invested in the development of mono-cropping such as maize production.

A study conducted in Son La province from 2007 to 2010 (Huyen et al., 2012) indicates that small farms were at their limits of forage availability and had labor shortage. Non-market values of cattle were higher than the beef market value. Cattle were sold at low frequently, less than one cattle per year (Huyen et al., 2013; Tuan et al., 2014b).

Cattle competed with other livestock in the use of limited farm resources on small farms. Better-off farms could reduce this competition by more frequent adoption of innovation (forage cultivation, use of agricultural and industrial by

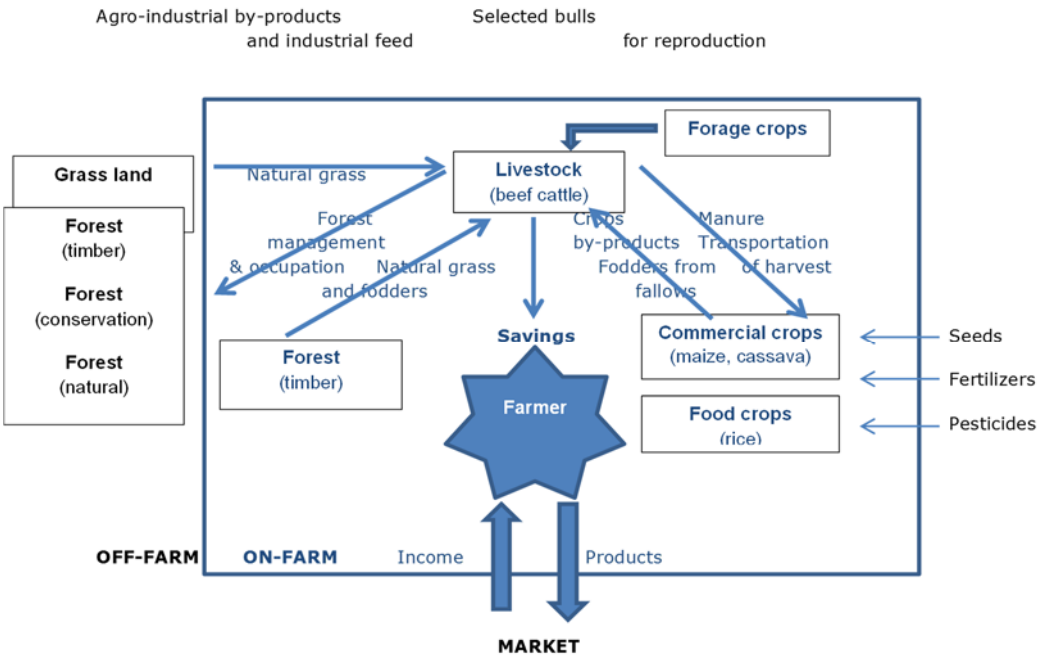

Figure 1. *The multiples functions and linkages of grasslands, livestock, forest and crop cultivation at farm scale*

products, etc.). The less poor farmers had more advantages than the poorer in allocating different resources for keeping higher numbers of cattle together with other livestock, while resource poor farmers had to reduce the numbers of animals. For the poorest, small animals were more suitable than cattle (Huyen et al., 2013; Tuan et al., 2014 a). The large entrepreneur-type of farms, were characterized by high economic losses, high feed costs and low animal performance, mostly because of poor forage availability and still not developed beef markets. The most promising type of farm for profitable beef production in the study region was the mixed farm in high mountains, where the farmers could increase their cattle production on the basis of available fodder resources from pastures with limited use of supplemental feed. Figure 2 compared net benefits from cattle production in the low mountains with that in the high mountains.

Rinawati Setianingrum (2010) and Trung (2011) carried out a follow up research in the same study sites, where the natural pastures are available for raising cattle. Setianingrum (2010) found that the size of communal pastures varies a lot, dependent on the villages, and ranged from 20 to 187 ha.

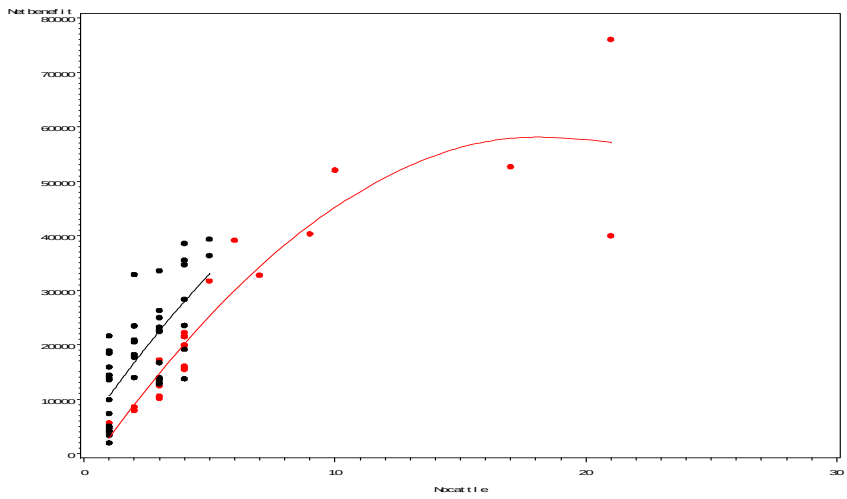

Figure 2*. Plots of net benefit from cattle production versus number of cattle (c) kept per farm in highlands (Huyen et al., 2010)*

In general, all households in a village are allowed to graze their cattle on the communal pastures of the respective village. However, in some villages, there were arrangements for dividing communal pastures into several plots, bordered by stream or fence. The plots were further occupied by different groups of cattle keepers, which were formed based on family relationship or neighborhood. The communal pastures could be in the form of woodlands, which is pasture under perennial trees in the forest, or in the form of grassland with less perennial trees. Farmers who had access to communal pastures practiced mainly free-grazing or tethered grazing. Stall feeding was not common practice in the study sites. Some cattle keepers, practicing free-grazing, kept their cattle on communal pasture for the whole year, while some others practiced seasonal movements: they grazed their animals in communal pastures during the cultivation period, and in harvested fields after the harvest. Those who did not move their cattle from communal pasture to harvested fields justified this by the too far distance between the pasture and the fields. Tethered-grazing was also influenced by season in terms of available feedstuffs. During the cultivation period, cattle were herded or tethered on roadsides or fed on a cut-and-carry basis. Farmers did not access to the pasture practiced herding or tethering their cattle on roadsides, field borders, and fallow land. Tethered-grazing was also practiced by cattle keepers who do not utilize communal pasture, even though they have access to such pasture areas. Reasons for not utilizing pastures were far distance, lack of labor, and unsafety due to theft. The distance to communal pastures on hill tops or sloping areas from the homestead ranged from three to eight kilometers and it takes hours to reach them.

It is recognized that natural pasture areas declined time by time in the study region. For instance, in one H'Mong village (Pa Dong in Mai Son), Huyen et al. (2006) indicated that around 100 ha of natural pasture were available in 2004, whereas according to Rinawati Setianingrum (2010), no more natural pasture were used in 2010.

It is noted that where protected forests are accessible, cattle can graze in. Maize and rice fields' area are used for grazing in post-harvest period. Coffee fields do not allowed access to cattle. Therefore, expansion of coffee fields reduces post-harvest fields for cattle. Nevertheless, coffee needs cattle and buffalo manure. It can be understood that on the one hand the development of coffee need the development of cattle. On another hand, the development of coffee reduces grazing lands (Cesaro, unpublished field data).

The utilization of crop residues for cattle feed is related to the kind of crops cultivated by the cattle keepers. For example, the utilization of rice straw in mid-elevation mountain zone is more prominent than in high altitude. It is understandable because all cattle keepers at mid-elevation mountain zone are cultivating rice, which is not the case in higher altitude. However, not all cattle keepers utilized their crop residues. The revealed reasons are long distance between crop fields and cattle stable, lack of labor and enough native grass for cattle during harvest time. Table 1 gives an example of the major use of pastures by different cattle production systems.

	Crop-Livestock integrated Smallholder farms			Specialized beef farms
Location	Lowland/highland	Highland	Highland	High land/ Lowland
Cattle per farm	1–5	1–9	3–21	90–650
Ethnicity	Thai/ H'Mong	H'mong	Thai	Kinh
Pasture	No	Natural pasture	Natural pasture	Growing pasture
Feeding	Tended /Cut-and-carry	Free ranging on communal pasture; or seasonal movement to harvested field	Free ranging on communal pasture	Stall feeding and additional ranging on the pasture
Type of feeds	Natural grass; growing elephant grass; crop by-products (rice straw, maize leaves and stems, rice bran, sugar cane tops); cassava, banana stems, pumpkin	Natural grass	Natural grass	Fresh elephant grass; silage feeds (maize stems and sugar-cane tops and elephant grass); dry rice straw; additional concentrate feed (maize meal and premix)

Source: Modified from Huyen (2010)

***Table 1**. Example of the major use of pastures in different cattle production systems in Son La province*

PROSPECTS FOR IMPROVING PASTURES MANAGEMENT AND THE VALUE OF GRASSLANDS

According Huyen et al. (2010) and Tuan et al. (2014b), the availability of feed resources for cattle was found to be a major factor affecting herd size and cattle management on household farms in Son La province. Feeding systems practiced by smallholders are governed by several factors such as access to communal pasture, labor, ethnic, altitude and production objective. Specialized beef enterprises practice zero-grazing with utilization of improved grasses, collected or purchased crop residues, silage, and concentrates, which is not the case for smallholder farmers. The mixed farms with access to natural pastures reveal a potential for profitable beef production in the future when keeping more than 10 animals, a number that could be realized if cattle management was improved (Huyen et al., 2010). A more in-depth investigation of feed quality and pasture improvement possibilities would be the next required step in determining the scope for development of this system. The latter will also depend on the potential for the establishment of a beef market in the region, which needs to be evaluated by market research. The support of the province is recommended for the development of market structures and the implementation of appropriate policies and credit programs is required, at least in the initial phase (Huyen et al. 2011; Tuan et al., 2014 a). Cooperative organization of short food supply chains could be an appropriate solution for marketing a defined meat quality from younger animals, further contributing to the shortening of production cycles. The formation of farmer groups, which has enabled medium farms to reduce labor costs for cattle keeping, could be developed favorably towards cooperative beef marketing (Huyen et al. 2010). The initial evidence implies that the development of pasture management is highly related to the existence of improved value chains. The setting up of weekly market places, or local modern processing units linked with distribution companies in big cities like Hanoi, are likely to boost farmers outlets, and their motivation to improve their feeding practices in Son La province (Tuan et al., 2014a) as well as in other northern highland regions (Tuan et al., unpublished; ACIAR project LPS/2008/049).

For years, with an attempt to improve beef cattle performance, the Son La province has implemented some policies carried out by several extension programs by introducing improved Laisind bulls[1] and breeding cows to smallholders. The province also supported some large-scale specialized beef breeding farms in the import of exotic beef breeds (Draught Master, Brahman) with the aim of providing breeding animals to households. However, the large farms, in spite of important governmental subsidies during their establishment, could not cope with the high feed cost because of scarcity in natural pastures areas and consequent high shortage of green feed resources, especially during the winter. Furthermore, smallholder did not want to keep exotic cattle because of their lack of knowledge and resources for managing exotic cattle, less adapted to the local conditions than the local breed. In addition, the large farms could not get access to markets for high-quality beef, a market segment that is in great demand through-out the country (Huyen et al., 2006; Setianingrum, 2010; Huyen et al., 2012; Duterutre, 2014). Setianingrum (2010) stated that farmers seemed to prefer cattle breed with higher body weight, such as Laisind. However, in reality, cattle breeds kept by farmers do not entirely correspond to farmer's preferences, due to their lack of feed, lack of labor and lack of knowledge about preferred breed. Moreover, altitude, ethnic groups and remoteness were also influencing traits preferences. In addition, large-framed cattle in semi- and free-grazing systems need supplementation in the dry season. For small-framed cattle, stall-feeding with a fixed ration and supplementation with urea-treated straw is not an option. Economically, supplementation in the rainy season does not make sense. This is not expected to change as long as marketing of meat is not developed (Trung, 2011 and Huyen et al., 2012). Many policies and programs for developing cattle fattening in northern highlands focused on evaluating and selecting bulls and cows for natural breeding to improve the cattle quality, supporting households in building cattle sheds, forage cultivation (mainly King grass and Ghinee grass), vaccinating cattle to prevent infectious diseases, and providing free of interest loans. There was very little support in terms of grass cultivation by giving VND 2.5 million/ha for grass seedling purchase in the first season of grass cultivating to households which transformed the low productive annual crop or mixture-plants-garden land to cultivate grass for animal raising. However, the improvement of available pasture management and the promotion of farmer motivation for using certain unfertile plots for improved grass are not considered (Duteurtre, 2014).

The results of Uplands Program - SFB 564 and ACIAR project AGB/2008/002 in Son La suggests that planting of hedgerows or vegetation strips with king grass is one of the long-term methods to slow down the soil erosion in the upland fields. However,

[1] *The Laisind cattle (in Vietnamese: bò Lai Sind) is a cross-bred cattle obtained from local zebus (yellow cattle - bò vang in Vietnamese) and an exotic Indian zebu breed (Red Sindy)*

farmers only make the decision in changing their practices only when they see a better benefit. It means that if planting grass in a certain unfertile plots to extend cattle production, the higher benefit from this need to be clearly defined. Recently, a number of farmers who want to extend cattle production recognize the importance role of having a suitable land for grass cultivation in addition to natural pastures and crop residues to ensure the green feed for the cattle. A percentage of cattle keepers in Son La spend some land area at home garden or around ponds for forage cultivation 48% of farmers do not use natural pasture and 25% of farmers using only natural pasture (Setianingrum, 2010). A study of Tuan et al. (2014 b) in the frame of the beef project ACIAR LPS/2008/049 in Mai Son also found that households in different scales have different grass

areas. Some households with 10 cattle and more have larger improved grass areas than others (10,000 m2 compared to 677 m2 in the scale of 6-9 cattle/ farm; and 200-250 m2 in the scale of smaller than 6 cattle/ farm).

Duteurtre et al. (2012) carried out an initial study on the institutional and policy options for improving the economic value of grasslands in the Son La Province. The authors found that the importance of grassing land for cattle production is perceived by all stakeholders in the beef cattle value chain. In which, beef produced in the traditional extensive production in the grazing land is preferred by traders and consumers, and can get higher price. This is also confirmed by Tuan et al. (2014a). The availability of grazing land for reducing the production costs is a major attractive factor of cattle keepers. However, grazing lands are not formally recognized and not concerned by local institutions as cropping and forest lands. So far, the increase in the demand on beef might lead to the promotion of value chains to encourage local meet production. This might bring land users and local authorities to recognize the value of grasslands and to develop cattle production in a sustainable manner.

LESSON LEARNT

In the above overview in Son La province, the results reveal that the extensive smallholder cattle production based on natural pastures need to be promoted and improved by additional use of appropriated land for forage and alternative residue feeds. Further, the development of grassland management is highly related to the existence of improved value chains. The setting up of regular market places, or local modern processing units linked with distribution/ retail enterprises in big cities, are likely to boost farmers outlets, and their motivation to improve their feeding practice.

So far, the care for long term of efficient use of grassland is autonomously by few farmers having some successful already in beef production. However, in this region, without the involvement and governance of local authorities (at village and communal levels), the over-grazing problem could not be solved, and the value of grasslands could not be improved. Currently, this issue is neglected.

In general, farmers only think and try on the investment when they can see or have foreseen about a good benefit from the action. This is also true for the care and support of local authorities. The matter is how to provide reasonable proof for the necessary of improving pasture management to all stakeholders and local authorities.

The coordinated actions should be on the establishment of farmer organization; the knowledge in grassland management and required support from local authorities; and the policies to the development of market chains. The perception about the value of grasslands will go along with the success of beef cattle value chains in the regions and as a base of the consideration for improvement of pasture management.

The formation of common interest groups can help the poor farmers in accessing to the grass lands or other resource needs for beef cattle production. The linkage of farmer organization with traders and local institutions can develop beef value chain as well as enhance the effort in improving the management of grasslands.

CONCLUSIONS

Although Government has encouraged beef production development in the highlands, multi-functionality of livestock, forest and crop cultivation are not mentioned in the development programs. Furthermore, grasslands are not formally recognized by local institutions as a valuable feed source for livestock production. Consequently, government support funding is rarely available to sustain and improve natural pastures. Collective action is required from all different stakeholders to develop strategies for sustainably managing this important and valuable resource.

The involvement of local authorities and other stakeholders with the researchers during the study is very important. The main objective of the study should be in the same route with policies and direction the local authorities. Further, it is also very important if the study can fill the gaps of the policies and local plans. The sustainable and efficient results from improving beef value chains linking with grassland management need to be aware by farmer themselves, other stakeholders in the value chain and local authorities.

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Livestock dynamics and sustainable development of a French wet mountain territory: local stakeholders' points of view

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GASL

INTRODUCTION

As an activity strongly rooted in a socio-economical network and a local space where it provides multiple products and services (Rubino et al., 2006), livestock is recognized as contributing to sustainable development of rural territories. Livestock changes are at the heart of European and national concerns for several reasons. Livestock farming is sometimes the only possible economic and agricultural activity in some areas like mountains, and plays an essential role in the production or maintenance of typical landscapes. These constitute an attractiveness which is often source of development for the tourism in such areas. From a social point of view, livestock activity is considered as an element of cohesion and identity (Duteurtre and Faye, 2010), and contributes to maintain a resident population and different networks in rural areas. From an environmental point of view, livestock is both a user and producer of specific ecological services (Costenza et al., 1997, Gibon 2005, Quétier et al., 2007, Zhang et al., 2007) thanks to maintenance of grasslands and semi-woody vegetation. However, livestock breeding also shapes these ecosystems and can affect their quality through production practices and land-cover reconfiguration (Carpenter et al., 2006, de Groot et al., 2009, Le Roux et al., 2009; Knoke et al., 2009, Le Roux et al., 2009).

The sustainable development of territories is based on well negotiated changes that integrate the point of view of stakeholders concerned (Vavra 1996). This is why it is necessary to well-know the expectations of the stakeholders of the livestock territories (Blaikie et al., 1997).Thus, we focused on a french mountain territory with the objective to highlight the diversity of local actors' visions on the productive, environmental and social functions of livestock..

As part of a research project initiated in 2010 concerning the livestock farming at territorial scale (Dedieu et al., 2009), we have set up an analysis of the roles and expectations about livestock supported by the various stakeholders concerned by this activity in the Livradois-Forez, a territory located at the east of the french Massif Central.

Firstly, a literature review highlights the difficulty to find consensus on livestock futures and models associated to sustainable development. Secondly, material and methods are presented. Thirdly, the results on the multiplicity and variety of actors' regards on livestock roles are presented concerning the Livradois-Forez case. Then a discussion highlight the necessity to share the different points of view between actors, in order to favor a sustainable development rooted in to a coexistence and hybridization of livestock models on the territory.

AGRICULTURAL FUTURES AND STAKEHOLDERS' POINTS OF VIEW

From a general point of view, i.e integrating the different scales of agricultural fact (value chain, practices at farm or plot scale, diversity of production at territory scale), the literature opposes classically two models, in the sense of an analytical category. The conventional and agro-industrial model is often associated with unsafe food, asymmetric bargaining power and weak returns from agriculture, and environment degradation (Bowen and Zapata, 2009). In opposition, the alternative model consists for some authors in enabling consumers to make connections between the place of production, the production methods employed and/or the people producing the food (Marsden et al., 2000;

Renting et al., 2003). This "alternative" model thus allows access to the market of marginalized producers, the mitigation of risks linked to global chains, the preservation of cultural heritages, and is associated with more 'natural' practices (Murdoch et al., 2000; Frayssignes , Higgins et al., 2008, Bowen, 2010, Fourcade et al., 2010). However, this alternative agri-food model is the subject of various studies showing the limits of this alternativity. The impacts on sustainable development depend obviously on the practices of the different stakeholders involved in the value chain (Born and Purcell, 2006; Baritaux, Houdart et al., 2016). Finally, scientists highlight the fact that these two archetypical models underlie a wide of models based on the hybridization of these two archetypical models (Fournier And Touzard, 2014), whose axes of differentiation are multiple (links to markets, resources, etc.) (Duru and Thérond, 2014 ; Hervieu and Purseigle, 2015).

In all cases, a large number and a great diversity of stakeholders influence livestock dynamics at different scale and pathways to sustainable development. At the national or supra-national scale, there is public policies, global markets and their regulations (Chatellier and Delattre, 2004). At the local level, some socio-economic stakeholders have a key-role (Tonneau and Sabourin, 2007, Morales and Dieguez, 2009, Tekelioglu et al., 2009; Houdart and Poccard, 2016). It is thus often hard to find a consensus between local stakeholders concerning the models of livestock that may support sustainable development in their territory, as these stakeholders are numerous and varied to be concerned by the livestock activity (Fleury et al., 2004; Dufour et al., 2007) and have each a different way to consider the three dimensions of sustainable development (Laurent et al., 1998).

In this context, it is essential to be able to describe this diversity of points of view about livestock and sustainable development according to a local situation. What are the specific and common views of stakeholders on the role and futures of livestock? Do their visions account for all the dimensions of sustainable development? How do the points of view concern each level of organization (farms, territories and sectors)?

MATERIAL AND METHOD

Case study

The Livradois-Forez is a middle mountain rural territory, located at the east of the Massif Central in France (Fig.1). It covers 322,000 hectares with a population of approximately 110,000 inhabitants. Agriculture is 9% of the employment (PNRLF, 2016). It comprises two massifs of low mountains (the Livradois max altitude1200 m and the Forez 1600 m) largely covered by forest and grassland (respectively 51% and 30% of the total area). This rural region is currently a livestock area and has a diversity of environments and landscapes: bocage, open up-lands, wetlands, forests, glades and small plains.

In this area, livestock farming is a major economic activity. It is largely based on grasslands (two thirds of the UAA are permanent grasslands) and cattle breeding dominates (dairy cattle, beef cattle, dual-cattle) although a variety of other farming orientations exists: sheep, goat, pork, poultry and mixed productions. Farms are small despite an enlargement tendency in recent decades (44 ha on average, against 55 for the national average (RGA, 2010)). They suffer from climate and soil conditions, slopes and land splitting which impede high farm productivity. Dairy production benefits from two PDO (protected designation of origin) for cheeses (Fourme d'Ambert and Bleu d'Auvergne); nevertheless the added value transferred to producers is not rewarding. Since the late 60's, Livradois-Forez as other dairy mountain areas, has considerably evolved and has faced many changes: political (successive reforms of the CAP, implementation of milk quotas in 1984, abolition of these quotas in 2015), demographical (population decline until 2000, the rise of urban influence from those years) and economical (increases of energy and feed prices, and of volatility of milk price in the last decade). Today, 1/3 of the farms (1700) rear dairy cows and 90% of the milk produced over the area is collected by two main operators: a private one (40% of the collected milk), and a large cooperative located at the border of the territory. These two operators produces AOP cheeses as well as others generic cheeses.

In this area, land ownership structures are very small. During 19th century, farms were very small and most of numerous farmers were multi-active. They were home handworkers (making clogs, laces, rosaries…), and their farming systems mainly based on crop and animal production for self-food consumption. Then, during the 20th century, the population declined significantly, and farms turned to livestock systems while a lot of landowners choose to plant forest. But land ownership structures remained small. A lot of owners decided to keep their property when leaving the area, and nowadays, a large part of the land owners do not live on the territory. Most of the agricultural land is private village) with special regulation.

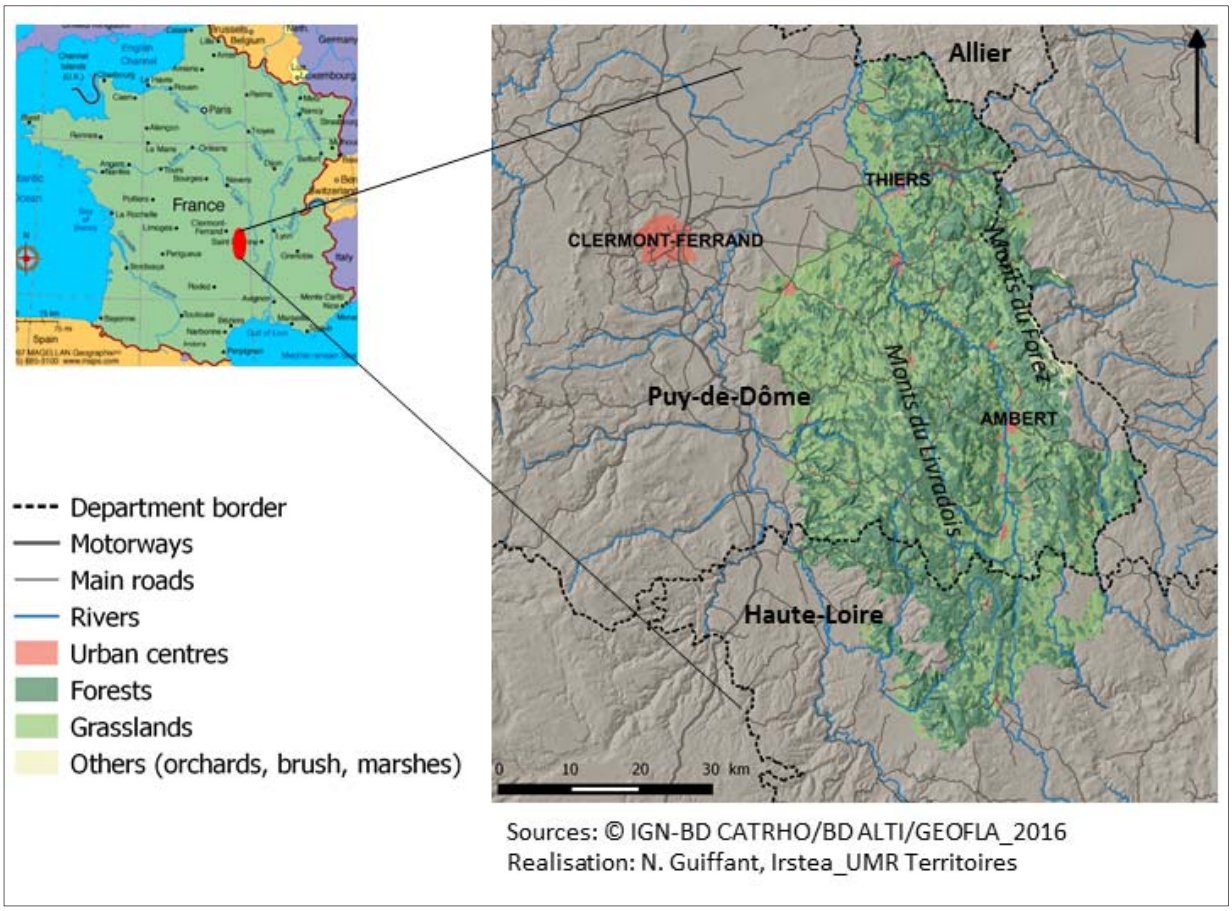

***Figure 1**. The RNP of Livradois-Forez in France*

Method

The first step was to identify the different stakeholders involved in livestock on this territory. For this, a "reputation" approach was adopted. An exhaustive list of stakeholders involved in livestock farming in Livradois-Forez was drawn up on the basis of the expertise of the research group, the themes identified during the analysis of institutional documents and exchanges with the Livradois-Forez Regional Natural Park (RNP) agricultural adviser. This list was then organized into five categories of actors: breeders, other stakeholders of the food chain (i.e. retailors, processors), institutional agricultural stakeholders (i.e agricultural chamber), institutional stakeholders of the environment, and institutional stakeholders of the territories.

The second step consisted in the development and then the realization of a maintenance guide to capture the role, the point of view and the expectations on the livestock activity of each actor. In addition to information on the actor himself (institutional and personal positioning towards the territory), he was also asked to present Livradois-Forez livestock activity today, the past changes, the issues under discussion, its future with a 10-years horizon and the necessary orientations and priorities. Semi-structured (recorded) interviews were conducted with 28 stakeholders: 6 livestock farmers, 5 other stakeholders of the food chain, 9 institutional agricultural actors, 3 institutional stakeholders of the environment, 5 institutional stakeholders of the territories. This sampling, which aimed to be representative of the diversity of points of view of stakeholders concerned by livestock activity and development issues for the territory, would undoubtedly have to be improved if we wanted to quantify the respective weights of different points of view on the territory. Furthermore, this analysis doesn't take into account the differences in knowledge and skills on livestock between stakeholders but highlights the diversity of "expert" knowledge (Blaikie et al., 1997).

Finally, a systematic analysis of the surveys was carried out, using a grid structured according to the three dimensions of sustainable development. To each dimension of sustainable development was hung up a series of interview extracts. The analysis then focused on three axes: specifying what are the themes and sub-themes defining each dimension of sustainable development; identifying the actions to be implemented in order to respond to the dimension of sustainable development; identifying the global representativeness of the stakeholders (how many people speak) and within each cate ory of actors.

sustainable development; identifying the actions to be implemented in order to respond to the dimension of sustainable development; identifying the global representativeness of the stakeholders (how many people speak) and within each category of actors.

RESULTS

A multiplicity of livestock's roles

Overall, the sample of respondents presented a vision of the roles of livestock roughly equally shared between the economic, social, cultural and environmental roles: 17/28 stakeholders address its economic role; 13/28 its cultural and social role; 16/28 its environmental role. These three roles assigned to livestock are expressed in each of the 5 stakeholders groups. It can therefore be said that livestock is perceived as an activity participating in the sustainable development of the territory. However, the stakeholders considered individually attribute a more or less wide range of roles of the livestock, even within the same group of actors.

The economic role: most often cited

This role is rarely present in the discourses of environmental stakeholders (only 1 of the 7 respondents), while for other categories of stakeholders it is major.

The economic role is often perceived as being intended for the farmers (income, employment, etc.). To a lesser extent, it is also considered for its effects on the territory and the sectors. Concerning the territory, the stakeholders underline the capacity of this activity to maintain population and thus to strengthen a "presential" economy. The development of the tourism on the territory is also addressed by three actors, specifying sometimes that this capacity is not sufficiently exploited in Livradois-Forez. Concerning the sectors, the stakeholders mention the fact that this activity is linked with the employment of retailors, processors.

Sometimes an economic role set out by some stakeholders is called social for other actors. Thus, for 3 actors, the production of products intended for human consumption contributes to the economic role of livestock, while this role is perceived as social by other stakeholders (see "social and cultural function" below).

The social and cultural role: multiple forms

The social and cultural role is tackled mainly by breeders, institutional agricultural stakeholders and stakeholders of territorial development through several items (social links, quality of living environment, food, education ...). No actor of the environment addresses it.

The main content of this role is the maintaining rural life thanks to maintenance of an active population and families, of tourist attraction. In addition, livestock contributes to the well-being of permanent and occasional populations by preserving or promoting open spaces that offer aesthetic qualities.

More generally, some stakeholders emphasize the role of livestock for global society: "*feeding Man*". Another emphasizes the "*educational*" dimension of livestock: to enable the inhabitants to know "*how farming works, how a farmer works, a beekeeper, a breeder*".

The environmental role: shared by all categories of stakeholders

The environmental role of livestock is largely expressed in terms of maintaining open landscapes, regardless of the categories of actors. The contribution to the maintenance or even the development of the biodiversity is approached only by 3 stakeholders of the environment and sectors. This environmental role, concentrated on the landscape and biodiversity items, seems to be a consensus among the stakeholder groups, since at least half of the stakeholders in each group tackle this issue.

The desired livestock forms: differences according to the scale concerned

All the stakeholders interviewed do not express themselves about the forms of livestock to be promoted. When they did, the stakeholders were able to evoke several tracks each. The different desired forms of livestock farming for Livradois-Forez expressed by the stakeholders then refer to three different scales: farm (12/28 farmers talk about this scale), territory (6/28), sector (4/28).

At the farm level: differences concerning size and specialization and the importance of autonomy

Points of view are many different, especially among breeders linked to their different professional and trade-union sensitivities.

Some stakeholders (none of those working in the environment and territory institutions) insist on the need of a generalization of competitive farms. Linked to this, the need for modernization is approached from different angles by 4 of these actors. One actor justifies it by the persistence of a lack of "*professionalism*", a lack of "*dynamic of progress*" at the individual and collective level (in reference to their little use of the technologies of Information and Communication). For some, it aims at simplifying work to improve living conditions. For others, it is a path to better economic performance through specialization and the development of large operating structures. For some, this is the prerequisite for "*rearing livable livestock and working conditions (possibly with wage labor) and installation to several rather than alone*", and to "*a corporate approach*". For some actors, enlargement is therefore the only way to remain competitive and to survive on the territory.

But, other stakeholders put forward farms whose enlargement is reasoned, even moderate, in order to limit the increase in energy and labor burdens, the difficulty of transmission, and the blocking of other installations on small diversification structures. The mode of production advocated is then extensive and valorizes the territory and the ecological resources: a "*livestock more in connection with the territory and less consuming resources (energy, land)*", "*extensive considering the potential of the environment*".

Whatever the model of livestock carried by the actors, the improvement of the autonomy (forage, food, energy ...) to face the vagaries of the market or climate, appears a necessity for 4 actors. The stakeholders most directly involved in the production stages (breeders and institutional agricultural actors) speak of a necessary return of the "*grass cultivation*" and a greater autonomy of food and fodder. This search for autonomy is sometimes contradictory with other forms of autonomy (energy, financial ...). For example, one of the stakeholders explains: "*We are far from everything, we are far from the ports, we have transport costs, logistics costs are enormous whether it is in cereals, in fertilizers in food ... Yes I advocate for forage autonomy* ". However, he weighs his remarks and believes that farms will never be 100% autonomous: "*because if they want to be self-sufficient in grass, they will have to put in fertilizer, they will have to weed them if they want to have productive meadows ... they will have to renew their meadows ... because if they leave the prairie 20 years, such as, without doing anything ...*".

At territory level: the need for a diversified livestock farming, with the maintenance of processing industries and restructuring of land

There is a general desire for a diversified livestock form in the territory, about several aspects. For 4 actors, it concerns the land use. They insist on the need to strike a balance between agricultural land and forest, avoiding a growing influence of the forest on the territory, while maintaining a "*breeding of clearing for biodiversity*". For an actor (breeder), diversified farming refers to the farm structure (size, location, fragmentation). Another producer talks about the necessity to combine in the territory both extensive and intensive farming. Finally, an environmental actor advocates the diversification of production orientations at the territorial scale: "*The territory must be based on what it knows how to do (fourme, Billom's garlic, etc.) and develop certain domains (small fruits, hemp)* ". Diversification is therefore highly desirable, but in very different terms.

The questions of farm structure (the need for enlargement or the problems posed by excessively large structures, the need for grouping plots) are frequently stressed by the actors. They cite the fragmentation of agricultural land as one of the main handicaps of this territory. One of them also considers that the department of Puy-de-Dôme (Fig.1) is "*behind*", "*backward*" compared to others, due in particular to the small size of the farms (about 40-50 cows on average against 60 -80 in the neighboring Allier department (Fig.1)) and the poorly concentrated structure of the farms. All the stakeholders described the territory as penalized by a fragmented and heterogeneous land, that is to say both the dispersal of parcels of the same farm (distance to be traveled) and the fragmentation of ownership (farmers lease a large part of their surface to a multitude of owners). This severely constrains the operation of the farms and affects the work of the breeders, limiting the possibilities of evolution and enlargement of farms and complicating their transmission.
One of the stakeholders explains: "*the fragmentation of the parcels of land causes labor costs but also transport (to move the animals, to carry the manure).*

We are in a semi-mountain area here, hillsides, you can not do everything everywhere. And then it creates problems: doubling of the fences to avoid that the flocks mix. There is no arrangement between farmers for land: it's taboo". The restructuring of land is thus a strong expectation for the majority of actors, although the latter evoke the contradictory tensions and views on the ground as regards the reparcelling. Three stakeholders emphasize the difficulty of access to land, linked to land pressure, between farmers first ("*There is competition for access to the plots that are being liberated*"), but also between agriculture and urbanization close to the cities (Clermont-Ferrand, Thiers, Ambert, Fig.1). The risk of new competition between agricultural space and forest land is not highlighted.

The maintenance of tools and factories to transform meat and milk on the territory (slaughterhouse, dairy) is also desired by several actors. The proximity of these tools is seen as a means of retaining some collectors and some productions of the territory. But the need to keep production volumes and a minimum density of producers to ensure the profitability of such tools is well perceived.

At the sector level: developing short and quality food chains

The expectations in terms of valorization and marketing are shared by the 5 categories of actors, more often by the institutional ones. The valorization of milk and meat products (i.e. by the specification of origin) is generally recognized as insufficient by most stakeholders. They are in favor of various marks like mountain quality, organic, PDO, or any commercial or territorial ones. But this shared expectation is the subject of some controversy.

Organic farming is developing, supported by local and regional authorities (Park and Region), and more recently taken into account by the Chamber of Agriculture. This type of farming is still perceived by the majority of livestock stakeholders (breeders and institutional actors) as anecdotal, niche, little "*professional*" and "*aside*". Owing to the emphasis on organic farming, some conventional farmers feel that they are being misled "*on the side of polluters*" when they consider their livestock systems to be extensive and not degrading for the environment. Some of them also envy the price level of organic milk.

A high controversy exists concerning the PDO cheese. For some, this is to be developed in long food chains, for others in short food chains. With regard to the existing PDO Fourme d'Ambert, some actors, mainly those of territorial development, point out that demand for farm cheese exists and is not covered. This encourages the preservation and increase of the number of producers of PDO, but limits are mentioned: the product is not very specific because of a very extensive appellation area, and a processing which is essentially industrial one, hence a price of milk to the producer and a gain in slightly different image of a non-PDO cheese. Thus, farmers remain outside the PDO and tensions exist between PDO and non PDO cheese producers.

The question of quality is also linked to that of short and long food chains. Short food chains are put forward by all actors, with the exception of the stakeholders in the sectors, as a possible alternative to the race for enlargement, a better valorization of products in these circuits to allow small and medium-sized farms dimension to better hold. These short food chains are also seen as a means of being more autonomous vis-à-vis the markets and industries (facing the threat of abandonment of milk collecting in certain areas), and more "*energy-efficient*" by decreasing energy consumed to reach the consumer (low transport cost, storage and distribution). However, the small size of the local consumption basin and the remoteness of large consumption poles are sometimes stressed as limiting factors for the development of such food chains.

DISCUSSION- CONCLUSION

Our case study pointed out the three dimensions (economic, social and environmental) of the livestock roles assigned by the local stakeholders of this activity. It does not reveal extremely diverging or contradictory discourses between the categories of actors. However, these categories of stakeholders do not give equal importance to each of these 3 dimensions. The economic regard is the most refined: several themes are mentioned and the stakeholders clearly specify the different economic areas of the activity. Conversely, the environmental dimension is not very developed: only on "landscape" and "biodiversity" aspects. In the same way, the social dimension is not very thorough: only on social fabric.

No mention is made, for example, of cultural heritage, festivals and meetings, around the activity, the valorization of grasslands or a breed. Thus livestock farming does not appear as a key to identifying the area, probably because of the great diversity of this activity in Livradois-Forez (small and large-scale structures, breeding and dairy farming,

specialization and diversification, pluri-activity, insertion both in long food chains and short ones, etc.).

This diversity of livestock activity also explains the great variability of the desired forms of livestock farms on the territory from the large specialized intensive structures with large capital and investments to the smaller, more extensive, diversified structures (or even pluriactive) in the mobilization of local resources (territory and environment). According to the meat and milk sectors, the stakeholders have also a composite view: betting on commercialization by an intermediary outside the territory and by various local channels (with or without intermediaries). Some stakeholders support and wish the complementarity of the two forms within the territory in order to ensure its development.

All these results drive to the question of the way and modalities for coordination between the forms of socio-techno-economic development, and between the stakeholders and scales concerned. Indeed, the visions of livestock can differ widely according to the stakeholders and can, like the stakeholders with environmental competence, focus on one dimension (the environment). These divergent points of view question the links to be developed for a global consideration of this issue of territorial sustainable development. Several stakeholders identified during the interviews, the networking of stakeholders as one of the stakes for livestock. This networking and co-ordination could take place between organic and conventional farmers, between urban and rural populations, between professionals in the agricultural and tourism sectors, (cooperatives / private traders) notably in order to avoid competition or conflicts of interests and resources.

Finally, addressing the issue of the sustainable development of a rural area by one of the main activities of this territory constitutes an entry to foresee the diversity, the reconfiguration, the hybridization of the models linked to this activity and the diversity of the scales involved in these modalities. In doing so, this entry leads us to grasp the multiple paths that this activity can take to contribute to the sustainable development of the territory. It emerges a reflection to be put in place to articulate the different scales of development while confronting the models, sometimes antagonistic, advocated by the actors. In all cases, this work recalls, if necessary, the importance of taking into account the local level and the points of view of the different stakeholders in a context that is nevertheless highly regulated and guided by national public policies or supra-national organizations.

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Agenda for research-development-training actions regarding the future of pastoral activities in French Mediterranean territories

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INTRODUCTION

In France, from the last general agricultural census of 2010 performed by the Ministry of Agriculture, the rangelands occupied 4 millions of hectares, i.e. 7 % of the national area. They supported the activity of 35 000 livestock farms, i.e. 18 % of the total of livestock farms, and contribute to feed 1.5 million of Livestock Units (suckling cattle and sheep, dairy sheep and goats). They are located in mountainous areas (*Alpes, Pyrénées, Massif Central, Vosges*…) and Mediterranean, with a high diversity of land cover, from Mediterranean shrublands to alpine meadows.

Livestock is an important economic sector in Mountain and Mediterranean areas, generally since a long time. Beyond the delivery of animal commodities (meat, milk…), livestock farming systems are known for providing multiples services at territory scale, assuming their multifunctionality (Moulin, 2014). Pastoral farming provides animal products of high quality, recognized through various signs of quality (Aubron et al., 2014) and supports local economic activities (farmers, operators of the commodity chains…), contributing to the vitality of the territories. Pastoral farming contributes also to environmental quality. It maintains open space, enhancing the biodiversity, preventing forest against fire, and building agropastoral landscape (CEN L-R, 2017).

But pastoral farming is also facing serious challenges in France. The rangelands are the support of multiple uses, such like hunting or hiking, limiting their access. Pastoral activity is often labour intensive, with many works constraints (Aubron et al., 2016). The farmer incomes depend highly on European subsidies (Bataille et al., 2015). Climate change decreases the biomass production and the climatic hazards increase, in frequency and magnitude. The presence of large predators, under a strict status of protection, is also a threat (Meuret et al., 2018). All these points of weakness threaten the viability of pastoral farms and may lead to their disappearance. In consequence, the positive impacts of pastoral activities would decrease.

In this context, several institutions shared their resources to create in 2015 a new group, called Technological Mixed Unit (UMT Pasto) dealing with the pastoral farms in the Mediterranean areas. The aim is to produce knowledge and methods to support pastoral farming to cope with those challenges and to enhance its contribution to a sustainable development of Mediterranean areas. In this presentation, we depict the organization and the agenda of the UMT Pasto. Then we illustrate some ongoing activities of the group.

ORGANIZATION AND AGENDA OF THE UMT PASTO

The UMT Pasto

In France, research, education and extension are historically distributed in different institutions. So, actors supporting the development of pastoral activities were embedded in various structures, in national institutions (research and education) or in structures organized at local level (extension). They used to cooperate through projects and built shared knowledge, for instance about grazing systems based on rangelands (Girard and Hubert, 1999). But the objectives and the actions needed to be discussed again for each new project, at the initiative of one of the partners.

The lack of formalized relationships did not enable a strategic thinking of the action programs to be carried on.

Since 2006, the French Ministry of Agriculture developed an instrument to organize partnerships (http://agriculture.gouv.fr/les-unites-mixtes-technologiques-umt), called Mixed Technology Unit (UMT). It is a modality to develop in-depth working relationships between public research organizations, public higher education institutions and professional technical institutes, in charge of national programs of applied research and extension. The UMT "Pastoral livestock farming in Mediterranean territories" (UMT Pasto) was labeled in 2015 by the Ministry, showing the national interest for the pastoral issues in France.

The aims of the UMT Pasto are to i) consolidate a French applied research group building pastoral competencies, at the Mediterranean scale, ii) to integrate research and extension actions in partnership with all the actors of pastoral activities, iii) contribute to the training of the actors of livestock farming and environment management.

Three institutions participate to the UMT Pasto: INRA (French Agronomic Research Institute), Montpellier SupAgro, a higher education school in Agronomy, and the Livestock Institute, dealing with herbivore livestock sector (cattle, sheep, goat, and horse). The UMT Pasto is based in Montpellier and gathered 30 persons. Three domains with sheep pastoral farming are partners of the UMT, representing various pastoral environment and breeds (Le Merle, Montpellier SupAgro, near Salon de Provence, with a transhumant system between Mediterranean plain and the Alps; Carmejane, Ministry of Agriculture – Livestock Institute, near Digne, with a sedentary system using woodlands in the *PréAlpes*; La Fage, INRA, near Roquefort, using calcareous rangelands of the *Causses*). In Montpellier, the UMT Pasto has strong support from the Selmet (Mediterranean and Tropical Livestock Systems) Joint Research Unit, associating INRA, Montpellier SupAgro and CIRAD (French agricultural research organization working for development in the South). This unit addressed pastoral issues in various part of the World, in Sub-Saharan Africa, North Africa, and South America. Through Selmet unit, the UMT Pasto developed also collaborations with other research groups in France, dealing with animal sciences, such Genphyse (Toulouse) or UMRH (Clermont-Ferrand), or more broadly with dynamics of farming systems in the territories, such Innovation (Montpellier), AGIR (Toulouse), Territoires (Clermont-Ferrand), and LRDE (Corte).

Agenda for research, training and extension actions

Three axes structure the actions of the UMT Pasto. The first one deals with the contribution of the pastoral activities to the sustainable development of territories. We consider that the diversity of livestock farming systems, and their dynamics, is a key tool to understand how the livestock activities contribute to sustainable development in a territory. It enables thinking the local governance policies that impact the dynamics of the pastoralism, according to the types of farming systems. We pay a peculiar attention to the integration of crop and livestock activities, at farm and at local levels. The contribution to local development could be analysed through various theoretical framework, such as multifunctionality or the providing of a bundle of services. Finally, we propose to investigate the various modalities of installation of pastoral farmers, in order to have a better understanding of the issues and the stakes to maintain pastoral farming in the territories.

The second axis deals with the design of technical and strategic management of pastoral livestock farming system, in line with agro-ecological principles, in order to support the development of productive and resilient systems. The research issues concern, in a holistic approach, the technical and economic performances, the workload and the labor organization, the environmental impacts of the activity and the adaptation capacities of the pastoral systems. All of these elements of analysis prove to be necessary in order to reinforce the viability of the pastoral systems with a future. In this axis, we pay a peculiar attention to the use of new technologies of information, that could facilitate the management of grazing, and the use of the trees in livestock systems, through agroforestry.

The third axis implies to think the devices for extension and training. The challenge is to take into account the specific pastoral situations in terms of training and advice (diversity of the farms and of the pastoral practices implemented, diversity of actors in the world of pastoralism) and improve the transmission of pastoral knowledge.

Two ways to build multi-stakeholders partnerships

The research program of the UMT Pasto operates through projects, funding by several funding instruments of various institutions at regional, national or European levels. .Most of the actions of the UMT Pasto is thus carried on through partnerships with stakeholders of the pastoralism and the management of the environment and with representatives of the local communities.

Those partnerships are based on historic and formalized relationships between members of the UMT and other stakeholders. For example Livestock Institute is engaged with local services of extension, in the Livestock Farm Networks (Jousseins et al., 2015). They are also based on inter-personal relationships, based on previous collaborations through projects, such about multifunctionnality (Bernard et al., 2006) or silvopastoralism (Aubron et al., 2013). Beyond the collaboration of members of the UMT, which are from institutions at national level, we organize relationships with various kinds of stakeholders of the pastoralism at local levels. First, the UMT Pasto organized regular meetings with the pastoral advisory services in *Occitanie* and *Provence-Alpes-Côtes d'Azur* (PACA), to plan together the actions to carry on together. The UMT Pasto is also invited to participle to working group of the Livestock Farmers House in PACA, to have a regular view of the ongoing actions and to draw the future projects where collaborations could be relevant. The UMT wanted also develop relationships with institutions in charge of the management of the environment, such as National Park, in peculiar the *Cévennes* National Park, which is inhabited and is the support of permanent pastoral activities, or *the Entente Causses-Cévennes*, in charge to maintain the cultural landscape of Mediterranean agro-pastoralism, which has been nominated by the UNESCO at the World Heritage List. Colleagues of the UMT are members of the Scientific Council of these two institutions.

If partnerships are built and implemented especially in the context of research and development projects, the UMT organizes also an annual meeting of the pastoralism stakeholders. These meetings aim to gather the diversity of the stakeholders (livestock farmers, representatives of professional unions, staff of extension services or environment management services, researchers,…) in order to discuss specifically the implementation of the overall project of the UMT Pasto. The meeting is organised an all-day through in Montpellier. This day has a double objective: i) clarifying, with the partners, the concrete issues to be addressed by the UMT Pasto and ii) exhibiting the results of the ongoing actions. The first meeting day, in January 2016, gathered around 100 people who debated on five themes, in order to orientate the issues to be addressed and consolidate the relevance of future actions. Those themes concerned: i) the modalities of installation in pastoral activities, ii) the use of new technologies to support pastoral activities, iii) the place of the trees in pastoral farming systems, iv) the bundle of services provided by the pastoral activities at the territory scale, v) the stakes of extension and training in pastoralism. Two other days have been organized in 2017 and 2018, with the same level of participation. The synthesis of the discussion and the presentations of results made during the 3 meetings are available on the website of the UMT (http://idele.fr/reseaux-et-partenariats/unites-mixtes-technologiques/umt-pasto.html).

SOME ONGOING RESEARCH ACTIONS OF THE UMT PASTO

We choose to illustrate each axis of the agenda of the UMT through three on-going research projects.

The bundle of services provided by a diversity of farming systems in a Mediterranean area in the south of French Alps.

At a territory scale, the bundles of services provided by the livestock activities depend on the land occupation and the diversity of livestock systems. The crop-livestock integration, based on the diversity of the component of the farming systems and closing the nutrient loop, is potentially relevant to the multi performances of agriculture. In Mediterranean, specialization pathways of the farms had destroyed this crop-livestock integration, but dynamics at local level are arising with crop-livestock relationships between specialized farms. The purpose of the research is to analyse how integration of crops and livestock mediate the bundles of services provided at territory scale. We developed a simulation model depicting the farm and territory scales, without any explicit spatial representation. From a real case of a territory in *Provence*; we built a stylised territory with a reference scenario of the diversity of farming systems. From census data, we distinguished 6 farm types (3 specialized sheep farms, 2 mixed crop-livestock farms, 1 specialized crop farm). Then we assigned all farms (n=52) to one of the six types. Technical operations and economic results of farm types had been derived from the farm cases built in the Livestock Farm Network, describing 17 pastoral sheep farm types in the French Mediterranean (Bataille et a!., 2016). Surveys (n=9) enabled characterizing the straw and manure management and the exchanges between farms in and out the territory. We tested two scenarios. First, we considered that all the mixed farms abandoned livestock and were replaced by specialized crop farms. In the second, we considered that all crop farms were replaced by mixed farms. We showed that the current situation maximized the number of farms in the territory. On one hand, the crop specialization decreased the total number of workers (- 18%), with a slight increase of the income per worker (+ 3%), and led to an abandon of 50 % of the rangelands used in the current situation. On another hand, the diversification with livestock enabled maintaining the amount of cereal production, increased meat production (+ 24 %) and use of rangelands (+ 44 %). The current trade-offs enabled maximizing the number of farms and workers with a good level of the average income per worker (rural vitality), but

at the expense of the use of rangelands (environmental issues). This analysis showed the interest of a diversity of farms in a territory, but also the difficulty to maximize all the services inside a bundle.

ROLE OF THE TREE TO ENHANCE THE RESILIENCE OF THE MOUNTAIN LIVESTOCK FARMS

Tree functions in livestock farms are various: feeding and shelter for the herds, diversification of the incomes, etc. Those well-known functions are a lever to enhance farm efficiency and resilience. This issue came at the agenda of several research and development project in France and in EU those last years. The UMT Pasto has been solicited by the *Chambre d'Agriculture,* farmer advisory service, in *Ariège*, located in the Pyrenees mountain chain and a group of farmers valorising the wood-products from their trees. The project AGROSYL has been built with the UMT Pasto, through the framework of the European Innovation Partnerships, new instruments of European Union to foster the innovation through the synergies between stakeholders. AGROSYL, through a five-year work program, aims to develop the agroforestry practices in livestock farmers, valorising the already acquired knowledge in France and EU, and performing pilot action in *Ariège*. During the first year, we carried on a diagnosis in order to define the pilot actions. The area concerned by the project, in the Piedmont of the Pyrenees, gathered 585 cattle or sheep farms. The objectives were: i) to make an inventory of the trees and their uses in the farms; ii) to appraise the perception of the trees by the farmers, iii) to express the needs of the livestock farmers and the potential technical solutions implying the trees to fill those needs. The diagnosis was carried on through three steps, with meetings gathering farmers, advisors and researchers; face-to-face individual surveys (n=15) with farmers interested by the use of the trees; phone survey (n=62) with a randomly sampling of livestock farmers. The trees are very common in the livestock farms: 91 % of the farms accessed woodlands and 92 % had hedges around their permanent grasslands. On the contrary, only 41 % of the farmers had hedges around their cultivated lands (mostly with temporary leys) and the trees implanted in cultivated land are very rare. Trees are also extensively used: 81 % of the farmers detaining woodlands led their herds in those woodlands; 79 % used wood-products for self-consumption (wood heating, posts for fences) and 25 % considered that wood could be a source of income diversification. The multiples functions of the trees are recognized by the livestock farmers, from the classic one as shelter to enhance the well-being of the animals (92 % of the farmers) to the prevention against soil erosion or carbon storage (57 %). But the trees, hedges or small group of trees inside the grasslands, are also considered as constraints. The main constraint was to burden the workload (67 %). We identified 10 needs and 34 solutions implying the trees. In the end, we chose 5 solutions to be tested through 7 pilot actions with 5 volunteer farmers: i) plantation of fodder tree (n=1), thinning of woodlands to increase forage production and quality of wood (n=3), use of tree-leaves and fruits in woodlands to feed the herd (n=1), use of wood chips as litter to enhance the animal well-being and reduce the purchase of straw (n=2). Those pilot actions will be monitored for at least 2 or 3 years, to get data and build local technical references on those solutions. Visits on the pilot actions farms are also organised with farmers, stakeholders and researchers to disseminate the on-going ideas on agroforestery.

Rangeland Rummy: designing a new advisory and training tool

"Rangeland Rummy" is a board game, including a computer model, to help pastoral farmers to develop a collective thinking of changes about their grazing systems, according to various objectives (increasing the herd number or the duration of grazing period, management of climatic hazards…). At the beginning, farmers collectively design a rangeland-based livestock system on a board with sticks depicting the feed resources available for combinations of vegetation types and their management practices and cards defining animal batches and their feeding requirements, throughout the year. Charts and balances are available to test the consistency of the system, enabling a first discussion between farmers and the animator. The second step thus consists in collectively and iteratively designing and evaluating rangeland-based livestock systems, while confronting the players with new contextual challenges or new farmers' objectives. The game have been adapted from a forage rummy developed by INRA (Farrié et al., 2016), through tests with pastoral farmers in *Occitanie*. Applications show that it tends to develop farmers' adaptive capacity by stimulating their discussions and the exchange of locally-relevant knowledge on management strategies and practices in pastoral livestock systems. It is also a relevant tool for training and use in various tracks in Bachelors and Master level in high education at Montpellier SupAgro. Training sessions are also proposed for professional public (advisors, etc.).

CONCLUSION

To conclude, we point that the labellisation of the UMT Pasto by the Ministry of Agriculture allowed a new dynamic of collaboration about researches on pastoralism in France. Gathering the competencies of the three national institutions implied in applied research and education about pastoralism, the UMT Pasto constitutes a research group of critical

size, with a strategic definition of a research agenda. It allows maintaining the potential of competencies about pastoralism in these institutions. It starts a new cycle of collaboration with the stakeholders of pastoralism in order to design research projects and find funds to carry them on. Since its creation, new projects have begun, about the use of information technologies to help to the management of the grazing of flocks on rangelands, the grazing under perennial crops such vineyard or orchards, through relationships between farmers, the grazing of horse on rangelands… After a first 5-year program, the stake will be to maintain those collaborative dynamics inside the group, even without a financial support of the French Ministry of Agriculture. It is a condition to keep ahead the partnerships with a diversity of stakeholders of the pastoralism, in order put at the agenda the news issues relevant to support the resilience of socio-ecological systems based on rangelands.

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Migration and Adaptation Features in Pastoralist Communities

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GASL

Pastoralism is the main livelihood in many drylands and marginal areas, where other forms of agricultural practices are impossible. In such challenging territories pastoralism presents the best livelihood strategy to provide food, income and employment. Equally important, pastoralists contribute to efficient management of natural resources, governance of rangelands and protection of biodiversity.

Global figures indicate that pastoralism supports worldwide more than 200 million households[1] and one billion head of animals including camelids, cattle, and small ruminants contributing to about 10% of the global meat production (FAO, 2001). Pastoralism is practiced on roughly 25% of the world's land area[2], contributing about 10% of the world's meat production. It produces food and ecological services, and is often the only significant economic contribution in the world's poorest regions. Besides, it is the cultural backbone of longstanding civilizations (Nori and Davies 2007).

Despite their importance, pastoralists are marginalized in most parts of the world. While societies and citizens increasingly recognize the value of pastoralism, many still regard it as backward and as a threat to national security; some governments or policies still try to lure (or even force) pastoralists into permanent settlements. While pastoralists want their voices to be heard, they are often not given the opportunity for this, and they lack the ability or the tools to organize themselves to gain political influence.

DESCRIPTION/PURPOSE/OBJECTIVES

In this context, Vétérinaires Sans Frontières (VSF) International and its partners, with the support of the International Fund for Agricultural Development (IFAD) conducted a consultation process to evaluate the main challenges faced by pastoralists across the world, and understand how to better support them. This c**onsultation process, organized between September 2015 and February 2016, included:**

- **Five participatory regional meetings** for West-Central Africa, East-Southern Africa, North Africa and West Asia, Central and Southern Asia, that gathered over 200 representatives of pastoralists organizations from 38 countries (Table 1). The regional meetings aimed to identify the main challenges faced by pastoralists in each sub-region and to define key priorities for investment in pastoral development, along with recommendations for pastoralists' inclusion in policy dialogue and partnership with development organizations. The meetings contributed also to strengthen alliances and networks of the pastoral civil society in each region and at international level. The conclusions from the different regional meetings were consolidated at global level through the Statement of the Farmers' Forum Special Session with Pastoralists and Livestock breeders.

[1] A commonly used figure in recent years quantifies pastoralists at more than 500 millions (McGahey et al. 2014), however this is only based on estimations.
[2] No uniform definition of pastoralism and rangelands exists, which leads to the situation that estimates of pasture area may vary between 18% and 80% of the Earth's land, depending the measurement and calculation methodology used in more than 300 published definitions (Lund 2007).

Table 1. *Regional consultations with representatives of Pastoralist CSOs*

Region	Location and date	Participants
Western & Central Africa	Bamako, Mali. 7–9 January 2016	85 participants from 10 countries
North Africa & West Asia	Hammamet, Tunisia. 14–16 January 2016	39 participants from 10 countries
Latin America	La Paz, Bolivia. 17–19 January 2016	30 participants from 5 countries
Eastern & Southern Africa	Nairobi, Kenya. 21–23 January 2016	28 participants from 8 countries
Asia	Hustai NP, Mongolia 25–26 January 2016	30 participants from 5 countries

- **A survey on the current status of enabling environment and policies related to pastoralism in 26 countries** from Africa, Latin America and Asia (Figure 1). In each country, we questioned at least three well-informed interviewees on political integration, and at least three on availability of services (enabling environment). To select the target countries, we identified all areas where grassland-fed-livestock-based household incomes surpassed 50% of the overall community income, assuming that this is a limit between agropastoralists and pastoralists (Swift 2001).

- **A survey of pastoralist practices and realities in 8 "hotspots"** where pastoralism is a major form of livelihood: the Arkhangai in Mongolia; the Altiplano and Chaco in South America; Wagadou and Gourma in West Africa; Tiris Zemmour in the Sahara and the Afar and Chalbi areas in the Horn of Africa (Figure 1). As part of these surveys, 315 members of pastoralist households were questioned about the use of natural resources, herd size and market access, animal health services, adaptation to drought and climate change, nutrition and food security, information sources and social networks.

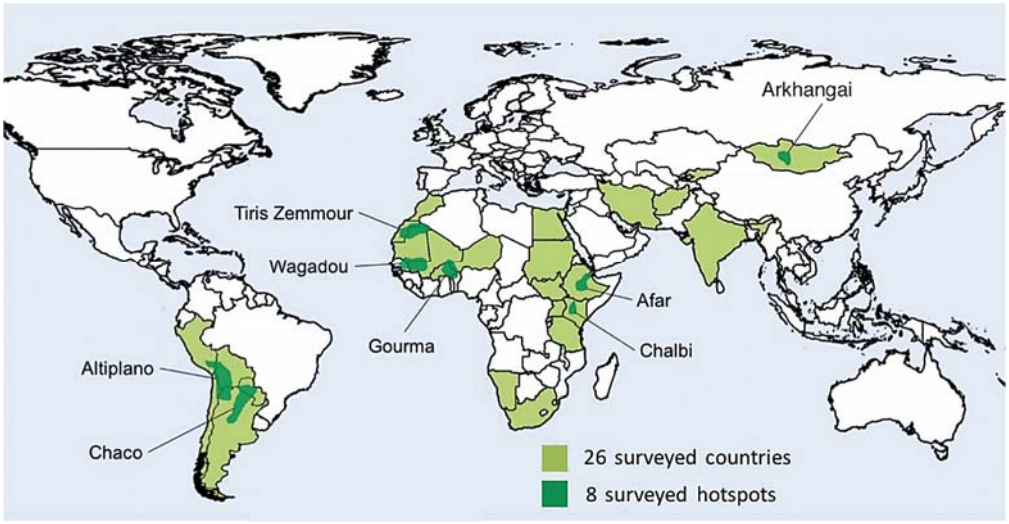


Figure 1: Countries and 'hotspots' included in the survey

Together, the results of the surveys and the conclusions of the regional meetings provided a number of indications concerning current challenges to pastoral livelihoods in the different regions and recommendations to policymakers and development organizations in order to promote sustainable pastoralism.

RESULTS/DISCUSSIONS

Land tenure is one of the main challenges pastoralists face and is the root of many conflicts. Rules on land tenure vary widely among countries, but most formal legal systems do not recognize or guarantee customary tenure rights.
In our survey, only a minority of the 315 pastoralists interviewed owned land with formal title: 19% with individual title and 8% with a community-owned title. For much of them, land is owned through a customary agreement: 59% of the respondents had an individual customary agreement, and 49% stated that the community holds customary tenure.

In the past, this lack of formal rights did not matter: outsiders regarded pastoral land as unproductive and of little use. But this has changed: the discovery of oil and minerals, the expansion of intensive cropping, urbanisation and the designation of nature reserves and wildlife parks have boosted interest in pastoralist territories. Such uses often occupy

the best-watered land, cutting off herders' access to pastures and water sources they rely on in the dry season, and have serious consequences in terms of contamination of natural resources. The declining land base for pastoralists is to be analysed in a context of demographic growth, and this may also fuel conflicts between different user groups, who compete for scarce resources.

Directly linked to land-use rights, mobility is another key feature of pastoralist livelihoods, which is often at stake. Mobility is key to enhancing livestock production as the herds move in search of pastures and water. Mobility is also strategic for trading as well as to manage risk due to drought, conflict, disease outbreak, or in other periods of hardship. Restricting mobility poses serious challenges to pastoralists' livelihoods, economy and overall security. In West Africa, for instance, there is an historical interdependence between the landlocked Sahelian countries and the coastal countries in the south. Sahelian pastoralists move with their herds to neighbouring coastal countries to find pastures during the lean period (transhumance corridors), while high demand markets in the coastal countries welcome their livestock and products (marketing corridors). However, the increasing obstacles to convey their herds across different territories or to get access to watering points, as well as the high administrative burdens (high and even illegal taxation), are a major concern for millions of pastoralists.

Results from the survey revealed that interviewed pastoralists in Afar (East Africa) (annual migration distance 85 km ±14.1), Arkhangai (Asia, 67 km ±13.4), Chaco (55 km ±12.7) and Altiplano (67 km ±8.1) (South American) were characterized by limited mobility, while pastoralists in Tiris Zemmour (North Africa, 100 km ±13.3), East Gourma (168 km ±14.1) and Wagadou (105 km ±14.1) (West Africa) reported migration from significant higher distances and were only exceeded by pastoralists from the East African Chalbi territory reporting in average 345 km (±14.1) annual herd migration. Even though in the present study we have not analyzed the historic dynamics, it is though widely assumed that movement patterns of pastoralist have dramatically declined over time.

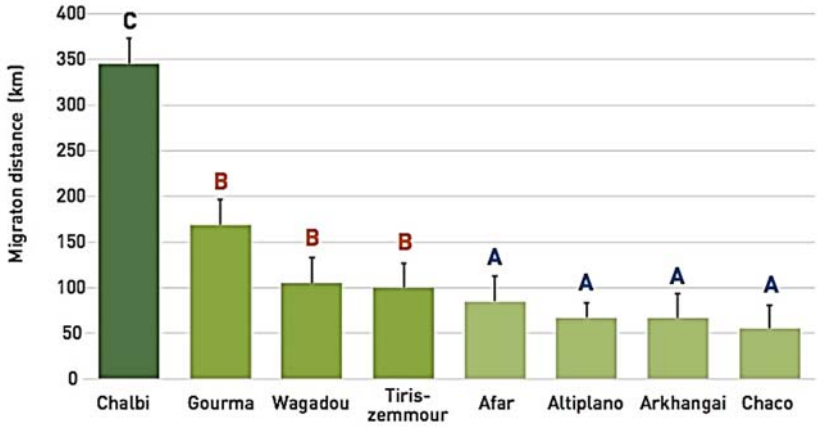
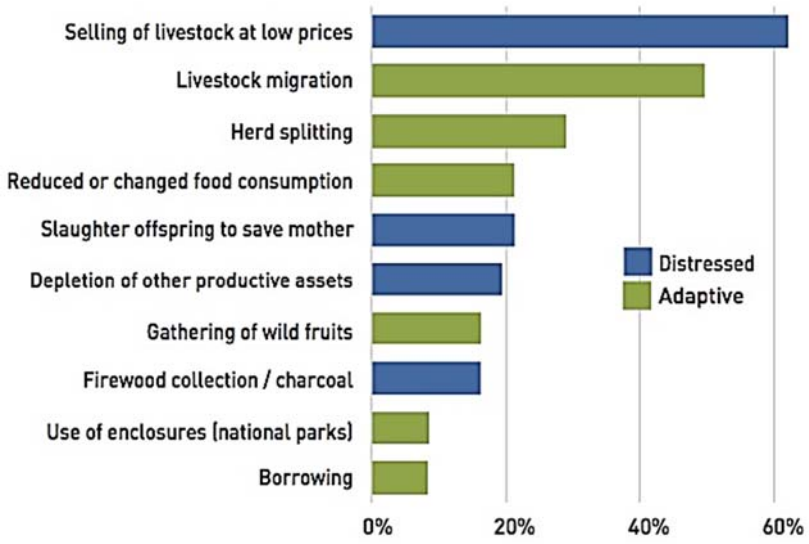


***Figure 2**. Average annual migration distance of pastoralist groups in each hotspot (in km). n=315 pastoralists.*

***A, B, C** represent significant difference among groups (P < 0,05) by multiple comparison following Tuckey procedure. Bars represent standard errors.*

The existence of obstacles to mobility is also suggested by the fact that, when asked about the most important drought adaptation mechanisms, migration and herd splitting were only mentioned by 50% and 29% of the pastoralist respectively. The most of respondents (62%) indicated selling of livestock even with reduced prize was the main coping mechanism during periods of stress (Figure 3). It is remarkable that pastoralists chose distressful coping mechanisms which require longer periods to recover over adaptive mechanisms that do no harm.



If mobility plays a decreasing role as coping mechanism, market access becomes important.

Pastoralism is a major contributor to the economy of many countries. In Sudan, for example, it accounts for 80 % of the agricultural gross domestic product. Pastoral communities seek additional and better marketing options to ensure they receive fair prices for their products. A typical example is meat, milk and dairy products. When producing these products, pastoralists often ensure high standards of animal welfare and environmental protection. Despite the high demand for these products and services by urban consumers, the way in which value chains are managed or governed does not accordingly benefit pastoralists.

In the assessed pastoral hotspots, the findings highlighted that rural markets play a dominant role for pastoralist trade, except for processed dairy products. A share of 60% of the interviewed pastoralist stated that they sell live animals in rural markets in contrast to 27% who trade live animals in urban markets.

While rural markets are important for live animals (60% of respondents said they sold in such markets), milk (45%), meat (41%), hides (28%), and wool (22%), urban markets tend to be important for processed dairy products such as butter and ghee (15%) and cheese (22%) (Figure 4).

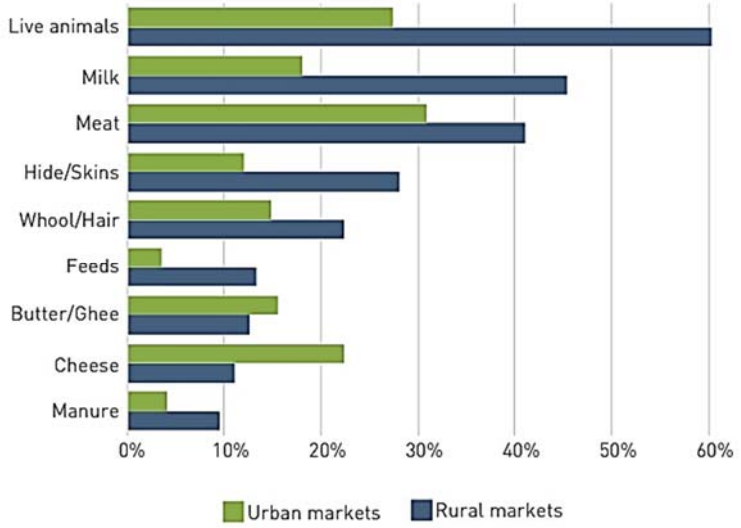


Figure 4. *Percentage of respondents in the 8 hotspots selling livestock and livestock products at rural and urban markets (n=315 pastoralists).*

Several trade barriers have been identified by respondents to our survey (panel of experts form 26 countries), which may explain partially this phenomenon. Besides the frequently mentioned trade barriers such as transport and feed cost, barriers related to information access and governance ranked among the most decisive. High cost of middlemen, rent-seeking behavior of value chain actors, market inefficiency and information asymmetry are clear indications that governance and information policy in pastoralist territories have to be rethought.

As the pastoralists' representatives stated during all the five regional meetings, efforts and investments are needed to improve access to market and value chain development. For instance, improved information systems, adequate and accessible infrastructure, education, technical training to guarantee quality standards of livestock products, capacity building and micro finance, and access to veterinary services are some practical measures mentioned by pastoralists. Special attention is also required for the transboundary dimension of mobile pastoralism, which requires inclusive and coordinated transboundary services in areas such as animal health, epidemio-surveillance, early warning systems, value chain development and market information systems (Statement of the Farmers' Forum Special Session with Pastoralists, 2016).

Pastoralist areas are often poorly served with basic services compared to other areas in the same country, and this applies also for veterinary services. Provision of animal-health services is extremely important to pastoralists, not only to protect their livestock assets (which ultimately assures their food security) but also because such services are an important link to public institutions. As with other services, animal health services need to be adapted to the herders' mobile lifestyle. One way to promote animal health services to mobile and dispersed populations is through Community Based Animal Health Workers (CAHWs): members of the pastoral community that have been trained and provided with a basic animal health kit, and who work at community level in permanent connection with a veterinarian.

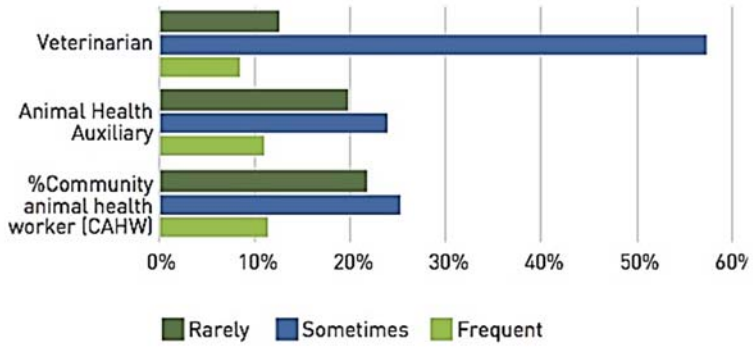


Figure 5. *Frequency of consulting with animal health service providers in the hotspots (n=315 pastoralists)*

In our seven hotspots, more than 57% of the pastoralists indicated regular but few consultations by veterinarians, while 25% by either community animal health workers or veterinary-para professionals. The low numbers are probably explained by the fact that in several countries CAHWs are not officially recognized (although often they are *de facto* tolerated as the only way to serve the needs of pastoralists in remote areas). In any case, only about 10% of the pastoralists we questioned said they frequently get the service of a veterinarian, animal health auxiliary or community animal health worker (Figure 5). As potential change agents, animal health service providers can bridge the gap between pastoralists households with policymakers.

Improved linkages with decision makers, functioning information services and participatory mechanisms in the definition of policies and implementations of projects are sought by the consulted pastoralists.

As revealed by our survey, communication and information exchange among pastoralists is occurring mainly through physical presence and information exchange among peers. In some areas, mobile technologies are increasingly important. Although with marked differences between regions, according to interviewed pastoralists, group meetings were the most common information tool, with 45% of the respondents saying they were available; they were followed by local radio, cellphone, television and individual meetings. Social media, videos and newspapers ranked below 10% in terms of usage (Figure 6).

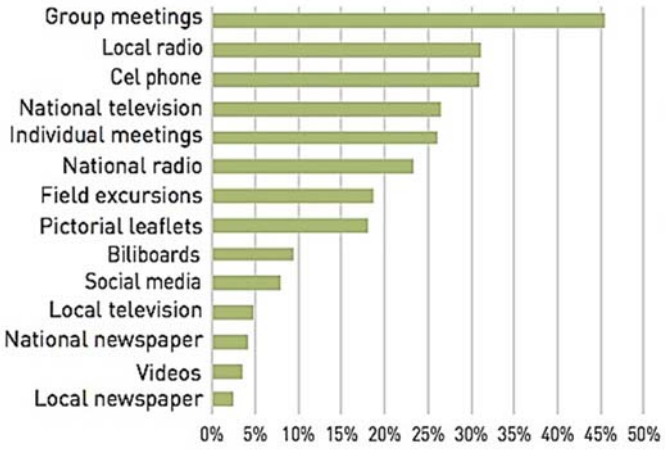


Figure 6. *Available information tools as reported by pastoralists in 8 hotspots (n=315 pastoralists)*

CONCLUSIONS

Rather than regarding pastoralists as a problem, policymakers should see them as a major and indispensable contributor to the development of sparsely populated, marginal areas. Pastoralism itself is a way to manage remote and difficult areas, keeping them inhabited, productive and secure.

Efforts to develop pastoralism need to be focused on the local area or territory (which might involve cross-boundary cooperation or a regional framework), rather than on national-level policies. They need to build on the pastoralists' own knowledge, traditional organizations and social networks; recognize and protect customary land-tenure rights; and support herders' mobility also through the provision of adapted services.

Pastoral CSOs and their networks should be strengthened at local, national, regional and international levels to engage in policy dialogue and in designing and managing projects that benefit pastoralists. Communities should be involved in planning, building and managing infrastructures and facilities in pastoral areas (e.g. water sources, trading facilities, ...). Furthermore, in order to fill the information gap that many pastoral communities face, a combination of investment in mobile technologies and apps, and in the physical presence of change agents in the field could help.

Policies should support mobility of pastoralists rather than trying to restrict it, and should recognize and protect customary land-tenure rights, traditional rules and rangeland management norms, and communities should be able to formalize their customary and collective tenure. Government should also assure more control over corporate investments to protect pastoralists access to land and natural resources.

Finally, efforts are needed to provide services (including education and human and animal health) that are adapted to the mobile lifestyle of pastoralism.

It is worth noting that today herders are not only asking for services for their livestock, or rights on their lands. They demand as well for their recognition as citizens of a wider society: "*Pastoralism is more than livestock production; it is a way of life, a culture and an identity. We pastoralists are citizens and our rights, culture and customary institutions should be recognized and respected. (International organizations and national policymakers should) recognize the uniqueness of our livelihoods that need tailored approaches and investments."* (Statement of the Farmers' Forum Special Session with Pastoralists, 2016).

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The Regional Sahel Pastoralism Support Project (PRAPS): a multifunctional initiative to strengthen the resilience of pastoralists in the Sahel

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CONTEXT AND ORIGINS OF PRAPS

Pastoral systems in the Sahel have adapted and readjusted to the many changes and shocks that have been a feature of their existence for thousands of years. They represent a way of life and a system of production founded on mobility in which environmental, economic, social and ecological factors interact with one another (SIPSA 2012, Hesse et al., 2016). The environmental impacts of herding are highly controversial: pastoralism is often the only productive activity to make use of arid and semi-arid regions, yet it is accused of contributing to ecosystem degradation. At the same time, however, it has been shown that under conditions that maintain mobility and therefore control pressure on resources, herding safeguards reservoirs of biodiversity and is both competitive and profitable across all range areas (Behnke & Scoones 1992, Thébaud & Hesse, 2008). It is therefore appropriate to consider the multifunctional nature of pastoralism and its constraints to understand and anticipate its production potential and the social, economic and ecological dynamics at work. It is just as important, however, to situate pastoralism in the context of the current development and security challenges the Sahel and West Africa have to face.

This context formed the backdrop for a regional symposium on the sustainable contribution of pastoral livestock production to development and security in Sahel-Saharan areas, held in Ndjamena, Chad in May 2013 with the support of a number of technical and financial partners. The conclusions of the symposium included recommendations to: i) improve governance; ii) strengthen the resilience of pastoral societies; iii) enhance the economic sustainability of the pastoral livestock sector; and iv) enhance the social sustainability of communities in Sahel-Saharan areas. In October 2013, the World Bank organised a joint high-level forum with the CILSS and the Government of Mauritania on pastoralism in Nouakchott, Mauritania. The forum called for the adoption of a sub-regional approach to respond to the challenges associated with pastoralism, addressing the need to harmonise and reform agricultural policy, develop capacity and make strategic investments. It called on the international community to join forces to support the Sahel, renewing the political commitment of the Region, the Sahel countries and technical and financial partners, and forming an international coalition for sustainable consideration of the issue of pastoralism. The Nouakchott Declaration that resulted from the forum was adopted on 29 October 2013. The stakeholders in the Declaration made a commitment to "securing the way of life and the means of production of pastoral populations and increasing the gross proceeds of herding activities by at least 30% in six Sahel countries (Burkina Faso, Mali, Mauritania, Niger, Senegal and Chad) over the next five years, with a view to substantially increasing pastoralists' incomes in 5 to 10 years from now."

To improve and strengthen services to producers, the Declaration provides that "the programme may seek to improve: (i) Animal health services by: (a) strengthening public veterinary services (in particular, the organization and operationalization of cross-border services) and private veterinary services (through investment, training and structuring assistance); (b) promoting sub-regional cooperation with regard to animal health and animal welfare; (c) gradually bringing national veterinary services up to the standards of the OIE (World Organization for Animal Health)." At the close of the Nouakchott forum, the heads of state and government in attendance were unanimous in affirming

that the context was conducive to action that would recognise pastoralism as an effective practice and lifestyle suited to conditions in the Sahel and Sahara. They also affirmed that pastoralism should be placed at the centre of strategies and policies promoting stabilisation, sustainable development and national and regional agricultural development, bringing in issues relating to the sustainable management and equitable sharing of resources, political inclusion, security, access to markets, health, education and gender. They called for ambitious commitment from all stakeholders, their own countries, regional organisations for economic and technical integration (ECOWAS, WAEMU and CILSS), civil society, including associations of agricultural producers, pastoralists and livestock producers, and the private sector; and they called for relevant international organisations (FAO and OIE) and Technical and Financial Partners (TFP) to respond to requests to mobilise their resources at the appropriate level and for the required period of time to support pastoralism in the Sahel and, more generally, livestock production in the sub-region.

This desire to take action in support of pastoralism was built into the World Bank's Sahel Initiative, launched in November 2013. The CILSS was assigned responsibility for technical coordination of this pastoral programme, under the political leadership of ECOWAS/WAEMU, plus Mauritania and Chad. The World Bank stated its willingness to contribute some US$248 million to an extensive regional project to support pastoralism in the Sahel (PRAPS). In January 2014, each of the six countries involved in the project (Burkina Faso, Mali, Mauritania, Niger, Senegal and Chad) appointed a "PRAPS Focal Point (PFN)", with regional technical coordination provided by the CILSS and the formation of a Regional Task Force on Pastoralism (TFRP). Supported by the World Bank, they began the process of formulating the Regional Sahel Pastoralism Support Project (PRAPS).

The Regional Task Force on Pastoralism (TFRP) met four times in 2014-2015 and held more than a dozen video conferences, enabling the countries to take a participatory and inclusive approach to the process of formulating PRAPS. The project was evaluated and approved by a series of meetings and technical discussions which culminated in ratification by the Board of Executive Directors of the World Bank on 26 May 2015. Most of the countries met the conditions for implementation between June and December 2015, bringing the project into operation. The CILSS was effective from 25 September 2015.

ISSUES FOR PRAPS

PRAPS is the World Bank's operational response to the objectives of the Nouakchott Declaration. Since the end of 2015, the project has been implemented in the six countries of the Western Sahel belt (Burkina Faso, Mali, Mauritania, Niger, Senegal and Chad), with the Permanent Inter-State Committee for Drought Control in the Sahel (CILSS) providing coordination at regional level. The project development objective is to "improve access to essential productive assets, services, and markets for pastoralists and agro-pastoralists in selected trans-border areas and along transhumance axes across six Sahel countries, and strengthen country capacities to respond promptly and effectively to pastoral crises or emergencies" (WB, 2015). The project supports the regional priorities of productivity improvements and the sustainability and resilience of assets for pastoral existence, as reflected in the Nouakchott Declaration on Pastoralism, via a combination of strategic investment, capacity development and political dialogue. The central focus is improving living conditions for more than 2,000,000 pastoralists and agro-pastoralists who will benefit directly, at least 30% of whom are women.

The area covered by the project maps to the transhumance routes in the Sahel. Each country has identified specific concentration zones within this area, linked to the major cross-border commercial routes for transhumance. PRAPS comprises three technical components:

1) Improve animal health: this primarily involves strengthening national veterinary services and the epidemiological surveillance of animal diseases in the sub-region, as well as the control of two priority diseases (ovine rinderpest/PPR [*peste des petits ruminants*] and contagious bovine pleuropneumonia/CBPP) by means of vaccination campaigns.

2) Develop and secure access to the natural resources that are especially crucial for pastoral activity: essentially, this involves access to grazing lands and drinking water.

3) Move pastoral products up the market value chain by building new infrastructure, facilitating the movement of animals and pooling commercial information.

Since the project is located in the Sahel region where there are repeated crises (particularly climate-related), PRAPS is also developing a crisis preparedness and rapid response component supported by early warning systems, the diversification of sources of income for pastoral/agro-pastoral communities and an emergency fund.

IMPLEMENTATION OF PRAPS

Four criteria are used to determine the national activities for implementation of the project. Firstly, the proposed activities must be national priorities (with potential for sub-regional benefits); secondly, they must be clearly aligned with the regional activities defined by the countries themselves and/or form part of the ECOWAP agricultural programme; thirdly, they must have the proven potential to meet the immediate and long-term needs of the livestock production sub-sector; and fourthly, the host country must demonstrate that there is value in implementing and sustaining these activities (CILSS-WB 2016). Activities fall under the components below.

Component 1: Animal health improvement. PRAPS will support critical national and regional efforts to build more sustainable and efficient national veterinary services (NVS), and will conduct surveillance and control campaigns for major diseases affecting large and small ruminants. The project will focus specifically on providing local animal health services in remote pastoral areas. The intermediate outcome to be achieved under this component is a reduction in the regional prevalence of two priority livestock diseases (CBPP and PPR). The short-term outcomes are an increased proportion of animals vaccinated against CBPP and PPR and the construction and rehabilitation of veterinary units. The outcomes to be achieved for this component in the medium-term are (i) an increase in post-vaccination immunity against ovine rinderpest (PPR) and (ii) a reduction in herd prevalence of infection with contagious bovine pleuropneumonia (CBPP). This component will benefit livestock owners, including women, who often own domestic animals, particularly small ruminants.

Component 2: Natural resource management (NRM) enhancement. This component aims to enhance pastoral and agro-pastoral communities**'** sustainable management of and secure access to natural resources, focusing specifically on water and rangeland resources, which often extend across national boundaries. The medium-term outcomes to be achieved in the target localities are an increase in the land area where sustainable land management practices have been adopted, a reduction in serious conflicts over access to grazing, and a reduction in the average distance between functional water points accessible to pastoralists and agro-pastoralists in the target localities. To achieve these outcomes, the areas under joint management will be increased, a greater proportion of conflicts will be referred to mediation and conflict resolution mechanisms and the number of functional water points in target localities will be increased. Women will be involved in rangeland management activities and will also benefit from improved access to water, since they will spend less time collecting it.

Component 3: Market access facilitation. Herders have a comparative advantage in the production of ruminant livestock, and ensuring producer access to competitive, inclusive markets is likely to foster broad-based poverty reduction and improve the resilience of herder households. Unfortunately, a series of constraints related to infrastructure, institutions and logistics impede access to markets in pastoral areas, especially for small-scale producers. This component aims to increase producers**'** access to competitive, inclusive markets and to increase trade

in pastoral products (especially live animals) in select areas of each country where the project will operate. The medium-term outcome is expected to be an increase in the number of animals sold at reference markets (a proxy for improved market access). The short-term outcome is expected to be an increase in the number of reference markets operating according to specified criteria. Investments related to small-scale dairy collection centres and processing units will benefit women in particular.

Component 4: Pastoral crisis management. This component is intended to improve crisis preparedness, prevention and response at national and regional levels. The medium-term outcome to be achieved is a reduction in the time required during a pastoral crisis to reach 50% of the target beneficiaries (as identified in a crisis intervention plan developed previously that specifically includes pastoralists). The short-term outcomes are an increase in the number of specific pastoral parameters built into national early warning systems and a reduction in the time required to provide governments with funding to respond to a pastoral crisis that meets the eligibility criteria. The activities financed under this component will build greater resilience by: (i) strengthening early warning systems; (ii) enhancing the crisis response at national and regional levels; and (iii) supporting income diversification in vulnerable pastoral and agro-pastoral communities. The emergency response mechanism enables participating countries to reallocate funds to deal with any serious pastoral crisis. Support for vocational training and micro-project financing under this sub-component – much of this support will specifically target women and young people – will help to diversify livelihoods and incomes and give households the means to better withstand intermittent crises.

Component 5: Project management and institutional support. This component focuses on all aspects of project management, including fiduciary management, monitoring and evaluation (M&E), knowledge generation and management, communication and monitoring mitigation measures related to safeguards. It also supports critical needs for institutional support, capacity building and training identified in the six participating countries and by the CILSS. The institutional arrangements for implementing this project reflect the fact that it will operate at three levels, regional, national and sub-national (local). Training and other institutional support provided under this project will benefit women as far as possible. The areas of financial management, procurement, M&E and communication will receive specific attention. In line with the subsidiarity principle, this component will also organize regional forums (for launching PRAPS and the project's mid-term review) and undertake regional studies identified with Sahelian countries during project implementation. It will also develop and maintain the project's regional website.

PRELIMINARY RESULTS AND FORTHCOMING DEVELOPMENTS

PRAPS proposes to build a solid alliance to support pastoralism by pooling the expertise and resources of various actors (bilateral and multilateral technical and financial partners, governments, the private sector and pastoral civil society organizations). This support is aligned with national priorities, considers the dynamics at work in the region and complies with the subsidiarity principle. The project will enhance the current frameworks for joint action to develop a consolidated, regionally harmonized framework that provides a platform for multiple actors to promote sustainable action that will support pastoralism. This approach provides the flexibility to link country-specific outputs with broader, region-wide priorities through additional, expanded initiatives that include coastal regions, such as the Regional Dialogue and Investment Project for Pastoralism and Transhumance in the Sahel and Coastal Countries of West Africa (*Programme Régional de Dialogue et d'Investissement pour le Pastoralisme et la Transhumance au Sahel et dans les Pays Côtiers d'Afrique de l'Ouest*, PREDIP) and the Regional Investment Programme for Livestock Development in Coastal Countries (*Programme régional d'Investissement pour le développement de l'élevage et du pastoralisme dans les pays côtiers*, PRIDEC), which is currently being formulated.

On the ground, extensive support for vaccination campaigns in the six countries reached around 30 million animals for PPR in the 2016-2017 campaign, and this figure is expected to increase sharply over the next few years in line with the national strategies for eradicating PPR and controlling CBPP that all the countries have developed (Ba Dio & Berger 2018).

One of the first outcomes of PRAPS is that it has put pastoralism back on the international agenda: as a result, scores of other donors have followed its lead by providing additional support for this sector, which is a source of regional integration in West Africa.

With the mid-term review of PRAPS activities now approaching (this may provide an opportunity to refocus some support measures), the immediate operational challenges for the project are to ramp up animal health activities to capitalise on achievements to date, and to build and/or upgrade a whole host of pastoral infrastructure in 2018,

including water points, transhumance corridors, livestock markets and other storage facilities.

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Towards Total Economic Valuation (TEV) of Pastoralism in Chad

(Abstract of the poster presented)

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The prevalent multi-functionality of pastoral systems should be so far addressed through their TEV (Kr tli, 2014). Supported by the PREPAS[7], we take this process one step further by valuing the production of Chadian pastoral households for their own consumption.

A socioeconomic database collected in 2015 from 476 households allows comparison between relevant income indicators and a survival threshold of 384 SD/person/year tabulated as lateral thinking of poverty traps.

Livestock monetary incomes insufficiently satisfy 61 of vital needs while additional income diversification permit to reach at most 63 . By integrating the self-consumption, households ensure their food security.

Pastoral systems support different functions as income generation, work force for diversification and food security. The provisioning of other services from pastoral systems are themselves insufficiently measured (biomass production, biodiversity, water cycling, social impacts). That will be the next phase.

[7] *The PREPAS (Projet de Renforcement de renforcement de l'élevage pastoral dans le Batha, le Wadi Fira et l'Ennedi in French), which aims to strength pastoral farming in the regions of Batha, Wadi Fira and Ennedi. Funded by the Swiss Cooperation for 3 phases of 4 years, the first phase of this project is implemented since 2014 by CA 17 through a consortium constituted by CIRAD and COSSOCIM with a strong partnership of IRED.*

Pastoralism - Key to global crises

(Abstract of the poster presented)

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GASL

BACKGROUND/INTRODUCTION

Pastoralism is a sustainable response to the five global crises - Food, Energy, Employment, Climate and Peace. Pastoralists are providers of food; use minimum input to convert marginal resources into productive outputs; depend on hands than machines and generate dignified employment; their production systems are extensive which are efficient, sustainable and environment friendly; and believe in values which promote sharing of common resources and customary norms.

DESCRIPTION/PURPOSE/OBJECTIVES

In the entire South Asia the pastoralists are largely ignored from the government policies and development schemes. Additionally there is a tremendous pressure on common property resources which is the main reason for the decline of pastoralism in the region. Furthermore the global markets have adversely affected the local markets and bargaining power for the pastoralist produce. Lessons learned/Results: Policy advocacy for people centred land governance and creating market opportunity for pastoral produce are recognised as the critical interventions to strengthen pastoralism in South Asia. Pastoralism is one of the few context in South asia which traditionally is gender neutral.

CONCLUSIONS/NEXT STEPS

Organise the pastoralists and their organisations in South Asia for policy advocacy, particularly on common land. Document and Disseminate positive stories on pastoralism and its contributions to food sovereignty, energy efficiency, job creation, green economy and peace building. And finally create opportunities for pastoral youth to find a dignified existence in pastoralism.

Pastoralism - Key to global crises

(Abstract of the poster presented)

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BACKGROUND/INTRODUCTION

Pastoralists are the ones who have safeguarded millions of
sources of the nomadic culture, tradition and food, and inherited the land for centuries dignifying our history and ancestral law.
Customary land tenure systems, extensive rangeland use and production, mobility, flexibility, adaptability and resilience strategies are at the heart of pastoralism that provide vital response to unique ecological challenges and better solutions for more sustainable and equitable development. In such challenging territories pastoralism presents the best livelihood strategy to provide food, income and employment; these benefit not only pastoral communities, but also those living in farming areas, urban centres and coastal regions, who all profit from regional trade and from the value chains of pastoral products. Pastoralism also provides essential eco-system services such as carbon sequestration and biodiversity conservation.
Pastoralists use our traditional knowledge and land tenure systems to access rangeland, produce food and seize market opportunities. Mobility is essential for adaptability and resilience strategies of our communities to cope with climate variability and to mitigate crisis situations. Pastoralist women play a crucial and increasing role in conflict resolution, cohesiveness, peace building and strengthening the food sovereignty. When there is not enough food, people fight each other. Pastoralist women`s role is essential to build peace in this situation.
Women are the ones who hold peace. The climate change impacts women. Pastoralist women play
important role in food security, safeguard seeds and breeds, create employment through adding value to the livestock products and transfer knowledge to youth.

DESCRIPTION/PURPOSE/OBJECTIVES

Nomadic pastoralism is the key livelihoods in the dry and extensive rangeland ecosystem in Central Asia that has been proven for centuries. In Central Asia the pastoralism has been largely affected by the socialist system in the past and that impact has been kept until today on the issues particularly of inheriting the traditional knowledge, local food systems and rangeland management. Rural employment creation through supporting territorial markets is an emerging topic for the pastoralists that needs policy support.

LESSONS LEARNED/RESULTS

Building a platform of pastoralists and other stakeholders through the Pastoralist knowledge hub on the discussion on the value of pastoralism and its sustainability has been played crucial role in information sharing, bringing issues to discussion and intervention and eventually influencing policies. Pastoralists have been protecting their rangelands through collective actions in Mongolia that have made them possible to grow healthy food with high nutrition from healthy animal.

CONCLUSIONS/NEXT STEPS

In order to overcome and mitigate the challenges in pastoralism, there are needs for advocacy and capacity building for the pastoralist champions and their processes of national, regional and global coordination, motivating and supporting leadership and balanced representation of pastoralist women and youth and strengthening the existing networks like MANIP, PACA and WAMIP. Peoples. It is essential to develop local food production, which has high nutritional value, and protect the territorial markets and sustainable use of rangelands in pastoralism.

Recovering traditional pastoralism management for long-term sustainability

(Abstract of the poster presented)

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BACKGROUND/INTRODUCTION

North Africa and the Middle East have a strong pastoralist character, with arid and semiarid climates and, unsurprisingly, all its peoples (berbers, arabs) traditionally dedicated and culturally adapted to livestock keeping. Pastoralist management in the region has traditionally been based on a set of rules for sustainable exploitation of natural resources. Several factors, however, threaten the survival of pastoralist systems. While land privatization and increased inequality among livestock keepers is putting the traditional management at risk, subsidies to animal fodder and capital-intensive investments have greatly increased the livestock numbers, triggering land degradation.

DESCRIPTION/PURPOSE/OBJECTIVES

Analysis of traditional governance systems can help designing strategies to adjust them to modern legal frameworks, while a better understanding of the environmental services provided by pastoralism can also help designing more favourable policies. Lessons learned/Results: Both Hima governance systems in the Mashqeq and Agdal systems in the Maghreb have been increasingly studied and understood in the region, with initiatives to apply them to modern frameworks. At the same time, different national institutions are working on applying environmental criteria to restore degraded lands and regain sustainability of pastoralist production.

CONCLUSIONS/NEXT STEPS

The importance of re-learning from traditional approaches is proven to be key to achieve sustainable management in rangelands. However, it is also important to apply modern perspectives, which is only achievable through educated members of the pastoralist communities who steer the process. The valuation of pastoralist products for sound rural development necessarily needs the acknowledgement and promotion of environmental values in pastoralist systems.

Multifunctionality of pastoralism in Uganda

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INTRODUCTION

Pastoralist communities in Uganda occupy and utilise the country's dry lands forming approximately 44% of the country's land mass. The rangelands constitute what is known as the cattle corridor stretching from the South East, through the central region and to the north eastern area. The area's contribution to the economy is largely understated due to a number of factors including inadequate or unreliable data, inaccessibility to the power centers due to poor infrastructure, wrong assumptions that the rangelands are homogeneous and general poor understanding of the drivers of the socio economic factors in these areas. This presentation seeks to show that there is a need to pay more attention to the rangelands by appreciating its enormous contributions.

PURPOSE

The purpose of this presentation is to demonstrate the importance of pastoralism in Uganda in terms of food and income security as well as coping with climate change related challenges by optimal utilisation of the rangeland resource as well as exploiting the vast knowledge the communities have built over time. In the process, we seek to show how all these benefits add to the welfare of the economy of Uganda. Thus the specific objectives of the presentation are to:

- Draw attention to the diverse benefits accruing from pastoralism;
- Illustrate the threats to the pastoralist sector of Uganda; and
- Propose solutions for improving the lives of the pastoralists including creating a harmonious coexistence between them and other communities with whom they are increasingly sharing the natural resources.

DISCUSSIONS

Pastoralists take advantage of the scanty natural resources i.e. water and pasture to feed livestock and produce value for human beings i.e. meat, blood, milk, hides and skins. The conditions under which they survive are not conducive for arable farming unless a lot of investment is made in terms of irrigation. However, most of the areas they occupy are already water stressed making irrigation a very costly intervention. Pastoralism is therefore a low input production system that takes advantage of strategic mobility to reach resources whose availability varies in time and space.

Uganda's rangelands provide a unique environment for flora and fauna that is of great use to the economy of the country. Pastoralists are the custodians of the rangelands and ensure it is sustainably utilised by practicing strategic mobility from time to time to take advantage of the available but variable resources. The benefits, however are taken for granted and minimal public investment is made to improve the lives of people who live in the rangelands especially the pastoralists. Livestock products like meat, milk and butter play a big role in providing food security for the concerned communities but also in downstream industries like food processing, hotels and restaurants where milk and meat are regular features of the menu. In 2014, indigenous breeds of livestock that are commonly raised in the rangelands by pastoralists produced 745million litres of milk or 48% of the total despite the relatively low investment in the sector.

This is a very important contribution without which milk would have to be imported. It is unlikely that imported milk would be accessible to the rural communities based on cost and the marketing channels that tend to favour high income high population density urban areas. The main economic activity in the rangelands is livestock raising. In Uganda, this accounts for 4.5% of GDP and contributes substantially to the 70% employment generated by the agricultural sector. The bulk of the country's livestock is concentrated in the rangelands.

Karamoja sub region which is the driest part of the country though comprising of 11% of the country's landmass, still hosts 19.8% of the national cattle herd. All this is achieved despite the fact that 53.8% of Karamoja land is not accessible to the grazing community having been taken over by government for conservation purposes.

The next important activity in the rangelands is tourism. Pastoralists have demonstrated strong ability to coexist with wildlife which is the main attraction in the game parks. Many of the pastoralist communities have for centuries adopted various animals and plants as totems. This means that a member of a clan whose totem is a certain animal or tree species is not allowed to kill, eat or otherwise hurt such an animal or plant. That has greatly led to preservation of various species of flora and fauna thus offering support to the state and private sector conservation efforts. Unfortunately, these efforts have not been reciprocated by other profit motivated people who have carried out poaching that is a threat to wildlife in general but most especially to the African elephants and rhinos.

In the year 2014, four major national parks in Uganda all found in the rangelands accounted for 156,341 visitors to parks making 77% of the 202,885 that the country registered. The pastoralist communities are actively engaged in tourism by producing artefacts which are sold to tourists thus generating alternative incomes and helping to conserve traditional knowledge.

The rich flora includes medicinal plants like *aloe vera* as well as the shea butter tree both of which are commonly used for a wide range of medications and as a formulation of organic beauty products like soap, lotions and body oils. Pastoralists often use their knowledge of the plant life in the rangelands to treat both humans and livestock. In an area which is poorly served by the public sector, knowledge of medicinal plants is crucial for human and livestock survival. This traditional knowledge is often passed on but most importantly when applied well, it reduces the amount of foreign exchange that would have been spent on imported drugs. Increasingly, pastoralists are commercialising their knowledge of traditional medicine thus sharing their knowledge with the rest of the communities. There is need, however to document this knowledge and protect it as cultural heritage to ensure nobody tries to claim it as his/her knowledge and charge money for it.

The unfortunate thing is that many of the benefits of pastoralism still go unnoticed. This is premised largely on the remoteness of the areas where it is practiced meaning that data often goes uncaptured. A typical example in Uganda is a case of livestock numbers. For example the National Livestock Census in 2008 put the cattle population in Uganda at 11.4 million. Prior to the census release, the national cattle herd had been estimated by the Uganda Bureau of Statistics at 7.5 million. In other words, overnight the census increased the cattle population by 3.9 million heads indicating a pre-census data underestimation of 52 percent.

This partly explains the under investment in the sector. According to the country's current National Development Plan (2015/16 to 2019/20), access to water for livestock was estimated at 48.8 percent. This was true even when the same plan notes that "the country is increasingly facing a major challenge of prolonged droughts and unexpected floods due to climatic change and variability and is predicted to be water stressed by 2025". The prolonged drought of 2016 that saw the decimation of livestock and food shortage in the country is a wakeup call that water for livestock needs to be attended to as a priority.

Pastoralist resources of livestock also boost food production in a number of ways through integration with crop farming. For example, livestock provide draught power including ox ploughing. This not only reduces drudgery associated with low technology village farming (dominated by the hand hoe) but also increases the area that can be tilled hence increasing output. Livestock also provide manure which is increasingly being used to fertilise farms as an alternative for processed fertilisers. This, in the case of Uganda has led to most of the farm output being organic which has a comparative advantage in the global market. Many pastoralists are making money through the sale of manure. In the western Uganda district of Mbarara area for example an eight ton truck of cow dung costs an equivalent of USD 100. Thus manure plays roles of strengthening community food security and providing income to the pastoralist communities.

Pastoralism through a structured access to and control of livestock resources has in built mechanisms of creating gender empowerment. For example in most communities, women are in charge of milk and milk products as well as

the small ruminants (goats and sheep). This gives them food security for the family and incomes on sale of these products. Since these products find their way to non-pastoralist communities, the contribution to national food security is thus great.

Livestock and livestock products find their way into the export markets through both formal and informal routes. For example, there is a thriving trade in live animals between Uganda and both South Sudan and Kenya. Milk products are exported to Rwanda and the Democratic Republic of Congo (DRC), meat is exported to the DRC. Hides and skins are also exported contributing to the external earnings of the economy. In 2014, livestock and related products contributed 2.1% of total exports.

The livestock sector also contributes much through processing and marketing of livestock products and by-products. Right from the villages where animals leave the farms to the abattoir or other markets, both the local and central governments collect taxes. The business also generates direct and indirect employment for transporters, cattle trader middlemen, mobile money operators, livestock loaders, civil servants engaged in licensing and then the butchers and other processors.

Culture plays a big role in the lives of the people of Uganda. Pastoralists or non-pastoralists all have certain celebrations and rituals which are incomplete without livestock or livestock products. Pastoralists supply the livestock used as dowry in most of the communities' marriages, animals are also slaughtered for funerals and other community rites like marriages, baptism, academic graduations, family get together functions etc. It has also become like a tradition that evening entertainment is almost incomplete without an accompanying piece of roasted meat. The bulk of the meat indeed comes from the pastoralists.

In a country devoid of old age pensions and welfare payments, livestock bridge the gap and act as insurance by being a source of income. This is important to enable the elderly meet their challenges like medical bills and university education for children. Therefore, pastoralism plays the role that ideally would be on the shoulders of government i.e. taking care of the elderly.

Pastoralists have also built skills in livestock breeding through lengthy observation and have been able to breed livestock that is resistant to the hard conditions of the rangelands as well as improving on the production and productivity of animals. These selected animals are sold to other members of the community thus benefiting from the knowledge developed by the pastoralists.

Contrary to a popular misconception, pastoralists are an integral part of the economy of Uganda. Even the most subsistence oriented, must come to the market to buy essentials like human and veterinary drugs, clothes, air time for mobile phones, salt, grains, cereals and lentils. In turn, pastoralists exchange livestock, herbal medicine, livestock products and handicrafts. They therefore contribute to the economy and are no longer isolated as some people would wish to portray.

Threats to the pastoralist sector of uganda

The biggest threat to pastoralist sector in Uganda can be said to be the insecurity of land tenure of pastoralist lands. These are largely held as communal lands with communities having user rights and not registered ownership rights. This has since the colonial days led to appropriation of their land for conservation and other uses like army ranges and prison farms without compensation. In Karamoja area alone as noted earlier on, 53.8% of the land is under conservation. Moreover, the areas taken over by government include those with better rainfall like the Namalu Prison Farm in Nakapiripirit district right in the middle of the so called "green belt" of Karamoja.

As if conservation was not enough, the discovery of oil and gas in the Albertine Graben has also led to the displacement of many pastoralist communities often with no or poor or delayed compensation. Discovery and exploitation of minerals in the Karamoja area also continues to alienate formerly grazing land by vesting in in the hands of the so called investors.

Another challenge is climate change and related issues like prolonged droughts and occasional floods. Since pastoralists' livestock largely depends on natural pastures and water, they are over exposed when droughts occur and

suffer very badly from such occurrences. Yet droughts have become more frequent with Karamoja experiencing consecutive droughts in 2015 and 2016. The effect of droughts on pastoralism is best illustrated by the findings of the effects of the 2010 – 2011 rainfall deficit in Uganda. Of the total loss to the GDP of USD 1,174.1, the livestock sector lost USD 473 or 40% of the total.

The country's policy makers from the President all think that sedentarisation of pastoralists will deliver more economic benefits than allowing mobility. Even when the effects of 2016 droughts are still clear to us and it was evident that more livestock died in sedentary communities in the western and central parts of the country than in the northwestern part where livestock moved, the truth is swept below the carpet and sedentarisation is the dominant message.

Provision of public sector services needs to be boosted in the dry lands continues to be poor. Schools and health units need to be tailored to the mobile life system so as to attract and retain students and patients respectively.

Data on livestock continues to be scanty and unreliable which provides government a convenient excuse for allocation of little resources for the livestock sector.

Proposed solutions for harmonious coexistence between pastoralists and other communities which whom they share natural resources.

The National Land Policy of 2013 proposed interventions that would lead to restitution of pastoralists lost lands. These are supported by other interventions like the Voluntary Guidelines on Responsible Governance of Tenure of Land, Fisheries and Forests in the Context of Food Security (VGGT) and therefore the sooner they are implemented, the better for pastoralists' livelihoods.

Climate change mitigation measures including building resilience for pastoralists like increasing water for production in the dry lands and planting pasture seed especially in the degraded areas so as to ensure more water and pasture during the droughts and minimise losses in the sector should also be given prominence.

Government and other stakeholders like the African Union Interafrican Bureau for Animal Resource (*AU-IBAR*) of the African Union must implement measures that ensure that reliable livestock statistics are available on a regular basis. Only then can evidence based advocacy be made and the sector receives the equitable share of public resources.

Government needs to accelerate the process of finalising the National Rangelands Management and Pastoralism Policy. The draft policy provides on regulation of access to the dry lands of the country accepting pastoralists as the prime users of the resources while admitting that alternative users also have rights. This is meant to preemptively address possible conflicts in resource use.

CONCLUSION

Uganda has a lot of opportunities to benefit from its livestock industry that is dominated by the pastoralist producers. There is however, urgent need to recognise the benefits that the sector renders to the economy and proportionately provide resources to meet the social and economic needs of the pastoralists. Issues like mobility, pasture and water need urgent attention with government realizing that mobility in pastoralism is a strategic decision to optimize randomly available resources and not a luxury. As mobility is looked at, it should be from both internal and cross border perspectives given that all the five neighbours of Uganda have pastoralist communities that cut across the borders.

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Multifunctionality of livestock to support plain-mountain complementarities. The Fricato case study in the french mediterranean area

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GASL

As a result of the public policies and agricultural development models imposed during the second half of the 20th century, there are contrasting sides to the Mediterranean territories in France: intensive monoculture on the plains or lowlands, viticulture in the coastal zone, and a neglected inland area, where pastoral livestock farming is the basis for an economic and social activity. Today, this model has reached a point of exhaustion. In the coastal peri-urban zones, abandoned and uncultivated land is expanding, as a result of the successive campaigns to grub up vines, and the severe land pressure. This abandoned land can cover 40% of the territory, as in Claira (on the edge of Perpignan, Pyrénées Orientales). In the piedmont areas, small family agriculture is in constant regression. This leads to a closing up of rangeland and woodland, making it increasingly difficult to maintain agricultural activities in these spaces. Territories in both the plains and piedmont areas are under threat, leaving us with the question: *Could abandoned peri-urban land become a resource at regional level, to strengthen synergies between pastoral farming in piedmont areas and diversified agriculture in the on the plains?*

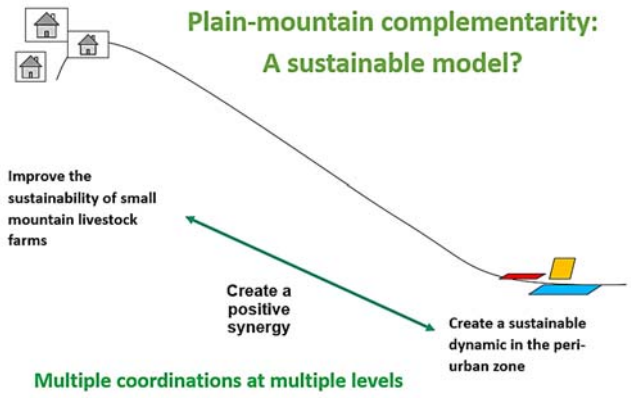


***Figure 1**. Plain-mountain complementarity: a stake in increasing the sustainability of activities and territories?*

The Fricato project for plain-mountain complementarity[3] allows reflection on the sustainability of the activities and territories, while improving the efficiency of pastoral livestock farming in piedmont areas and renewing agricultural models on the coastal plain. It is part of a collective drive to encourage cooperation at regional level between different territories and activities. It received support from the French Ministry of Agriculture (Casdar MCEA[3] call for proposals 2013), under the "agro-ecological project for France" framework (Le Foll, 2012).

[3] Hunting and Nature Trust

Most approaches for the integration of agriculture and livestock farming that have been studied involve either private situations between (geographically close or distant) crop or cereal farmers and livestock farmers, reorganisation projects between farms to connect crop and livestock systems, or neighbouring farmers sharing their land to better manage rotations via crop diversity (M.Mohammed, 2015, Couturier et al, 2016, Thérond, 2016; Moraine, 2016; Duru et al, 2015, RMT Spyce). The Fricato project stands out because of its ambition to co-design collective action, in order to resolve the double problem of abandoned, uncultivated land on the plains and of maintaining pastoral farming in the mountains. The multifunctionality of livestock farming lies at the heart of the project. It must meet the expectations of local stakeholders on the plain, and those of livestock stakeholders in the mountains. Pastoral farming is an essential component of this complex system, which must build connections between contrasting territories and satisfy the diverse concerns and expectations of the stakeholders.

This text aims to analyse and learn from this innovative project. We will examine the multifunctionality of livestock farming via the concerns and perceived stakes for the actors affected by the project, both on the plains and in the piedmont area. We will describe the origins of the project and its current operation, and identify its strengths and weaknesses. In the discussion, we will return to the issue of livestock farming multifunctionality.

A BRIEF OVERVIEW OF THE PROJECT

© Commune de Claira

The Fricato project aims to strengthen the synergies between coastal and inland areas, and between crop and livestock farming, to solve a double problem concerning feed autonomy of piedmont livestock farming and the revival of abandoned land on the peri-urban plain. Therefore, looking beyond the Fricato project, this is a reflection on the sustainability of activities and territories, on the level of the small region between plain and mountain.
The municipality of Claira (Pyrénées Orientales coast), has long been trying to slow the spread of abandoned land on its territory and restore agricultural diversity. In 2012, the local council contacted livestock farmers in the Canigou piedmont area. Since 2013, it has been cooperating with seven livestock farmers from the Canigou piedmont area in the Pyrenees (a 1-2 hour drive away), by building collective action supported by the Fricato project. The council provides facilitation for land access and usage issues, to encourage landowners to give livestock farmers free use of their uncultivated land. The livestock farmers cultivate this formerly neglected land, to produce feed and cereals for their animals. This project, which is seen as a challenge by lowland and mountain stakeholders, fosters collective action and mutual learning. We will examine the project in detail later in the study.

METHOD

We chose to approach our subject via a case study (Michel, 1983). We conducted comprehensive interviews (Darré, 1990, Kaufmann, 1996, Darré et al, 2004) with all the livestock farmers involved, local players on the plains (land issues facilitator, councillors, etc.) and institutional partners concerned by FRICATO (livestock farming adviser at the Pyrénées-Orientales Chamber of Agriculture, the *Maison de la Chasse et de la Nature*[3], the biology-agronomy IUT[4]). The interviews focused partly on characterising the activities of the stakeholders and on how they viewed these activities, and partly on how this project changes their activities. Via a cross-analysis of these interviews, we identified the main elements in how the actors talk about this project. This revealed both limitations and advantages. By reconstructing the origins of the project, we were able to identify the actor networks, and the initiatives and conditions that contributed to the emergence and outcomes of this experiment (Darré, 1996, Callon 2001). Participants were observed during events organised by the partners (celebratory meal held by the livestock farmers and the municipality for those concerned by the project in 2015 and 2016, reception and tour for a visiting group of wine producers from Burgundy who were interested in this project in January 2016). Finally, a student working on several examples of livestock-crop complementarity in Southeast France met Fricato partners for semi-structured interviews (Mohammed, 2015).

[4] *University Institute of Technology*

LONG-STANDING CONCERNS

Close connections between livestock farming and the landscape in the piedmont area

Working to reclaim environments and facilities: The livestock farmers settled on farms outside the family framework 10 to 30 years ago, on the Canigou piedmont area, in zones of agricultural decline and neglect. In the past, these spaces had been used for small-scale farming, but they closed up from the 1950s. Since they set up here, the livestock farmers have been progressively reopening the old fields and gardens, clearing woodland, and restoring access routes and buildings. *"I restored the meadows with my chipper. It can't be mechanised. Looking at this brushland, you wouldn't think it, but there's a huge resource, if you open it up. Back in the day, these grasslands were the gardens of the village. There are pretty terraces now, around the village. I've had nothing but positive feedback." (B.V., livestock farmer, May 2015).* This work to clear and open the land, as difficult as it may be, is crucial for livestock farming. Each meadow re-opened provides more pasture for the herd, in addition to the rangeland, and sometimes, when the land can be irrigated, it provides some hay for the winter. The herds are moved (transhumance) to graze in the Canigou mountain pastures in summer. This keeps the grass short, reducing the risk of avalanches. In the piedmont area, grazing therefore provides essential maintenance for environmental diversity. The network of environments gives value to the landscape of the Canigou territory. These landscapes, which are closely intertwined with pastoral activities, are harnessed as a regional tourist attraction by local players. For example the Catalan Pyrenees regional park was officially recognised in 2004, and Canigou was recognised as a major tourist site (*Grand Site*) in 2012.

***A delicate balance*:** The seven sheep farmers involved in the project have small flocks (100 to 200 sheep). They have no (or very little) arable land on their holdings. They feed their animals by grazing (woods, moors, natural meadows), except in winter (Annex 1). It is a frugal system, aiming to manage their flocks in a way that is compatible with the available territory, to limit inputs (flock numbers and management). *"It will always be a small flock, because the land is dry here. Feed resources are limited. I have to work according to my environment, as far as possible. For the rangeland I have, I need to keep numbers no higher than about 120" (G.D., livestock farmer, May 2015).* However, these small flocks provide little economic margin. It is a delicate balance.

Livestock farmers' motivations to participate in a project for plain-mountain complementarity

<u>Reducing winter feed costs</u>: The increase in feed prices since 2008 is a drain on the income of livestock farmers. Limiting winter feed costs is crucial for the sustainability of their farming activity. Having arable land on the plains is one way of producing the feed and cereals they need for winter.

<u>Building a new agriculture</u>: *"I'm sick of being caught between a feed trader who provides everything and a slaughterer set up in the mountains. The person who takes over the land doesn't have to worry about how to bring in grass. We leave them shares in the SARL, and they don't need to invest in any equipment. CUMA and SARL[3] can help them take over the farms. When we go, either the young people take over, or it all collapses. If nothing is in place for when we leave, it's over.*" (J.T., livestock farmer, May 2015). In this context, Fricato assists farm set-up in the piedmont area. The SARL is an organisational innovation, which could facilitate the takeover of piedmont farms without cultivable land.

<u>Thinking collectively and rising to the challenge</u>: *"There are several of us with the same interests. It's a good idea to build something together."* (C.B., livestock farmer, May 2015). The SARL becomes a framework to encourage exchange between peers. In this case, the peers are the livestock farmers concerned, who recognise and describe themselves as "*small piedmont sheep farmers outside the family framework*." The Fricato project gives them clear collective meaning and recognition.

[3] *CUMA: Agricultural Equipment User Cooperative. SARL: Limited Liability Company*

The question of resuming cultivation on abandoned land on the plains to produce feed for mountain livestock farmers has been under debate for a long time in agricultural and livestock farming networks: *"We've been talking about the idea of using this uncultivated land for 20 years. Fricato is the first example of a collective project. It's the first full-scale test." (*A.R., livestock farming adviser at the PO Chamber of Agriculture, January 2017*). "Being a collective meant we could go for it. Alone, it was impossible" (G.D., livestock farmer, May 2015).*

Piedmont livestock farming multifunctionality in brief: gradually, the livestock farmers have restored agricultural value to the farmland, but also enhanced the local landscape…. They help to maintain agricultural, economic, social and tourist activity in the piedmont area. The utility of this dynamic goes beyond their farming activity alone. However, it is a delicate balance. It is important to make these farms more sustainable, both for the farmers and for society in these piedmont territories.

The inexorable spread of abandoned land on the plains

The successive campaigns to grub up vines have allowed the spread of uncultivated wasteland in these coastal zones where land pressure is severe. In Claira, this land covers 40% of the territory. The growth of these areas, the biodiversity loss and the negative image surrounding them are all recurring concerns for stakeholders in the plains.

The ACCA[1] hunters and the technicians from the Maison de la Chasse et de la Nature are critical about biodiversity loss in Claira. Since 1990, they have made various attempts to reintroduce islands of biodiversity (local planting schemes, introduction of species, etc.).

The Pyrénées-Orientales viticulture advisor complains about the loss of agricultural land: *"We've lost 40% of our agricultural surface in 15 years. To maintain an agricultural sector in Pyrénées-Orientales, we would need to plant 1000 ha per year. Only 300 ha are replanted each year. It's vital that we avoid losing farmland, either by diversifying crops, or by using agro-ecological techniques."* (25/01/2016).

Claira's councillors dislike the image that this neglected land gives to the community: *"We are the gateway to the department. The first thing that people see in Pyrénées-Orientales on their way to the sea is abandoned land and illegal dumps…."* (Mayor of Claira, 25/01/16). They are worried about the fire hazard. They are looking for ways to revitalise their territory, diversify agriculture and find solutions that work with the local conditions. In a proactive step, they collaborated with the Perpignan IUT[1] to conduct a territorial analysis in 2008. This showed that abandoned land made up 40% of the territory. In response to this observation, the local authorities hired a land issues facilitator in 2010. Her role is to encourage and support agricultural diversification in Claira, *"by finding little niches"* involving products, adapted varieties, and suitable commercial circuits, and by harnessing all the available contributors and resources.

There have been various actions since 2008, in partnership with numerous actors and institutions[1]: trials involving medicinal plants, and plantation trials for 15 varieties of trees tested on 8000 m², including pomegranate, pecan, almond and rubber trees (guayule). A mill has been restored, and 4 ha of land have been replanted with old breadmaking varieties (10 varieties, including "Barbu du Roussillon" wheat). The municipality is working to increase residents' knowledge and awareness about this initiative, and aims to create a local dynamic, so that landowners can be encouraged to allow use of their uncultivated land.

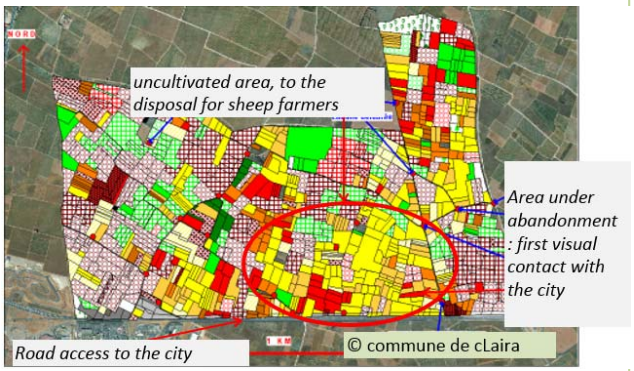
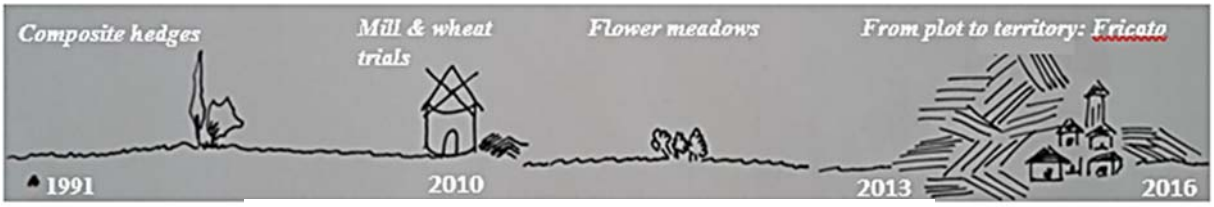


Figure 2*. The northern part of Claira*

In short, in terms of multifunctionality, the concerns for stakeholders in Claira are:

- Maintaining an agricultural sector in the area, and preserving agricultural land
- Relaunching diversified agriculture with suitably adapted value chains
- Harnessing uncultivated land for agro-ecological schemes.

[1] ACCA: Approved Communal Hunting Association
[4] Perpignan University Institute of Biology and Agronomy
[5] The municipality, the agronomy-biology IUT, the Cirad (French Agricultural Research Centre for International Development), the Maison de la Chasse de la Nature (Hunting and Nature Trust), etc



To see what the stakeholders say (in French), follow the links below:

Video from the specialist agriculture site "pleinchamp.com", by agricultural journalist Raphaël Lecocq: http://www.pleinchamp.com/vigne-vin/actualites/du-vin-aux-ovins-ou-comment-reconvertir-des-friches-viticoles-en-cultures-fourrageres

Two videos from the French Ministry of Agriculture: Full version: www.lacledeschampsfleuris.fr; Short version: http://agriculture.gouv.fr/de-lautonomie-alimentaire-pour-les-troupeaux-sur-les-terres-dune-commune

A CONVERGENCE OF DIFFERENT INTERESTS TO PROMOTE PLAIN-MOUNTAIN COMPLEMENTARITIES

The Fricato project for plain-mountain complementarity

The Fricato project was initially driven by local stakeholders on the plain. In 2013, they made an offer to the Canigou piedmont ovine farming cooperative: to make land that was uncultivated (and sometimes had been for 20 years) available to livestock farmers free of charge, so that they could recultivate it using agro-biological techniques. Seven piedmont sheep farmers (located 1 to 2 hours' drive from Claira) joined the project. Finding land to grow feed allowed them to improve their autonomy in feeding their flocks.

Thanks to the work of the land issues facilitator, the total uncultivated area available to the livestock farmers increased from 33 ha in 2013 to 70 ha in 2016. The local authorities paid for the recultivation of the first 33 ha (650 to 950 euros per hectare). The livestock farmers were responsible for funding recultivation on the remaining hectares. Most of the land was made available for one year (free loan). In 2016, the livestock farmers were given a 5-year lease, for around 30 ha (necessary to obtain MAE[6] aid).

The recultivation of old, unused vineyards, with a transition towards organic farming, requires specific know-how and expertise. The livestock farmers had to learn about growing crops: a new skill for them. They received mentoring from a cereal farmer from Aude, funded for 3 years by the Claira council. They set up crop rotations to produce feed in the form of legumes, cereals (barley, meslin) and straw. The feed and cereals are transported to their livestock farm to feed their animals in winter. Whether it is in the lowlands or the mountains, storing feed and cereals is problematic.

Those involved (livestock farmers, hunters, crop farmers, municipality, etc.) use the crop selection and work periods to discuss and help each other. 10% of the recultivated land is allocated to encouraging biodiversity. In cooperation with the municipality, the hunters, and the *Maison de la Chasse de la Nature*, flower strips are planted in certain areas, to create islands of biodiversity.

The livestock farmers formed a **SARL** in 2014. It receives aid under the CAP[7], to farm land on the plains. This funding is invested to cultivate land in Claira. (5 years?). The livestock farmers have no farming and harvesting materials. They primarily rely on service providers to recultivate the abandoned land and harvest the crops. However, the scattered nature of the plots, their small size (3000 m² on average) and the poor quality of the land (heavy, stony soil), mean that using the services of agricultural entrepreneurs is an impractical solution.

Eventually, in 2016, the livestock farmers formed a **CUMA**[8]. They bought two tractors and harvesting equipment so that they could grow and harvest the crops themselves. The Fricato project obtained **GIEE**[9] status in December 2015. It was also a winner in the 2016-2017 Agro-Ecology Awards (see link to French Ministry of Agriculture website, op. cit.).

Finally, the Fricato project brings together numerous players. These include the Chamber of Agriculture, the ACCA, the *Maison de la Chasse de la Nature*, the biology-agronomy IUT, the BIOCIVAM[10], the DRAAF[11], landowners, local farmers and piedmont livestock farmers.

[6] *MAE: Agricultural Environmental Measures*
[7] *CAP: Common Agricultural Policy*
[8] *CUMA: Agricultural Equipment User Cooperative*
[9] *GIEE: Economic and Environmental Interest Group*
[10] *BIOCIVAM: Organic-focussed Initiatives Centre for the Promotion of Agriculture in Rural Environments*
[11] *DRAAF: Regional Department for Food, Agriculture and the Forest*

Lessons from the first years

Many lessons and positives

A successful land access dynamic: Since 2013, the amount of land made available to the livestock farmers has been constantly increasing. The success of the project in Claira has generated interest among other communities and landowners. The region can learn much from this pilot project.

On the plains, the agro-ecological transition is clear and significant. This transition concerns the conversion and revival of both the plots (nature of species, technical itinerary for organic farming) and the plains territory as a whole (a way of combining diverse crops to encourage biodiversity). This project to resume cultivation on abandoned land using agro-ecological techniques gives new agronomic value to the plots, and enhances the value of the local environment and landscape. It opens the way towards new agricultural models. In 2015, the local facilitator wrote: *"This project gives new life and hope to forgotten and abandoned crops, feed types and cereals. In the future, I think that this project could encourage farmers on the plains to diversify, and perhaps even work in a complementary way with livestock farmers. For now, this project is in its early days and is proving successful. (…). It doesn't try to revolutionise lowland agriculture or livestock farming, but today, agricultural models are showing their limitations, and this pilot project could be an unexpected model, because it is driven by regional players and not by the economy (or in any case not directly), and because it comes out of a real need and is adapted to the local context. It is a project that is destined to develop and evolve, for the local livestock and crop farmers, and for everyone involved."*

Consolidating the flock grazing and feeding calender. To be sustainable, the system used must provide ways to improve the operation and technical-economic results of pastoral farming in the mountains. The analysis of the Fricato project shows that with the production of feed and cereals on the plains, the livestock farmers find different ways of organising the grazing and feeding calendars for their flocks. The best natural meadows available to livestock farmers in the piedmont area will no longer be reserved for cutting. They will be grazed in spring by mother ewes, as a complement to the rangeland. Until now, most of the livestock farmers have not given commercial food to their sheep. They want to use the cereals produced in Claira to supplement food supplies during lambing. These changing practices (grazing management and supplementary feed) will improve the nutrition of the sheep early on in lambing season, supporting their lactation and helping the lambs to grow faster.

Beyond improving feed autonomy, the ability to control the quality of the food given to the flock suits the farmers' perceptions of their profession. The recognition surrounding the Fricato collective action gives legitimacy to their search for an agricultural model for small-scale pastoral farming in the mountains.

A project that changes how livestock farmers see the role of their activities. For pastoral livestock farmers, the multifunctionality of pastoralism with regard to the mountain territories where they have settled is obvious *("I've had nothing but positive feedback"* (op. cit.)). The Fricato project has given them a broader perception of the multifunctionality of their activity. They are becoming open to new dimensions, in connection with what their activity can offer to peri-urban areas far from the plains. *"Initially, I didn't consider the territorial project, the pilot experiment. Now, I'm very proud of it: we have photos showing that the fire in Claira stopped at our crops."* (G.L., livestock farmer who joined the project in 2016, speaking in January 2017).

Establishment of a collective dynamic on the plains between the various stakeholders, livestock farmers and landowners, hunters, councillors, and the people of Claira. The livestock farmers' lack of experience and the image surrounding small livestock farming in the Pyrénées-Orientales mountains creates solidarity and sympathy for this project, among the many stakeholders (from landowners to ordinary citizens).

Knowledge for the "scaling" of collective projects for plain-mountain complementarity. Based on these first years, those involved have drafted a model for a collective entity: around a hundred hectares gives winter cereal and feed autonomy to 5 to 7 small piedmont pastoral farmers (100 to 200 sheep). This format seems compatible with the governance of collective action by the livestock farmers, to cultivate land on the plains. However, a hundred hectares may not be enough to balance out the costs of equipment and land issue facilitation (see below).

There are several difficulties when it comes to consolidating this kind of project:

Organising the work is very difficult. Firstly, this concerns the organisation of work at farm level. The livestock farmers are often alone on their land. In certain periods, particularly spring, they are forced to juggle the demands of their livestock farming and their work in Claira. For livestock farmers, this lambing and early suckling period is crucial, and

has a big impact on lamb production. It is also a crucial period for successful cultivation on the plains. The SARL can provide some solutions. Working as a collective means they can organise the distribution of work in Claira. The SARL manager's coordination of the livestock farmers' collective is a hard job, but it is vital to the project.

Setting up farm facilities to support farmers' participation in the project. To free up time, particularly in spring, livestock farmers need to be able to put their flock in paddocks, and therefore need a few enclosed plots. They must be equipped with a silo to protect the cereals produced in Claira from rodents. However, little consideration was given to this aspect at the start of the pilot project, especially as Casdar funding must essentially go towards organisation and facilitation. Learning from the experience of this pilot project, it seems necessary to take into account these dimensions from the design phase of a complementarity project.

Good equipment: After three years of the pilot, it became apparent that farming and harvesting equipment needed to be acquired for those involved. Via the CUMA, the livestock farmers invested in this equipment, subsidised to a level of 40%. However, with 60% of the investment left to pay, they took out a loan. This investment, without which the project cannot continue, is a heavy burden for small mountain farmers. Moreover, the productivity gain is very slow for the abandoned ex-vineyards that they have taken over.

Access to aid: The conditions for setting up this kind of project are not always compatible with the conditions for obtaining CAP aid. To access MAE-bio aid for organic agro-environmental measures, they need property rights of 5 years or more, which is not the case for all the recultivated plots in Claira. Moreover, certain piedmont pastoral zones (moors – woodland) are not recognised as grasslands that help to feed the flock, thus restricting this aid to open natural meadows alone. The specific characteristics of recultivating abandoned land on the plains, such as grazing in rangeland and woodland within piedmont areas, make it difficult for innovative collective actions for plain-mountain complementarity to qualify for CAP aid for the land. To support this kind of project, aid schemes need to do more to accommodate a multifunctional vision of agriculture.

Property rights to enhance the value of recultivation: Recultivation takes a lot of work and money (650 to 950 euros/ha on average, estimated based on the cost of the first 33 ha). It takes several years to restore the economic potential of this degraded land. The current short duration of property rights (1 to 5 years) is an obstacle. The livestock farmers think that 7 to 10 years would be an acceptable compromise, to restore the agronomic value of the land and truly benefit from this redevelopment.

The need for land issue facilitation in this type of project: The average size of the plots is 3000 m². In 2016, the 70 ha of recultivated land was shared between 75 owners. Land issue facilitation must be continued, to encourage owners to make their uncultivated land available, and to manage a portfolio of hectares over time (Clément et al, 2018). Local facilitation, by someone who is familiar with the area and the various stakeholders in the plains, is indispensable when it comes to implementing this kind of project and running it in the long term. How can this facilitation be continued? The small community of Claira (with a population of 4000) invested in this facilitation for 3 years to launch the project, but the scope of this kind of position would need to be broadened. For example, it could be envisaged on another level, in connection with an intercommunal approach. Finally, the spatial entities to which the policies apply often disconnect plain, mountain and piedmont territories, which can be detrimental for this kind of project.

FROM THE FRICATO MODEL TO ITS INTEGRATION IN A TERRITORIAL DYNAMIC: DEVISING A REGIONAL MODEL

This collective action opens up innovative possibilities for dealing with a double challenge: firstly, the emerging acceptability of diversified agriculture on the plains and in peri-urban zones, and secondly the maintenance of family pastoral farming in piedmont areas.

Based on the first years of implementation, *it is possible to draft the format for a livestock – crop farming integration model*. A format involving 5 to 7 livestock farmers, with 120 to 200 sheep per holding, and who have around 100 ha, would be compatible with the governance of the SARL by the livestock farmers and with the objective of feed autonomy for the SARL flocks. However, this scale (100 ha) alone is not enough to justify a employing a land issues facilitator for the plains. As suggested by those involved, it might be possible to share the facilitator on a bigger scale, within a community of communes or a metropolitan area, like Nantes Métropole for example (Perrin et al, 2018). In such a model, the facilitator would be in contact with several livestock farmer SARLs, from different mountain territories, cultivating land portfolios on the plains.

The question remains open, with possibilities on a regional scale… The livestock farming adviser indicates that this kind of project would concern 60 to 80 small piedmont holdings without arable land. OG, livestock farmer, SARL manager, and AFP GP[12] administrator reflects on the possible scope of this kind of project in the department:

"With an extra 1000 ha of feed, the local livestock farmers would be autonomous in their department. There are over 10,000 ha of abandoned land in the department." (May 2015).

This type of project can be a solution for supporting livestock farming in piedmont areas. It allows "small" farms without arable land to cultivate their own feed, so that they are not dependent on fluctuating market prices and can produce organic feed and cereals to get quality produce… in line with the agricultural model to which they wish to contribute.

On the scale of a department like Pyrénées-Orientales, this model of plain-mountain complementarity seems like an interesting solution to support activity in piedmont areas and to add value to the lowland plains. Many of the unknowns from the start of this project are now resolved: the possibility of finding land on the plains, of forming a positive dynamic, of producing feed and cereals, etc. Others persist, such as investment for equipment, visibility regarding the duration, and access to aid. The Fricato project has received support from the Ministry of Agriculture, mainly for the organisational and facilitation aspects. These are important issues. However, in the case of the Fricato project, where livestock farmers are responsible for cultivation, but do not have the necessary equipment, it seems that the purchase of materials and equipment is essential for the success of the project. This leaves us with the question of how the farmers might acquire this equipment, which is useful to everyone (to the livestock farmers for feed production, and to actors on the plain so that their uncultivated land can be cultivated again). Who should be responsible for these investments? In the launch phase of such project, should some of the support be used to fund the purchase of equipment? There are several possibilities, including "over-funding" of investments and facilitated access to aid portfolios.

The numbers of proposals to make land available are increasing. It therefore seems that the crop-livestock complementarity principle could usefully be replicated in the department and the region. The question of the equipment needed to recultivate the land requires careful consideration. It might create competition for the granting of these lands between piedmont pastoral farmers (like those in the Fricato project) and farmers in neighbouring crop-livestock polyculture regions, who already have their equipment. In this case, the perspective of cultivating land on the plains could not help to maintain a pastoral activity in the piedmont area. It is undoubtedly easier for a territorial authority on the plains and for landowners to make contracts with farmers who already possess mixed crop-livestock holdings, and therefore already have the equipment and knowledge to grow crops. The plains provide these farmers with ways of producing more feed, so that they can have more animals in their herds.

In the Fricato project, the model is entirely different. It seeks to support pastoral activity for livestock farmers in the piedmont area, who are threatened by the lack of cultivable land. Without a solution to improve their income by reducing costs, pastoral activity in the piedmont area is struggling, and territories are at risk of closure.

Of course, this is not about opposition between models of complementarity seen through the filter of the actors concerned ("mixed crop-livestock farming – plains agriculture" complementarity, versus "small mountain pastoral farming – plains agriculture" complementarity). Given the extent of land abandonment in the lowland viticulture zones, as in Pyrénées-Orientales, we could undoubtedly envisage a regional coexistence of these models of livestock-crop complementarity. *Here, we wish to emphasise the differences between these two schemas, in terms of territorial development at regional level.*

It is useful at this point to bring in the concept of a common good (Orstrom 1990; NSS, 2012). In the case of plain – mountain complementarity with a double objective, the activity of piedmont pastoral farmers might be considered a common good. The benefits of their work extend beyond their activity and can be appreciated by society as a whole (for example: production and protection of landscapes promoted by local labels, maintenance of social activities in these territories, the mutual enhancement of different geographical zones in the department, etc.).

The move from the model to its integration within a territorial dynamic goes beyond sectoral questions, and also brings in political factors: Which projects are suited to which territories? For plain and piedmont areas?

Ultimately, there is a political choice to be made, on the national, regional and local levels. For the plain – mountain complementarity system to work and be sustainable, with the dual objective of relaunching diversified agriculture on the plains and supporting pastoral activity in piedmont areas, it is necessary to consider, from the start of the project,

[12] *AFP GP: Pyrénées-Orientales Pastoral Land and Pastoral Groups Association*

the conditions that are indispensable for its success, by integrating the two functional entities: the plains and the mountains. In other words, these land rehabilitation projects are often led by stakeholders from the peri-urban plains. These project leaders mostly focus on the plains (the constraints to overcome, the means required, the organisation to federate, etc.). However, the schema here is not one of providing an environmental service. We are trying to create resource synergies between distant and contrasting rural and peri-urban territories. The system must be based on a consideration of the conditions that support activities in both territorial entities. Crucially, this means that the reflections underlying these projects must also take into account what happens in the mountains and in small piedmont farms (the conditions required to allow livestock farmers to participate).

CONCLUSION

Creating synergies between the plains and the mountains to support agricultural activities and agro-ecological transitions in these contrasting territories is a difficult task. The Fricato pilot project shows that this kind of initiative could be sustainable, and that it meets the different needs expressed by the diverse stakeholders. This form of multifunctionality is based on re-establishing connections between the coast and inland areas, and between rural and peri-urban zones. It is defined by a set of technical, economic, environmental and social expectations and dimensions. These dimensions must be taken into account in a complex system that allows them to be combined in a coordinated way, and allows collaborative management of interactions. The Fricato project shows that a joint collective action initiative can be introduced and can work. However, the analysis of the first years of operation shows weaknesses that might jeopardise the success of this kind of project. The questions of facilitation for land access and land issues on the plains, of equipment needs, of property rights and finally of the conditions for accessing agricultural support are major limitations. The resolution of most of these problems is not solely down to those concerned within the scope of the project. They must also be approached on other levels, bringing in other actors and institutions. This case study demonstrates the invention of new agricultural models, and renewed solidarity between territories at regional level. The transition from the pilot development project to the creation of plain-mountain complementarity projects raises the issue of political support for projects of this kind, and the measures provided to support their emergence.

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Livestock farming and territory permanent seminar: http://umr-selmet.cirad.fr/seminaires/seminaire-permanent-elevage-et-territoires/presentation

ANNEX 1: PASTORAL LIVESTOCK FARMING IN THE PIEDMONT AREA: KEY CHARACTERISTICS

The sheep farmers participating in the Fricato project have their holdings in the Canigou piedmont area, at an altitude of 500 to 1400 meters, in neglected zones between the valley and summer pastures. The set-up is based on a heavy investment in terms of work, but very little capital investment. They often have very little equipment and materials. Their flock size is small (100-150 sheep). The available surfaces are essentially pastoral (moors – woodland), sometimes with a few natural meadows on the moors.

- 100 to 200 sheep
- 80 to 150 ha, essentially pastoral land and woodland.
- 0 to 15 ha of natural meadows
- 1 labor unit
- Little material and equipment on the farm
- Little land owned
- Annual hay requirement:
- Annual grain requirement:

The flock is mostly fed by pasture grazing from April to December.
Lambing season takes place in late spring, so that the flock's production period coincides with the grass growth period. The lambs are weaned in early summer, before the ewes go out to graze in summer pastures. Since the sheep farmer has little land suitable for cutting or crops, most of the winter feed (hay) given to the sheep and the additional feed given to the lambs (hay and grain) is bought.

Example flock management calendar

					Lambing				Sale of lambs			
Month	**10**	**11**	**12**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**9**	
										Summer pasture		
Woodland-moors	Moors Woodland		Chestnuts		Rangeland (leaves)			Moors Woodland				
Meadows	Move to meadows						Move to meadows					
Hay			Hay 1 meal		Hay: 2 meals		1 meal					

NB 1: Putting sheep out to graze pastures from January to March as indicated here is only possible if there is no snow.

NB 2: Not all holdings have cut meadows.

For further information: typical meat sheep scenario "Ovin viande en reconquête pastorale" 2014-2015 situation- reference collection- INOSYS livestock farming networks. 8p.

Andean mutual breeding, multifunctional services and pastoral strategies against drought in the Argentine Puna Grasslands

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GASL

INTRODUCTION

Current debates about multifunctional pastoral systems in the drylands of the world have great importance in facing climate change that leads to longer and more severe droughts, increased temperatures, and changes in rainfall, among other phenomena in arid or desert areas. There are different dynamics and pastoralist processes all over the world. Let's take for example the situation in the European Union, where shepherds are seen as economic agents that produce high-quality food and that play an important role in the conservation of the environment (Tchakerian, 2008; Charbonnier, 2012). Their flocks, herds, and territories are subsidized in order to promote the occupation of rural areas, to enhance their popularity and support, to foster local identity, as well as improve conservation of landscapes. On the contrary, in Argentina, the shepherds that live in areas not suitable for agriculture, located in the vast national area representing the Argentine arid diagonal, are considered responsible for so-called anthropic phenomena of desertification (Quiroga Mendiola, 2013). We propose in this paper to question this assessment, by highlighting the main aspects of multifunctional-service pastoralism, especially in coping with periods of prolonged drought. We also seek to foster dialogue through the approach of "pastoralism multifunctional services" in the Southern Andes, with a new approach to "Andean mutual breeding" based on the complete integration of natural and social systems.

MULTIFUNCTIONAL SERVICES

From the perspective of ecological economy, environmental services are a kind of interface between natural resources and economic goods, and they are directly or indirectly provided.

Direct or indirect services can be described as: 1) provision services (of firewood, water, etc.); 2) regulation services (temperature or humidity regulation, waste processing, etc.); 3) support services (recycling of nutrients, pollination, biodiversity maintenance, erosion control, etc.); and 4) cultural services (esthetic values, identity, tourism, etc.) (Penna y Cristeche, 2008).

In their conceptual review, Viglizzo and collaborators (2010) say that environmental goods can be thought of as capital (an economic asset), and services can be seen as the return on investment, or in other words, interest generated by the capital. Services are the result of ecological functions, which in turn come from the ecological capital of the ecosystem. These authors propose that the biomass and the water volume existing inside an ecosystem are good parameters of the existing stock, and they allow assessment of the Functional Value of certain ecosystems or landscapes. Therefore, the Net Area Primary Production is a valid way to estimate the ecological services provided by the system.

Such approaches are very useful for reformulating the calculations made when estimating efficiency of the production systems, that is to say: adding those other elements called "externalities", which are rarely taken into account.

Pastoralism is a multifunctional system of for-profit extensive livestock production. Ragkos and Nori (2016) consider as Pastoralist Multifunctional Services, both running direct services of productive activity: providing food, wool, leather; as well as a number of other ecosystem and cultural services, direct or indirect, to generate income, or not.

Among its many services (sometimes called "externalities") are: the maintenance of productive rural lands; the high quality of the food produced (without agrochemicals nor animal confinement); the preservation of biodiversity; creating employment; the protection of watershed areas and wetlands; the preservation of genetic resources (such as indigenous breeds). All that together with the preservation of cultural resources such as indigenous languages, ancestral practices and knowledge; territory occupation and the maintenance of the diversity of natural grasslands (Ragkos y Nori, 2016).

These attempts to measure, quantify and evaluate healthy water and air, or the beauty of the landscape, for example, are the basis for valid arguments to protect watershed areas, wetlands, the soil and the air. However, the perpetual view of nature and humans as separate beings, disconnected from each other, seems to live on, as if they were not an integral part of the same natural and cultural ecosystem.

In many non-hegemonic cultures, we can find conceptual approaches that provide new ways of understanding and looking at the dynamics of the world.

LA CRIANZA ANDINA

Despite the long history of domination, and the relentless attempts to suppress indigenous languages and native cultures, in the southern Andes a way of life that considers relations as a "conversation" and "mutual breeding" has managed to survive. This more inter-dependent approach has survived to greater and lesser degrees in the different regions and countries of South America (Rengifo Vazquez, 2003).

In this context, for the herding families, livestock-breeding or animal husbandry means taking care of, feeding, suckling, giving affection, singing, and providing shelter, protecting, talking to, and growing fond of the animals in their care. Mutual breeding is not one-way, it is not an action taken by an active being and imposed on a passive being, but rather a non-hierarchical conversation. It is a service relationship between equal beings that carry on a conversation

The concept and term "chakra" (which means a breeding place in "quechua" language), is actually used in agronomic words to indicate a plot of land, a vegetable plot, or for crops. Nevertheless, depending on the level of "castellanización" (meaning the degree to which the indigenous languages have been replaced with Spanish), the word "chakra" means: a plot of crops, the hearth or the home, and even a llama (*Lama glama*), is a "chakra" with paws. Wild and domestic plants and animals are bred by humans or they breed among each other, evolving symbiotically, a kind of co-breeding, however these interactions may also involve the mountains, wild animals and plants, and water (Rengifo Vazquez, op cit.).

Within this framework, we should reconsider the concept of food sovereignty and safety. The PRATEC researchers use the term "food self-sufficiency" to describe biodiversity breeding (in which the intentionality of sowing a vast range of plants and breeding all kinds of animals is remarkable) taking into account not only a variety of domestic and wild species, but also lakes, waterways, all living in harmony ("*vivir bonito en familia*" as "beautiful life in family") (Valladolid, 2015).

Such natural beings as stars, the moon, "cardones" (indigenous columnar cacti) and foxes (an integral part of the Andean agro-eco-system) also participate in the task of co-breeding: they give the signals for different moments of the seasonal cycle (they emit signals to trigger sowing, animal mating, and signals to start migration, etc.).

THE PASTORALISTS OF SOUTHERN ANDES

In this text, we will refer to "Andean pastoralists", meaning the livestock producers and shepherds that actually live inside the vast area, which was part of the Inca empire (Nielsen, 2009), and how they perpetuate many ancient practices and traditions.

In the Puna and dry valleys of Peru, Bolivia, Northern Chile and North-western Argentina, the Andean pastoralists breed different livestock species. The indigenous camelids are remarkable because they are exclusive to this region. They include the domestic llama (*Lama glama*) and alpaca (*Vicugna pacos*), and wild vicuña (*Vicugna vicugna*).

From the archaeological evidence, the central role played by Andean pastoralists in the social and cultural reproduction of the Andean people becomes quite obvious (Nielsen, 2012; Yacobaccio y Vilá, 2012; Yacobaccio, 2014). During the Spanish conquest, the conquerors took note of the relevance of the camelidae within the Incan territories, although later the camelidae population was drastically reduced, due to local wars (Nielsen, 2012).

The exotic species introduced by the Spanish conquerors were quickly incorporated into the indigenous agro-eco-system: domestic livestock such as sheep, goats, cattle, horses, donkeys and pigs, which were bred in the same traditional ways and rituals as the camelidae. In the Altiplano zones, sheep were mainly integrated within the llama herding systems (indeed these herders were called "llameros"), while in the dry valleys, mainly goat- and sheep-breeding were developed.

THE PUNA AND DRY VALLEY PASTORALISTS OF ARGENTINA

In this section we will make firstly a distinction between the pastoralists exclusively located in the Puna, and the agro-pastoralists of the dry valleys. Later we will provide a description of the practices and multifunctional services of both kinds of pastoralists.

The Puna Grasslands are a high-altitude flat plateau located between the Main Cordillera de los Andes and the Western Cordillera. It is an arid or semiarid territory (100 to 300 mm rainfall/year), located at 3,000 to 4,000 m above sea level. In this area, endorheic basins, forming lagoons or salt flats at its base, abound. In this zone, the vegetation is mainly steppe, where Andean pastoralist communities live, specialized in llama and sheep-breeding, although they do breed multi-species herds that may also include goats, cattle, horses and donkeys. There are exclusive pastoral systems, with subsistence-farming of small potatoes, beans, quinoa and fresh vegetable crops. This production system is part of the traditional barter-system network that permits shepherds to trade and thus procure other goods that are not produced in the highlands.

In addition, the family-based economy is usually supplemented with income and provisions from off-farm work, money sent by family-members who have migrated to regional or capital cities ("remesas" or "remittances"). These incomes also can be state subsidies.

On the other hand, the dry valleys of the Cordillera Oriental is the first orographic mountainous barrier for moisture coming from the East (the Atlantic coast and Brazil), causing heavy rainfall (up to 4,000 mm/year) on its Eastern exposed slopes. As a result of this, there is an area of lush plant growth called the Yunga, or mountain jungle, whose last and highest-altitude vegetation level is the high natural grasslands on top of the mountains, which are used for livestock grazing. In these steep and rugged valleys live herding families whose main crops are corn, potatoes, alfalfa, beans and peas, supplemented by breeding goats and sheep in the high mountains, and who breed cattle with seasonal migration practices alternating between the jungle and the highland grasslands (Quiroga Mendiola, 2004).

Both in the Puna Grasslands and the western Cordillera Oriental great importance is attached to the animal mobility to ensure the flocks' well-being, by ensuring regular access to sufficient grasslands and water resources, both in quality and in quantity, accompanied by the shepherds.

Although there is a process of sedentarisation, modernization and outsourcing of production activities, it is still common for the shepherd to go daily accompanying the flocks to the grazing sites.

MULTIFUNCTIONAL SERVICES IN THE HIGH MOUNTAINS OF NORTH-WESTERN ARGENTINA

These descriptions allow us to better understand the Puna pastoralist's ways of doing and being in the world.

Although it has been strength cultural erosion in the Puna of Argentina, it can be observed many practices and concepts that refer to the Andean cosmovision of Nature.

Firstly, there are the obviously directly marketable multifunctional services, in other words items that can be bartered: meat and milk produced on natural grasslands, free of agrochemicals and animal suffering; wool (fleece or hand-spun) sometimes dyed with natural dyes; and even "*guano*" (manure) production as a scarcely-quantified and valued good, but which plays a very substantial role in the local agricultural ecosystems. The *guano* is used as fertilizer for the shepherds' peri-domestic subsistence crops, or more frequently, it is sold or traded with the agricultural or agro-pastoralist producers of the lower lands. These direct goods and services circulate in the communities by means of consumption, barter or sale, sustaining a social framework that strengthens the resilience of pastoral communities, and which can be placed on the list of the multifunctional direct and non-market -interchangeable services.

The main direct and non-tradable services of pastoralism are among others: carbon fixation, soil protection, biodiversity conservation, water infiltration, protection and preservation of ancestral knowledge, affirming identity, recreating the culture, and family maintenance.

Not only that, but it is also possible to identify indirect services that are not so easily quantifiable, such as the preservation of landscapes with potential for tourism, the preservation of waterways with potential to implant hydro-electric facilities, protection of fresh drinking water supplies, and last but not least, preservation of the wealth of knowledge about coexistence with difficult, variable, dry and cold environments that constitute a repertoire of learning opportunities on how to face climate change.

In relation to biomass, as an estimate of the Functional Services supply, proposed by Viglizzo et al., (2010), our measurements on Area Net Primary Productivity in the different Puna environments, as well as on the functional variations of native vegetation in relation to grazing pressure, show how herders manage to balance the fluctuating links between vegetation, climate and grazing (Quiroga Mendiola 2015b; Quiroga Mendiola et al., in revision).

Mobile pastoral practices, which flexibly distribute the use of vegetation across the various spaces and over time, show a complex set of pastoralists' knowledge of the agro-ecosystem. The shepherds interact to carry out their annual and multi-year decisions, minimizing the loss of natural goods that allow them to live in the high mountains of North-western Argentina (Quiroga Mendiola, 2015a).

ANDEAN BREEDING IN MOUNTAINS IN THE NORTH-WESTERN ARGENTINE

The studies on the Puna culture in Northwest Argentina have presented different contributions throughout the twentieth century, including identifying ceremonies or rituals associated with the initiation of everyday activities, be they social (construction and inauguration of a house), productive (beginning of livestock-mating and -breeding season), and/or economic (participation in a farmer's market).

In Argentina, the work of Merlino and Rabey (1978) was the first to identify and characterize constant communication between the Andean peasants and their deities through a "sober and severe dialogue" requesting protection, reproduction and abundance. These authors maintain the existence of an agrarian-ritual cycle that is also a religious-ritual cycle, in which these "dialogues" of petition and gratitude occur daily (see also Cruz, 2006; Cladera, 2013; Abeledo, 2013).

In the Southern Andes, the shepherds and livestock are considered related to each other. For example, in some places of the Argentine Puna, during the "señalada" (which consists of branding animals incorporated into livestock herds by birth or purchase), it is possible to observe the kinship between animals and people, the latter being the godparents of "the couple of the flock". A kind of marriage ceremony is held to unite the mating couple of the flock, in presence of their human godparents. In the same way the corrals are considered the home to the relatives.

The Puna people try to generate kinship or godparent links between all beings, between the animals among each other, and with the people. Also, there are propitious relationships: there are some people that have, or inherit, a certain gift, or "good luck" with some species, but not with others, in the flock. This seems to be proven throughout the breeding life of the family's children and that of the animals in the flock.

These "lucky" relationships are given by means of naming them: the flock of one member of the family is a part of the whole family herd, but on special occasions such as a birthday, marriage, or other social event, animals born are given as a gift and named after that family member. If animals do give birth and multiply the herd, they are considered to be "lucky" animals for the family member they are named after, and this person is also said to have good luck with the animals, so their offspring, called “multiplicos”, are celebrated. In this way, the beings establish a connection of prosperity (Bugallo y Tomasi, 2011).

The animals are treated with affection, they are given a name, they are spoken to, they are asked permission, they are even sung to, but it is also possible to be angry with them, and they could be rebuked and scolded, exactly the same way as with any relative (Rengifo Vazquez, op cit).

The animals are also sacrificed for sale or consumption, but this does not leave the shepherds indifferent. Before the animal is slaughtered, the shepherdess speaks within hearing of the animal selected; she apologizes to it, and thanks it for the life sacrificed, which will give life to another (Quiroga Mendiola, pers. obs.1982). Usually the animals are blindfolded before the slaughter, in order to avoid it seeing the place or the moment of its death. That allows its soul to return to the mountains and the flocks by way of new births (Nielsen, 2012).

We have observed many such examples of livestock sacrifice, and we have recorded several typical explanations of the experience, such as: “*I will not sell my animals to the truck that takes them to the slaughterhouse* (…) *it is true that a truck can move a lot of animals at once, and it would be easier, but I don´t want to do that, I cannot see my animals just before death*…” (shepherdess in Cochinoca, 2016). She preferred to slaughter her animals herself, in order to carry out the corresponding acknowledgement and farewell rituals. We have even found the breeding of animals that belonged to dead relatives, showing not necessarily only productive connections within the herder’s life. These relationships of affection are extended to all beings, including water, rocks and the climate.

The wisdom of the Andean world consists in knowing "how to raise, and how to be raised” (Kessel y Enriquez Salas, en: Bugallo y Tomasi, 2011). The animals, too, build relationships with the Pacha Mama (Mother Earth) leaving bits of wool hooked on the pastures, as a kind of payment for the food she gives them. In this way, the animals contribute to nourishing the grasslands which feed them, they form a part of the framework of conversation between beings. The herd also nourishes the people, and is nourished by them. In this world of conversations, the wild animals are also integrated (“*it is necessary to leave them something to eat* [referred to the birds which eat the crops]” (F.M. Iruya, 2005).

THE LONG DROUGHT

It is of particular interest to us to present some points related to the multi-year droughts, in order to prove a link between the ancestral knowledge and local practices of the Puna herders as a kind of “Multifunctional Services” that might have special significance and impact given the current uncertainty about the magnitude and effects of global climate change.

In North-western Jujuy the climate is subtropical with a dry season, and the rains mainly occur in the summer months. Morales et al (2015) provide evidence that severe droughts have occurred for the last 70 years. The regional climate models predict an increase in aridity in this region towards the end of the 21st century (Urrutia y Vuille, 2009 en: Morales et al, 2015).

Since 2014, the Argentine Puna has suffered a marked decrease in precipitation: in the rainy season 2014-2015 and 2015-2016 in two different areas of this region, a decrease in volume of rainfall of 50% to 70% respectively, was measured4. In the meteorological station of INTA Abra Pampa in Jujuy, the average rainfall per year is 326 mm (with a high value of variation coefficient: 31.5).

During the 36-year period between 1971 and 2007, there were only three years with rainfall of less than 200 mm. Whereas during the period from 2013 to 2017 (a 5-year period) it has occurred three times: in 2014, 2016 and 2017, generating a multi-year drought that directly impacts nature: the vegetation and the pastoral systems. In addition, in the period from 1971 to today, a global trend of precipitation decrease has been observed (Meteorological Station

INTA Abra Pampa). Furthermore, the consequences of the decrease in fodder are visible and tangible: there have been increases in mortality rates in both wild and livestock animals; fertility has decreased; there has been an increase in mothers abandoning their young; there are also more and more miscarriages; and so on. In addition, water access has become too difficult because there are fewer and fewer active springs; many lagoons have dried up or shrunk drastically in size, and the small streams disappear prematurely.

For the Puna shepherds, this is part of a climate "streak", which they explain is due to the connection between "human actions that show hardly any solidarity" and "the exhaustion of the years" emphasizing the empathetic links that exist between all beings of the mountains.

In order to cope with these "sad" times, the herders make decisions to moderate the use of the economic, environmental, and communal resources. These different strategies include: drastic reduction of the flocks (in the year 2016 it was from 35% to 55%): "*seeing the great drought this year, I made the decision to sell almost all the animals at the end of the summer, before they die…*" said one shepherd in the Puna of Jujuy (2017). The herders invested a part of this income to buy fodder (sometimes using savings, or borrowing money from relatives; or requesting help from the State). Moreover, they also modify the lengths of time and the amount of space destined for grazing, making the decision to lead the herd farther afield in search of grasslands, or on the contrary, leading herds closer to home for the purpose of saving energy costs. They reverse the time/space relations of grasslands-use: for example, in summer, they sometimes lead the herd to areas where they usually the winter months, or vice versa. A lot of herders have decided to maintain their flocks, though reduced, at great physical expense in effort and at great risk of suffering more losses. These are the results of the efforts they make in affection, their sense of identity, and to lessen the risks in the long-term: "*there you have seen my wife grazing the llamas… I have told her that we could sell off our flock, but she felt too sad and she refused, so we kept a few of them thinking of the future…*" (herder in the Jujuy Puna, 2017).

Thus, the connection that the shepherds make between the event of drought and herd losses, is part of their concept of insufficient care-taking of the earth, less solidarity, more sadness, and as a result, earth's exhaustion. Also they do not relinquish all their sheep and llamas, because the animals are the only capital they really own (usually they do not own the legal deeds to the lands they occupy). For the herding families, the herds are both symbolic and social goods, and their presence and care grant them the rights to the family grazing territory. Beyond the diversity and complexity of different strategies of the herders, there is a notable quest to achieve balance: their herding practices try to ensure the life and livelihood of the people, the maintenance of their herding activity by preserving pastures for the long-term, and the pastoralist agro ecosystem.

FINAL CONSIDERATIONS

Faced with the depletion of plant and animal species, the trend of extinction of languages and cultures in the Andes, and considering the urgent situation of having to cope with climate change, we consider it vital to take account issues such as: high-quality food production for our survival, and the protection of natural and cultural systems.

The dry-lands herders of the Puna provide many "Environmental Services" through their everyday practices, they are an integral part of the eco-system of Andean "mutual breeding" (it is a concept that pre-dates and will equip them). Their herding practices, the relationship they have with the animals, plants and grazing areas, along with their flexibility and speed in making decisions to adapt to water and fodder situations, their heritage and ancestral knowledge about the components and variability of the eco-system, are all aspects of the multi-functional services provided by herding, and these are not quantifiable for sale on the market, yet they are fundamental for life on these lands, and for what we have explained about food-production in difficult and changing climates.

In this article we have attempted to highlight the value of these Multifunctional Services provided by the pastoralists systems in the highlands of North-western Argentina, in order to contribute to a better understanding of the different ways of doing things, and the herder's strategies in dealing with extended multi-year droughts, with the aim of contributing to mitigating the effects of climate change, and increasing the resilience of agro-ecosystems affected by it.
We believe that one way to move forward, is by collaborative construction of technological innovations: it is time for dialogue between people with traditional and empiric knowledge, and people who study theoretical systems, it is time for dialogue between diverse cultural systems to work hand in hand.

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Intra-annual variability of the greenhouse gas balance of a sahelian rangeland ecosystem in semi-arid West Africa

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INTRODUCTION

It is now acknowledged that the planet's climate is changing and that human activities are mostly responsible for it via greenhouse gas emissions (IPCC, 2013). The three main greenhouse gases (GHG), in order of importance in terms of impacts on the climate, are carbon dioxide (CO2), methane (CH4) and nitrous oxide (N2O). In parallel, international reports and review studies draw attention to the contribution made by livestock breeding activities to GHG emissions (CO2, CH4, N2O) and to climate change. The contribution of the world's livestock sector to GHG emissions is estimated to 14.5% (Gerber et al., 2013; Caro et al., 2014). Extensive pastoral ecosystems, a quarter of the earth's land surface, are said to be major contributors to global warming. In sub-Saharan Africa, the sahelian rangelands are supposed to be responsible for the highest rates of greenhouse gas (GHG) emissions per unit of animal product (Steinfeld et al., 2006). Main reasons put forward are the low productivity of herds, low management level of pastures and high methanogenic potential of feed intakes. These regions are characterized by restrictive climatic conditions with limited rain falling within a short season, creating highly seasonal variability in terms of forage availability (Cissé et al., 2016), and pastoralism is the dominant farming activity. Pastoralism is rangeland management and extensive livestock management that uses these rangelands in a context of seasonal resource scarcity for animal watering water and forage (McGahey et al., 2014). Pastoralism is highly dependent on the availability of these two resources, which are strongly dependent on rainfall and soil fertility. Consequently, this activity is especially vulnerable to multi-year variation in rainfall and its distribution patterns (Nassef et al., 2009).
The GHG balance for these landscapes is commonly calculated at regional and yearly scales (Steinfeld et al., 2006; Gerber et al., 2013; Rakotovao et al., 2017). This study proposes a dynamic vision of a sylvo-pastoral landscape functioning by examining the intra-annual variability of the GHG balance. The objectives of this study are to describe the functioning of the sylvo-pastoral ecosystem during a full year and to propose a first assessment of the intra-annual temporal variability of its GHG balance of a study case located in the sylvo-pastoral Ferlo Region (northern Senegal) in the Sahelian zone of West Africa. The study is original in its capacity to integrate the various components of the ecosystem (animals, soil, plants) and to consider all components of the GHG balance at the landscape level.

MATERIAL AND METHODS

Description of the study area

The studied landscape is a circular area of 15 km centred on the Widou borehole (15°59'N, 15°19'W, 706 km²) representative of the sylvo-pastoral Ferlo Region in Sahelian zone of West Africa (North of Senegal) as described in (Assouma, 2016). This borehole was chosen due to the availability of a comprehensive database created by the survey activities of the group on Pastoral Systems and Dry Lands (PPZS) (Bah et al., 2010), the PAPF project (Ancey et al., 2008), and the presence of enclosed experimental grazing plots hereafter referred to as 'enclosures'. They were created 30 years ago as part of a project implemented by the German agency for Technical Cooperation (Miehe et al., 2010). Climate of the Ferlo region is characterized by three main seasons of four months each: a wet season from

July to October, a cold-dry season from November to February and a warm-dry season from March to June. Annual rainfall in the study area ranged from 105.4 to 478.4 mm/year with an average of 285.8 ± 84.2 mm/year in the period 1974-2015. Rainfall is normally distributed over 19±4 days during a single wet season from July to October. The mean air temperature in the two years period (2014 & 2015) was 28.4˚C fluctuating between a maximum monthly average of 31.2˚C in June and a minimum of 24.5˚C in January. Livestock husbandry is the main economic activity in studied area with a livestock population dominated by *Gobra* zebu cattle associated with *Sahel* and *Toronké* sheep and *Sahel* goats. Donkeys are raised as pack animals to transport water from the borehole to camps, while horses are kept for transport to and from the market and when families change camp. The studied landscape was stratified into six landscape units (Figure S1) based on topography, soils, vegetation and land use. The vicinity of the borehole (0.78 km², 0.1%) and the 354 pastoralist family settlements (44.46 km², 6.3%) were distinguished from the temporary ponds and surroundings low lands (19.34 km², 2.7%) and from communal rangelands (635.45 km², 89.9%). Tree plantations established during reforestation projects (6.23 km², 0.9%) and small protected enclosures (0.24 km², 0.03%) set up in 1981 by an experimental ranching project were also separated. The livestock system is extensive with free grazing in a communal rangeland with public access to fodder resources.

Survey of C stocks and GHG fluxes

The purpose of this study was to produce a vision of the seasonal dynamics of functioning in the studied ecosystem and its GHG balance. To that end, annual monitoring of the main N and C fluxes-stocks were conducted. The results of an initial GHG balance of the scale of a sylvo-pastoral ecosystem obtained by Assouma *et al.* (2014) based on IPCC Tier 1 led to the identification of the main GHG sources (enteric fermentation, faecal excretion by ruminants, termites and fire) and the main accumulated C stocks (soil, plants and animals). This first sizing of the fluxes and stocks helped to focus observations on the main flows and stocks to be monitored and to define an annual monitoring system to describe their monthly variations.

In order to establish the GHG balance in the study territory over a full year, observations were carried out on the scale of the whole Widou borehole area for a period of 18 months (from May 2014 to October 2015).

Methane emissions from livestock enteric fermentation were evaluated monthly using indirect approach: according to livestock resource intake and digestibility estimated through near-infrared spectroscopy analysis applied to faeces (F-NIRS) as described in Decruyenaere *et al.* (2009). GHG fluxes at soil and water level were measured at 13 of the 15 sites chosen for plant biomass and soil monitoring. The measurements were taken once a month in the wet season (July to October 2014) and once per season in the cold dry season (January 2015) and the warm dry season (May 2014). The GHG fluxes in soil were measured by the static chamber method described in Assouma *et al.* (2017). GHG fluxes at the water-atmosphere interface were measured by taking water samples from ponds, using the method described by Borges *et al.* (2015). The other sources of emissions (CH_4 from termites, CO_2 from fuel consumed by borehole motor pump and CO_2 from bush fires) were evaluated with the use of emission factors proposed in the literature.

Variations in the C stock in woody plants and soil were described from an inventory of woody plants and soil samples taken at 15 sites distributed throughout the Widou borehole coverage area. For these two C stocks, just one observation was carried out in January 2015 and used to characterize the plant cover and C stock in the soil in the different landscape units of the Widou borehole coverage area. In the soil, net carbon exchange was quantified from the difference between total carbon inputs and outputs in the soil. Total carbon accumulation in trees aboveground and belowground biomass was evaluated with in situ surveys and specific allometric equations available in the literature for the main species encountered in the region (Henry *et al.*, 2011). Variations in the C stock in animals were estimated by keeping track of changes in the livestock population through surveys at 11.3% of the settlements in the coverage area (i.e. 40 herds). The surveys were conducted each month from June 2014 to October 2015. Variations in animal weight were estimated from barymetric measurements (Njoya *et al.*, 1997). The evaluation of monthly variations of herd composition (by a survey among the herders) and herd weight evolution (in situ measures) were used to evaluate carbon sequestrated in the livestock.

Supplementary data on herbaceous biomass production were also collected to better explain the dynamic functioning of the studied ecosystem.

To establish the annual balance on a whole territory scale, all the emissions were accounted for positively and all the carbon variations were accounted for negatively. For the description of the temporal variability of the balance, these two flux and stock values were expressed in CO_2 equivalent and averaged over each of the three seasons described

above (wet season, cold dry season and warm dry season).

RESULTS

GHG emissions from animals, soils and water at whole landscape level

Our results underline the monthly variability of total GHG emissions in the whole study area (figure 1). Most of the emissions occurred during the rainy seasons with quantities that were slightly larger than the annual average in July and October. Emissions were lower overall in the dry season; emissions were a little higher in the cold dry season than in the warm dry season. The relative contribution of each pool was somewhat homogeneous over the year, with a major contribution of i) N_2O emissions from soil related to animal dejection onto the ground (17.4, 5.6 and 3.7 $GgCO_2$-eq/Month in the rainy season, cold dry season and warm dry season, respectively) and ii) enteric CH_4 emissions from ruminants (2.1, 1.6 and 1.2 $GgCO_2$-eq/Month in the rainy season, cold dry season and warm dry season, respectively). The only pool that varied between seasons (90.5, 2.3 and 7.2% $GgCO_2$-eq/Month, in the wet season, cold dry season and warm dry seasons, respectively) was CH_4 emissions from hydromorphic areas (surface water and soil). This contribution was much greater in the rainy season because of the existence of water ponds. Nitrous oxide N_2O was the most emitted GHG (59% of total emissions), then methane CH_4 was the second most emitted GHG (41%) and third came carbon dioxide CO_2 (<1%). The three main pools were animal dejection excreted onto the ground (66%) and into the water ponds (20%) and enteric methane (11%). Another flux that was not insubstantial was transfers from water to the atmosphere in the water ponds (20% of total GHG emissions). According to our estimations, termites could emit 3% of total emissions, via methane from enteric fermentation.

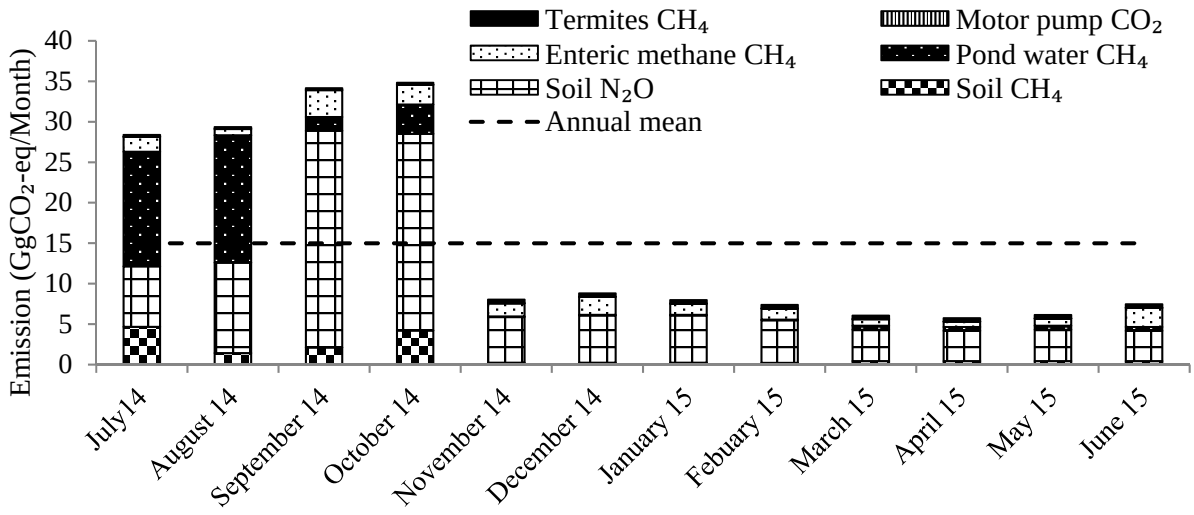

Figure 2. *Monthly variability in total GHG emissions at landscape level (all sources included)*

Carbon accumulation in trees, soil and Livestock

Our results underline the monthly variations in C accumulation in the main ecosystem compartments (figure 2). Most C sequestration in the different pools occurred during the dry season, and mainly during the cold dry season. Conversely, in the rainy season C stock variation was globally negative because of high gaseous C losses at soil level. Monthly variations in C stock on a territory scale were somewhat stable in the warm dry season and variable in the cold dry season and even more variable in the rainy season. There were accumulation periods (in the cold and warm dry seasons) and salting-out periods (in the rainy season) in the soil, even though there globally remained a major C sequestration source over a full year. These different results highlight the important role of soil in C stock intra-annual variation on the scale of a complete sylvo-pastoral ecosystem. C accumulation in the other fauna (termites, insects, rodent, birds, and microbes) was negligible in this study. Woody plants and soil were the main stocks where C accumulated within the whole sylvo-pastoral area. They amounted to 71% and 28% of the area's annual C sequestration potential, respectively.

As for the animals, they sequestrated around 1% of the annual gain in total C stock in the form of animal biomass in

the herds. Overall, the ecosystem sequestrated 0.7tc/ha/year according to this distribution: trees 0.45tC/ha/year, soil 0.26tC/ha/year and animals 0.006tC/ha/year.

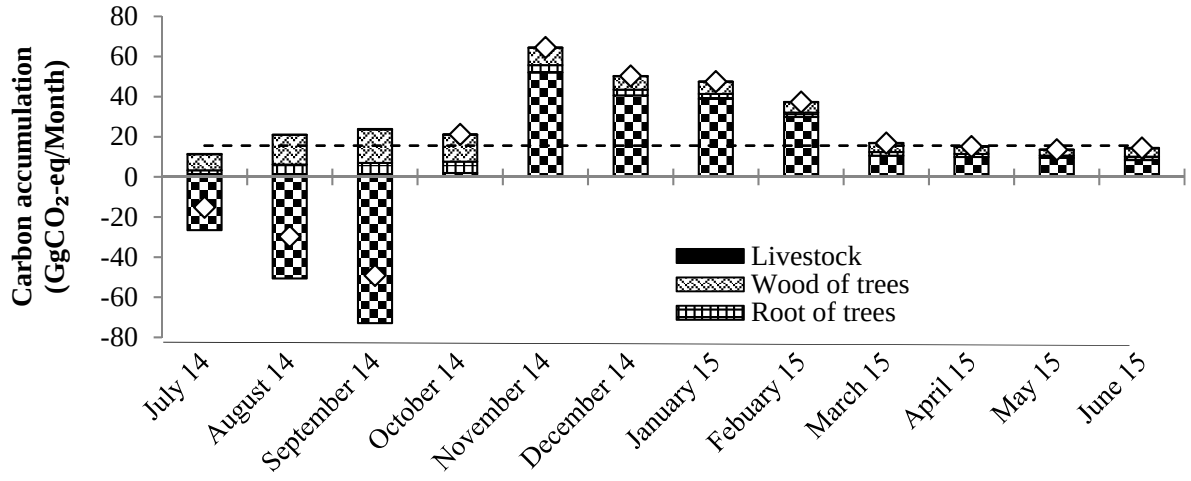

Figure 3. *Monthly variability of C stock variations at the whole landscape level*

Temporal variability of the GHG balance at the Whole ecosystem level

Our result highlights seasonal variation in the GHG balance on a territory scale (figure 3). This representation enables a distinction to be made between emissions and sequestration depending on the season. The GHG balance was positive in the rainy season (+199.33Ggeq-CO_2). It varied from +13.65 to +8.32Ggeq-CO_2/month in October and September, respectively. The GHG balance was negative in the dry season; it was intermediate at -67.47Ggeq-CO_2 in the cold dry season and – 34.64Ggeq-CO_2 in the warm dry season. In the cold dry season, the monthly balance varied between – 56.48 and – 29.96 Ggeq-CO_2/month in November and February, respectively. In the warm dry season, the monthly budget varied between – 10.85 and – 7 .40 Ggeq-CO_2/month in March and May, respectively. A seasonal or monthly negative balance meant that GHG emissions were compensated for by C accumulation. Overall, all the landscape units of the territory emitted +2.601 teq-CO_2/ha/year, on average, and sequestrated -2.64 teq-$C0_2$/ha/year, on average. That is equivalent to an annual GHG balance of -0,72teq-CO_2/ha/year. Thus the sylvo-pastoral ecosystem might sequestrate -0,01teq-C/ha/year.

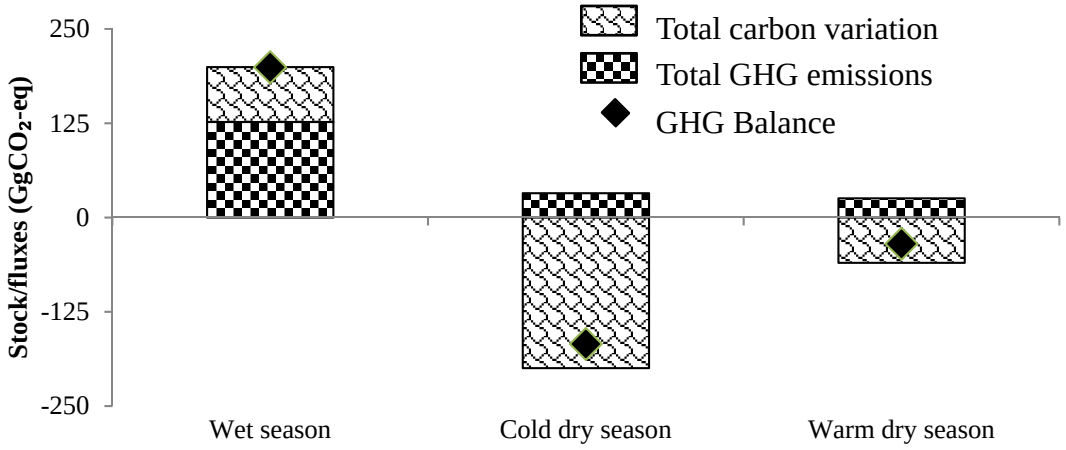

Figure 4. *Seasonal variability in the GHG balance at the whole ecosystem level*

DISCUSSION

It seems important to take into consideration the main GHG transfers from the ecosystem to the atmosphere in order

to understand the impact of land-use management on global warming (Smith *et al.*, 2001). This study provides the first rather detailed balance of the net CO_2, N_2O and CH_4 transfers on a sylvo-pastoral territory scale, while covering spatial heterogeneity of land uses. We approached this balance from an eco-systemic angle, thus considering all the ecosystem components (animals, soil and plants) and their interactions.

Monthly monitoring of all the components of the GHG balance highlighted strong seasonal variability in the balance. This is rarely found in the estimations of annual GHG balances usually implemented on a production system scale (Schönbach *et al.*, 2012) or a territory scale (Karki *et al.*, 2015). The rainy season was the most sensitive period, as highlighted in the seasonal variability obtained in this positive balance due to major GHG emissions. Indeed, organic matter decomposition occurs during the rainy season (hot and humid season) (de Souza Rezende *et al.*, 2016) while organic matter accumulation, its fragmentation and burying mostly occur during the dry season (Coleman *et al.*, 1989). This balance highlights the direct and indirect roles played by animals in sylvo-pastoral ecosystem functioning. During the rainy season which was absolutely fundamental in this balance the high rate of animal presence in the study area was explained by the return of transhumant herds to the study area due to rainfall resumption and subsequent grass regrowth. This high presence rate resulted in a large quantity of dejection onto the ground with a major concentration around settlements and ponds full of water at that period. Together with rainfall effects (increase in soil moisture and filling of ponds), major animal activity stimulated a rather significant increase in soil emissions and above all from water ponds (Figure 5.11). Indeed, the input of faecal matter on the ground, directly followed by a humidification period after rainfall, stimulated biological activity at soil level, thus emitting large amounts of CH_4 and N_2O (Franzluebbers *et al.*, 2000; Kim *et al.*, 2012). Moreover, in this season, large emissions of CH_4 occurred from the surface water of ponds, because of direct excretion into the water while the herd was drinking (Assouma *et al.*, 2017). On the one hand, the positive balance in this period resulted from a low return of plant biomass to the soil (herbaceous growth period and renewal of woody plant leaves). On the other hand, negative balances during both dry seasons resulted from a decrease in emissions due to soils and ponds drying up, and also high biomass returns to the soil via animal dejection, woody plant leaf senescence and burying of herbaceous litter. The high animal presence rate and the large quantity of available litter in the cold dry season stimulated more carbon accumulation during that season, thus making the balance even more negative.

The strong variability in the balance arose from i) seasonal climate variations that influenced GHG emissions processes as well as carbon fixation processes, and ii) pastoral practices characterized by seasonal herd mobility.
The rainy season balance was positive because of high GHG emissions. As demonstrated before, free-grazing leads to *in situ* consumption of slightly more than one fourth of herbaceous biomass production in the whole borehole area, and to *in situ* recycling of more than 50% of this ingested biomass via animal dejection. This recycling facilitates the return of faeces to the soil, thus contributing to carbon sequestration (Soussana *et al.*, 2010) and positively influencing GHG emissions (Akinori and Masayuki, 2015). In addition to this, the effect of cattle trampling during grazing facilitated the transfer of standing biomass (e.g. straw) to the litter, and its fragmentation and burying in the soil.
For this strong seasonal variability, the tropical sylvo-pastoral ecosystem balance was still globally negative over the annual cycle. This study confirms the sequestration potential of grazed ecosystems as demonstrated by (Soussana *et al.*, 2007) working on pastures in temperate climates. However, sequestration potential seems to be lower in a semi-arid tropical climate because of faster organic matter turnover on sandy soils (Kalbitz *et al.*, 2000), and in hot climates (Kotir, 2011).

CONCLUSIONS

This study highlights strong **seasonal variability** in the GHG balance on a sylvo-pastoral ecosystem scale. The rainy season was characterized by major emissions from the soil (N_2O), water and animals (CH_4). Conversely, the dry seasons were more particularly carbon accumulation periods at tree and soil level. Carbon biomass inputs mainly occurred at the beginning of the dry season, in the cold dry season, when animals had yet to leave for transhumance (animal dejection, burying of litter in the soil) and trees were still in their growth period (humid soils in the deep layers). This strong seasonal variability was explained by abiotic factors (e.g. rainfall seasonality, soil humidity and forage availability), biotic factors (e.g. seasonality of livestock animal presence, soil biological and termite activity) and by

livestock farmer practices (e.g. adaptation of the animal stocking rates to the available forage).
The annual net GHG balance was -0,01teq-C/ha/year over the 2014-2015 cycle. The sylvo-pastoral ecosystem seemed to generally perform as a **net sink of carbon**, like other grazed ecosystems, such as systems in temperate climates better documented in the literature.

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Livestock farming in the special areas

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GASL

THE HISTORY OF PLACE

Special Areas is a unique type of municipality in Western Canada, to the east of the Rocky Mountains, in southeastern Alberta, on the border with the province (state) of Saskatchewan to the east and the U.S. state of Montana to the south.

The area is bordered on the north by the Battle River and a range of hills called the Neutral Hills. The southern and south western boundary is the Red Deer River and the eastern boundary is the Saskatchewan border. The Special Areas is composed of about 2.1 million hectares.

One of the first and most significant people to visit the area was Captain John Palliser. He spent 3 years (1857 to 1860) touring through the prairies assessing various areas for their potential for settlement and development. He identified an area he called the Palliser Triangle which in his opinion was not suitable for agricultural development. The Special Areas is in this area. We know the climate in the area cycles. Sometimes Pallister is right and people wonder why they stay. Then the weather pattern changes, the rain comes, cattle graze on lush grass, and crops are good.

In the late 1800's and early 1900's ranchers moved into the area. They shipped large herds of long horn cattle to Montana, United States or Medicine Hat in southern Alberta from Texas and Mexico and then trailed into southern Alberta and what is now Special Areas. George Emerson had 3,500 head, the Gordon ranch 12,000 head. Some present-day ranching families came about that time. The Peakes at Dorothy, Forsters at Wardlow, Hunts west of Sullivan Lake and Madges on the East Berry Creek to name a few. These ranches had headquarters on the Red Deer River and grazed either north or south of the river during the summer and then wintered cattle by grazing along the river. The Old Mexico ranch buildings in Dinosaur Provincial Park, and the Peakes cabin at Dorothy are a couple of historical land marks of that era. Grass was reportedly wagon wheel high and told to turn the rowels on your spurs as you rode through it on a tall horse. People living there now find that story hard to imagine.

The winter of 1906/07 was a particularly hard winter with very cold temperatures and deep snow. Those conditions destroyed most of the big ranches. They had not put up feed and the cattle could not get down through the deep snow for grass. They say there was still snow in the coulees until August. Normally snow has melted and grass is growing by later in April.

By the late 1920 there were 26,000 people living in the area now known as the Special Areas. As the weather cycled back into drought in the late 1920's the land could not sustain that population. The 1930's were called the Great Depression in Canada. Coupled with the drought in Western Canada they were about 10 years of disaster and hardship.

Farmers defaulted on loans and taxes. People, businesses and the 27 rural municipalities went bankrupt. Over 890308 hectares (2.2 million acres) of land was lost under tax recovery proceedings. The provincial government stepped in and in 1938 the Special Areas Act was passed. The 27 municipalities were dissolved, and the Minister of Municipal Affairs became the Council for the Special Areas. The Minister could do any thing by Ministerial Order that a municipal council could do by bylaw.

The Minister was also given land management responsibilities for the 809,371 ha (two million ac) of tax recovery lands and 607,028 ha (1.5 million ac) of Crown land. This governance structure is still in place.

ENVIRONMENTAL

Annual precipitation is about 325 – 355 mm (12.8-14 inches), with 177 – 228 mm (7-9 inches) falling as rain in the growing season and the remainder coming as snow in the winter months. The area operates in a mean moisture deficit created by strong summer winds and high temperatures. There are extreme annual rainfall fluctuations which result in great uncertainty in crop yields from year to year. This also creates great uncertainty in forage production and the carrying capacity of pastures for livestock.

The area has two soil zones. Dark brown soil underlies about a third of the area, primarily north of the city of Hanna. This soil is relatively more fertile than the brown soil zone which is found in the remainder of the area. There are also solonetzic soils found in the region.

The natural vegetation is classified as the northern plains which in Special Areas is primarily mixed grass prairie ecozone. The North American grassland ecosystem is significant as pasture and wildlife habitat as the basis for extensive cattle production and western culture

The area provides habitat for many of the sixty-prairie species at risk. Federal and provincial management plans for those species guide producers' practices. It is one of the important areas of the province for native grasses and the biodiversity that ecosystem provides.

In Special Areas land tenure is a mix of 1,052,182.7 ha (2.6 million ac) of government lease land (Crown land) and about 971,245.5 ha (2.4 million ac) of privately owned land. The land management is a mosaic of cultivated acres for both crops and tame forage for grazing and hay production, and native grass pastures.

ECONOMIC

Special Areas faces significant environmental, economic and social challenges. The average household income is about 90 per cent of the provincial average income. In the past 10-20 years there have been few new private or public-sector investments. The average age of the population is increasing, a situation exacerbated by a high percentage of young people who leave the area looking for employment. The workforce is about 6900 people with about 39 per cent directly employed in primary agriculture (farming and ranching). Several issues have impacted beef production, one of the major commodities produced in the re ion, resulting in a significant loss of equity.

In 2000 the population of the area was 11,200, a density of 1 person per 188 ha (450 ac). About half of the population in the region live in small urban areas. There are more than 30 hamlets (communities smaller than villages) located in the Special Areas.
The average age of the population is increasing, a situation exacerbated by a high percentage of young people who leave the area. Over the years the Special Areas Board has worked to develop traditional recreation opportunities in the form of parks, camp grounds and golf courses.

In 2001 the discovery of the disease Bovine Spongiform Encephalopathy (BSE) in the Canadian cattle herd, prevented exporting of product and subsequent loss of income. Droughts, fluctuations in currency and a recently resolved country of origin labeling initiative in the United States have also had a negative impact on income for beef producers.

The viability of these working landscapes is in question due to long term decline in agricultural income. Will the next generation be able to survive and thrive? Declining farm incomes also have a negative impact on intergenerational transfer within the agricultural community with young potential farmers being driven to urban areas for employment and resulting depopulation of the rural area.

Recent upturn in cattle prices have encouraged agricultural producers and there are more young people returning to their communities. Overall however the trend continues in decline.

Overall there is a sense of optimism in the area despite the challenges. Farm and ranch units are viable often because of the increase in size. Many are greater than 10,000 acres. There is an economy in scale and often producers are able to afford more skilled labour.

Producers in this area are very dependent on exporting their products into the international commodity markets. There are some initiatives looking to market locally and regionally but distance to any population centres of reasonable size presents significant challenges.

Although the system of leasing government land has worked well in the past with a recent change in government there is increased uncertainty in the security of tenure.

SOCIAL ISSUES

For Special Areas, rural livelihoods are tightly tied to a harsh environment for agricultural production, distant markets, fluctuating prices and changing consumer needs and desires for products and production management. Sustainable agriculture requires improving human management of this landscape by finding the synergies in these areas. The challenge is to develop an approach to ensure landscape performance is continually improving.

The average age of producers continues to increase. Now 54.5 up from 52 years in 2006. The labour shortage and volatile commodity prices add challenges to farm and ranch viability and ability to afford new technology.

SUMMARY

Although there are numerous and significant environmentally, economic, social multifunctionality challenges in this region there is also a strong sense of community and a spirit of cooperation. The majority of the residents do see the area as special, with a natural beauty in the native grass lands and its wildlife. There is a uniqueness to the region that is believed to be marketable.

People here are very independent, self reliant and independent. But there is a very real sense of community and neighbours step up to help each other.

Farmers and ranchers continue to innovate and become more resilient often in spite of government assistance.

Pastoral farming in the Mediterranean and multi-functionality: A case study in French southern alps

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The place that livestock farming holds in society is subject to question. This seems like a particularly opportune moment to re-examine its place and future direction in the Mediterranean region, building in a multifunctional approach to the activity at regional level. Several features of Mediterranean livestock farming underscore the challenges of multifunctionality. It is an activity with strong links to the identity of those working in livestock farming and of the landscapes and regions (Blondel, 2006). Its substantial pastoral component involves a variety of regional landscapes (cultivated areas, rangeland, forests, mountain meadows, etc.), often going beyond the strict scope of land appropriated for farming to include public spaces or areas used for multiple purposes (Garde et al,2014).

Recent reforms to the Common Agricultural Policy have seen these often implicit multifunctional dimensions make their way back onto the European political agenda, particularly in France (Bazin G., 2003). This paper analyses the conditions for and forms of development of pastoral livestock farming in the Provence-Alpes–Côte d'Azur region of France over the last 30 years in relation to public support policies and in light of the expectations of local stakeholders in upland areas of the Southern Alps.

CHANGES IN LIVESTOCK FARMING IN THE SOUTHERN ALPS IN RESPONSE TO LATE 20TH CENTURY PUBLIC POLICY

Recent developments in agricultural policy and local conditions in the second half of the century warrant a plan for the future of livestock farming in the French Mediterranean, linking it closely with territory-wide issues of multifunctionality.

Aspects of domestic policy

France's post-war agricultural outline laws set out a framework for farming modernisation, representing a break with the largely subsistence-based nature of large facets of agriculture in the Mediterranean and upland regions. In the first instance, this translated into extensive cereal growing on the great lowland areas of France. The emergence of this geographical specialisation had some significant impacts, as follows: i) the marginalisation of cereal growing in upland regions; ii) not having been fully "modernised", livestock farming emerged as a "safe haven" activity in these regions; iii) the massive decline in sheep farming associated with lowland cereal growing unlocked a market for the production of sheepmeat in regions where this activity persisted.

The technical and regulatory framework for crop production was further developed from 1964 onwards with the addition of laws on the development of livestock farming This led to substantial productivity improvements where investment and the opportunities offered by the environment allowed. In the past, the difference between upland and lowland farming was seen primarily in field crops, leading to intense specialisation in lowland areas, with an avoidance of livestock production. Ultimately, the modernisation of farming and the laws that govern it have significantly marginalised livestock rearing in upland areas, where there is a growing productivity differential with lowland regions, particularly for dry mountains, Bazin (1985) makes a distinction in this respect between wet uplands which are able to compete with lowland areas through beef and dairy cattle farming (capitalising on traditional products thanks to a long-established tradition of cheese-making) and dry regions focused on sheep farming.

The result of these changes and opportunities is a clear difference between livestock farming in the Southern Alps (mainly sheep farming, largely pastoral in nature and geared towards meat production) and in the Northern Alps, where it mainly involves grass-fed cattle and is geared towards high-quality cheese production.

Local conditions for the development of livestock farming

Between 1980 and 2000, the local context influenced approaches to the development of livestock farming in the Southern Alps.

Specialisation in sheep farming intensified with the shift away from cattle farming in response to the collapse in the beef and dairy cattle sectors. Opening up the Europe-wide market for sheep meat exposed French producers to competition from the United Kingdom, causing prices to tumble. As a consequence, as part of the common organisation of the market, the support systems for activity that defies any form of crisis response were stepped up with the introduction of more productive models. The introduction of the Compensatory Premium for Sheep was calculated on the difference between the market price and the guide price and was allocated in such a way that payments to farmers were largely dependent on flock size.

The mountain laws, national consultations on agricultural development and regionalisation laws have enshrined a number of considerations on upland farming: i) it is specific and needs to find its own paths for development; ii) it needs specific support to compensate for the difficult conditions in which it takes place; iii) its importance to the local economy and its contribution to maintaining the landscape mean that it must be protected.

More generally, this period saw the deepening of the demographic separation between coastal and upland regions, with mountains being assigned the role of recreational areas at regional level as well as more widely with the development of mass winter mountain tourism, creating local opportunities for new activities as alternatives or in addition to farming. Support for this mission as a “recreational green lung” that requires protection came from the consolidation of the role of the national parks (Écrins and Mercantour, designated in the last decade) and the regional nature parks.

Regional population dynamics have driven the transformation of the coastline into a major conurbation sitting cheek by jowl with extensive open spaces covered by large tracts of forest that developed following the large-scale abandonment of farming and the marginalisation of pastoral livestock production. This makes the whole area highly susceptible to the outbreak of the fires that were a regular feature of the summer in the early 1980s. A system of fire prevention was then developed that included both resources for firefighting and spatial planning to make the region less susceptible to fire. The creation of firebreaks once again raises the compelling issue of flocks in forest environments, which historically were off-limits for sheep, to help control vegetation.

Development of a livestock farming model based on the challenges of multifunctional use

These conflicting demands have given rise to a period of confusion about the forms of livestock farming to be encouraged for the Southern Alps. There is a strong desire to leverage local pastoral resources in formulating an alternative to traditional forms of development based on intensification (not something that was applicable locally) and this is supported by the presence of farmers new to rural life and the area who are responsive to these kinds of development options. The main issue then lies in the ability to increase access to grazing resources that are largely associated with public forests in lowland areas and with alpine meadows and high-altitude forests in the mountains. For stakeholders in livestock farming, this means justifying their place in the multi-use framework while the positions of other users of these spaces are being strengthened. Leisure and outdoor activity is a growth sector in mountain areas. In lowland areas, competition is fierce on grazing land that is either covered by the forestry code or is being eroded by urban sprawl. Improving access to such land is one of the issues in the recognition of livestock farming as a multifunctional activity.

At the same time, stakeholders in the Mediterranean forest are closely involved in the development of firefighting measures. The closing off and standardisation of environments traditionally involved in pastoral activity as a consequence of rural decline has been identified as a risk factor. Despite a few ups and downs linked to the dubious history between foresters and shepherds in the Mediterranean region, goat, cattle and sheep farming all have a seat at the table for discussions about the introduction of the forest fire prevention policy.

This then leads to deliberation on the relationship between livestock farming and the region, involving stakeholders from outside the agricultural community. The aim is to tie the dynamics of grazeable semi-natural areas to the integration of livestock farming into the issue of how to manage natural spaces and the contribution of farming to the

resolution of environmental questions. As a result, pastoral services are organising the large-scale movement of flocks to areas with societal expectations in respect of grazing. In particular, this will involve arranging for winter grazing of the coastal forest areas by animals coming down from upland farms.

Increasing public support under the CAP

The ramp-up of the modernisation in farming has resulted in increasingly substantial differences in productivity between lowland and upland livestock farms, jeopardising the future of agricultural activity, primarily livestock farming, in mountain areas. As a specific support measure, the compensatory allowance scheme for areas with difficult natural conditions will be increased during the period. This measure was introduced under the agricultural policy to compensate for an inability to effectively implement the production models being promoted. These support measures are in fact linked to a multifunctional view of livestock farming, with the aim of maintaining an activity that is assumed to be beneficial to the overall mountain economy and the conservation of outstanding landscapes that protect specific biodiversity. As these support measures are increased, they will need to be consolidated and legitimised on the basis of social and environmental arguments. This convergence between the growing importance of the support provided by the CAP, with payments calculated on the basis of flock size, and opportunities to access new forage resources in communal spaces that acknowledge the services provided by grazing, is driving the profession to widen the scope of its analysis of the forms of livestock farming to be developed and identify the three components of income from livestock farming: product sales, allowances intended to make up for low incomes and benefits for environmental services.

CHANGES TO FARMS AND PUBLIC SUPPORT FOR LIVESTOCK FARMING

The constant expansion of French farm structures since the 1960s has clearly come at the expense of the number of farms and farmers but also, more generally, the number of farm assets. In pastoral areas of the Mediterranean uplands, this trend means that there are now just a handful of farms in each community, contributing to the decline in farming-related economic activity. Table 1 shows the change in sheep flock structures in the départements of the Southern Alps between 1993 and 2010. Large flocks, the order of the day for pastoral livestock farming, have increased quite substantially and the increase in the proportion of large flocks (more than 500 ewes) and very large flocks (more than 1,000 ewes) is plain to see. In 1993, 21% of the sheep population in the départements of the Southern Alps belonged to flocks of more than 500 ewes, compared with 37% in 2010 (Table 1). Between 2000 and 2010, these large livestock farms were more effective in maintaining their operations than more modestly sized farms. While herds of more than 1,000 animals were exceptional at the start of the period, in 2010 they accounted for 16% of the sheep population. Ewes in flocks of more than 500 ewes accounted for 47% of the total population in 2010, compared with 21% 17 years previously.

	1993	**2000**	**2010**
Flock size between 500 and 1000 ewes number, contribution (%)	110, 5.8 %	149, 8.8%	126, 9.1%
ewes within flocks sizing 500 to 1000 ewes number, contribution (%)	72870 18.9 %	108722 24 %	90480 21 %
Flock size > 1000 ewes Number, contribution (%)	6 0.03 %	25 1.5 %	43 3.1
ewes within flocks >1000 ewes number, contribution (%)	8351 2.1 %	36091 7.9 %	66426 16 %

***Table 1**. changes in sheep farms flock size in southern alps between 1993 and 2010*

The allocation of public aid to livestock farms, as determined from surveys of all 60 farmers in a very pastoral area of the mountains shown in figure 1, shows that it is largely routed to farms with the largest flocks (Grawitz, 2011). Family holdings with the smallest flocks, which often correspond to young farmers who are just setting up (who can be considered most vulnerable), received up to 6 times less in terms of public aid than holdings with large flocks. By and large, the bulk of this aid was distributed for multifunctionality in agriculture(compensation for difficult natural conditions, agricultural environmental measures, etc.).

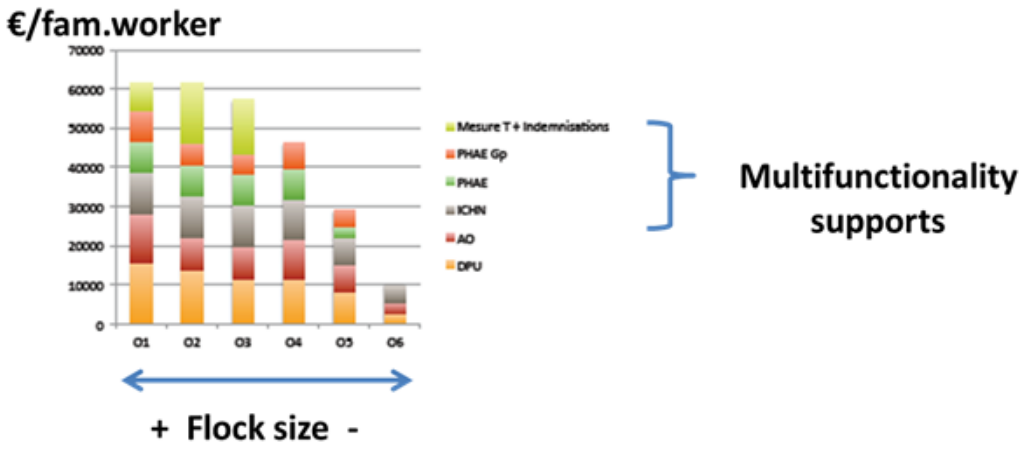

***Fig 1**. Distribution of public supports to sheep farms according the flock size, on a sample of 60 farms in 2011. (from Grawitz T., 2011).*

It is not hard to make a connection between flock expansion, the pastoral nature of the activity and public aid bound up with the recognition of agriculture as multifunctional, essentially on environmental grounds. Social aspects, particularly in relation to employment and social cohesion, appear to be the "poor relations" in these policies.

A variety of expectations of livestock farming currently being asserted

A series of interviews were conducted with local stakeholders and territorial decision-makers in the Alpes de Haute Provence; these were supplemented with interviews with regional operators in agriculture and the agricultural sector, elected officials and government and regional representatives (Lasseur et al., 2017). Respondents expressed three key areas of concern regarding the way that livestock farming is appraised. A concise breakdown of these three areas of concern and the debate they generate is set out below.

Contribution to the operation of the supply chain

For operators in the long supply chain, the aim is to create a supply chain covered by a quality label. This sets them against farmers who are well integrated into the supply chain and against pastoral livestock farmers. The pursuit of added value on lamb (through labelling) is seen as a promising route for livestock farming, ensuring increased income for farmers. Signing up to the contractual requirements of a label is seen as the route to technical advancement and this shapes guidance to farmers on matters such as the animals' carcass qualities, the choice of breeds and control over the production schedule.

For regional stakeholders, maintaining a complex of farms with deep roots in the local area in terms of social networks and the economy is paramount. They see developing short marketing chains by providing support for reorganising the sector as a way of contributing to this objective.

There are two areas of disagreement between operators in long supply chains and other stakeholders: by offering "poor quality" lambs, pastoral production would hinder the development of the organised industry and the technical advancement that is driven by registration for labelling. Developing short supply chains at the instigation of local stakeholders would weaken the organised sector and would only provide farmers with a short-term alternative to efforts to improve the quality of products from livestock farming.

Contribution to local activity and social inclusion

In the view of managers in agriculture (excluding supply chain operators), livestock farming has developed and modernised through specialisation. The emergence of large instead of small flocks on diversified farms has helped to maintain sheep numbers across the region, making it an activity that is still economically strong. This trend gives sheep farming a significant role in the issues of spatial management that regional players stress are taking precedence over the issues of food production. This contributes to increased farm specialisation and to expansion.

For regional stakeholders, the challenge is to maintain the network of farms in sparsely populated communities where agriculture is crucial for the economy. Alternatives to expansion based on breaking up farms at the end of the farmer's working life are therefore being actively explored. The hope is that these alternatives will enhance the value of products from local livestock farming by developing short supply chains and diversify farms, providing complementary revenue streams to ensure that modest-sized farms are economically viable. Regional stakeholders are further concerned that the future development of livestock farming should be factored into local development by making more of its cultural aspect, strengthening the identity of a region that is bound up with pastoral production. This bodes well for creating stronger synergies with tourism. An additional concern is promotion through recognised local cuisine and a network of farm visits for tourists, which would help to encourage interaction for a profession that tends to be isolated: the two do not always coincide.

With regard to the matter of contribution to economic activities and local inclusion, there is a consensus on the importance of consolidating livestock production activities, but some differences of opinion on how to achieve this.

Contribution to landscape management and the environmental quality of the area

The issues of land use and the contribution of livestock farming to the management of ecological dynamics involve the preservation of the agricultural potential of this area and concerns around pastoral production and biodiversity.

The spontaneous development of forest areas is highlighted as a threat to the area by agricultural operators and regional stakeholders (this stance is qualified by forestry workers, however). Livestock farming is specifically identified with regard to its contribution to managing the uneasy balance between forests, cultivated areas and rangeland that is peculiar to the declining Mediterranean regions. The ability to keep formerly cultivated land open through grazing is subject to question. The growth in flock sizes and the resurgence of pastoral production are perceived as positive. There are questions relating to issues of land use from forestry workers, who take the view that not all land is necessarily pastoral in nature and that land needs to be set aside for forestry. At the same time, local authority initiatives to promote activity by means of brand new infrastructure tend to identify these areas as public property that is easier to leverage than private land.

The positive connections between livestock farming and biodiversity issues are being developed by environmentalists who complain that these new systems of agricultural production have not shown that they can coexist with wolves, and by national park officials who lament the abandonment of agricultural practices, particularly the mowing of certain natural meadows which become spread when incorporated into grazing land and lead to a loss of biodiversity. These are all reasons to relax an over-exclusive focus on pastoral production.

Developments in livestock farming in the PACA region in recent decades have underscored multifunctional aspects by building on public support mechanisms. The resulting pastoral model is strongly interconnected with the issues of managing the open environments that symbolise the regional landscapes whose identity dimensions it reinforces. Support policies have made a substantial contribution to these changes and to the emergence of large-scale livestock structures at the expense of maintaining on the operations of multi-activity farms contributing to regional economic vitality. If the challenges of making livestock farming work with the ecological dynamics of natural grazing land are concerns for local societies, they do not exclude wider social issues. The expectations of local stakeholders appear to be contrasting and constantly changing. Looking ahead, if it appears important to support the transformation of livestock farming from a multifunctional perspective, it is without doubt essential for enhancing the long-term ability of the regional-level activity (Godard et Hubert, 2002) to find compromises between the different concerns raised and maintain the resilience that will enable the activity to develop hand in hand with local social expectations.

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CONCLUSION

Some elements captured in Saskatoon towards the next arena

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After Hohhot and Rosario, our group has organized its 3rd Workshop taking advantage of the Xth International Rangeland Congress. Focusing this time on the issue of the multifunctionality of pastoralism, this workshop has been supported by the World Bank (Livestock Global Alliance, LGA) and the FAO (Global Agenda for Sustainable Livestock, GASL). I am honored to write some concluding remarks about this event in its proceedings.

At the beginning, an issue of institutional understanding

Many agricultural practices are today unsustainable and counter-productive, because they focus purely on how much resource can be produced and harvested, rather than thinking of resources as ever-changing and deeply connected within complex ecosystems (Hubert & Ison, 2011). Thus, there is a need to think sustainability as an emergent property of stakeholder-resource interaction, and not as a technical property of the ecosystem. It's why, with some colleagues from different parts of this world (Europe, North and South America, North and Sub-Saharan Africa, Pacific, South and East Asia) we have designed ten years ago the LifLod network to better investigate the functions of livestock farming in territorial development.

Our goal was to overcome simplistic standpoints on individual animal productivity either C sequestration vs GHG emission … by a collective approach to characterize the functions performed by livestock farming activities, and their contribution to a sustainable development, considering economic, sociological, cultural and ecological criteria.

How does livestock farming fulfill these functions? How and under what conditions or contexts does it contribute to sustainable development? What is the role played by systems developed by States and institutions that guarantee income security or satisfaction of primary needs ? How to maintain a diversity of livestock farming functions for territorial development, i.e. supplying animal products (meat, milk, fiber,...) and ecosystem services, contributing to local development projects and to alleviation of population vulnerability... briefly said: multifunctionality!

New challenges for livestock farming!

The presentations at the workshop and their transcription in the previous chapters illustrate the range of the challenges livestock farming has now to face:

- To be integrated in new cities/countryside networks: i.e. to have to manage relationships with new neighbors and partners, less and less involved themselves in agricultural issues, to take care of labor (family unpaid in competition with non agricultural employment, constraints and strain at working in livestock husbandry), water allocation between a diversity of uses in a context of increasing scarcity in many grazing and pastoral areas, etc.
- To contribute to a secured food supply: risks linked to anthropozoonosis and anti-microbial resistance, products traceability, food quality/diversity (controversies about meat consumption and animal products in regard of diets, GHG emission...), ethics considering animal welfare and farming and breeding conditions…
- To be adapted to prices instability in a global market

- Moreover public policies and public actions entangled in complex frameworks : international commitments (UN environmental conventions on one side and WTO rules on the other), inefficiency of sector-specific policies to deal with wicked issues linking economics, environment and health, role of corporate initiatives at the global as well as local levels…

How to overcome such wicked situation?

From the discussions among the participants, we caught up 4 areas of reflections for our community:

1. Four cross-over key issues for the future of pastoralism

- Mobility as an asset and a "modern" multi-scale way to create resources from living ecosystems under climate change threats!
- Diversity as a component of pastoral systems: resources/land, animals/products, people/cultural values, skills/knowledge, tasks/labor allocation …
- Evidence based basics vs gossips and factoids
- To involve all concerned stakeholders (producers, land managers and owners, processors, retailers, consumers, policy makers …)

2. From a community of practice to an epistemic community?

By developing a system thinking practice involving all participants into a collective working process through a mediating tool in order to overcome disciplinary standpoints and give priority to functions, e.g. the modeling exercise initiated by Jean-Pierre Muller during the workshop.

And taking care of combining, as a duality, (i) a "systematic" approach: watch the real world as "a (dynamic) system", which relies on considering systems as ontologies, with (ii) a "systemic" approach: perceive ourselves as actors of a system thinking process modeling a diversity of standpoints about the real world at different scales, which relies on considering systems as epistemologies (Hubert & Ison, 2016).

With these views, modeling is considered as a collective conceptual action, in order to explore a range of pathways leading to a diversity of instruments for research, decision making, local action, etc. (Paillard et al., 2010).

3. Issues towards decision makers

In most of the case studies, a priority is to secure land tenure by thinking in terms of bundle of rights allowing mobility (even trans-boundary) and not only in terms of land ownership, followed by actions aiming to facilitate access to market (roads, dairies, slaughterhouses, managing rivalry with imported goods, protecting of typified products …) and to all services (education, health …) (McIntyre et al., 2009).

Of course, there is a huge challenge to recognize pastoralism as a professional activity: i.e. training for young people, gender equity, insurances, etc. and not as a past and quaint matter with nothing really to worry about!

To achieve such goals and following the item above, there is a need to facilitate multi-stakeholder local dialogues using mediating tools.

4. Perspectives for research

There is also a need on the research side to make pastoralism as a living and recognized activity contributing to vibrant territories. Thus, researchers have to be more involved in participatory/collaborative research with practitioners in order to mix different knowledge and know-how and to use the right wording (taking into account how practitioners introduce themselves and name objects and situations) in order to perform with the right categories and not outsider's views and caricatures as it is too often drawn. That for, researches have to be carried on about collective action facilitation (mediating tools, co-creation of new frameworks …).

Anyway, there is still a huge demand of knowledge on the basics of pastoralism: ecology, social, cultural, economics (from a wider point of view including crop-livestock systems, which has been hidden by the promotion of specialized productions as the one best way all over the world!). This leads to designing multi-criteria performance indicators beyond the usual technical and economic parameters, which are not appropriate for assessing the diversity of the functions establishing multifunctionality.

As researchers we also have to investigate the changes induced by ICTs towards markets, meteorology, availability and state of resources, social relationships… and induced risks and assets for pastoralists.

And now to building collectively an agenda towards the next workshop

The aim we are sharing consists to maintain a diversity of production systems and food habits, taking care of reversibility, which is needed by the creation of landscape mosaics and the alleviation of poverty of small family farmers across the world.

This requires a close collaboration among involved stakeholders to elaborate an enlarged spectrum of performance criteria (rural employment, environment, food quality & safety … and cross over!) and new forms of social organizations within economic sectors as well as at the territorial level, by mobilizing researchers and practitioners to re-give sense to pastoral societies and listening herders and breeders.

A shared effort is needed to identify new pathways for research in regard of the threats we'll identify in order to improve viability, livelihood, sustainability of livestock systems!

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A multi-dimensional look at pastoralism: its culture, its contributions and its constraints

By the organizing committee with support of Nancy Hart

Pastoral systems use, modify and conserve ecosystems through extensive grazing / ranching using various livestock: sheep and cattle that graze mainly grasses, and goats, donkeys and camels that graze on herbaceous and woody plants. The livestock systems concerned are nomadism, transhumance, agro-pastoralism, mixed systems, ranching. It
is an economic and social system based on herding of livestock, relying on mobility and significant use of natural rangelands for grazing. It is an agricultural system continuously adapting to its environment across millennia – a system receiving increased attention in these days of globalization, climate change, food insecurity, ecological concerns, and a rising consumer demand for livestock products. Hundreds of millions of pastoralists herd their animals on arid and semi-arid lands, in mountain systems and lowlands, and often in socio-politically critical areas. They call upon their empirical knowledge in breeding and caring for their animals, protecting the rangelands they rely on and, in return, provide their world with many ecosystem services. Pastoralists have built real societies with their own regulations, cultures and civil societies, adding value to marginal lands through their agricultural system – a system that is not only adaptable and resilient, a system that gives back.

As pastoralism is questioned about its efficiencies and sometimes relationship with environmental concerns, it is time to reconsider it for the multiple contributions it provides to society, and to invoke appropriate policies that will support this unique economic and social system. Four interconnected dimensions of pastoralism – goods production, environmental concern, socio-economic outcomes, and local development contribution – are proposed here, which taken together with both their synergies and trade-offs, provide an overview of pastoralism's opportunities and challenges, and its contributions to the Sustainable Development Goals of the UN 2030 Agenda.

BACKGROUND

The agriculture of today's world owes a lot to the pastoralists of the past. From their indigenous knowledge of local ecosystems gained over millennia of co-evolution, interaction and mobility, pastoralists have been able to produce food on lands and areas where agriculture cannot. Whether cattle or camels, goats or sheep, reindeer or yak, by grazing their herds in areas where crops will not grow, they contribute to food security, converting low quality grasses into high quality and nutritious livestock products of milk, cheese, and meat from a diversity of animal breeds all over the world. At the same time, they have maintained the health of pasturelands and open landscapes with minimal disturbance of natural forests, and provided food, income, cultural assets and social cohesiveness for their pastoral communities.

Today, as the world deals with changing climates and environmental degradation, pastoralism is positioned to make important contributions. The mobility of pastoralists and herds favor adaptation to fluctuating availability of forage, and helps maintain and fertilize pastures, countering environmental degradation.

In spite of its contributions, problems that threaten this way of life continue to emerge. Increasing constraints on land access and efforts to "modernize" pastoralist systems by promoting sedentary livestock rearing have often led to poorly managed land use; sometimes reducing the resilience of the whole socio ecological system. In addition to relying on lands for pasture under strong natural constraints, the pastoralists themselves have been marginalized, often left out of discussions on land tenure, for example, or left without access to education or health care.

The pastoralist systems are significant at a global scale but finite in terms of the land area it occupies, the number of people it can sustain directly and indirectly, and the food it produces.Sometimes, young people who have been sent to town to learn a trade and earn a living would not come back to herding animals, even if they consider themselves pastoralists. In addition, as population and global food demand have increased, it has led to increased need for agricultural fields, which invariably spread into pastures or forests. Historically , mainly common pool resources

managed through community based rules, on recent periods few have been done to foster adaptations to new contexts. This have led to privatization of pastures and fragmenting of the landscape for agriculture or commerce, which often leaves pastoralists unable to maintain their sustainable herding pathways and, in turn, leads to degradation. As a consequence, it may be economically risky in a context of increasing frequency of economic and climate crises; including quite big income gaps between traders with large herds and people with unsustainably small herds.

Need for coexistence of a broad diversity of systems ranging from pastoralist and extensive grazing to intensive commercial production systems

The extensive pastoralist system of free-range grazing stands in contrast to highly productive livestock production systems which rely on costly inputs, such as fertilizers and pesticides needed to improve feed production and often antibiotic drugs needed for animals kept in close quarters. These last have been designed as a classical "industrial" process, according to the model which consists in transforming an input (animal feed) into an output (meat, milk, fiber ...) like a car industry. In order to "optimize" such production systems, a standardization is needed leading to a stabilization and an homogenization of the dynamics and the diversity of the living world. These techno-efficient systems can produce high quantities of livestock products quickly at low cost to consumers. Although known to pollute soil and water resources, actors of the industrial system are making major efforts through research and implementation of new feeds and waste disposal methods to clean up its environmental footprint. On the other side, extensive pastoral systems require low inputs, are adapted to the diversity, variability and uncertainty of ecosystems and produce low quantity of products per hectare or per animal even in harsh environment but of high specificity and sustainably in uncertain conditions over long periods.

It stands to reason that coexistence of the various systems –pastoralist, but also extensive grazing, mixed crop and livestock, and intensive commercial – is critical for a world seeking to feed safely a rapidly expanding and urbanizing population while conserving natural resources, mitigating climate change and maintaining landscapes. But this diversity relies on strong political wills in order to regulate economic competition between two schematic facing models: regarding need for food one is highly productive of standardized products, while the other one is producing goods rooted in cultural habits recognized as high quality products. First is based on inputs, capital and need to control all livestock environmental parameters; while consuming a wide range of lands the other rely more on traditional skills and a best adaptability and ability to deal with changing environmental parameters and the complexity of unpredictable ecosystems. So as well as on commercial opportunities, social expectations and resources availability there is room for both if relevant public policies managed it taking into account a multidimensional vision of rural activities.

THINKING PASTORAL SYSTEMS THROUGHOUT FOUR DIMENSIONS

It needs to take a holistic view of pastoralism and its multi-functionality to recognize its potentials and needs. Four interconnected dimensions of pastoralism – production, environment, socio-economic and local development – are proposed here, which, taken together, illustrate how pastoralism fits into today's agricultural reality. Although each dimension can stand on its own, the four dimensions also must be looked holistically, in terms of the synergies and tradeoffs.

Production

Pastoralism is known as an extensive production system, meaning animals graze across landscapes rather than in a confined, or intensive, production system. Although the amount of milk or meat they produce may be limited at the global level in terms of production and productivity, it can be very important at the national, or local, level where these systems can produce a significant share of food and contribute to the national economy. For example, approximately 70% of red meat consumed in Kenya would come from pastoral and agro-pastoral systems; in Mongolia, it is 80% of milk. Pastoral production systems also provide leather, wool, manure and animal power – all of which having market value. Also, the animals raised in these environments sometimes offer a unique quality of products, with, for example, the vegetation they graze that give specific taste to milk, cheese or meat. This can make those products particularly appealing to consumers and may provide opportunities for niche markets.

Environment

The rich biodiversity of plants and animal species and breeds that is found in today's pastoral and agro-pastoral landscapes often results from coevolution of pastoral grazing and farming activities. Maintenance of this diversity and

richness is a major contribution of pastoralism. If a rational resources management is applied, pastoralists give back to the land, through natural fertilizer, through maintaining pastures, open landscapes, and conserving biodiversity. While mainstream agriculture calls for cutting trees, pastoral animals graze among them, keeping grass at a low level that helps deter fire, fight erosion, cycle water, and also allows for storing carbon in soil, vegetation and animals. In most cases, pastoral herds graze on marginal or already degraded lands, giving them value by turning their feeble grasses into healthy animal protein. Of course, as with all livestock, pastoral herds are contributing to methane gas emission to the atmosphere, but the grazing systems landscapes can balance the GHG emission by their low level of consumption of non-renewable energy and positive contribution to carbon sequestration. Grasslands which account for 30 % of the land surface (3,5 billions of ha), store 30% of C soil stock (in the soil organic matter), or nearly 4 % of anthropogenic GHG emissions. However, the carbon sequestration potential would range from 0 to 4 t C/ha/year depending on the ecological zone, soil characteristics, climatic conditions and agricultural practices (Soussana et al. 2010). In pastoral ecosystems, the mechanisms driving the exchange of GHG between soil and water and the atmosphere are complex and knowledge on these ecosystems is lacking (Valentini et al. 2014), especially in tropical environments (IPCC 2013). This potential can vary from 0 to 150 kg C / ha / year in arid regions and from 100 kg to 1 t C / ha / year on wet and cold regions . Recent research results including level of production and forage intake estimate that the total balance in CO2 equivalent at the pastoral system level in African drylands is slightly negative (e.g. in favor of CO2 storage) (Assouma et al. 2016).

Social and economic

Historically speaking, pastoralism has made an enormous contribution to our global understanding of communities, because pastoralists have survived by working together to manage the common lands where their animals graze. Along a lasting history, sometimes blurred, they have established strong social organizations and inclusive economies in which their animals – their assets – provide social capital and insurance. As herds grow, so does the status of the herder. Because the animals are fed with natural graze, they have little need to purchase or gather fodder. As a result extensive pastoral systems, which rely more on herders know-how than on technical devices and feed purchasing, have few expenses and, if there are problems accessing pasture and water resources, they are mobile enough to move to new locations. This autonomy makes them less dependent on markets although in times of crisis, if they are forced to sell animals, they risk selling at unsatisfactory prices. This makes them especially resilient to environmental and economic crises – mobile enough to move to new locations in case of environmental change, without the expenses of inputs, they are less impacted by market changes than other systems. As an example, in Khomin Tal area, Mongolia, the high dependence of rangeland-based livestock farming systems to environmental uncertainty makes the resilience of these systems as important as production (Sabatier et al., 2017).

Local development

Over the millennia, pastoralists have bred and adapted their animals to survive in the harsh, remote environments where they live. By doing so, they keep on making best use of local resources (forage, labor force, etc...) to produce goods and manage their livelihood. In addition, the infrastructure and social organization that support the production and marketing of pastoralist livestock products bring a host of benefits ranging from employment for local people to providing an identity to the place and people. While this activity reinforce identity of whole regions and contribute strongly in maintaining environmental assets (biodiversity and wildlife richness particularly) it can also contribute to new opportunities in local development as coupling farming with tourism (e.g., Namibia, Kenya, Mongolia). For instance regarding mountain regions of southern Europe (e.g., Pyrenees, Alps), pastoral activity contributes to maintaining landscape, biodiversity or local identity, directly related to tourism and building on of recreational areas. In addition to building community pride, this branding associated with pastoral productions can add value as consumers recognize the important cultural identity as well as the quality of the productions. Pastoral activity contributes in maintaining relationship between urban areas and regions set aside from industrialization.

Practical application of pastoralism's four dimensions

A multifunctional approach to pastoralism development is based on considering each of the four dimensions of pastoralism, integrating also their synergies and trade-offs.

The proposed approach enables to examine each of the dimensions and determine if the success from one dimension balances what may be a negative impact of another dimension which have also to be mitigated. It also calls for involving all the stakeholders who eventually may impact or be impacted by pastoralism to add their expertise and

support, including the pastoralists and herders but also the land managers or owners, processors, retailers, consumers and, of course, the policy makers who can help establish the environment where positive outcomes balance any negatives.

CALL TO ACTION

It is time to recognize and support pastoralism for its contributions to sustainable development

Pastoralism needs attention and requires deliberate support from agriculture policies toward livestock farmers to be maintained while their products can hardly compete with industrial farming ones due to lower labor productivity. This in turn could draw future at risk, if these policies build strong dependencies toward supports too strongly connected to environmental conservation and disconnected of production, unable to foster local development capacities for the future.
A huge majority of livestock researchers are involved in researches aiming to increase the productivity of specialized animals, differentiated by species, in order to maximize the yield to transform feed into milk, meat, fiber, etc. This privileges the way identified above as "industrialized husbandry" at the expense of more extensive systems, like pastoralism, whose several interests and advantages for livelihood, environment, socio-economic development have been advocated within these few pages!

The proposed framework embraces the complex of interactions and interdependencies within four dimensions of pastoralism; it recognizes activities carried on by pastoralists. Considering as well the broad diversity of situations, more than ever pastoral systems needs to be taken into account by policy makers and the scientific community addressing the challenges and potentials of pastoralism.

To this effect, in terms of ***Research*** it will be critical to:

- Undertake surveys using multi-criteria performance indicators to substantiate impacts and contributions of pastoral systems;
- Include stakeholders in participatory and collaborative research in order to take advantage of all levels of knowledge and know-how;
- Establish lexicons that recognize the unique language used by practitioners in order to ensure dialogues lead to appropriate actions;

To this effect, in terms of ***Policymaking***, it will be critical to:

- Secure land tenure by thinking in terms of bundling rights to allow mobility, including trans-boundary rights;
- Work toward establishing natural resource access and rights, recognizing importance of pastoralist systems and sustainable grassland maintenance;
- Recognize pastoralism as a professional activity and the needs of pastoralists for education and health care;
- Develop infrastructure and productive alliances that will facilitate access to markets including roads, slaughterhouses, enabling pastoralists to take advantage of increased demand for niche products;
- Initiate training for young people in terms of connecting their empirical knowledge with modern approaches;
- Identify regulations to manage competition between imported and locally produced products;
- Facilitate multi-stakeholder local dialogues using mediating tools.

SOME FIGURES

In Sub-Saharan Africa, about 50 million people rely on pastoralism for their livelihood, or part of it; about half of these people are located in the Sahel and the Saharan fringes, and of these about 70 percent are poor.
http://www.livestockglobalalliance.org/pastoralism/

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GASL – ACTION NETWORK
"RESTORING VALUE TO GRASSLAND"

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