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Livestock farming embedded in local development: Functional perspective to alleviate vulnerability of rural communities

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■ INTRODUCTION

The aim of this thematic issue was to increase our understanding of how livestock farming can contribute to the functional integrity of socio-ecosystems and which dimensions of livestock farming are embedded in local development. Today throughout the world, livestock farming is mainly considered for the goods it produces for the market. But it also has other major and secondary functions which include savings, food for home consumption, transport, draft power, production of by-products and manure to fertilize crops or for heating; it is a key factor in pastoral landscape management; and as an essential component of heritage, traditions and local knowledge it plays a major part in social rules and collective actions, relevant domains for policy making. In other words many roles of livestock interact with local development.

Based on local study cases, this issue presents a global overview of both the functional integrity and the roles of livestock farming in local development. The fourteen contributions that make up this issue cover various countries across the world, from China to South America (Brazil, Argentina and Uruguay), and from Europe (France and Norway) to New Zealand, passing through Africa (Egypt, Morocco and Sudan). The study cases regard contrasted biomes, from the Amazonian rainforest to the arid areas of Northern Sahara and Southern Patagonia, and from the dry highlands of

the Tibetan Plateau to the humid Pampa in Argentina, Uruguay and Southern Brazil.

Depending on the local context, the authors attempted to answer the four main following questions:

- How can livestock farming contribute to reduce the vulnerability of livestock farmer populations and how to build vibrant rural communities by adding value to local resources, especially from a natural and social point of view?
- How to assess the contribution of livestock farming to local development notably through the importance of its different functions? These functions address livelihoods and household economy, but also the life of communities and local society, the environment and agriculture, all domains interacting with sustainable development.
- How and under which conditions or contexts does livestock farming (even if it is just a fragment of rural history) contribute to local sustainable development?
- What is the role of policy making, at local, national and regional scale that guarantees income security or satisfaction of primary needs – food, health and education – in pastoral areas?

The present articles differently address the four questions. The role of livestock in reducing vulnerability is mainly discussed in Waquil et al., De Carvalho et al., Ding et al., Wedderburn et al., Metawi, Elfaki et al., Alary et al., and Dedieu and Pailleux. Articles more focused on the contribution of livestock to local development are those of Srairi, De Carvalho et al., Nogar et al., Wedderburn et al., and Coronato et al. The conditions and context of the interactions between livestock and local development are addressed by Waquil et al., Srairi, Asheim et al., Coronato et al.,

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and Dedieu and Pailleux. The role of public policies are dealt with especially by Sraïri, Ding et al., Lambert-Derkimba et al., and Jousseins et al., the latter highlighting method issues to assess the links between livestock farming and local development.

■ LIVESTOCK FARMING VULNERABILITY

Small-scale breeders, particularly in extensive pastoral systems, are vulnerable to any sort of crisis and in many cases do not have access to social protection systems. The dependence on mono-production, e.g. animal breeding, and external inputs such as feed, veterinary products, cereal grains, leads to the loss of control over the livestock system, and thus increases further small breeders' vulnerability to change. World trade rules, local environmental regulations, consumers' expectations, and decreasing agricultural prices for locally produced food reduce small farmers' competitiveness and aggravate even more poverty and indebtedness. These pressures will be intensified by the greater risk of harsh weather conditions caused by climate change that will specifically increase uncertainty in the extensive livestock system. This vicious cycle pushes many poor breeders out of their activities forcing them to join the masses of poor daily labor either in the rural areas or in the cities in developing countries. The situation is little different in developed countries. The pressure impacts on grasslands or rangeland livestock systems may contrive amalgamation of properties to achieve efficiency gains, shifting the farm ownership structure from family owned and operated farms to corporate structures that may or may not be family owned. These changes are reflected in changing rural communities and urban perceptions of agriculture.

■ VULNERABILITY AND SUSTAINABILITY: FROM RESOURCE SUFFICIENCY TO FUNCTIONAL INTEGRITY

The theoretical approach about the nature and function of socio-ecosystems became institutionalized at particular moments in history. This process leads to specific practices and policies which may outlast commitments for which they were built. For example, two philosophical approaches to sustainability have now emerged (Thompson, 1997): 'resource sufficiency' and 'functional integrity'.

The resource sufficiency measures the rates at which resources are used in food production, distribution and consumption. In livestock production, the main challenge is to maintain the increasing efficiency, while reducing pollution and finding substitutes for scarce inputs. Thus, the resource sufficiency approach leads to policies based on the ethical importance of agriculture in terms of its impacts on the welfare and rights of present and future generations. Vulnerability is thus related to insufficient resource maintenance or inefficient resource management that lowers producers' income.

The functional integrity focuses on the vulnerability caused by systemic interactions, especially the gap between production practices, including innovations, and processes of ecological and social renewal. This approach positions agriculture as a socio-system, which embodies complex and poorly understood value commitments and ecosystem relationships. It gives rise to policy strategies that emphasize the preservation of the capacity for resilience, the avoidance of irreversible effects and systemic understandings designed to mitigate unintended consequences. The issue thus forestalls irreversible changes in the socio-ecosystem while pursuing better understanding of critical trajectories and tipping points.

The current organization of agricultural sciences favors the resource sufficiency approach. Resources are considered as a capital – or stock – more or less renewable or critical. There are three ways to maintain sustainability when resources are declining and become limited. Sustainability requires either a decreasing rate of consumption, or increased efficiency, or substitution with other resources. Thus, many technical recommendations regarding rangeland uses relate to a decrease in stocking rates (lower needs), the introduction of improved pasture (better efficiency and substitution). Critical factors are therefore the resources that are scarce, either by being in short supply or consumed at rates that cannot be sustained. As previously mentioned, research and policy have to focus on increasing efficiency of scarce resources by introducing new technologies with better yields, as well as by finding substitutes.

At the opposite, the concept of functional integrity presupposes a system based on crucial elements which are reproduced over time at a rate depending on the previous system states, as well as those generated by the dynamics of the different living communities interacting within the system, according to their own changes and variations. These elements may be, for example, soil fertility, herd reproduction, crop-livestock interactions, diversification and complementarity in land use, animal and vegetal biodiversity, but also the know-how in management practices or product processing, or even institutions such as the family, rights regimes, specific markets.

Extensive livestock farming is a good example of the functional integrity because its many aspects – e.g. stocking rate, forage, crops, biodiversity, produced goods such as milk, meat, wool and manure, landscape and water access, seasonal migration, herd management and services – produce complex relationships. These elements of livestock systems can remain in a dynamic equilibrium for extended periods of time, but disequilibrium can appear suddenly (or with substantial time lag) as a consequence of critical changes in the reproductive capacity of any single element. Several practices can threaten the functional integrity if they drive the system into states from which reproductive processes cannot recover. But, these practices are part of the system itself. That means the functional integrity can be disrupted in many ways, including the simple failure to perform an action, which is crucial to reproduce some system element or to maintain it in a changing context. Several context changes can occur, such as the market demand and price, new regulations, consumers' behavior, social troubles, and climatic events.

People will perform critical actions only when a complex web of social and cultural prerequisites is in place. They must have the knowledge and capacity needed to perform the activity, and they must have incentives or inducements to do so. Making changes in the socio-ecosystems relies on the knowledge of these socio-ecosystems, and how social institutions and human incentives can be regenerated. The key challenge for the functional integrity is to conduct researches that lead to a better understanding of the critical factors themselves, subsystems, or the systemic interaction of components that allow the system to regenerate or adapt. It presumes that norms, values and perceived obligations are themselves components of the socio-ecosystems.

In summary, the resource sufficiency assumes that an agro-ecosystem is simply the sum of the resource transformations and consumption elements involved, or that such relationships are sufficiently stable to be ignored. However, for the functional integrity it is precisely these system-level dynamics and changing interrelationships that are the primary objects of study, which presumes that ignoring the mechanisms for system regeneration and transformation is potentially a

fatal error. Thus, ecology, ecosystem modeling, systems analysis and systemic inquiry are crucial to this approach. Although much of the empirical knowledge about specific elements of socio-ecosystems can be found in traditional agricultural disciplines as well as in the local knowledge of day-to-day practitioners, the praxis of synthesis remains comparatively weak.

■ LIVESTOCK FARMING AND LOCAL DEVELOPMENT

Livestock farming refers to a human activity based on the management of domestic animals for various purposes at different scales. At farm level, the livestock farming role is the production of goods for market and self-consumption, savings, transport and workforce, rituals and social status, manure fertilizer and by-products, an added-value to cropping system and marginal areas, etc.

It also has several and diverse functions at local level in different domains such as economics, the environment, and social issues. In economics, many authors, especially Alary et al. (2011) mentioned the key function of livestock in animal supply chains, in particular the consumption of inputs, the created employment and the production of commodities for food industries. Livestock farming is a major component of the landscape through the presence of animals, grasslands and rangelands, animal husbandry tools and infrastructures, crop-livestock synergies and urban-rural relationships. From an environmental point of view, livestock interacts with the biodiversity, water cycles, soil nutrients. With regard to social issues, livestock contributes to the mental models of rural people, but also of urban populations. Frequently, it is the pillar of heritage and traditions.

Livestock farming is a global issue. On one hand the environmental impacts are significant, especially greenhouse gas emissions, around 18% of the total emissions, which are linked to the specific physiology of ruminants (Steinfeld et al., 2006). On the other, deforestation generated by pasture cultivation, biodiversity loss, underground and surface water pollution as well as soil pollution are some other significant effects of the livestock industry on the environment.

In the past in many countries and currently in many areas, cattle and sheep ranching is one of the main symbols of land conflicts between large-scale farmers, smallholders and landless peasants. The fence across the prairie is the image to both manage the herds and forbid the entrance to non-authorized people. The 'process of clearance' started in the United Kingdom in the 18th century, especially in Scotland and Ireland. Then it spread to the Americas, Australia, South Africa and to some islands. Across the centuries, animal husbandry has appeared as a tool of colonization and its expansion a key factor in genocides.

However, animal production is also a key factor of the global economy. Meat, milk, wool, leather are commodities that easily move around the world. Many times they are produced in one region and consumed in another according to the market and the international demand. Some authors consider that globalization started in 1885 in the town of Frey Bentos, Uruguay, with the building of a slaughterhouse by an English company to commercialize meat in the global market. Finally, the last decades have been plagued by scandals linked to animal production, e.g. bovine spongiform encephalopathy, dioxin in chicken meat, melanin in milk powder, avian flu, and horse meat as a substitute to beef in fast food preparations.

Livestock farming appears as a part of diverse systems which are interconnected. A relevant literature exists about the

multifunctionality of livestock at farm level, mainly in the last decades. More recently, several institutions have been interacting on the resource sufficiency of animal production at global scale. This thematic issue focuses more on the functional integrity of animal breeding at local level, especially how and where livestock interacts with local development. The local scale could be quite relevant to understand better the diversity and dynamics of farming patterns and functions of livestock farming activity which is contributing to local development processes. Moreover, this issue is mainly on extensive livestock systems which are here defined by the use of rangelands or grasslands as the main source of feed for livestock (Sere and Steinfeld, 1996).

Extensive livestock farming is intricately linked to spatial dimensions since animals are mobile, e.g. nomadic or transhumant, crossing vast areas under some conditions. Extensive livestock farming leaves a cultural and environmental imprint in areas where it is present as well as in areas where it has been historically present. The local or "territorial"⁵ level therefore seems like a relevant entrance point to reflect upon the future of extensive livestock farming because this is the level at which the choices made by societies play a role in the organization and transformation of local areas, especially through policy making.

The analysis of extensive livestock farming systems embedded in their local situations and influenced by their past and present may address questions such as how to alleviate the breeding system vulnerability and build adaptive capacity from farm to consumer. Taking into account individual and collective behavior, this analysis enables an innovation systems approach which identifies, in partnership with the stakeholders, what the issue is and looks for collective means to address it.

In conclusion, based on case studies located in contrasted biomes and socioeconomic contexts, this issue focuses on the contribution of livestock farming to local development. Livestock farming appears as a relevant component of the sustainability of pastoral and agropastoral socio-ecosystems, especially to alleviate the vulnerability of rural communities. The functional integrity approach allows describing and understanding better the interactions inside the socio-ecosystems, and not only the dynamic of its interacting entities.

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5. According to Brunet's (1992) definition: "The territory is a stretch of area used and managed by human societies." This definition thus embeds "territory" in the disciplinary field that associates nature and society and factors in their relationships. It confers upon "territory" a double dimension: a physical-spatial dimension and the other which is socially constructed. Territory is considered here at the local level, i.e. the level which allows for a system of interconnections and interrelationships between actors.

Vulnerability of family livestock farming on the Livramento-Rivera border of Brazil and Uruguay: Comparative analysis

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Cattle, family farm, risk factor, Brazil, Uruguay

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Summary

Social, ecological, and economic sciences have all shown interest in studying the social group called family livestock farmers. The main characteristic of this group, which is present in the Pampa biome in Southern Brazil and Uruguay, is beef cattle production based on family work on small lands, expressing an autonomous way of life which is, however, highly dependent on strong relations with the physical environment and marked by risk aversion. In this study we made a comparative analysis of vulnerability factors of family livestock farming in Brazil and Uruguay. We also compared these social actors' perceptions of risks, and the strategies built to mitigate threats. A survey was thus carried out and included 16 family livestock farmers' interviews, eight in each country, near the cities of Santana do Livramento (Brazil) and Rivera (Uruguay). Although these cities are next to each other on each side of the border and thus present environmental similarities, we chose them because family farming was not subjected to the same political and economic conditions which might (or might not) have influenced farmers' perceptions and reactions. Results showed that livestock farmers were mainly affected by vulnerabilities arising from external elements such as the climate (e.g. droughts or harsh winters), but also from internal elements (lack of land access and successors). From the family livestock farmers' standpoint, the highest risks to their production systems and social system reproduction were more related to climate than to price and market variations.

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■ INTRODUCTION

Social, ecological, and economic sciences have all shown interest in studying the social group called family livestock farmers. This group, which exists in significant numbers in the Pampa biome in Brazil and Uruguay, is characterized by the production of beef cattle based predominantly on family work in small areas, expressing an autonomous way of life marked by risk aversion and dependent on strong relations with the physical environment. This relation is through the appropriation of nature, with typical elements of the agricultural premodernization period, using primarily energy from nature, with a low degree of manipulation of environmental elements and changes in the landscape.

In general, family livestock farming derives from the dispute for agricultural space with activities that use industrial inputs, industrial models of production, processing and distribution, i.e. crop or livestock production able to provide larger levels of intensification. As a

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result, historically family livestock farming occupied marginal areas that, besides having little interest for capitalism, required innovative approaches, both technological and organizational, to fulfill its productive potential. This situation has been keeping this group with little relation to the agricultural modernization and access to markets, but has been providing an important degree of autonomy, responsible for its own sociocultural and economic survival.

The strategies of social reproduction of family livestock farming may be under threat from a number of factors including the continued lack of awareness of the institutions responsible for generating appropriate innovations to this complex reality, coupled with cultural traits that hinder more advanced levels of social organization, besides the lack of specific public policies for family livestock farming, the rearrangements of agrarian capitalism – which rediscovers the potential of marginalized areas –, drift from the land especially by young people and women, as well as phenomena like climate changes.

The aim of this paper was to make a comparative evaluation on the aspects that cause vulnerability of family livestock farming in the border region between Brazil and Uruguay, as well as these social actors' perceptions on the risks and strategies forged to mitigate the threats.

■ BRIEF REVIEW ON VULNERABILITY

In the context of processes of socioeconomic and environmental changes that have been perceived in contemporary societies, the term vulnerability has emerged as an important heuristic tool for the analysis of events of different nature, intensity and consequences. In Latin America, a general analysis on the overview of rurality shows that since the 1990s there has been an intensification of social inequalities, reflected in the increase of social exclusion and rural poverty (Schejtman and Berdegue, 2003), increase of tensions and conflicts in the countryside (Kay, 2007), and expansion of environmental problems caused by rampant actions toward the appropriation and use of natural resources for the service of the capitalist economy (Leff, 2000). These are the most visible consequences of a modern society that is in a state of crisis and increasingly 'manufactures' uncertainties (Giddens, 1991).

In this sense, the notion of uncertainty becomes a key element to understand the new socio-spatial arrangements, and vulnerability constitutes a promising element to understand the present uncertainty under different spatial and temporal dynamics (Marandola and Hogan, 2006).

The concept of vulnerability takes a polysemic meaning in the literature even with no conceptual consensus (Gunther and Hartgen, 2009); it usually encompasses the concepts of exposure to risks, uncertainty and the inability to recover (resilience) when facing these situations. For Chambers (2006)* vulnerability refers to the exposure to contingencies and stress, and the difficulty to deal with them. From this, the author mentions that vulnerability can be understood through two overlapping sides, the external (exogenous) that arises from situations that cause shock, stress or risk, and the internal (endogenous) which is the ability to react to impacting external situations.

This approach on vulnerability has become a sort of basic reference for the conduct of works in recent years that deal with the issue of social vulnerability within the social sciences and has also made possible concrete proposals for action in different

international institutions. In this sense, social vulnerability takes into account the insecurity and exposure to risks and disruptions caused by events or economic changes considering at the same time resource availability and strategies that the families adopt to cope with the impacts that affect them (Alves et al., 2008).

In agreement with De Sherbinin et al. (2007), in social sciences vulnerability has been considered the result of three main factors: the degree of risk exposure, the susceptibility to risk and the adaptive capacity (resilience) before risk materialization. In this regard, the situation of higher vulnerability would occur for those people or social groups that in the midst of a dangerous situation have a lesser ability to recover (Moser, 1998). For Sen (2001) vulnerability combines a situation that involves the notion of basic capabilities of individuals from exposure to a risk situation since in these cases the individuals are worsening their well-being situation (deprivation of their freedom). Thus, the higher degree of vulnerability (risk exposure) is proportional to the increase in poverty.

According to Bole et al. [quoted by Mayorga and Mayorga (2011)] the most vulnerable individuals, groups, classes and regions are those who find themselves with a considerable level of exposure to disturbances and have limited mitigation ability, suffering more from the impacts of socioeconomic or environmental crises and, finally, with reduced ability to recover after a crisis.

Part of these findings about the predictability of the future in terms of the past lies in the fact that some strategies adopted by individuals to overcome disturbances are derived from experiences lived in the past (Chambers, 2006). Knowing these strategies is a key step to make predictions about the possible reactions to be adopted by individuals. Ribot (1995), in a study carried out in semiarid regions in the tropics, notes that the identification of strategies adopted by inlanders to face drought supplies important elements to develop policies that will reduce vulnerability, as it is necessary to know the means of problem solving (adopted strategies) that the individuals have, that is, it should focus primarily on how they perceive their own vulnerability.

Chambers (2006) points out that the vision focused on experts' opinion only may not reflect reality because the needs of the poorest has been formulated in parts from models designed by the wealthier dominant group. For this author it is necessary to know what they (whether individuals or groups) perceive as vulnerability and capture the symbolic factors involving needs and priorities.

Considering the nuances between the two – theoretical and ontological – perspectives present in social and natural sciences on the notion of vulnerability, it is important to recognize that both perspectives offer major elements to ponder the questions relative to vulnerability. For this reason, to make a broader theoretical-ontological picture incorporating the different approaches and perspectives around the issue of vulnerability constitutes a challenge for the advancement of knowledge.

This means assuming that the phenomena involving situations of vulnerability do not occur in isolation in separate social and natural contexts. The risks associated with vulnerability occur in specific contexts but both the social and natural dimensions are interconnected. In this sense Marandola and Hogan (2006) offer important elements for reflection. They state that when an investigation on vulnerability is undertaken, it is fundamental to question: "Vulnerability to what?" In other words vulnerability will always be defined from a hazard or set of them at some specific natural and social context.

Based on this theoretical framework, this paper seeks to show what the family livestock farmers along the border region between

* The original work is from 1989, Chambers R., Vulnerability, coping and policy, *IDS Bull.*, 20 (2).

Uruguay and Brazil perceive as vulnerabilities, the risks they face in the context of socioeconomic and environmental changes, and their capacity to adapt/react to these risks considering the differences between the two countries.

■ METHODS

Research context

The study was conducted in Gaucho Pampa, on the border between Brazil and Uruguay. We interviewed sixteen livestock farmers, eight near the city of Santana do Livramento (Brazil) and eight in Rivera Department (Uruguay). In Brazil, the survey was conducted in the town of Cerro da Arvore, and in Uruguay near Tranqueras, in the towns of Ataques and Valle del Lunarejo.

Santana do Livramento is located at 30° 53' 27" S and 55° 31' 58" W with an altitude of 208 meters. This is the same position for Rivera, as both zones constitute practically one location called the 'Integration Border', with a dry border that allows intense cultural, economic and social interconnection.

Santana do Livramento's main agricultural activity is livestock farming (beef and dairy cattle, and sheep), rice and fruit production representing a minor activity. The city has experienced a decline in the population (although mainly in the urban population) with high dropout rates (-9.18%) between 2000 and 2010. Rivera is the capital of the department of the same name in Uruguay where beef cattle and sheep husbandry predominates and, more recently, forestry (monoculture of eucalyptus and pine trees).

Characteristics of family livestock farmers

Access to land

Sixteen family livestock farmers were interviewed: eight in Brazil, where the farms covered between 30 and 230 ha with an average of 120 ha, and 71% of the farmers owned the land; and eight in Uruguay, where the farms covered between 31.5 and 572 ha with an average of 260 ha, and 81% of the farmers owned the land. In both countries land availability was a limiting factor for the farmers. In Brazil, the main strategy used to overcome this difficulty was to lease areas from neighboring farmers where their animals were moved to, paying monthly for each ('cattle per head'). In Uruguay, this strategy was not used because of the presence of forestry companies which raised land price and thus increased competition and reduced land availability for livestock farming. Most people interviewed (75% in Brazil and 50% in Uruguay) had access to land through inheritance with some later acquisitions. Although there was a quest for more land, the restrictions were greater in Uruguay, where 57% of interviewees kept their areas stable vs 37.5% in Brazil who extended their lands through leases.

Cattle herd

The cattle herd average of the family livestock farmers interviewed in Brazil was around 130 head and the main commercialized categories were calves and cull cows. In Uruguay, the cattle herd average per interviewed farmer was around 216 head and the main commercialized categories were also calves and cull cows.

Families

Most families comprised a couple and one child (50%) or only a couple (25%). In Brazil, in most of the studied cases, one child (or more than one) migrated to the city in search of alternatives. This configuration denotes a situation similar to that observed in other studies (Azevedo, 2010; Matte, 2010; Ribeiro, 2009). The predominant level of education of the interviewees in Brazil

was incomplete primary level. In Uruguay, education levels were higher, only 25% had primary education and 50% of the interviewees had a relative who had received technical courses.

Experience in the activity

The experience of the head of the family in livestock farming was significant in both countries, with an average of 42 years in Brazil and 46 years in Uruguay, which also might show aging of the farmers interviewed (although it could not be generalized to the entire population). Despite this similarity of age there was a major significant difference with regard to access to retirement pensions. In Brazil, 75% of interviewees had at least one retirement pension within the family, which significantly contributed to the support and social reproduction of the family. In Uruguay, the law obliges farmers to retire from farming when they claim their retirement pension. Thus, the Brazilian family farmer was able to rely on an important external income, contrarily to the Uruguayan farmer. In Uruguay we met some producers who had a family member who retired from urban activities and returned to live in the countryside. This was a notable difference between the two countries that contributed to an increased vulnerability of Uruguayan family livestock farmers and which also influenced their production ways because the income had to come entirely from farming.

■ RESULTS AND DISCUSSION

Interviewees identified some issues as their main vulnerabilities, both external and internal, assigning scores from 1 to 5 according to their perception of the importance of each factor (Table I). In general, both in Brazil and Uruguay the question of succession was regarded as one of the major internal vulnerabilities in the medium and long terms (Table I). Interviewees considered that this kind of situation had worsened in recent years as the sons and daughters left to study or work and did not return to the farms. In general, in both countries the vast majority of interviewed people intended to continue their livestock farming activity and preferred that their children also remained on the farm, especially to keep ownership of the land. About 62% of respondents assumed that some of their

Table I

Perception of family livestock farmers on the main vulnerabilities to which they are exposed

Variable	Brazil		Uruguay	
	Average*	SD	Average	SD
Difficulty in identifying potential successors	4.50	1.41	4.50	1.41
Mobility difficulties (roads in poor conditions)	4.38	1.40	1.00	0.00
Weather factors (drought and harsh winters)	4.25	1.48	5.00	0.00
Difficulty in hiring labor	3.88	2.10	4.50	1.41
Exchange rates, uncertainties in prices received	2.78	1.98	5.00	0.00
Input price	2.25	1.83	5.00	0.00
Cattle theft	3.63	1.77	3.86	1.85

SD: standard deviation

* Calculated from a score of 1 (not important) to 5 (very important)

children would be interested in staying. The Brazilian livestock farmers pinned down the access to schools as a major constraint to motivate children and/or young people to stay in the countryside. The relatively long distances from schools combined with transportation difficulties were elements that made life in the countryside difficult. In Uruguay, the level of confidence expressed in livestock farming as a way to survive was much higher than in Brazil.

Table I also shows a similarity between the two countries in relation to cattle theft. Although most livestock farmers in Brazil had not been confronted with cattle theft in the last two years, they knew that it was a chronic problem that impacted livestock production in general. Uruguayan livestock farmers cited animal theft as one of the causes for the decrease in sheep breeding.

A similar perception of climate change issues was also shared by both countries. There was consensus among livestock farmers that weather events (especially droughts) constituted a major problem with regard to production. Thus, around 80% of the interviewees stated that they constantly faced difficulties caused by weather conditions and that they should from then on establish measures to deal with these situations.

Another similar characteristic to both countries related to the difficulty in hiring labor. In Brazil, although the activity was largely based on family labor, the near 'disappearance' of people who work in the field was striking, as stressed by a livestock farmer: "there are no more people in the field." In Uruguay, the difficulty in hiring labor initially related to the competition with intensive crops but today it is rather caused by forestry companies and saw-mills that attract much of the labor in the region. However, one major difference between the two countries concerned reciprocity, i.e. the exchange of services among neighbors without compensation. In Brazil this is a common practice and it helps surmount the lack of manpower, whereas in Uruguay it is not and it thus causes difficulties in some seasons.

Among the differences the Brazilians emphatically cited the poor road conditions that restricted movement, hampering thus cattle trade, services, and more generally commercialization possibilities. The Uruguayans on the other hand did not cite road conditions as an important factor because they considered them as well maintained (especially by forestry companies) and, with the heavy traffic of trucks (also from forestry companies), there was always the opportunity for a ride to the city.

Another difference between the family livestock farmers of both countries concerned commercialization issues. Although neither faced difficulties in accessing distribution channels, the Uruguayans gave more importance to vulnerability factors related to uncertainty over prices charged or prices paid than the Brazilians. The Uruguayans cited as uncertainties the variations in the price of cattle mainly caused by fluctuations in the exchange rate. Above all, they almost unanimously mentioned the high price of inputs. According to the Brazilians commercialization was difficult because of its small scale, lack of definition of breed standards and payment uncertainty. Furthermore, some Brazilians reported buying inputs in Uruguay because they were cheaper than in Brazil.

An analysis of family livestock farming vulnerability ought to include farmers' behavior, strategies, and how they react or would react when faced with a situation of uncertainty or crisis. Some works on family livestock farmers highlight their risk aversion and, among their objectives, tradition, land attachment and satisfaction to work in the field of livestock farming, not necessarily profit (Azevedo, 2010; Matte, 2010; Ribeiro, 2009). These studies

agree with the present research findings. When interviewed on their actions in a crisis situation, the farmers emphatically comment on three main strategies (Table II). The strategy the most often reported by farmers from Brazil and Uruguay was to reduce expenses and wait for the crisis to end. This was probably associated with the ways they managed production, as well as their approach to decision making. Risk aversion made livestock farmers find mechanisms to reduce costs without tinkering with the production system and agrarian structure. Indeed the sale of land or part of it was rather a non-option for this type of livestock farmer.

The Brazilians pointed out, as a second strategy in a crisis, the sale of animals regardless of the price of cattle; the Uruguayans did not mention it. Retirement pensions were identified as a buffer in times of crisis. It was noteworthy that in Brazilians' case they consisted in rural pensions, whereas in Uruguayans' case they consisted in urban pensions brought along by family members.

Although they considered it a difficult activity with high costs, in the event of surplus financial resources the Brazilians would acquire land (average 3.63) and improve housing conditions (average 3.25). Uruguayans would ignore land acquisition as the price of land had risen greatly in the areas because of investments by the forest industry. Thus, Uruguayans' investments aimed more at improving beef cattle breeds and feeding (average 3.86), as well as reinforcing structures and buying equipment, e.g. fences, sheds and tractors (average 3.86).

■ CONCLUSION

These results showed the existence of a group of livestock farmers on the border between Brazil and Uruguay presenting the general characteristics of family farming in small areas, who had very similar perceptions on some issues and some very different ones on others. The similar perceptions of the farmers from both countries on vulnerabilities they might face related to external factors such as the weather (especially droughts), as well as to internal factors such as the lack of successors and the difficulty to expand land by purchase or lease. The dissimilar perceptions on vulnerabilities were caused by differences in public policies (retirement and access to credit), infrastructure (roads) and market (exchange rate fluctuations) conditions. However, the family livestock farmers' perceptions of risks that threatened their production systems and family reproduction were more related to climate than to prices or markets.

Table II

Possible strategies of family livestock farmers facing a situation of crisis and/or vulnerability in 2011

Variable	Brazil		Uruguay	
	Average*	SD	Average	SD
Reduce expenses and expect the crisis to end	4.50	1.41	4.00	1.73
Commercialize cattle	4.25	1.49	1.00	0.00
Use money from retirement pensions	3.50	2.07	3.75	1.89

SD: standard deviation

* Calculated from a score of 1 (not important) to 5 (very important)

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Résumé

Waquil P.D., Neske M.Z., Ribeiro C.M., Schlick F.E., Andreatta T., Perleberg C., Borba M.F.S., Trindade J.P., Carriquiry R., Malaquin I., Saravia A., Gonzales M., Claudino L.S.D. Vulnérabilité des éleveurs familiaux à la frontière entre Livramento et Rivera au Brésil et en Uruguay : analyse comparative

Le groupe social appelé les éleveurs familiaux a suscité l'intérêt des sciences sociales, économiques et environnementales. La principale caractéristique de ce groupe, présent dans le biome Pampa au sud du Brésil et en Uruguay, est la production basée sur le travail familial sur de petites parcelles, exprimant un mode de vie autonome, très dépendant toutefois de fortes relations avec le milieu naturel et marqué par l'aversion au risque. L'objectif de cet article a été de faire une analyse comparative des facteurs de vulnérabilité des éleveurs familiaux du sud du Brésil et d'Uruguay, ainsi que des perceptions de ces acteurs sociaux sur les risques et les stratégies mises en place pour atténuer les menaces. Une enquête a été menée dans le but de répondre à ces questions, à partir d'interviews de seize éleveurs familiaux, huit dans chaque pays, dans les villes de Santana do Livramento (Brésil) et Rivera (Uruguay). Le choix de ces communes a été lié au fait que, malgré leur proximité géographique de chaque côté de la frontière et leurs similitudes environnementales, l'élevage familial n'était pas soumis aux mêmes conditions politiques et économiques, ce qui pouvait ou non influencer leurs perceptions et leurs réactions. Les résultats ont montré que les éleveurs étaient principalement affectés par les vulnérabilités provenant de facteurs externes comme le climat (sécheresses ou hivers rudes, par exemple) mais aussi de facteurs internes (accès à la terre limitée, successeurs). Du point de vue des éleveurs familiaux, les plus grands risques pour leur système de production et leur mode de reproduction sociale étaient plutôt liés aux variations climatiques qu'aux facteurs de prix et de marchés.

Mots-clés: bovin, agriculture familiale, facteur de risque, Brésil, Uruguay

Resumen

Waquil P.D., Neske M.Z., Ribeiro C.M., Schlick F.E., Andreatta T., Perleberg C., Borba M.F.S., Trindade J.P., Carriquiry R., Malaquin I., Saravia A., Gonzales M., Claudino L.S.D. Vulnerabilidad de las explotaciones ganaderas familiares en la frontera de Livramento-Rivera entre Brasil y Uruguay: análisis comparativo

Las ciencias sociales, ecológicas y económicas han mostrado interés en estudiar el grupo social llamado explotaciones ganaderas familiares. La principal característica de este grupo, presente en el bioma de la Pampa en el sur de Brasil y Uruguay, es la producción de ganado de carne, basada en trabajo familiar en pequeñas extensiones de tierra, expresando una forma de vida autónoma, la cual es sin embargo, altamente dependiente de las fuertes relaciones con el medio ambiente físico y marcada por la aversión del riesgo. En el presente estudio realizamos un análisis comparativo de los factores de vulnerabilidad de las explotaciones ganaderas familiares en Brasil y Uruguay. Comparamos también la percepción del riesgo de estos actores sociales y las estrategias implementadas para mitigar las amenazas. Se llevó entonces a cabo una encuesta, que incluyó entrevistas en 16 establecimientos ganaderos familiares, ocho en cada país, cerca de las ciudades de Santana do Livramento (Brasil) y Rivera (Uruguay). Aunque estas ciudades están próximas una de la otra a cada lado de la frontera y por lo tanto presentan similitudes ambientales, las escogimos porque las fincas familiares no están sujetas a las mismas condiciones políticas y económicas, que podrían (o no) influenciar las percepciones y reacciones de los finqueros. Los resultados muestran que los finqueros ganaderos estaban principalmente afectados por vulnerabilidades originadas en elementos externos como el clima (ej: sequías o inviernos inclementes), pero también en elementos internos (falta de acceso a la tierra y sucesores). Desde el punto de vista de los finqueros ganaderos familiares, los mayores riesgos a sus sistemas de producción y a la reproducción social del sistema estaban más relacionados al clima que a las variaciones de precio o mercado.

Palabras clave: ganado bovino, explotación agrícola familiar, factor de riesgo, Brasil, Uruguay

Opportunism and persistence in milk production in the Brazilian Amazonia

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Keywords

Family farming, milk production, milk collection, sustainability, Amazonia

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Summary

In Amazonia milk production is considered as an opportunity to improve the viability of small farms because of the double function of milk and calf production, which is promoted by the high forage potential resulting from the hot and humid climate. However, dairy production does not depend on fodder only, the challenge is more complex. This paper describes how the local milk supply chain and the context restrict the productivity and innovation process in the dairy sector. It also outlines short-term development possibilities. We implemented a new method that combined three complementary approaches in order to understand better the complexity of dairy production in Amazonia. These approaches were based on i) a farm typology carried out during two different periods to build farm trajectories, ii) a retrospective analysis to describe changes and persistence in the involved factors, and iii) a supply chain analysis based on secondary data and information collected from key informants. The obtained results completed the significant knowledge gathered by researchers over the past ten years. The typology revealed the frequent and sudden changes in farm strategies, with two main trends: opportunism and persistence in relation to management practices, especially animal reproduction, feeding, and dairy product marketing. The latter highly depends on the capacity of local dairy factories to build a trusting relationship with the farmers. However, this partnership is difficult to set up because of transportation constraints, insufficient access to the market, and national production norms. This context explains the frequent creation / closing out of dairy factories. This is why many farmers center their production on calves and consider milk as a by-product. Others, however, keep up producing milk and calves for cultural reasons, looking out for alternatives to milk marketing. Three scenarios have been developed: i) intensification, ii) increase in the local demand, and iii) demanding environmental policies.

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■ INTRODUCTION

Agricultural changes have been very dynamic in Amazonia for the past fifty years, especially along the 'arc of deforestation' where pioneers of several populations have been building new agricultural basins, using slash-and-burn practices to destroy natural

rainforest and plant their crops and pastures (Maia et al., 2011). This region is regarded as a frontier, characterized by agricultural colonization launched since the middle of the 1960s by the Brazilian federal government (Hurtienne, 1999), which also decided that cattle ranching would become the main activity of colons' families with around 80–90% of deforested areas planted in pastures. A low level of infrastructures, especially for energy, transportation and communication or services, is a characteristic of the Amazonian frontier (Mertens et al., 2002; Margulis, 2003). This situation strengthened the place of livestock because most of the producers considered extensive cattle ranching as an efficient solution to survive under such precarious contexts (Da Veiga et al., 2004; Vaz et al., 2012). But this also led to serious consequences regarding both the environment (deforestation of the rain forest, soil degradation, low use of agroecological potential) and the social issue with low income generation, land concentration and conflicts (Pacheco and Pocard-Chapuis, 2012).

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Since 2005, strict national policies have blocked cattle ranching expansion with the objective of stopping deforestation and use of fire which are the two main consequences of these extensive production systems (Maia et al., 2011). Nowadays, farmers need to adopt new strategies and practices in order to increase, or at least maintain, their forage production despite smaller available areas, and therefore to increase their income (Vaz et al., 2012). Small farmers are especially vulnerable within this challenge and milk commercialization could be an adapted solution for the intensification of their production. Small dairy production systems could generate increased income thanks to great forage production, even in fire-free and deforestation-free conditions (Poccard-Chapuis et al., 2003b). This possibility has become a priority for some public policies to ensure the stability of family farms on the Amazon frontier (Vaz et al., 2012). However, in this isolated region, innovations in the farm systems are linked to commercialization conditions (Da Veiga et al., 2004). The purpose of this paper was to present and debate recent evolutions in dairy farms in the Brazilian Amazonia, their capacities to stabilize an intensification trajectory, and the difficulties in relation to the dairy sector at local scale.

■ MATERIALS AND METHODS

Study area

The research was carried out in Brasil Novo County located in the area known as the Transamazon, in reference to Federal Highway 230 (the Transamazon Highway) built in the 1970s, during the military government, at the beginning of the National Program for Agrarian Reform and Amazonia Colonization (PIN). More than two hundred thousand families settled along the Transamazon Highway in a few years, with little assistance or public services (Léna and Da Silveira, 1993). As everywhere else along the colonization roads, Brasil Novo County received migrants from various regions of Brazil, some of them settling through government colonization programs, others rather spontaneously. Families had to adapt knowledge and practices to the Amazonian agroecosystem conditions. They used slash-and-burn agriculture to grow annual crops such as corn, rice and cassava, and perennial crops such as coffee, cocoa and black pepper. Their main constraints were plant diseases, conservation and commercialization (Sablayrolles and Simões, 2003). They also developed extensive cattle ranching, which are less sensitive to these constraints, for calf and milk production and for savings (Da Veiga and Tourrand, 2000; Tourrand et al., 2013).

Each 45–50 kilometers along the Transamazon Highway, PIN planned a small urban center in order to support the rural activities of the pioneers settled in the surroundings. Brasil Novo Town (3° 18' 17" S, 53° 32' 8" W) was at first one of these small colonization villages created during the highway construction. The village grew and the county was established in 1991, covering 6400 km². In the 2010 census, Brasil Novo counted 17,960 inhabitants, with 6912 and 11,048 in urban and rural areas, respectively (IBGE, 2010).

Brasil Novo County's economy is based on extensive cattle beef and dairy production, perennial crops (e.g. cocoa, pepper and fruit), annual crops (e.g. beans, rice, maize and cassava), trade, small cottage industry and sawmills. The county has a poor road network, with a total of 13 secondary roads where farms are located. Because of weather conditions and the lack of maintenance, the road network is damaged, causing isolation of the families and hindering the flow of agricultural production. The county is not able to support the population needs for health services and schools in the rural areas. Recently, because of the 'Light for All' federal program, farms installed along twelve of the secondary roads have had access to electricity.

Before colonization, Brasil Novo County had been entirely covered by natural rainforest. The implementation of agricultural activities, especially the expansion of cattle ranching, led to deforestation. In 2008, according to INPE database, Brasil Novo was among the 36 most deforested counties in Brazilian Amazonia (IBGE, 2010).

Methodological procedures

The research focused on two main objectives: i) to understand better the dairy production system at farm level, using the systemic approach and establishing relations between the farms and various local levels, and ii) to describe the medium-term evolution and diversity of the livestock systems. Five specific methods have been combined, articulating different spatial and temporal scales and all based on a systemic approach, combining quantitative and qualitative data collected from farmers or local stakeholders. Details on this approach are described in de Carvalho (2010).

Structural and functional farm typologies

A survey addressing structural issues was implemented in 2001 in order to describe the main characteristics of the 103 farms of the study, including their constraints regarding dairy production and marketing. A statistical analysis with R software derived from Ferreira (2001) was developed to build a typology designed to identify the structural diversity of the dairy systems. The principal component analysis revealed four types of farms. This structural typology is detailed in de Carvalho (2010).

In 2009, another survey was conducted in 70 farms. As only 52 of the farms of the first study were still accessible, 18 other farms were added to the sample. The collected data focused on practices rather than on the farm structure since the objective was to understand how the dairy systems were run. Statistical analyses were carried out to build a typology based on experts' knowledge and random logic. Local experts with knowledge of the study area and dairy systems defined the different types, as described by Perrot (1991), and Perrot and Landais (1993). The software Genetype was used to calculate the degree of similarity of each farm with every predefined type (Perrot and Leroy, 1995).

Specific interviews with producers who stopped milk production

From 2001 to 2009, many farmers gave up milk sale. Between December 2008 and February 2009, 40 families were interviewed using a specific questionnaire developed to understand the reasons behind this decision. According to the method described by Ferreira (2001), the analysis focused on descriptive statistics, the production system and the herd, but no typology was done.

Retrospective analysis

In 2009, ten farmers were selected for a retrospective analysis among the seventy producers involved in the 2009 typology survey. The selection criteria were the time spent in the dairy business, the distance between the farm and consumers' centers, the marketed products, and the use of direct sale to consumers or not. The objective was to collect qualitative information on agricultural and nonagricultural activities, land, beef and dairy herds, pasture and animal feeding, milk production, dairy products, and commercialization to understand the role of milk production in the family history during the last decade. The method used was that proposed by Moulin et al. (2005).

Key informant interviews

Interviews were also carried out in 2009 with local stakeholders selected according to i) their knowledge of the area where they had been living for a long time, and ii) their direct or indirect

professional connection with the dairy sector (e.g. transportation, transformation, distribution to consumers, credit, animal health, local policy makers). The data collection method was adapted from Da Veiga et al. (2004). The objective of these interviews was to describe and understand the evolution of the public policy at local scale in Brasil Novo County and the Transamazon area, and its impacts on the dairy sector, marketing, supply chains and their evolution. The method was adapted from Pocard-Chapuis et al. (2003a), which was implemented in the same region. In the following section only the main results of the presented study have been reported.

■ RESULTS

Dairy supply chain

The dairy supply chain in Brasil Novo consisted of three different circuits in 2009. They were all relatively short, with local production, local consumption and few intermediate operations. In many cases, a same person assumed more than one function in the chain (Table I).

Circuit 1: mini dairy factories

These mini dairy factories (n = 3) collected, processed and distributed fresh milk, cheese, yogurt and butter. All three were informal in terms of labor relations and technical standards of production (far from health standards), working without any registered license. Their daily milk processing capacity was low: one of them was able to receive 9000 liters per day and the two others 500 and 800 liters, respectively. Only the biggest dairy had a large radius for milk collection, with six collecting circuits up to 50 and even 90 kilometers from the town of Brasil Novo. The other plants were based in the rural area and had a shorter radius, collecting only along two secondary roads. Distance was a serious constraint because of poor traffic conditions, as well as the farmers' small scale production, most of them producing daily 20 liters only. Another problem was the poor milk quality, with high and irregular degrees of acidity and biological contamination, because of bad hygienic conditions in the farms and lack of refrigeration during farm storage and transport to the dairy factory (from two to five hours).

The dairy factory sector in Brasil Novo County has a short history, characterized by successive and quick sequences of opening and shutting down. The reasons are diverse, ranging from mismanagement, corruption, lack of respect of health legislation or

of business authorization. For these reasons, farmers did not trust local dairy factories whose owners did not invest to improve production, productivity and profitability of their dairy activity. As a result, the dairy system was based on extensive practices, low production, and low milk quality.

Circuit 2: direct milk sale to urban consumers

Farmers who used this circuit were mainly installed near the town, no more than 15 kilometers away, in relation to the available transport means (bicycle, horse or motorcycle). Direct sale had two main advantages: higher selling price (at least twice that of the first circuit) and a more stable market. Usually, each farmer had regular and occasional buyers, with a slight risk of not selling. Consumers accepted non-pasteurized milk. The delivery was done daily by the farmer's family, directly to customers' homes or bakeries.

Circuit 3: direct cheese sale to urban consumers

Some farmers produced homemade cheese. They might choose this option because their farm location was too far from town or the milk collection routes of the dairy factories. Moreover, some producers preferred to have their own cheese circuit, deeming it more secure than dairy factories and easier than direct milk sale. The cheese could be sold only once a week or once a month, directly to consumers, or to brokers, grocery stores, bakeries, etc. Cheese long-life ensured that all production was sold. A major constraint for the farmers was to produce regular quantities of cheese. In some cases, they could not maintain this regular production and ended up losing customers. Another key challenge was to find the time and labor to make the cheese since this task is time consuming. Cheese processing know-how was also important to keep regular customers.

Functional farm typology

The first typology carried out in 2001 did not explore relationships between milk production and farm structure. The 2009 retrospective analysis showed that farm strategies were sometimes very unstable, with periodic changes along the milk intensification scale. Some farms could thus have periods of high milk production, investment and adaption of management practices to optimize their milk production, and then periods of low production, shifting to a calf production oriented system where milk was a secondary product. These changes strongly depended on milk commercialization possibilities (see above) and other external factors such as credit policies or market prices for plant products.

The 2009 typology allowed quantifying these changes in terms of farm number, highlighted the existence of two farm types according to the degree of intensification and evaluated their degree of similarity. The first one was the 'Persistent' type where farms maintained a relatively intensive milk production regardless of external factors that might be unfavorable, such as commercialization or transportation. The other was the 'Opportunistic' type where farms adopted the opposite strategy, dropping intensive milk production when conditions became unfavorable. The extreme tendency of this opportunism was a third type, 'No milk production', where farmers gave up dairy production. The 'Milk intensive' farm type, an evolution of the Persistent one, should emerge in the near future, with better practices in terms of productivity and quality.

In 2009, 18 farms were of the Persistent type (more than 60% of similarity) whereas 52 farms were categorized as Opportunistic. As the studied sample focused on milk producers, the No-milk-production type did not appear. However, we know that, by 2009, 50% of the farms included in the 2001 structural typology survey dropped dairy production or abandoned farming all together.

Table I

Main characteristics of the dairy circuits in Brasil Novo County in Amazonia in 2009

Milk chain	Num. of farms	Milk price at the farm	Estimated total eq. milk	Final product
Dairy mini industries	51	0.33 BRL/L	10,500 L/day	Various dairy products
Milk direct selling	5	0.80 BRL/L	1,000 L/day	Raw milk
Cheese direct selling	14	0.60 BRL/L	1,000 L/day	Artisanal cheese

Eq.: equivalent; BRL: Brazil real

Farms could move from one type to another. In fact, each farm had several similarity coefficients with the core of each type, but many of them had similarities with the three types. This represented a kind of transition between the types (Figure 1).

Persistent type

The main characteristic of the Persistent-type farms was to sell lastingly milk or homemade cheese. They had the most technically efficient dairy production systems and were located either near or far from the town. The geographic and cultural origin of the owners was clear: 78% of the households were from the southern and southeastern regions of Brazil where milk and cheese production is a tradition. This showed the importance of dairy production skills and knowledge in maintaining a persistent strategy of milk production. In this type family members were the main labor force, and 28% of the farms also had one or two permanent employees. The average farm size was 234 hectares, with a high standard deviation (SD: 144). This fact supported the statement made by some key informants that the farm size was not a decisive factor in defining farm types in this region. The cultivation of cocoa was present in 50% of the farms from this group, which allowed a relatively high investment capacity because of the high cocoa revenue in the region, even if this crop entails strong investments and labor costs.

The average number of dairy cows was 59 (SD: 22) and, at the time of the interviews, the average number of milking cows was 35 (SD: 18). The average milking period was seven months. In some cases, the calf stayed longer with its dam, until the age of 8–10 months. This was a strategy used by many farmers to have a heavier calf and thus a better price. The revenue from calf sales was as a result of another important income, even in this Persistent type.

The average daily milk production was 171 liters, i.e. around five liters per milking cow. Eleven percent of the farmers provided feed supplementation using mainly sugar cane and elephant grass (*Penisetum purpureum*). This percentage was significant for the region where feed supplementation was usually based only on minerals.

Opportunistic type

Farmers of this type sold milk only when the market was favorable in terms of price, transportation and collection at the farm. Otherwise, milk production was for home consumption only. The dairy

system was less efficient than the Persistent type. The priority was to sell calves for ranches. The level of investment in dairy production and related labor was lower because this activity could be stopped at any time.

This type was not present near Brasil Novo Town (less than 15 kilometers) but was found instead 20–90 kilometers away. The geographic and cultural origin of the farmers was mainly from the northeast region (52%) where milk production is not a tradition. Only 13% of the farms used permanent labor for milk production and 77% used temporary labor for pasture cleaning, as it was also the case in the Persistent type. The average number of dairy cows in this group was 30 (SD: 19) and the average number of milking cows was 16 (SD: 10). The milking period was six months, a clear strategy to favor calf growth. Only 29% of the families weaned immediately after milking cessation. The average daily milk production was 49 liters with around three liters per milking cow. Eight per cent of the farms practiced feed supplementation.

No-milk-production type

This group was characterized by the temporary suspension of any dairy production. The forty interviewed farmers of this group had been producing milk in 2001 but had stopped doing so by 2009. The reasons were related to family problems, lack of payment for the dairy products that had been distributed, excessive labor for milk production, and lack of infrastructure, mainly roads and electric energy.

Retrospective interviews

If a functional typology can characterize and quantify farm changes along the milk intensification gradient, it is necessary to understand better the transition conditions and processes, and the factors that set a farm in one type or another. Based on the retrospective analysis, a diachronic vision of some typical farms was built. It highlighted successive coherent stages and transition periods. To illustrate these results, the evolution of two farms are detailed, one of each type, representing these factors and conditions in Brasil Novo County.

Opportunistic type: Case of MM's farm

The global trajectory of this farm has been characterized by the rapid consolidation of the production system thanks to external

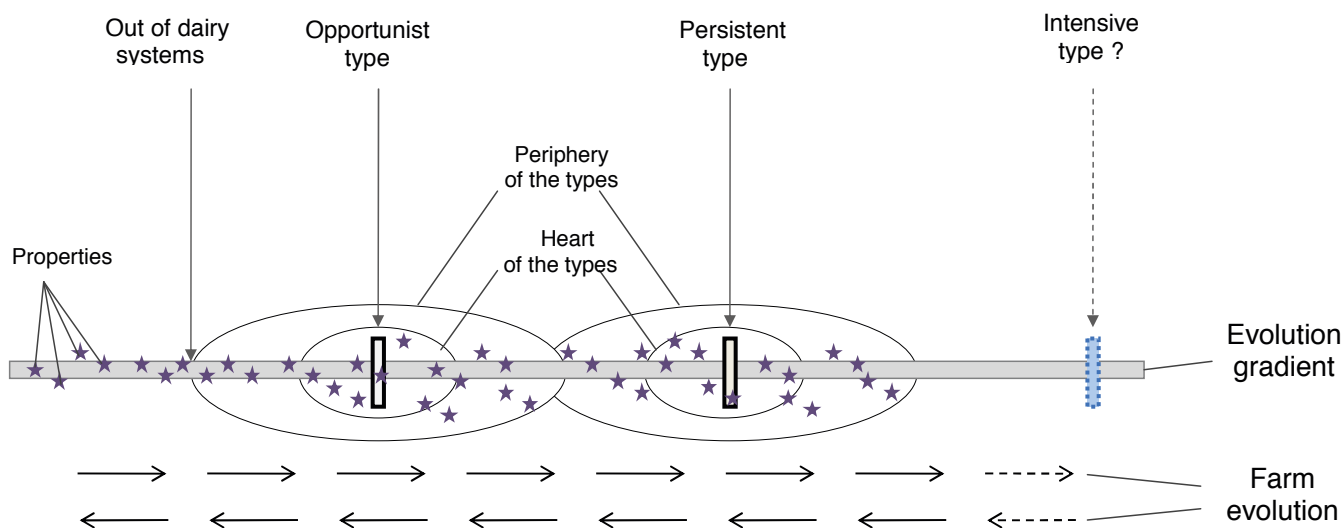


Figure 1: Farm evolution between the types along the gradient of intensification in Brazil Novo County in Amazonia.

revenues from the region of origin. Since the family had settled in the Transamazon, milk production has been mainly for home consumption and sometimes for sale, but milk has never been a priority in the farm strategy, nor a main source of income. However, this family has been afflicted by successive serious health problems.

The trajectory presented two main coherent periods. The first 15 years constituted the settlement phase – installation and consolidation – during which the family invested in an urban activity (meat selling). The farm activity was mainly calf breeding, with a low milk production dedicated to home consumption and sometimes sold to neighbors or friends. During the second period, which extends into the present, the family has mainly been living from breeding and crop production, while investing in cocoa in order to enhance soil fertility.

The main factor of change was the death and illness of family members. A large part of the herd was sold because of financial needs. The family gave up the urban activity and decided to invest in a new rural model based on cocoa crop and to stop milk production because of labor requirements. Later on, as a result of a credit program for purchasing dairy cows, the farm chose to maintain milk production and generated an added value by making traditional cheese. This second period has been sustained until today.

Persistent type: Case of JC's farm

This farm is a success story: the family moved from being poor migrants without capital or livestock and created a small rural business. Milk trade played a central role in this evolution.

Three successive coherent periods have been defined: settlement, breeding, dairy production and processing. During the settlement phase, the farmer worked as a cowboy in large ranches, investing his savings in acquiring a milking herd. He used the milk to produce cheese which was sold in the city. After ten years, the system was quite consolidated. But when the father died, the family had to sell immediately a significant part of the herd which marked the beginning of a transition phase. The milk trade decreased but did not disappear. Seven years later, JC bought a Holland bull and started improving his herd. He began by selling the milk production to a dairy factory then bought cheese-making equipment. At the same time, he opened a shop in town to sell his own cheese and he is now planning to buy milk from neighboring farmers. Today, he has adopted artificial insemination, and production has been quickly increasing.

■ DISCUSSION

The study confirmed that the structural characteristics of the dairy farms were not decisive to explain their dynamics. Factors such as land and pasture surface area, cow number and family labor were surprisingly not informative. This inconsistency is explained by strong family factors which impacted during the settlement and consolidation phases and led to significant changes in the technical projects. On the other hand, market access and its strong instability was a determinant factor. For these reasons, permanent projects prioritizing milk production were few. Milk producers either accepted that constraint or considered milk as a secondary option. In that case, they aimed at more steady beef, cocoa or other plant productions, along with urban activities. These choices were as unpredictable as the key factors cited above.

The transition between persistent and opportunistic milk systems was progressive. It was visible in some managerial practices such as the time between milking cessation and calf weaning or the

daily quantity of commercialized milk throughout the year. On the other hand, differentiation in genetic management is not clear since both farm types could work with dual capacity cows. Moreover, genetic innovations were not easily implemented in these isolated regions. Milk production of the farms was thus strongly limited by local and external factors.

Other studies showed that coordination between local actors is the major challenge at regional scale (Rocha and Couto, 2002; Pocard-Chapuis et al., 2003b; Da Veiga et al., 2004). But in this particular case, there was no regulation between components of the production network and public policies. Moreover, national dairy laws are not adapted to the Amazonian frontier context where it is for example not possible to reach sanitary standards. Similarly, credit policies, which were designed for more developed regions, have negative results such as farmers' excessive debts. For their part, environmental requirements to stop deforestation affect the local feeding systems but no alternative solution has been proposed. Conflicts or contradictions also exist between credit and environmental local policies. On the other hand, no regulation or public information system allows price control or ensures payment of products sold to consumers or dairy factories. In this context, three scenarios for future evolutions have been elaborated.

The first scenario suggests the evolution of farmers and dairy systems along the production gradient toward intensification. Over a period of ten years, it has been observed that farmers adapted their dairy projects according to the dairy market at local scale and to the opportunities. This impacted the intensification level of milk production. A stronger intensification is thus limited by temporary factors, such as social instability during the first period after installation of the migrants, but also by external factors at local scale. In a global process of frontier stabilization, both factors can have a positive evolution. In this case, farmers' projects can be more stable and institutional coordination can be more effective, which can facilitate the emergence of a new intensive dairy system inasmuch as transition along the intensification gradient is linked to few adaptations in managerial practices. Only a holistic process targeting farmers, supply chain, public policies and regional development can thus achieve a strong evolution in the dairy pool of Brasil Novo, which entails coordination and collective decisions. Milk production needs to become a priority for all actors, not only for small farmers.

A second scenario promotes the development of the local demand for dairy products which would result from the installation of the Belo Monte hydroelectric structure in Altamira (45 kilometers from the study area). With this enterprise (ELETRONORTE) and its 15,000 workers over five years the region will change. It is expected to accelerate frontier stabilization, promote investment, and consolidate local milk industries. Sanitary legislation should be adopted through local negotiations in the dairy sector since one of the objectives of ELETRONORTE is to promote sustainable development. The consolidation of a dairy sector should become a priority. Some farmers would like to invest in milk production with the help of new specialized credit lines. Furthermore, good salaries and professional training programs in Belo Monte would attract young people.

The last scenario anticipates stronger environmental policies. Brasil Novo is one of 36 counties which are in a critical state of deforestation. For this reason, the Arco Verde (Green Arc) federal program supports a strict policy for deforestation repression in the region. In the near future, a new phase would apply special regulation of credit, land price and tenure, as well as agribusiness investments in order to avoid new deforestation trends and to enforce environmental protection. Local farmers should however,

with incentives, promote livestock intensification on their farms. But small farmers would be vulnerable if they could not see good perspectives for their activities. Simultaneously, new migrants would be attracted in Brasil Novo by business options. They would come from Central Brazil with skills, knowledge and investment capacities to develop intensive systems of food production with no deforestation practices, but these systems would depend on high levels of chemicals and motorization. In this context, the price of land might increase and small farmers would be prompted to sell their properties to go to urban peripheries resulting in an increase in social inequalities and urban problems.

■ CONCLUSION

Diversity among dairy farmers in Brasil Novo County is complex and depends partially on factors related to the farm structure and the family trajectory. But the main difference in the objectives and strategies of the farmers, especially regarding intensification, appears to be in relation to some key factors, mainly the efficiency of the dairy system at local scale. There is an evolution gradient, on which each farm has a specific and temporary position. This notion of gradient is well adapted to explain the influence that social, economic and environmental policies have on the dairy sector. The farms constantly change their positions along the gradient in reaction to changes in their contexts. Market access is the stronger factor for instability and is a result of local interaction between sanitary, credit policies and transport conditions. The consolidation of dairy industries thus appears to be the highest priority for expansion of the dairy basin and local development.

Milk production could be a way to intensify livestock production and contribute to the reduction in native forests deforestation. Furthermore, it is possible to adopt new practices related to the genetic improvement of the dairy herd as well as new sustainable pasture management that enhances the agronomic potential of the region. A food system should simultaneously promote the potential of tropical grasses and legumes, and associate them with a good mineral supplement. This requires specific policies in market access, a better local coordination and credits for livestock, farm monitoring, capacity building and trainings.

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Résumé

De Carvalho S.A., Pocard-Chapuis R., Tourrand J.-F. Opportunisme et persistance dans la production de lait en Amazonie brésilienne

En Amazonie, la production laitière est considérée comme une opportunité pour améliorer la viabilité des petites fermes du fait de la double fonction (production de lait et de veaux) de cette activité qui est favorisée par le fort potentiel fourrager dû au climat chaud et humide. Mais la production laitière ne dépend pas que du fourrage, la question est plus complexe. Cet article décrit ainsi comment la filière laitière locale et le contexte limitent la productivité et l'innovation dans ce secteur. Il esquisse également les possibilités d'évolution à court terme. La méthode mise en œuvre a combiné trois approches complémentaires afin de mieux comprendre la complexité de la production laitière en Amazonie. Ces approches se sont basées sur a) une typologie des fermes, réalisée à deux périodes différentes, afin d'identifier leurs trajectoires, b) une analyse rétrospective décrivant les changements et les invariants des facteurs concernés, et c) une analyse de la filière reposant sur des données secondaires et des informations recueillies auprès d'informateurs-clés. Les résultats obtenus ont complété l'expertise développée depuis une dizaine d'années par l'équipe de chercheurs concernée. La typologie a révélé les fréquentes et soudaines modifications de la stratégie des fermes suivant deux tendances principales, opportunisme et persévérance, en lien avec les pratiques d'élevage, notamment la reproduction, l'alimentation et la commercialisation des produits laitiers. Cette dernière dépend fortement de la capacité des laiteries locales à établir une relation de confiance avec les éleveurs. Ce partenariat est délicat à mettre en place à cause du contexte local, en particulier du fait des difficultés de transport, de l'accès insuffisant au marché, des normes nationales de production. Ce contexte explique les fréquentes créations et disparitions de laiteries. C'est pourquoi de nombreux éleveurs se concentrent sur la production de veaux et considèrent le lait comme un sous-produit. D'autres, en revanche, souvent pour des raisons culturelles, continuent à produire du lait et des veaux, recherchant des alternatives à la commercialisation du lait. Trois scénarios ont été envisagés : a) intensification, b) augmentation de la demande locale, et c) politiques environnementales exigeantes.

Mots-clés : agriculture familiale, production laitière, collecte du lait, durabilité, Amazonie

Resumen

De Carvalho S.A., Pocard-Chapuis R., Tourrand J.-F. Oportunismo y persistencia en la producción de leche en la Amazonía brasileña

En la Amazonía la producción de leche se considera como una oportunidad para mejorar la viabilidad de las pequeñas explotaciones, debido a la doble función de producción de leche y de terneros, promovida por un alto potencial forrajero resultante del clima cálido y húmedo. Sin embargo, la producción de leche no depende solamente de forraje, el desafío es más complejo. Este estudio describe cómo la cadena local de suministro de leche y su contexto limitan la productividad y el proceso de innovación en el sector lácteo. Se presentan también las posibilidades de desarrollo a corto plazo. Implementamos un nuevo método que combina tres enfoques complementarios, con el fin de comprender mejor la complejidad de la producción lechera en la Amazonía. Estos enfoques se basan en i) una tipología agrícola llevada a cabo durante dos períodos diferentes, para construir las trayectorias de las fincas, ii) un análisis retrospectivo para describir los cambios y la persistencia de los factores que intervienen, y iii) un análisis de la cadena de suministro basadas en datos secundarios e información obtenida de los informantes clave. Los resultados obtenidos completaron el importante conocimiento recogido por los investigadores en los últimos diez años. La tipología reveló los cambios frecuentes y repentinos en las estrategias agrícolas, con dos tendencias principales: el oportunismo y la persistencia en relación con las prácticas de gestión, especialmente la reproducción animal, la alimentación, y la comercialización de productos lácteos. Este último depende, en gran medida, de la capacidad de las fábricas de productos lácteos locales para construir una relación de confianza con los agricultores. Sin embargo, esta asociación es difícil de establecer debido a las limitaciones de transporte, acceso insuficiente al mercado, y las normas nacionales de producción. Este contexto explica la frecuente creación / cierre de fábricas de productos lácteos. Por esto muchos agricultores centran su producción en los terneros y consideran la leche como un subproducto. Otros, sin embargo, mantienen la producción de leche y terneros, por razones culturales, buscando alternativas a la comercialización de la leche. Tres escenarios se han desarrollado: i) la intensificación, ii) aumento de la demanda local, y iii) exigir políticas ambientales.

Palabras clave: agricultura familiar, producción lechera, recogida de leche, sostenibilidad, Amazonia

Rangeland management in the Qilian mountains, Tibetan plateau, China

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Keywords

Sheep, yak, rangeland, household, governance, land policy, Tibet, China

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Summary

In the past, several tribes from Northern and Central Asia, such as Tibetans, Yugurs, Mongols and Hans, traveled through and settled in the Qilian mountains. Because of the high altitude (on average 3000 meters) the main land use is the rangeland, pastured by yaks and sheep herds. Before the 1949 Chinese Revolution, the pastoral system was based on complex agreements between breeders' tribes and the monasteries that controlled the rangeland. Since the 1950s, the collectivization of the land and the herds abolished this system. Rangeland degradation worsened because of the concentration of herds. At the beginning of the 1980s, the Household Contract for Responsibility System (HCRS) policy aimed at both improving livelihoods and rangeland management. HCRS progressively became the pillar of land, resource and livestock management, by adopting a collective action involving the households, the community leaders and the local governance. Recently, new policies related to the local demand have been implemented. Sixty years after the revolution, the Qilian mountains' people succeeded in implementing a socioeconomically efficient farming system. However, this system presents two main weak points: the poor sustainability of rangeland management and the low interest of young generations for rural activity. In order to face these challenges and produce key elements for policy makers, some scenarios of future farming systems have been built and debated with local stakeholders in order to improve the sustainability of rangeland management.

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■ INTRODUCTION

The Qilian mountains are located in the North-Eastern Qinghai-Tibetan plateau, along the ancient Silk Road (Figure 1) at an average altitude of 3000–4000 meters and with a peak at 5500 meters. At this altitude, rangeland is the only land use. Few crops can grow in the lowlands of the valleys, especially in Hexi Corridor (ex Silk Road). In the past, because of their location several ethnic groups passed through the Qilians, and many of them settled and are still present today, especially Tibetans, Yugurs, Huis, Mongols and Hans. Up to the middle of the 20th century, rangeland management was defined

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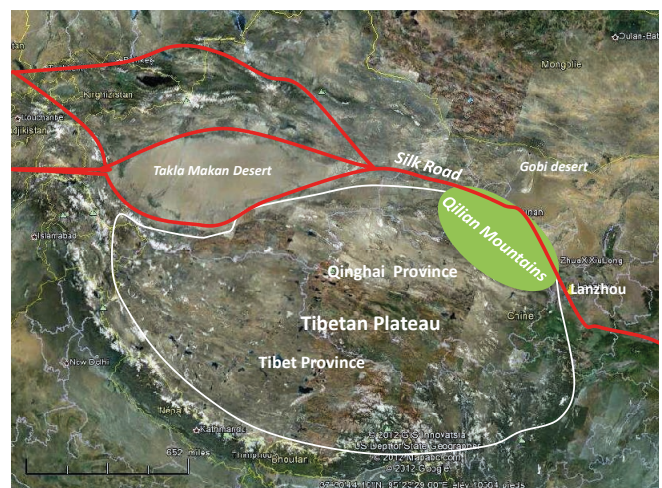


Figure 1: Location of the Qilian mountains in the Northeast of the Tibetan plateau, Gansu Province.

through a complex set of agreements and partnerships between herders' tribes and the monasteries that were the landowners (Zhang et al., 2007; Brown et al., 2008; Squires et al., 2009).

The 1949 Chinese Revolution, followed by the 1966–1976 Cultural Revolution strongly impacted the traditional people and rangeland management, mainly land and herd collectivization. In the span of a few years, probably because of the lack of control over rangeland management, serious degradations occurred, particularly near new urban areas and watering points for people and herds. At the beginning of the 1980s, specific public policies, such as the Household Contract Responsibility System (HCRS), were implemented to reduce the degradation of the Chinese rangeland in view of its major role in the national water supply, and thus avoid strong soil erosion with severe consequences on flows and floods downstream. HCRS still defines today the dynamics between the three key pillars of rural society, i.e. herders' households, community and local governance, and their link to national policy makers. Thirty years later, the challenge is yet to be met. However, change occurred at different scales, including the pasture plot, collective rangeland, herder's household and global governance. In this context, this study aims at describing the main trends of animal husbandry in the last decades and presents some future scenarios for sustainable development drafted with the local stakeholders.

■ MATERIALS AND METHODS

Based on the literature review and the local research team's knowledge, two contrasted research sites were selected in order to have a better overview of the livestock diversity in the Qilians: i) Tianzhu County and ii) Huang Cheng township in Sunan County (Figure 2). The contrast concerns four factors relevant to livestock production:

- Location, on the eastern and western slopes of the Qilians, respectively;
- Distance, 300 and 800 km, respectively, from Lanzhou, capital of Gansu Province and main urban area to trade products and purchase inputs, and other cities along the Silk Road, such as Wuwei, Zhangye and Yong Chang, which have significant local markets;
- Rainfall, around 400–500 mm in Tianzhu and 700–800 mm in Huang Cheng, a factor that determines rangeland productivity;
- Settlements, with a majority of Tibetan and Han breeders living in Tianzhu, and Yugur herders living in Huang Cheng.

The research sample was built by selecting 35 key informants, 17 in Tianzhu and 18 in Huang Cheng. They came from various

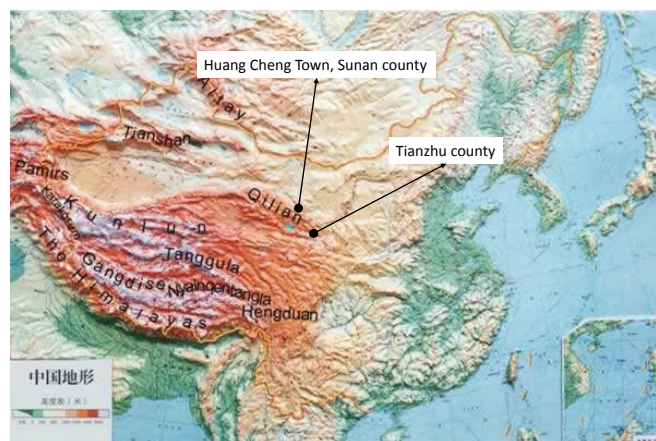


Figure 2: Location of the two research sites along the Hexi Corridor (or Silk Road).

sectors of the livestock supply chain, covering the spectrum from farm to fork, including twelve breeders, five community leaders, two agribusiness managers, four input providers and traders, eight scientists and technicians from development and funding agencies, and four policy makers. The individual interviews were mainly held with breeders and policy makers, whereas group interviews of two or three stakeholders were conducted with traders. Moreover, two workshops were held with technicians from local development agencies. The interviews were centered on the following topics: perceptions of the past and current livestock situation in the area, scenarios for the future, hopes and fears of local people working in the livestock sector, main debates and conflicts regarding animal production, and new projects linked to animal husbandry in the area.

The average time for an interview was around two hours, and longer with farmers and agribusiness managers because of the time spent on the visit of the farm or of the enterprise. Following each interview, we wrote a two to three page report to document the main data collected, as well as relevant and complementary information given by the informants (Figure 3).

Data analysis was carried out by two complementary ways. Firstly, an overview of the mental model regarding livestock activity was drafted for each key informant and group of key informants based on reports from the interviews. Secondly, we drew up a table comparing the viewpoints of the different key informants regarding the main questions which structured the interviews.



Figure 3: Interviews with an agribusiness manager (1) and breeders (2, 4), and informal workshops with traders (3) in the Qilian mountains.

■ RESULTS

The three main results revealed by this study were: i) the rangeland provides the main part of the feed for the herds, even though some alternatives are being developed; ii) the herders' livelihoods improve considerably because of strong support from public policies, especially with the implementation of HCRS as a partnership between herders, community and local governance; and iii) the weak rangeland management and low attractiveness of animal husbandry to young people are the two main future challenges.

It is noteworthy the rare information key informants gave on pre-Chinese-Revolution times, as if that period had no effects on the current and future situations. This is surprising since there was a significant change in landownership, access and management during the first years of the Chinese Revolution and throughout the

decade of the Cultural Revolution. The lack of historic references may be partially linked to the young age of the stakeholders, since many of them were born after that period. Only one key informant, member of a recognized breeder family since before the revolution, provided details about the change at that time, especially on land and herd collectivization, and consequently the new land access and relationship between breeders and the local communities, and the migration of some of them. On the other hand, the literature describes rangeland management before the Revolution as bringing a great harmony in the socioecosystem (Zhang et al., 2007; Wang et al., 2010), and the efficiency of breeders' practices in managing the rangeland that was owned by the monasteries; a situation like a pre-Revolution paradise.

Rangeland, as main feed provider, pillar of animal husbandry

In general in the Qilians, each household manages his herds of sheep and yaks, which are the main and sometimes only source of income. Usually, the couple is the only labor in the farm. Sometimes, grandparents help when they live in the household and are able to do so. Children also help when they are not in school, or during vacations for those going to the university.

Sheep are of Merinos (locally called fine-wool sheep) and Tibetan breeds. The household chooses to have one or the other or both according to its objectives, strategies and practices. Yaks are of black or white Tibetan breed, especially in Tianzhu. Goats are present in a few herds. Usually, the herds are composed of around 150–200 ewes and 25–40 yaks, with some smaller and others with as many as 300–400 ewes and 80–100 yaks. Some households only have sheep, mainly for lack of labor.

Figure 4 shows the seasonal mobility of the households and herds of Huang Cheng, according to feed availability in the rangeland in the course of a year. It is a classic seasonal mobility in mountain areas with alpine meadows. In Huang Cheng, stakeholders noted the presence of small differences between households and villages. They related to the farm location, the distance between the farm and pastures, and the size of pastures. In Tianzhu, many pastures were common, but the seasonal mobility was more or less the same depending on weather conditions.

At the end of spring, i.e. end of May and June depending on grass growth, both herds and herders move to summer pastures. They stay there for about two months. Each household has a tent with

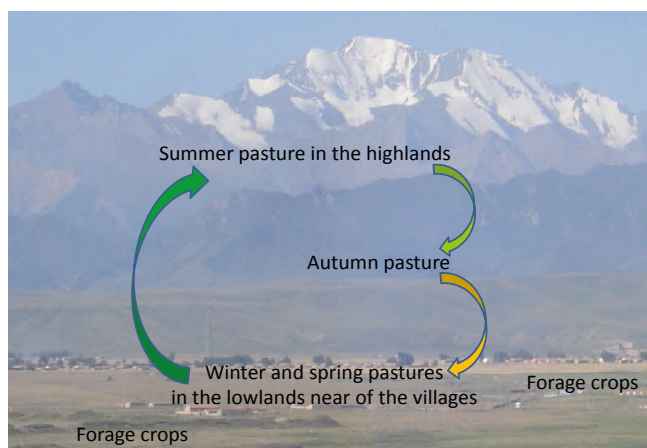


Figure 4: Seasonal mobility of people and animals in the villages of Huang Cheng town, Sunan County in the Qilian mountains.

basic equipment (see further on). Because of the cold and the snow, people and animals cannot survive there during winter. So, at the end of summer, sheep and people move to the autumn pastures at a lower altitude, where weather conditions are better and feed is still available. The yaks usually stay in the summer pasture, as they can better resist the cold. However, every day or so, one person of the family goes to check up on them. From mid-autumn, just before the first frost, sheep and herders' families go back to the villages. The sheep graze on winter pastures. During the same period, the yak herds move to the autumn pastures, substituting the sheep herds. Depending on weather conditions, the rangeland and farm productivity, the yaks stay there all winter or move to the winter pasture where the sheep herds are. During winter and spring, the weakest animals are supplemented with oat forage grown in the lowland during spring and summer. Figure 5 summarizes the herd feeding system throughout the year.

According to the evaluation of local stakeholders in the counties of Tianzhu and Sunan, the Qilians herds are mainly fed by grazing (more than 80–85% of sheep and more than 95% of yaks). Although the cultivated forage represents a small part of the feeding system, it is still essential for the weak animals to survive. This justifies the herders' strong interest in having cropping areas. Moreover, a family who has more forage than needed can easily sell it in the local market or in other regions, which contributes to a significant additional income.

Because of the low number of family members working on the farm, all the labor is centered on herd management. Daily main tasks consist of i) quick checkups on all animals, possibly twice or thrice a day, during early morning, daytime and in the evening, ii) several daily checkups during lambing and calving to assist the females and care for the newborn, iii) caring for weak or sick animals, mainly the females and the young calves and lambs, and iv) forage feeding during winter and spring. Other activities are more flexible in term of time, e.g. treatment of the animals, maintenance of fences and equipment, marketing, and purchasing of inputs. These activities have to be integrated in the schedule of daily tasks. As mentioned by some stakeholders, it is interesting to notice that the herders spend the major part of their working time managing the herd and do not have time to manage the rangeland, which is nevertheless the pillar of their livestock activity.

Strong public policy support to breeders' people in the Qilians

According to Zhang et al. (2007) the Household Contract Responsibility System has been implemented in pastoral China as a set of policies based on the successful experience in cropping areas, and aims to improve the productivity of animal husbandry. From an environmental point of view, the result has been an increase in rangeland degradation (Banks, 2001; Han et al., 2008) since contextual differences between cropping and breeding areas have been ignored (Williams, 2002). However, during the interviews, most of the local stakeholders considered the implementation of HCRS to be a success in the Qilians because of the significant support to breeders in adapting their farming system to global change, including social as well as micro- and macro-economic changes.

The allocation of cropland for forage production and winter pasture between households seems to have been the most significant policy. The breeders can decide whether to reduce or increase the size of their herd according to the herd requirements since they become the direct managers of their winter and spring feed resources. They can also decide to rent more land in order to increase feed or produce forage to be sold. Land allocation has been decided upon according to the size of the household. It is

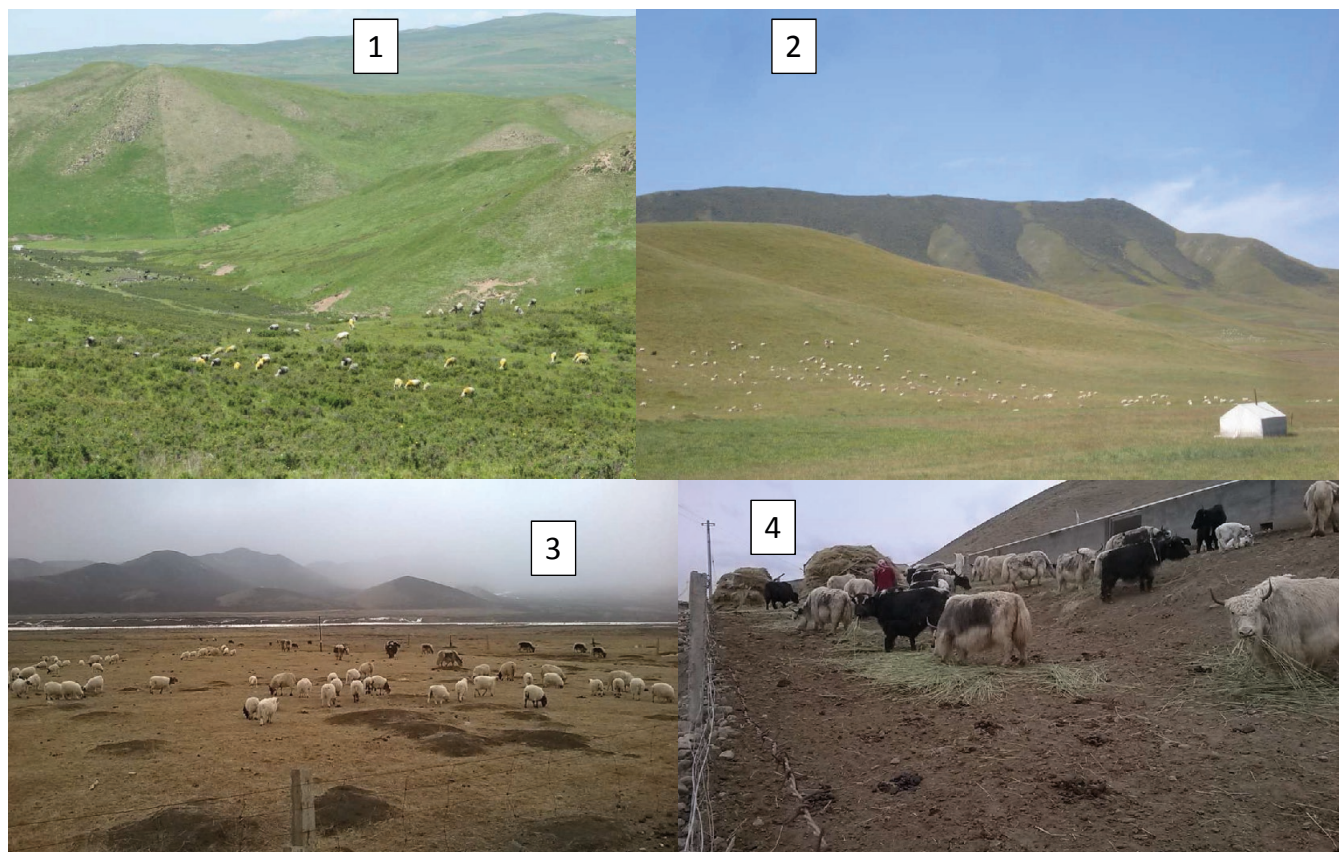


Figure 5: Summer pasture (1), autumn pasture (2), winter pasture (3) and supplementation of female yaks (4) in the Qilian mountains.

in function of the zone and can change according to the demand of new households and the retirement of old breeders. It is a land allocation and not a landownership. The land cannot be sold but it can be rented, as it is the case for some old breeders who thus complement their pensions.

In the village of Huang Cheng town, Sunan County, the average pasture per household is around 170 ha, 220 ha for winter pasture, and 3 ha for summer and autumn pasture and cropland. The most important demand of farmers without individual winter pasture allocation, who thus only have access to the common winter pastures, is to have land allocation at household level, at least for the winter pasture. This enables them to manage better the rangeland at household level according to their herd requirements.

The land allocation of summer and autumn pastures seems less significant because of the bigger availability of pastoral resources during these seasons. However, several breeders consider that they need contracts for summer and autumn pastures in order to avoid herd concentration in the best places. With these contracts, the households could manage their summer and autumn pastures according to their objectives, strategy and knowledge, under control of the community.

In addition to land allocation, households receive financial subsidies according to their pasture area. The subsidies are fixed per unit of land: around 220 €/ha [110 yuans (¥) / mu] for cropland, 60 €/ha (30 ¥/mu) for winter pastures and 2.78 €/ha (1.39 ¥/mu) for summer and autumn pastures. The land subsidies per household in Huang Cheng are around 1362 € (10,220 ¥), with reference to the farm budget which is around 16,256 € (121,921 ¥), corresponding to the sales of lambs, yak bulls, culled ewes and female yaks.

Besides land allocation and subsidies, another significant policy is the financial support allocated per household to improve livelihoods

and invest in the farm. Each household has access to funds to build a greenhouse/stable to shelter the herds during winter and spring, and to build tents in summer and autumn pastures. Depending on the situation, the part of the subsidies dedicated to the tents is around 30–50%, which amounts to 200 € (1700 ¥) approximately, from a total price of 450 € (4000 ¥). Nowadays, tents in the alpine meadows are more comfortable and well equipped with a bed, a small table, a few stools, one or two small chests or shelves for storage, and a stove for cooking and heating. Some have one or two solar panels to store energy to watch satellite TV and charge cellular phones.

Although the subsidy is lower to build a new house, it is still significant amounting to 15–20% of the cost. Moreover, households can have access to apartments built in a town near their village, whether to reside there or to move in upon retirement. Households also have access to interesting loans to buy motorcycles and three-wheel tractors.

Several other infrastructure policies also impact on the local development. For instance, road construction and maintenance facilitate access to the market and inputs. Trail maintenance is particularly important, because of long distances between the villages and alpine meadows, i.e. in general 15–40 km, sometimes 60–70 km and up to 100 km. Many antennas have been erected for cellular phones in the Qilians. Furthermore, since 2004, to the already existing free primary education, the elementary school has also become free.

New challenges: efficient rangeland management and better attractiveness for youth

Over the last three decades, the two main weak points of the local development system in the Qilians have been the poor rangeland management and the low attractiveness for the new generation.

The HCRS policy aims to reduce rangeland degradation by controlling the rate of animal stocking in order to adapt it better to rangeland productivity. According to local stakeholders, up to present time the strategies adopted by the breeders have not integrated the control over the animal stocking rate on their pastures.

Two main reasons explain this disturbance. Firstly, rangeland degradation is a real constraint for the breeders because it reduces the production of feed and consequently the productivity of the herd. However, the reduction in rangeland degradation is a complex or long term process based on specific strategies and several friendly practices for vegetation use and protection. In contrast, HCRS subsidies help sustain herd productivity with minimal interaction with rangeland management. Therefore the breeders adopted the easier strategy based on subsidies and did not apply sustainable practices for rangeland management. Secondly, there is a lack of stocking rate control. The adoption of sustainable rangeland management practices is hindered by two constraints: the apparently poor knowledge about the right practices at local scale and the considerable need for investment in infrastructures, equipment, inputs and labor.

Furthermore, sustainable practices of rangeland management are usually more difficult to implement in common pastures because of the higher complexity of collective governance in relation to a single household. In contrast, the easier implementation at individual level does not mean better efficiency. Currently in the Qilians, rangeland management entails common practices such as the coordination and mutual assistance to move to the summer pasture and face the winter period, and the collective work to build fences and greenhouses. This mutual assistance extends beyond the same family to include friends and people in the same village. In conclusion, the complexity at the collective level offers some relevant opportunities and should not therefore be seen as a constraint.

The second weak point in the system developed in the Qilians is the poor interest of the new generation in becoming herders like their parents. Moreover, almost all parents consider that animal husbandry is not a good option for their children. They perceive the future of their children in urban areas. For this reason they seek education qualifications for them and stipends to attend the university since the yearly tuition of 2000 € (17,000 ¥) amounts to one third of the family income. Many breeders belong to minorities; they believe that once their children are qualified, they will be better integrated in the society. Consequently, almost none of the young people are interested in becoming breeders like their parents. They use the same arguments as their parents', talking about the hardship of labor for example during the calving and lambing periods, and the seasonal migration in the alpine meadow.

To face the low interest of young people in the pastoral system, a new policy was recently implemented to improve the efficiency of the livestock farming system and to offer rural jobs in urban areas, especially targeting the new generation. This policy supports breeders who decide to join their skills and means of production to fatten lambs and bulls in feedlots, based on irrigated forages in the villages, small towns or in city suburbs. Parents are in charge of breeding through their pastoral system in the countryside and some children are responsible for fattening in feedlots located in suburban areas. In order to encourage breeders to collaborate among themselves and build significant animal husbandry units, this policy is available only for herds of more than 500 bulls or 3000 lambs to be fattened. Some breeders are thinking of implementing dairy farms based on a similar integration system. During the milking period, the dairy cows stay in the barn and are fed with irrigated feed. The dried cows and the heifers are reared in the rangeland.

■ DISCUSSION

What about the future of livestock in the Qilians? In their analysis of public policies in the Chinese rangeland, Wang et al. (2010) discussed the strong and strategic commitment of the national governance i) to reduce rangeland degradation by a better care of natural resources, and ii) to improve the livelihoods of pastoral people who have been using these resources to feed their herds since the beginning of the 1980s. The same policy is expected to be applied in the following years because of the major role of these rangelands in China's water supply. Our results show significant livelihood improvement in the rural area of the Qilians, mainly because of the direct and indirect subsidies to breeders' households. Consequently, these households are expected to contribute in the effective implementation of a sustainable rangeland management. Moreover, reducing the stocking rate is not the only way to avoid rangeland degradation. Other efficient practices of sustainable rangeland management exist, namely the daily and weekly control of the pasture area, and grass growth time between two pasturing seasons. Three scenarios have been projected hereafter.

Current trend scenario

The farming population is aging progressively and there is a lack of intergenerational knowledge transmission because the young prefer urban jobs and urban life. The short and medium term impact of this trend is an increase in farm land size (because of land availability) by re-allocation or renting to retired farmers. However, a serious labor issue could emerge considering the current high workload of households and the lack of workers who are competing for urban jobs. On the medium and long term, the lack of farmers and workers will be a serious challenge.

Rangeland management scenario

Land would be reallocated in order to determine the most sensitive or degraded rangeland areas, restore them, and adopt common pasture management based on a strict control and on raising breeders' awareness. This scenario needs to succeed because of rangeland degradation and the impacts of rangeland management practices on a large scale. From the farmers' point of view, it will not be easy to define and implement a collective rangeland management regarding the use of common pasture. This may pose a greater challenge in terms of research and extension.

Intensification scenario

There would be an added value, through subsidies, to practices that reduced the stocking rate, as it is the case for the current double system based on lambing and calving on the rangeland, and fattening in feedlots with irrigated forage. The advantage of this scenario is its appeal to the young.

■ CONCLUSION

Rangeland degradation, especially around villages, was caused by the abolishment of the traditional system through land and herd collectivization during the Chinese Revolution of the 1950s, followed by a difficult period for breeders' families up to the 1980s. Over the following three decades, HCRS implementation led to a progressive and significant improvement of livelihoods in rural areas. However, the great challenge of rangeland degradation persists. Sustainable rangeland management could be the next scenario for local development plans in the Qilians. This requires an efficient set of sustainable practices with regard to the technology

used but also human development, mainly participative methods to discuss, test and assess adapted innovations. Policy makers are ready to finance and encourage such practices because of the strategic function of the Chinese rangeland in the national economy.

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Résumé

Ding L., Qi X., Long R., Yang T., Tourrand J.-F. Gestion des parcours dans les montagnes du Qilian, plateau tibétain, Chine

Dans le passé, les Monts Qilian ont été traversés et peuplés par diverses peuplades d'Asie centrale et du Nord, en particulier les Tibétains, les Yugurs, les Mongols et les Hans. En raison de leur haute altitude (en moyenne 3000 m), l'élevage de yacks et de moutons sur parcours y constitue la principale activité. Avant la Révolution chinoise de 1949, la gestion des parcours reposait sur des accords complexes entre les tribus d'éleveurs et les monastères, ces derniers contrôlant le foncier. Depuis les années 1950, la collectivisation des terres et des troupeaux a détruit ce système. La dégradation des parcours s'est aggravée en raison de la concentration des troupeaux. Au début des années 1980, une politique spécifique, le *Household Contract Responsibility System* (HCRS) visait à améliorer à la fois les conditions de vie en milieu rural et la gestion des parcours. Basé sur l'action collective impliquant les ménages, la communauté et la gouvernance locale, le HCRS est progressivement devenu le pilier de la gestion territoriale. Récemment, des mesures complémentaires ont été mises en œuvre pour répondre à la demande locale. Soixante ans après la révolution, les Monts Qilian ont réussi à mettre en place un système agraire efficient du point de vue socio-économique. Cependant, il présente deux faiblesses majeures : la faible durabilité de la gestion des parcours et le peu d'intérêt des jeunes pour le milieu rural. Pour faire face à ces défis et établir des éléments clés pour les décideurs, des scénarios alternatifs de systèmes agricoles ont été élaborés et discutés avec les acteurs locaux afin d'améliorer durablement la gestion des parcours.

Mots-clés : ovin, yack, parcours, ménage, gouvernance, politique foncière, Tibet, Chine

Resumen

Ding L., Qi X., Long R., Yang T., Tourrand J.-F. Gestión de pastizales en las montañas de Qilian, Meseta Tibetana, China

En el pasado, diferentes tribus del norte y centro de Asia, como los Tibetanos, Yugurs, Mongoles y Hans, recorrieron y se establecieron en las montañas Qilian. Debido a la gran altitud (3000 metros de media), el uso principal de la tierra es en pastizales, pastoreado por hatos de yaks y ovinos. Antes de la Revolución China de 1949, el sistema de pastoreo se basaba en acuerdos complejos entre las tribus de criadores y los monasterios que controlaban los pastizales. Desde la década de 1950, la colectivización de la tierra y los rebaños abolieron este sistema. La degradación de los pastizales se agravó debido a la concentración de los rebaños. A principios de la década de 1980, la política del Sistema de Contratos Domésticos de Responsabilidad (HCRS) tuvo como objetivo mejorar tanto medios de vida como la gestión de los pastizales. HCRS se convirtió progresivamente en el pilar de la tierra, manejo de los recursos y del ganado, mediante la adopción de una acción colectiva que involucra los hogares, los líderes de la comunidad y el gobierno local. Recientemente, se han implementado nuevas políticas relacionadas con la demanda local. Sesenta años después de la revolución, la sociedad de las montañas Qilian tuvo éxito en la implementación de un sistema de cultivo socioeconómico eficiente. Sin embargo, este sistema presenta dos debilidades principales: la escasa sostenibilidad de la gestión de los pastizales y el escaso interés de las nuevas generaciones en la actividad rural. Para enfrentar estos retos y producir elementos clave para los políticos, se han construido algunos escenarios futuros de sistemas de producción y discutido con los actores locales con el fin de mejorar la sostenibilidad de la gestión de los pastizales.

Palabras clave: ovino, yak, tierra de pastos, hogar, gobernanza, política agraria, Tibet, China

Contribution of small ruminants to household income in the agroecological northwestern coastal zone of Egypt

Helmi Metawi*

Keywords

Livestock, small ruminant, agroecology, farm income, animal performance, Egypt

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Summary

The study was conducted in the northwestern coastal zone of Egypt in order to explore the relative economic importance of small ruminant production. Based on water resources, the study area was divided into three agroecological sub-zones (AEZ): i) the rain-fed area (RA) in the west, ii) the dry area (DA) in the middle, and iii) the irrigated area (IA) in the east. Data collection was carried out through field surveys using a pre-tested questionnaire. Productivity ranged from 20.8 to 25.4 kg and from 18.9 to 20.9 kg for sheep and goats, respectively. Sheep and goat productivity was lower in DA than in RA or IA ($p > 0.05$). Small ruminant production was profitable under different AEZ. The returns on capital invested in sheep production were 22.3, 17.9 and 14.4% for IA, RA and DA, respectively. The corresponding figures for goat production were 16.5, 16.7 and 16.7%, respectively. The contribution of livestock to household income ranged from 40.8 to 71.6% across AEZ. Comparison between crop and livestock incomes in DA revealed that, whereas livestock accounted for 71.6% of the total net income, crop production contributed a mere 2.5–5%. Within the livestock sector, small ruminant contributed the highest (63.4%). Making farmers aware of the financial benefits of small ruminants may convince them to consider the latter as a better alternative to crop production in terms of income generation. This will probably influence their decision on the allocation of their limited resources to the competing alternatives.

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■ INTRODUCTION

The suitability of an area for either animal or crop production, and the type of animal or crop to be produced in the area depend on the agroecological conditions of the area (Tolera and Abebe, 2007). The extent of cropping and the type of crop, in turn, determine the quantity, quality and distribution of animal feed resources throughout the year. On the other hand, the feed resource bases determine the animal production system of the area. The most distinguishable example in Egypt is observed in the northwestern coastal zone (NWCZ) which extends from

Borg-Arab in the east for 520 kilometers to Sidi-Barani in the west. Based on agroecological conditions, different production systems are available as about one million head of sheep and goats are present in the zone. Lack of information on the profitability of small ruminant production as well as on its income contribution to the Bedouin folks is assumed to be the principal reason for the non-recognition of its importance by policy makers and relevant institutions and hence the resulting little attention given to its improvement in the zone. The purpose of this paper was to explore the relative economic importance of small ruminant production in NWCZ by assessing both its profitability and its contribution to household income.

■ MATERIALS AND METHODS

The study was conducted in the northwestern coastal zone of Egypt from February 2008 to August 2010 in order to assess

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the effect of water availability on the profitability and relative income contribution of small ruminant production to households. Based on water resources, the study area was divided into three agroecological subzones (AEZ): i) the rain-fed area (RA) in the west, from Sidi Barani to Matrouh, ii) the dry area (DR) in the middle, from Dabaa to Ras EL-Hekma, and iii) the irrigated area (IR) in the east, from Hammam to Borg-Arab. The study involved two districts from each area and about twenty-five households from each district, all selected randomly. Data collection was carried out through field surveys using a pre-tested questionnaire. A special questionnaire was designed to collect information on input and output parameters of different farm activities.

The agropastoral system prevails in the western region. The annual rainfall ranges from 150 to 180 mm. Agriculture relies on rainfall. Feeding mainly depends on natural ranges, barley and by-products. Animal movement is restricted to certain distances around the farm base and is characterized by more supplementary feeding.

Under the middle region condition, the pastoral system of production is dominant. The average annual rainfall is 80 mm. The transhumant farmers have a permanent base and move with their flocks to adjacent provinces where irrigated fodder and crop residues are available. They also use farm by-products and non-conventional feed sources.

Mixed crop-livestock farming system is the common practice of the eastern region. Agriculture relies on Nile water. The farmers allocate a larger proportion of their land (47%) for green fodder. Feeding mainly depends on berseem (*Trifolium alexandrinum*) from October to May, and summer fodder crops.

Barki sheep and Barki goats are the prevailing breeds reared in NCWZ. The whole farm budget was performed using Microsoft Excel spreadsheet. The returns were obtained by estimating the total value of production which included each product sold and consumed. The least square method (SAS, 2000) was used to analyze flock productivity (expressed as kilograms of live weight produced per breeding female per year) and financial performance.

■ RESULTS

Herd size, composition and age structure

The herd size and livestock composition in the studied areas are shown in Table I. Herd differed in size and composition between the different AEZ. Households in RA had larger herds (141 head) with about 79% sheep, 13% goat, 5% camel, and 3% cattle compared to the herds in DA (49 head), which were composed of about 64% sheep, 27% goat and 9% camel. The percentage of goats in the herds was higher in DA than in RA and IA. None of the surveyed farms in DA kept cattle. On the other hand, cattle and buffalo comprised about 20% and 3% of the total herd size in IA.

Table II presents the flock age structure in the different AEZ. The proportion of mature females in small ruminant flocks ranged from 36% in IA to 53% in DA.

Small ruminant performance

Productivity ranged from 20.8 to 25.4 kg and from 18.9 to 20.9 kg for sheep and goats, respectively (Table III). Sheep and goat flock productivity did not differ significantly between RA

and IR production systems. On the other hand, productivity was lower in DA than in RA or IA ($p > 0.05$). Table III shows that small ruminant production was profitable in the different AEZ.

Table I

Household ownership of different livestock species in the northwestern coastal zone of Egypt

	Species in agroecological subzones		
	Rain fed	Dry	Irrigated
Total herd size	140.7	48.9	123.00
Cattle (%)	2.70	0	19.53
Buffalo (%)	0	0	3.25
Sheep (%)	79.23	64.18	71.35
Goat (%)	13.25	26.84	5.25
Camel (%)	4.82	8.98	0.62
Livestock unit*	25.08	8.77	38.20

* 0.1 LU = 1 head of goat or sheep; 1.0 LU = 1 head of camel or cattle or buffalo

Table II

Flock age structure in the northwestern coastal zone of Egypt

	Agroecological subzones		
	Rain fed	Dry	Irrigated
Mature female (%)	40	53	36
Mature male (%)	3	2	3
Immature female (%)	25	18	22
Immature male (%)	13	6	18
Progeny < 4 months (%)	19	22	21

Table III

Small ruminant performance in the northwestern coastal zone of Egypt

Criteria	Agroecological subzones		
	Rain fed	Dry	Irrigated
Productivity			
Sheep (kg lambs/ewe/year)	25.4 ^a	20.8 ^b	25.4 ^a
Goat (kg kids/doe/year)	20.7 ^a	18.9 ^b	20.9 ^a
Return on capital (%)			
Sheep	17.9 ^b	14.4 ^c	22.3 ^a
Goat	16.7 ^a	16.7 ^a	16.5 ^a

^{a,b,c} Means in the same row with different superscript letters differ significantly at $p < 0.05$.

Contribution of small ruminant production to household income

Table IV shows that the contribution of livestock to the household income ranged from 40.8 to 71.6% across AEZ. Under DA condition, livestock production contributed 71.6% to the household income.

Table IV

Contribution of livestock to household income in the northwestern coastal zone of Egypt

Source of income	Agroecological subzones		
	Rain fed	Dry	Irrigated
Agriculture (%)	30.4	2.5	54.7
Livestock (%)	58.0	71.6	40.8
Large ruminant (%)	34.0	36.1	75.3
Small ruminant (%)	66.0	63.9	34.7
Off-farm income (%)	11.6	25.6	4.5

DISCUSSION

The proportion of immature females (18%) in DA was about three times higher than that of immature males (6%), reflecting the adaptive mechanisms to be set by farmers to cope with the negative effects of drought, such as early marketing of male lambs/kids.

The return on capital invested in sheep production agrees with the findings of Panin and Mahabile (1997), and Peacock (2008), who report that small ruminant production is profitable and economically viable. Profitability of sheep production was significantly higher in IA. But this statement did not include the family labor cost, knowing that cut-and-carry and indoor feeding systems are more labor intensive per animal unit. However, households in IA integrated small ruminant with crop production thus cutting down on feed expenses, which agrees with the findings of Savadogo (2000). On the other hand, the returns on capital invested in goat production were similar between the various AEZ ($p > 0.05$). The study revealed that goat production was more profitable than that of sheep in DA. According to Ahuya et al. (2005), the profitability of goat production emanates from the fact that goats require less feed and eat agricultural by-products that are of low value, hence the low production costs.

Within the livestock sector, small ruminant contributed the most (63.9%) to the household income. This finding is consistent with that of Shomo (2004) who reports that sheep are the main economic activity in dry areas, contributing 57–89% of the income of small-scale producers. La Rovere and Aw-Hassan (2005) report that the most vulnerable households of the country are those that depend solely on livestock production. The contribution of crop production to household income in DA systems was practically null, whereas other sources of income (mainly off-farm work) contributed 25.6%. On the other hand, crop production ranked as first

main economic activity in IA and contributed 54.7% of the household income. Furthermore, Peacock (2005), Safari et al. (2008), and Lwelamira et al. (2010) report that manure from livestock enables substantial improvement in soil quality, increases crop yield, and thus improves food security and income to the household.

CONCLUSION

Under DA condition, livestock production contributed 71.6% to the household income. Within the livestock sector, small ruminant contributed the highest (63.4%). Drought in the middle of NWCZ adversely affected both sheep and goat productivity and profitability of sheep farms. Subsidized feed and government-supported animal diets may lead to additional revenue for Bedouins through the activity of fattening lambs/kids. Reducing animal feed cost by enhancing crop by-product nutritive value is also recommended. The study revealed that goat production was more profitable than that of sheep in DA. The returns on capital invested in goat production were similar between the different AEZ ($p > 0.05$). Making farmers aware of the financial benefits of small ruminants may convince them to consider the latter as a better alternative to crop production in terms of income generation. This should influence their decision on the allocation of their limited resources to the competing alternatives.

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Résumé

Metawi H. Contribution des petits ruminants au revenu du ménage dans la zone agroécologique côtière du nord-ouest de l'Égypte

L'étude a été menée dans la zone côtière du nord-ouest de l'Égypte afin d'explorer l'importance économique relative de la production de petits ruminants. Sur la base des ressources en eau, la zone d'étude a été divisée en trois sous-zones agroécologiques (ZAE): a) la zone pluviale (ZP) à l'ouest, b) la zone sèche (ZC) au centre, et c) la zone irriguée (ZI) à l'est. La collecte des données a été effectuée au moyen d'enquêtes de terrain, à l'aide d'un questionnaire testé au préalable. La productivité a varié de 20,8 à 25,4 kg, et de 18,9 à 20,9 kg, respectivement chez les ovins et les caprins. La productivité des ovins et des caprins a été plus faible dans la ZC que dans les ZP ou ZI ($p > 0,05$). La production des petits ruminants a été rentable dans les différentes ZAE. Les rendements sur capital investi dans la production ovine ont été de 22,3, 17,9 et 14,4 %, respectivement dans les ZI, ZP et ZC. Les données correspondantes pour la production caprine ont été respectivement de 16,5, 16,7 et 16,7 %. La contribution de l'élevage au revenu du ménage a varié de 40,8 à 71,6 % dans les ZAE. La comparaison des revenus provenant des cultures et du bétail dans la ZC a révélé que, alors que l'élevage représentait 71,6 % du revenu net total, la contribution des cultures n'a été que de 2,5-5 %. Dans le secteur de l'élevage, la contribution des petits ruminants a été la plus élevée (63,4 %). Aider les agriculteurs à prendre conscience des avantages financiers des petits ruminants peut les convaincre de considérer ces derniers comme une meilleure alternative à la production agricole en termes de génération de revenus. Ces résultats pourront probablement influencer sur leur décision concernant l'allocation de leurs ressources limitées à des alternatives concurrentes.

Mots-clés: bétail, petit ruminant, agroécologie, revenu de l'exploitation, performance animale, Égypte

Resumen

Metawi H. Contribución de los pequeños rumiantes a la generación de ingresos en la zona costera agroecológica noroeste en Egipto

El estudio se llevó a cabo en la zona costera del noroeste de Egipto con el fin de explorar la importancia económica relativa de producción de pequeños rumiantes. Sobre la base de los recursos hídricos, el área de estudio se dividió en tres subzonas agroecológicas (ZAE): i) la zona rica en lluvias (ZL) del oeste, ii) la zona seca (ZC) media, y iii) la zona irrigada (ZI) en el este. La recolección de datos se llevó a cabo a través de encuestas de campo, utilizando un cuestionario previamente probado. Productividad varió de 20,8 a 25,4 kg y de 18,9 a 20,9 kg por ovejas y cabras, respectivamente. La productividad de pequeños rumiantes fue menor en ZC que en ZL o ZI ($p > 0,05$). La producción era rentable bajo las diferentes ZAE. Los retornos sobre el capital invertido en la producción de ovejas fueron de 22,3, 17,9 y 14,4% en ZI, ZL y ZC, respectivamente. Las cifras correspondientes para la producción de cabras fueron 16,5, 16,7 y 16,7%, respectivamente. La contribución de la ganadería a los ingresos familiares varió de 40,8 a 71,6% en toda la ZAE. En ZC, la comparación entre los ingresos por cosechas y por ganado reveló que el ganado representó el 71,6% del total de ingresos netos, mientras que los cultivos contribuyeron a un mero 2,5-5%; por otra parte dentro del sector ganadero, la contribución más alta (63,4%) fue la de los pequeños rumiantes. Concientizar a los agricultores de los beneficios financieros de los pequeños rumiantes podría convencerlos de considerar estos animales como una mejor alternativa a la producción de cultivos en términos de generación de ingresos. Esto probablemente les ayudará a decidir sobre la asignación de sus recursos limitados entre alternativas contendientes.

Palabras clave: ganado, pequeño rumiante, agroecología, renta de la explotación, desempeño animal, Egipto

Roles of small ruminants in rural livelihood improvement – Comparative analysis in Egypt

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Keywords

Sheep, goat, rural poverty, agropastoral system, coast, irrigated land, oasis, Egypt

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Summary

The study focuses on the assessment of the contribution of sheep and goats to reduce poverty and vulnerability in rural farming systems of three agroecological areas in Egypt: the pastoral area of the Northwestern coast (Matruh governorate), the irrigated areas of the Nile Valley (Sohag governorate) and the oasis area of the West Desert (New Valley governorate). An empirical study on 90 farms in the three agroecological areas on different social and economic indicators related to poverty gave indicators on the roles of sheep and goats in different farm types according to resource endowment (e.g. land, livestock, capital) and human resources. The results showed that sheep and goats provided the main source of income to landless and very small land owners to escape the poverty trap. Moreover, the livestock asset generated other sources of wealth that were not taken into account in the monetary poverty approach.

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■ INTRODUCTION

Recent studies highlight the different roles of livestock outputs in terms of food production, food security, income generation, employment all along the livestock chain, capital asset, but also in terms of services and input supply to the agricultural sector such as manure, transport and draft animal, and biological diversity (Ashley et al., 1999; Faye and Alary, 2001; Thornton, 2010). Livestock and specifically small ruminants contribute to the development of areas where other activities are not possible; they constitute a way to face risk events such as drought or family urgent needs (health) or social events (e.g. birth, marriage) (Faye and Alary, 2001). Many researchers gave evidence of the multiple roles of small ruminants in harsh Mediterranean environment (Haenlein, 2001;

Haenlein and Abdellatif, 2004; McDowell and Woodward, 1982) and also as a pathway out of poverty (Peacock, 2005; De Vries, 2008; De Haan, 2001).

Despite its potential importance to sustainable economic growth and poverty reduction, the livestock sector development has received limited attention from the international community and national governments in recent decades. In Egypt, agropastoral and pastoral areas raised less social and policy interests because of their marginal contribution to economic growth and food security. The irrigated system in the Nile delta and valley has allowed the husbandry development of large ruminants based on forage production, i.e. *Trifolium alexandrinum* (berseem) and *Medicago sativa* (alfalfa). In addition the small ruminant (SR) population represents around 50% of the total ruminant population against more than 80% for the majority of the countries in the Near East and North Africa regions (FAOSTAT, 2009; Alary, 2010). However, the sheep population in Egypt greatly increased from 3.1 to 5.3 million over the decade 1995–2005, whereas the goat population increased from 3 to 4 million and the cattle population from 3 to more than 4.5 million in the same period. One third of the sheep and goat population is in Upper Egypt, followed by the West delta with 22.8% of the population, and Middle Egypt for goats with 23.5% of the population. How to explain this increase in SR

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population in intensive agriculture conditions? This was one objective of the present study.

A rapid review of research studies in Egypt revealed the importance given to the analysis of the economic and biological efficiency of sheep or goat production systems. For instance, Soliman (1990) cited by Haenlein and Abdellatif (2004) estimated that the contribution of sheep and goats to the livestock income of Egyptian farmers was 9% for farms less than five feddans (1 feddan = 0.42 ha) but 2% in the case of larger farms. Similar work in Sohag recorded gross margins of about 12 to 22 US\$ per ewe and 4 to 12 US\$ per doe (Alsheikh et al., 2011). Siddik (Livestock and Poverty in Egypt, 2009, PowerPoint presentation) reported that poverty indices recorded a significant decrease from 22.9 to 19.6% from 1995-96 to 2004-05, whereas rural poverty increased from 23.3 to 26.8% during the same period. The poverty percentage was the highest in Upper Egypt rural areas (29.3%) and Lower Egypt rural areas (21.5%). There was a strong relationship between the number of small ruminants per feddan and the poverty level. This meant that small landowners or landless farmers invested more in small ruminants to cover family needs. The livestock per capita income varied from 70 to 88 US\$ in the delta, Middle and Upper Egypt, and up to 155 US\$ in the border governorates.

This causal relation between SR and poverty may explain policy makers' negative perception of small ruminants. SR is seen as a sign of poverty because of being unable to invest in large ruminants such as buffaloes or cattle. Yet it is difficult to find research studies that approach the SR roles in the system. Gihad and El-Bedawry (2000) cited by Haenlein and Abdellatif (2004) determined that for the price of one buffalo a farmer could buy 10 goats, which would produce 25% more cash income than the buffalo because of lower feed requirements. Goats are more profitable than sheep because they are more prolific and more tolerant to a harsh environment. But this statement did not include the financial and economic costs related to family labor, as cut-and-carry and indoor feeding systems are more labor intensive per animal unit.

Generally in this system, animals constitute a flexible source of cash, enabling farmers to purchase farm inputs and meet other urgent needs, and also a buffer against non-remunerative crop prices or poor harvest (Tabana et al., 2000). It is in addition a source of animal proteins and a way to satisfy social events and ceremonies. However few studies describe the roles of small ruminant activities in the household economy in relation to their contribution to reducing poverty and enhance livelihood improvement. The comparison between small ruminant and land gross margin cannot reflect the multipurpose functions of animals.

Based on the livelihood research approach (Carney et al., 1999; Ellis et Mdoe, 2003), the present paper proposed to analyze the contributions of small ruminant activities in terms of income generation, food security and capital endowment in three contrasted governorates of Egypt.

■ MATERIALS AND METHODS

In 2010 three surveys were organized among a stratified sample of 90 farms in three agroecological areas: the rain-fed arid area of Matrouh governorate, the intensive agriculture area of Sohag governorate in Upper Egypt and the Oasis area in New Valley governorate (Figure 1). The three areas represented different integrative crop-livestock systems with different levels of intensification according to irrigation access and land fragmentation.

The rain-fed production system was a complex system based on livestock, annual crops (mainly barley), trees (mainly fig and

olive) and off-farm jobs. This system was well developed by traditional farmers (Bedouins) in North coastal areas. The feeding system was based on barley grain, crop-residue grazing and seasonal rangeland in a normal rainfall year. Transhumance was practiced during late spring for grazing residual crops and during winter in the common pastures (desert) when rainfall had been good. Meat production was the main output; goat milk was used for domestic consumption. The main local milk product was a hard cheese called *gamid* that could be refreshed with water and used as raw milk. According to Ashley et al. (1999), the main constraints of these systems are the highly fluctuating feed supply due to erratic rainfalls which affect production and reproductive performances: the number of offspring per female and per year, the body weight and milk yield.

The irrigated production system was a typical mixed crop-livestock system that represented the majority of farms in the delta and Nile valley, around 76% of farming systems according to Tabana et al. (2000). The livestock activity integrated large ruminants (cattle and buffaloes), small ruminants and rural poultry. The feeding system of ruminants was based on berseem, green corn, crop residues, external feedstuff and concentrates.

In densely populated areas along the Nile valley, the mixed system was close to the farmyard household system in which small ruminants were associated with other animals: poultry, cattle and buffaloes. Farm size was usually small (less than five feddans) with high cropping intensity. The flock size was small with around 2–5 head.

The common feature between the three areas was their high poverty status and social vulnerability. One hypothesis was that sheep and goat activities might be one way to face socioeconomic constraints such as poverty, land fragmentation and climatic changes.

A stratified sample was used based on two hierarchical criteria: 1) the location of the villages (their distance and access to the main city), and 2) the flock size at farm level. In New Valley, with the agriculture land scarcity, landless farmers were also surveyed. Thirty farmers were surveyed in each governorate in the different locations (Table 1). The survey was based on a questionnaire with three components: 1) farm and family history; 2) farm description, i.e. cropping and pasture lands, livestock system, off-farm



Figure 1: The three studied locations in Egypt.

Table I
Description of the farm survey in Egypt
from April to June 2010

Governorate	Location
Matruh	Matruh Neguila Sidi Barani
Sohag	Sohag city, 2 villages Al Muncha, 2 villages Saqlta, 2 villages
New Valley	El Karga Darlha Paris

activities, and farm facilities; and 3) risk and poverty perception, and the role of SR to manage family risks. The farm description on the livestock system comprised different aspects such as herd structure, fattening practice, marketing strategy and domestic consumption, feeding system and other expenditure (labor, feedstuff and concentrates, veterinary costs). The data collected were only data declared over the last year.

To understand the socioeconomic status of farmers and more precisely the roles of livestock in the reduction of vulnerability, we used the conceptual and methodological approaches developed in the livelihood approach. Within the general framework proposed by Carney et al. (1999), we focused our approach on the evaluation of the livelihood assets that constituted a way to estimate the degree of vulnerability of the studied populations. The study

focused on the description of the farm and family livelihood assets in order to determine the relative contribution of livestock to poverty reduction. The analysis used also qualitative data on the social capital at family and community levels and the risks and poverty perception.

■ RESULTS

Each studied area had specific agroclimatic conditions that determined the dominant crop and livestock activities. Table II gives some characteristics of the prevailing farming system in each area.

The three systems were oriented to animal production with 60–75% of the land allocated to fodder crops; the largest small-ruminant herds were found in the pastoral area of Matruh and were based on a barley-pastoral system. During dry years, farmers had to purchase all feed requirements to maintain their stock. Following a number of dry years, 2010 was also a dry year, and the average annual feed cost of small ruminants was around 80 US\$ per head.

In Sohag and New Valley the livestock systems were mainly based on fodder crops such as berseem in winter and green corn in summer, and feed supplementation for all animals with approximately a double ration for growing lambs and kids, or lactating ewes and goats. According to the feed prices on the market in Sohag, some farmers preferred to sell their forage, especially green corn, and purchase straw or berseem hay for their animals. The variability of the herd size was more important in New Valley according to the land tenure and water source depending mainly on the date of installation. Feed costs estimated at 66 US\$/head were the lowest in New Valley because of their remoteness from the main markets of the Nile valley, compared to 105 US\$/head in Sohag.

To understand the links between small ruminant activity and the reduction of vulnerability, we used the capital asset approach. The two main hypotheses were: 1) the poverty level constituted a first approach of the degree of vulnerability faced to external risks;

Table II
Characterization of farming system in three governorates in Egypt

Governorate	Farming system	Cropping system (% utilized land)	Share of fodder crop on cultivated area (%)	Average num. small ruminants	Average num. large ruminants
Sohag	Mixed crop-livestock	Green maize, 36.8 Wheat, 20.9 Berseem, 18.2 Fruit trees, 6 Sorghum, 5.8	66.5 [15]*	7 [15.7]*	4 [4.8]*
New Valley	Oasian	Wheat, 22.7 Alfalfa, 23.5 Berseem, 17.6 Green maize, 16 Other crops, 7 Barley, 5.4	58.9 [16]*	54 [87.1]*	28 [45.6]*
Matruh	Agro-sylvo-pastoral	Barley, 83.4 Fruit trees, 15.6	75.26 [20]*	122 [155.9]*	1 [3.9]*

* [standard deviation]

2) the capital asset radian allowed analyzing the different roles of small ruminants according to the household capital asset composition. Four groups were defined: 1) very poor with less than 1.25 US\$/capita/day; 2) poor with between 1.25 and 2 US\$/capita/day; 3) medium with 2 to 6 US\$/capita/day; and 4) rich with more than 6 US\$/capita/day. Table III shows the distribution of the sample for each governorate. The daily net income was estimated from all agricultural and non-agricultural activities. For agricultural activities the outputs included all the production (including family consumption).

We noted the high percentage of very poor (with less than 1.25 US\$/capita/day) in Matruh compared to the other two governorates. This high percentage resulted mainly from the effects of the drought conditions that had been affecting the area since the last decade. Most of the breeders limited the sale of animals to cover urgent needs such as the purchase of animal feeds or family basic expenditures. Moreover the second main source of income was the fruit tree. In 2010 the yields have been very low or nil for all the farmers. This explained why very large farmers were often classified below the poverty line.

In Sohag and New Valley, two profiles of distribution of poverty could be distinguished. In Sohag, there was an equal distribution between the three classes, very poor, poor and medium. Due to land fragmentation, few farmers reached the rich level. In New Valley, the majority of very poor farmers were landless. The medium and rich groups cumulated different activities including government jobs that had been developed within socio-political programs of the 1970s and the New Land Reclaimed Program. The poor group reflected the situation of typical farmers that needed to manage their small land.

The capital asset radars (Figure 2) give some indicators to understand the different roles of activities to escape poverty. Two very large farms in the sample have been omitted. The radars show very specific profiles of capital assets according to each area and agroclimatic conditions. Matruh presented a very specific profile because of last years' agroclimatic conditions. The SR flock size did not allow escaping the poverty level fixed to no more than 2 US\$/capita/day. However the poor group was proportionally better endowed in human, physical and financial capital than the very poor group. The main gaps between poor and very poor groups were the access to the lowland area called *wadi*, the animal stock and the off-farm income. Among the poor group, 40% of the farmers had more than 100 head of small ruminants compared to only 26% in the very poor. The farms with less than 30 head in the poor group comprised around 8.5 family members compared to 13.3 in the very poor. So the family size, which may be a driving force

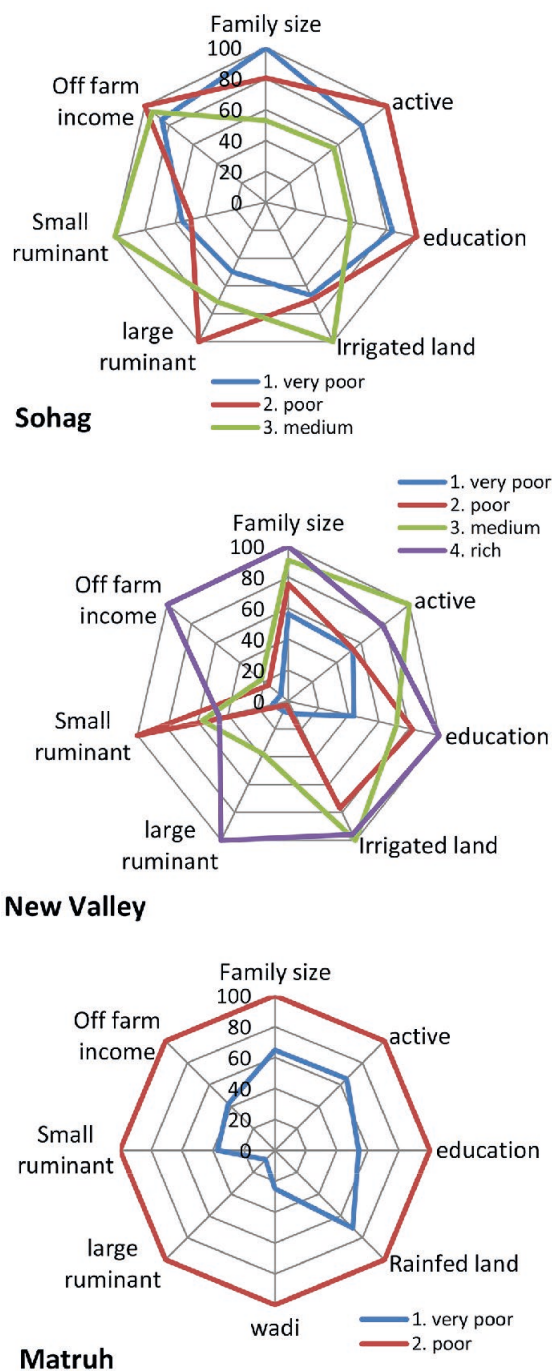


Figure 2: The eighty-eight surveyed farmers' capital asset radars in three governorates in Egypt.

Table III

Distribution of the levels of poverty between the three studied governorates of Egypt

Governorate	Very poor Less than 1.25 US\$/day (%)	Poor Between 1.25 and 2 US\$/day (%)	Medium Between 2 and 6 US\$/day (%)	Rich More than 6 US\$/day (%)
Matruh	76.7	23.3	0	0
New Valley	37.9	13.8	27.6	20.7
Sohag	34.5	34.5	31.0	0
Total	50.0	23.9	19.3	6.8

during good climatic years, becomes a factor of poverty aggravation during dry years.

Sohag and New Valley presented contrasted profiles with regard to the role of small ruminants. In New Valley, the main asset for the poor group which could pass the poverty threshold of 1.25 US\$/capita/day was the sheep and goat stock. When the households could invest in cattle, they could escape the poverty trap. The main assets of the rich group in our sample were the large ruminant stock with a remunerative off-farm activity thanks to a high education degree. Therefore we can say that sheep and goat capitalization constitutes a first step to escape extreme poverty. Its part decreases again when the household can invest in large ruminants (cattle or buffaloes). Off-farm activities constitute an important way to invest in large ruminants by providing a sort of collateral to bank credits. The education level is also a way to invest in land capital reserved to graduates on the New Reclaimed Lands.

Contrary to New Valley, the main difference between very poor and poor groups in Sohag was the large ruminant asset. Only medium-revenue farmers invested consequently in small ruminants. SR was often a new activity for the farmers who were in an early phase of investment. The figure also shows that the medium group had a low level of education compared to the other two poor groups. One hypothesis was that SR activity might be one way to diversify economic activities without jeopardizing the farm economy in case of low opportunity.

We then confronted the monetary poverty status with the perception of poverty in each area, mainly the main reasons and risks to become poor and the main factors to escape poverty (Tables IV and V). The main reasons to be poor corresponded well to our analysis of poverty. The main reasons in the rain-fed area were the climatic conditions in Matruh. In the irrigated areas, the main factors were land fragmentation linked to demographic and social pressure. The main risks mentioned in irrigated areas were animal diseases or the difficulties in developing animal activities. The

main social costs declared by the farmers were wedding costs, the risks of health problems or the loss of parents at an early age.

The main factors to escape poverty would be off-farm income diversification through migration and new job opportunities in rural areas. Despite different answers and experiences between the areas all of the farms expected a lot from public support either as part of development projects or subsidy policies.

■ DISCUSSION

The field research work showed different contributions of animal species to the household livelihood according to asset endowments, as well as social and agroecological environments. For the landless and very small land owners, sheep and goats provided the main source of income to escape the poverty trap as shown by Siddik (2009) and Soliman (1990) cited by Haenlein and Abdelatif (2004). As soon as the farmers were able to invest in cattle or buffaloes, sheep and goats became the basic cash flow whereas large ruminants provided a sort of family insurance. Poor farmers mainly used common lands along canals or took their flocks to graze on crop residues. In some arrangements with large landowners, agricultural workers had access to small parts of land to graze.

In New Valley and Matruh, one of the main constraints that affected sheep and goat keepers were feed costs. In New Valley, the majority of herders maintained small flocks in enclosures. The feeding system was mainly based on green fodder (berseem) and wheat residues in winter and green corn in summer. The problem of availability of water or the problem of water pump functioning led the farmers to buy feed outside New Valley and reduced the profitability of their livestock activity. This problem impeded also the development of milk productivity and milk marketing.

In Matruh, the feed cost was entirely linked to climatic conditions and the degree of remoteness. During the last years, herders were obliged to sell part of the flocks to buy feed from the delta; the

Table IV

Main reasons to fall in poverty according to the surveyed farmers in three governorates of Egypt

Governorate	Drought (%)	Land fragmentation (%)	Social events (%)	Employment (%)	Livestock risk (%)	Others (%)
Matruh	91.7	0	0	6.3	0	2.1
Sohag	0	54.9	21.6	9.8	13.7	0
New Valley		56.7	10.0	16.7	16.7	0

N = 90 farms; CIRAD/APRI, 2010

Table V

Main factors to escape poverty according to the surveyed farmers in three governorates of Egypt

Governorate	Employment/Off farm (%)	Development project (%)	Livestock development (%)	Social nets (%)	Others / no answer (%)
Matruh	38.0	32.4	18.3	2.8	8.5
Sohag	64.4	17.8	8.2	6.8	2.7
New Valley	26.6	20		16.7	36.7*

N = 90 farms; CIRAD/APRI, 2010

* The majority of the farmers mentioned reduction in living costs

feed ration was on average 0.3–1 kg/day/head of grain. The straw was negotiated at around 0.17–0.2 US\$/kg compared to 0.21–0.24 US\$/kg for cereal grain. This dependence on feed from outside the area might be reinforced in the coming years because of different factors, e.g. climate change that can disturb the quantity and quality of ranges in rain-fed areas, water access in irrigated systems, and feed prices in the market. Some herders covered their feed costs by selling young animals, mainly males between four and six months old. Furthermore this fitted with the development in market demand in nearby cities but could have major social and economic impacts at territorial level. In Sohag, sheep and goats constituted one way of income diversification for the medium households who did not have the resources to invest in other sectors. In poor households, the farmers preferred to invest in large animals that constituted a more consequent social and economic capital. These three case studies reflected the different roles of livestock as shown in Faye and Alary (2001).

When poverty factor perception was crossed with monetary poverty indications, some obvious factors such as the climatic factor in rain-fed areas and land fragmentation in irrigated areas were highlighted by the majority of farmers. In irrigated areas, other factors mentioned were social events in Sohag, or the loss of employment in New Valley. This corresponded to two particular realities. In Sohag, the farmers' main problem was land fragmentation because the married daughters left the family taking their land ownerships with them. In New Valley, off-farm jobs, mainly in the public services, were developed during the 1970s, which enabled each family to have a secure source of income. The loss of this job because of the retirement or the death of the head of the family caused uncertainty at family level, especially in families without livestock. In this area, animal and off-farm jobs were considered as a major source of income diversification.

The factors to escape poverty were more diversified and well embedded in the history of each area. For example in Matruh, besides off-farm diversification mainly through the social networks at the Libyan-Egyptian border, one way to escape poverty would stem from governmental development projects such as the Natural Resource Matruh Project (NRMP) that prevailed during ten years in the area. The development projects supported the development of many activities with subsidies to the breeders. In Sohag and New Valley, they mainly provided credits. The social support mainly reflected the development of social networks to get a job, facilitate migration, receive social support (religious associations), access loans, exchange animals. Livestock development was mainly cited as one way to escape poverty in Matruh, where livestock represented the main asset to face climatic conditions. The perception of livestock to escape poverty was entirely linked to the flock size.

■ CONCLUSION

These results showed that the national data do not allow approaching the multiple roles of sheep and goats at farm and regional levels in terms of poverty reduction, reduction of vulnerability, and local food security on the short and long terms, notably in harsh environments. A more in-depth survey on risk perception and the role of livestock will help better understand the role of livestock as a way of adaptation in the face of global changes such as climate change in rain-fed areas or demographic change in irrigated areas. Nevertheless, these first results showed different contributions of animal species to household livelihood according to asset endowments, societal and agroecological environments. For the landless and very small land owners, sheep and goats provided the main source of income to escape the poverty trap. The results also

showed some gaps between capital asset and poverty, especially for large herders in the pastoral and agropastoral areas of Matruh. The livestock asset produced other sources of wealth that were not taken into account in the monetary poverty approach.

The poverty profile analysis in rain-fed areas raises thus several questions. In such areas, we need to distinguish the structural poverty from the annual poverty linked to climatic conditions. Moreover the annual monetary poverty is not always a good indicator of the family poverty because of the strong social network in the society. In Matruh, major economic activity emerges from the social network in the society. This activity is based on animal exchange, keeper activities, smuggling activities or a combination of these activities at the Libyan-Egyptian border. This leads to the need to diversify the indicators of poverty in relation with the capital asset composition that reflects different roles of livestock at family level.

However, the key roles of small ruminant stocks in the different farming/household systems explain the increasing SR population at regional and national levels. Any development or research activity on small ruminants to sustain this endogenous development needs to understand well the multiple reasons of this development in link with the nature of the animals and family needs. Moreover, these interviews showed that the main constraints of livestock development in Egypt are the lack of know-how in the use of crop residues – notably with the recent price increase of concentrates –, the unavailability of credit lines for landless and small-scale landowners, but also the absence of associations to support sheep and goat breeders.

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Résumé

Alary V., Aboul-Naga A., El Shafie M., Abdelkrim N., Hamdon H., Metawi H. Rôles des petits ruminants dans l'amélioration des conditions de vie en milieu rural – Analyse comparative en Egypte

L'étude est centrée sur l'évaluation de la contribution de l'élevage de petits ruminants dans la réduction de la pauvreté et de la vulnérabilité des systèmes agricoles de trois zones agro-écologiques en Egypte : la zone pastorale du littoral Nord-Ouest (région de Sohag), les zones irriguées de la vallée du Nil (région de Matrouh) et les oasis du désert Ouest (région de la Nouvelle Vallée). Une étude empirique sur 90 exploitations dans les trois zones agro-écologiques portant sur différents indicateurs économiques et sociaux liés à la pauvreté a donné des indications sur le rôle des ovins et des caprins dans différents types d'exploitation, selon les dotations en ressources (en particulier terre, bétail, capital) et les ressources humaines. Les résultats ont montré que les petits ruminants constituaient la principale source de revenus des ménages pour échapper à la pauvreté, notamment pour les sans terre et les très petits propriétaires terriens. En outre, l'élevage était un capital qui générait d'autres richesses qui n'ont pas été prises en compte dans l'approche de la pauvreté monétaire.

Mots-clés : ovin, caprin, paupérisme rural, système agropastoral, côte, terre irriguée, oasis, Egypte

Resumen

Alary V., Aboul-Naga A., El Shafie M., Abdelkrim N., Hamdon H., Metawi H. Papel de los pequeños rumiantes en la mejoría del sostén rural – Análisis comparativo en Egipto

El estudio se enfoca en la evaluación de la contribución de ovejas y cabras para reducir la pobreza y la vulnerabilidad en sistemas agrícolas rurales en tres áreas agroecológicas en Egipto: el área pastoril de la zona costera noroeste (gobernación Matruh), las áreas irrigadas en el Valle del Nilo (gobernación Sohag) y la zona del oasis en el Desierto del Oeste (gobernación Nuevo Valle). Un estudio empírico en 90 fincas en las tres áreas agroecológicas sobre diferentes indicadores sociales y económicos en relación a la pobreza dio indicadores de los roles de las ovejas y las cabras en diferentes tipos agrícolas, de acuerdo a la dotación (tierra, ganado, capital, etc.) y a los recursos humanos. Estos resultados muestran que las ovejas y las cabras proveen la principal fuente de ingreso para escapar de la trampa de la pobreza para los propietarios sin tierra o con terrenos muy pequeños. Aún más, la posesión de ganado produjo otras fuentes de riqueza que no fueron consideradas en el enfoque de la pobreza monetaria.

Palabras clave: ovino, caprino, pobreza rural, sistema agropascícola, costa, regadio, oasis, Egipto

The paths to last in pastoral sheep farming in the Cevennes in France

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Keywords

Sheep, farming system, adaptation, sustainable livelihoods, Mediterranean region

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Summary

In a context of uncertainty of future conditions, which are the sustainable paths? We described the long-term action logics relied upon by the farmers to develop their farms or adapt them to their environment. These logics are based on choices related to increasing the farm size, specializing, the techniques used, marketing, production project debts, and technology incorporation. The data comes from sheep farms in the Cevennes, a pastoral Mediterranean region of Southern France, based on trajectory surveys of families, farming, and sheep management over 30 years (1982–2012). Although sheep farming hardly changed over this period, three different long-term action logics were identified: a clannish logic that gives the opportunity for the children to settle on the farm or nearby; a logic centered on sheep tradition with a focus on increasing the herd size; a multiphase logic, i.e. two or three successive sheep management types or combined household activities are explored. The identified action logics were similar to those described in other studies, except that they did not include logics based on increasing herd productivity by use of technologies, an option too removed from the kind of pastoralism practiced in the Cevennes.

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■ INTRODUCTION

Because of unpredictable global markets, policy changes, and increasing climatic disturbances, livestock farmers must plan their systems and their dynamics by integrating uncertainty about future conditions if they are to hold firm. The vulnerability (Chambers, 2006) of farming systems and the abruptness of changes seem greater in the South, because of weak mechanisms and the absence of any kind of incentives, in particular protection or regulation policies. But action under uncertainty (Lemery et al., 2005) is also the subject of increasing questioning in the North, including Europe, because of evolutions in the Common Agricultural Policy and vagueness about the reforms to come. Under these conditions of uncertainty, on what bases can farmers hold on in agriculture, how can they last?

The question of the “paths to last” has been producing a great deal of literature not only in the agricultural sector, but also beyond agriculture in the corporate world (e.g. Mignon, 2001). The concept of “path of development” (Evans, 2009) gave rise to many variations in the field of analysis of farming system dynamics. Structural evolutions, production orientations and technical configurations are formalized (Cialdella et al., 2009; Moulin et al., 2008; Ryschawy et al., 2012). In some of these studies, explicit account is taken of links to the farming family (Rueff et al., 2011), the dynamic of change in systems of activities, collectives and forms of work organization, with vertical (family line) and horizontal (the couple) methods of family influence on structural and technical evolutions (Terrier, 2013; Terrier et al., 2012). Another approach consists of updating the principles and their combinations (long-term action logics) on which farmers rely to develop their farms in their own context (Dedieu, 2009). These principles can be expressed as elements of a deliberate or emerging (Moulin et al., 2001) strategy of farm evolution patterns.

The present article is in line with this second approach which gave rise to variations in different livestock farming regions in France and South America (Argentina, Uruguay) (Dedieu and Ingrand, 2010; Levrouw et al., 2007). We have been interested in the long-term action logics of sheep farmers in the Cevennes, a

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Mediterranean mountain region of the South of France (less than 100 kilometers from Montpellier) where pastoral sheep farming is still practiced. Firstly, we presented the analysis framework of the principles / action logics and described the research project. Secondly, results (the action logic typology), and similarities and differences with previous studies were discussed, as well as the impact of territorial characteristics on the dynamics observed.

Taking inspiration from the concepts of flexibility and resilience and their application in dynamic approaches to farming systems (Darnhofer et al., 2012; Milestad et al., 2012), several studies (Begon et al., 2009; Lemery et al., 2005; Lewrouw et al., 2007) highlighted five sets of principles which farmers put forward to explain and justify the continuities and disruptions of their farm evolution patterns. These principles are fields of expression of what it is advisable to do to last. In their variety, they are subjects of controversy among farmers. These sets of principles are:

- Configuration of the family farm system with two principles relative to i) the size, “being big to hold firm” or on the contrary “getting big isn’t for me, you get lost in the process”, and ii) the combination of activities, opposing diversification, “not all the eggs in one basket”, and specialization “being competent and effective”;
- Financial or technical risk taking, for the improvement of the system, with the three methods, i.e. “never”, “necessary”, “only if it’s highly controlled”;
- Finances, i.e. with respect to debt (never, or a necessary evil), to savings (systematic or not), to the possibility of adjusting family direct debts in a difficult year;
- Operation of the technical system and work, with three methods corresponding to the emphasis placed by the farmers on different dimensions of this operation, i) strong technical ambition (“it is the guarantee for holding firm”) with work that has to follow, ii) management ambition (“what matters is optimizing all of the farm resources, including work mastered” as well as the fiscal aspect), and iii) the will to keep flexibility in the production process and in the work (“keep something in reserve”, “never be at the limit”);
- Socio-technical networks (information, discussion and advice enabling downstream to be controlled (“you have to invest in producers’ organizations”).

Boxes 1 and 2 (Dedieu and Ingrand, 2010) present the diversity of long-term action logics in Segala (Center of France, intensive dairy farming) and Uruguay (rather extensive milk and meat farms).

■ MATERIALS AND METHODS

Sheep farming in the Cevennes

Characteristic of the Mediterranean mountains of the south of France, the Cevennes landscape is covered in trees. Annual average rainfall in the valleys is 450 mm with severe summer droughts and mild autumns. Grasslands, when they exist, are located in the valley floors. Rangelands covered by old sweet chestnut groves – the main resource for humans and animals in the past – and holm oaks form a significant proportion of the flock feeding resources, from 35 to 75% of the on-farm flock intake (Dedieu, 1984) including chestnut fruit in autumn and winter. They enable livestock farming to find its place in these large areas.

Transhumance of the flocks toward the high pastures during the three months of summer makes it possible to take the load off the farmstead land and limit livestock work in summer: summer flocks are shepherded in a collective way by cooperatives. Finally, a very significant part of the food resource is found directly by the flocks. In a way that varies according to the systems, only short periods in

Box 1

LONG-TERM ACTION LOGICS IN DAIRY FARMING IN THE SEGALA (BEGON ET AL., 2009)

– To be technically efficient (the indicator is the level of production per cow)

Little modification to land, fast specialization at the beginning of farm evolution pattern, partner works outside or not. Some farmers evolve with time toward administrative planning.

– To be big with regard to milk production

Increase (by accumulation) land area, quotas and live-stock; tendency to specialize, in particular in dairy (even if in some phases there can be several agricultural activities). High level of performance required.

– To have a large dairy herd but also another herbivorous-related activity used as a buffer if a catastrophe occurs

Expand from the outset to include several activities at the same time but milk prevails; technical ambition concerning milk at the beginning then managerial ambition.

– To be a diversified business person: to be big with several activities of equal importance

“Doing business”, not necessarily doing what is best, with several irons in the fire and each one significant.

– To diversify activities in relation to local opportunities

Small structures; attempts at diversification or gathering; flexibility on dairy herd management, with no great ambition concerning the dairy production level, variable and dependent on forage resources (high degree of feed autonomy).

Box 2

ACTION LOGICS IN CATTLE FARMING IN URUGUAY (LEVROUW ET AL., 2007)

– To be diversified by doing odd jobs on a local basis

Diversification of farming activities; no expansion (land area and cattle head); no investments; continuous adjustments to activities and management patterns, with traditional (extensive) cattle management.

– To become bigger

Specialization in suckler cattle farming; expansion (herd and grassland area); investments on condition that previous savings are available; traditional extensive herd management.

– To optimize the technical system

Specialization in beef or dairy cattle farming seeking high level of animal productivity (annual milk yield per cow, calf crop per cow); debts from investment in technology; search for permanent innovation including risk taking.

– Maximum control

Milk or beef specialization seeking high level of productivity; expansion (land area and livestock); financial investments when savings are sufficient and a return clearly foreseeable. Innovation planned with cost/benefit calculation.

the autumn or at the end of winter are concerned with the distribution of forage stocks inside. The farming activity is still very pastoral today, with lambing in early autumn and winter and light lambs produced for fattening elsewhere. But the land base is uncertain: verbal rentals predominate (verbal authorization to use rough grazing), as land under ownership or lease is rather limited.

Fine control of farming systems makes it possible to limit, even benefit from structural and land handicaps, by making good use of the diversity of existing resources. Each livestock farmer coordinates the time when sweet chestnuts and acorns become accessible with the physiological stages of the animals when they can make best use of them. In all the farms, the management organization, shepherding, batching, even blocking lambing periods make it possible to have low requirement animals or ewes building up their strength when it is hoped that the richest resources are to be found under the trees.

The size of arable land available to the farmers (from 0 to 40 hectares) has a huge effect on the livestock system operations. For some, autonomy in stored fodder is total or partial but requires equipment. For others, the topography, the low proportion of grasslands combined with a 'pocket handkerchief' type of configuration of the grasslands in the Cévennes valley floors have directed systems toward annual purchases of fodder. This forage of very good quality is composed at least partly of hay from the Pays de Crau or of alfalfa. It is distributed at the end of pregnancy or during short lactations (two months for the light lambs, three months for the ewe lambs). Fed on supplements, the lactating ewes remain indoors (winter lambing) or are shepherded on grasslands or to old orchards (autumn lambing) where they can eat sweet chestnuts which have not been collected before the frost.

In many cases, fodder purchase is the main variable cost of the system. On the other hand, these farms limit their fixed (notably renting) expenses. Thus, the Cévennes are still today a region of pastoral livestock farming where livestock farmers seek to make direct and optimum use of local natural resources. But although some still base their systems on sheer pastoralism (with only a few purchases of hay) to the point of having no harvesting equipment (but also no related structural costs) and with the sale of light lambs of 14–18 kilogram live weight for fattening, others who have areas that can be mowed purchase equipment to be self-sufficient in forage. They are then more readily inclined to finish their lambs inside.

Study methodology

To treat paths to last in 2010, we carried out interviews in 12 Cévennes farms previously surveyed in 1981 (n = 3) or closely monitored during a doctoral thesis between 1981 and 1983 (n = 9) (Dedieu, 1984). These comprehensive interviews aimed at reconstituting the evolution pattern of the farm (Moulin et al., 2008), the flock and its management, as well as the household activities. Recorded and transcribed, the conversations gave access to i) structural and management dynamics over nearly 30 years, ii) changes and events marking various phases of evolution of family livestock systems, and iii) action logics analyzed according to the five sets of principles detailed above. The analysis led to a collective restitution with livestock farmers in March 2011 to validate the various paths.

To describe briefly the sample in 2010 in the 12 surveyed farms, the areas used were large (from 200 to 600 hectares), the stocking rate was still very low (from 0.65 to one ewe per hectare), and shepherding was still essential to use the resources. Only two of

the livestock farmers we met had put up fixed fences which surrounded a small area of their land.

RESULTS

Sheep farming systems changed very little in 30 years. In 2009, the environmental conditions still made shepherding absolutely essential, in spite of strong incentives to develop the use of fences that were given in the early 1980s. Under these conditions the size of the flocks only increased slightly for lack of sufficient manpower: it is difficult to keep more than 250 ewes in only one batch on these rough pastures under forest. Over time, breed types have been purified toward hardy local breeds (Raïole, Causse, Rouge du Roussillon) without any one breed getting the upper hand.

The flocks were still managed outside for most part of the year. Brought inside for short periods in autumn or winter, the required fodder stocks were not very abundant (50–250 kilograms of hay per year and per ewe). The question of self-sufficiency in hay was still crucial however: five farmers had to expand outside the Cévennes, in the plain, but these expansions had only been temporary in four out of five cases.

Reproduction management was still mainly centered on autumn lambing in order to coordinate the progress of the physiological stage of the ewes with the possibilities of making good use of available resources: mountain pasture (gestation), grassland regrowth (lactation), sweet chestnuts and acorns (body condition rebuilding). But this coordination also sought to limit competition with the lambs from the Aveyron Roquefort region at the time when light lambs were being marketed. However, some farmers had been innovating by exploring new market niches (lambs for the Muslim feast of Aid El Kebir paid 75% or more than a fattened lamb), even adapting to the changing dates of this feast by changing the lambing period (from autumn to spring).

The analysis of farming pattern data highlighted the transformations of a small farm in the traditional model: i) very diversified, in which sheep were associated with other activities (e.g. goats, onions, arboriculture, country cottage rental), ii) thrifty, where "each unspent coin is a coin earned", "no loans". In three cases sheep farming had ceased (the farmer retired without a successor, the shepherd stopped the activity, the farmer had conflicts with hunters). In one case, conflicts with neighbors because of the development of Protected-Designation-of-Origin (PDO) onion crops on formerly abandoned terraces led to a drastic reduction in the flock, from more than 200 to 30 ewes. In three other cases, the farm was taken over by one of their children.

Three types of long-term logics emerged more or less distant from this model (Table I). They are illustrated by three cases of farmers in Boxes 3, 4 and 5.

– A clannish logic aimed at establishing the children in or near the farm. Over the long term, it involved developing the system on the basis of two or three significant activities with regular investments (buildings, land, equipment). Sheep farming increased, with two lambing periods. It was self-sufficient in hay and the range of products was diversified (light lambs, lambs fattened for the Aid), the proportion of each being significantly adjustable from one year to the next.

– A logic centered on sheep tradition as the pivot activity. Enlarging the flock was generalized up to the limit of shepherding in the forest. In certain cases, shelters were built making it possible to use new areas that had been too distant from the main sheep shelters. Production was very stable and centered on the production of light lambs in most cases in autumn.

– A logic marked by the succession of several phases with radically different bases, where very different management systems and niche markets were explored over time (C1), or more generally by a profound change in the system of activities (C2) (Table I).

Box 3

A CLANNISH LOGIC AIMED AT ESTABLISHING THE CHILDREN IN OR NEAR THE FARM

Over the long term, the system run by Eric M. developed on the basis of significant activities: “We were in sheep and we did a bit of onions”. However, at the same time, investments were regular: “there were two opportunities in our life. One in 1979 when we were able to buy the Gasquet and one in 1999 when we bought here... we worked hard but we were lucky.” Adding buildings on both sites and the purchase of equipment marked out this evolution pattern during which sheep farming increased to 350 nursing ewes and 60 ewe lambs: “we never stopped investing but there are three children and we are happy.” In 2007, the onion activity was handed over to two of the couple’s children who settled down: “We told them: if you want to settle down... the onions part will be yours!” Eric and his wife have since refocused their activity on sheep (personal flock and managing private mountain pasture with 1300 ewes). “The flock is managed in two lambing periods which makes it possible to diversify the sale periods and the product range of the sheep unit (light lambs, fattened lambs for Aid). Land, part of which can be mowed, enables them to be self-sufficient in hay; exchanging workforce and equipment between farms enables work peaks on each farm to be better managed. For Eric: “In onions, they’re the ones giving the orders. In sheep, I’m the one in charge.”

Box 4

A LOGIC CENTERED ON TRADITIONAL SHEEP FARMING AS THE PIVOT ACTIVITY

“Nobody was pushing us, but to manage, we specialized. So we increased our flock numbers but within limits. There were 250 animals in the flock but if you reach 250–300, here, you pull everything out, there’s erosion so you can’t go beyond... and with that number of head you have a job to make ends meet... often, there are wages from an outside job which helps with family circumstances... that’s how it is.” Since the 1980s, “we’ve only sold light lambs at forty, fifty or sixty days” and “I don’t do spring lambing”. He has little or no debts because “that’s what makes us strong!” Gerard G. thinks he has enough equipment even if it is the “minimum”. For him, “our tradition is rough grassland... that’s why, concerning the economic aspect, for the time we are behind our sheep, we don’t do anything else but the technical side counts. I’m serious about my work so my ewes which have two lambs are in huts, and they stay three or four days alone with their lambs... That’s what takes time, organization, monitoring, all that...” In connection with marketing the autumn lambs, “I try to market all my lambs at the same time. Last year, they left on October 28th. This year, I postponed their leaving by a week because they were born a bit later at the height of lambing.”

Box 5

A LOGIC MARKED BY THE SUCCESSION OF SEVERAL PHASES WITH RADICALLY DIFFERENT BASES MARKING THE EXPLORATION OF VERY DIFFERENT MANAGEMENT TYPES AND NICHE MARKETS OVER TIME

Bernard G.’s farm evolution pattern illustrates this logic: “it increased enormously when we had the GAEC [*groupement agricole d’exploitation en commun*, i.e. farm shared with another farmer] and then, we had up to 260 ewes and we didn’t have enough... because everything went on direct sales... in 1990-91 we must have sent slightly more than 300 animals a year to the slaughterhouse. We were not just playing at it! My goodness, with GAEC, we certainly earned some money... the GAEC was earning and investing a massive amount of money. My associate’s doctrine was: we must give ourselves the means to do things, and indeed we did do things, it was an entirely different dimension. When I found myself all alone, I started by liquidating what did not interest me at all, i.e. the equipment, and then what interested me less, i.e. marketing, and I kept the basic core of ewes and transhumance... All the same, I decreased quite a lot... For a long time I kept about 210 ewes, as long as I had land in Saint Julien, then I reduced the number to 170 ewes.” In 2003, Bernard G. organized a new disruption in his professional path: “I had no lambs. At the time when everyone was saying you need to have out-of-season lambing, I already had a flock with out-of-season lambing, and I changed my flock back to spring lambing. A very early autumn lambing was very interesting when the lambs were sold really quite small but the longer you wait the more difficult it becomes to sell them. And then, I prefer to sell 50 lambs at 160 € rather than 160 lambs at 50 €, don’t you agree? Everything considered financially, I come out of it better now than before... it may seem paradoxical but that’s how it is.”

Table I

Changes in the number and lambing periods for the three long-term action logics in the Cevennes

Type of farm evolution pattern	Num. farms	Evolution flock num. (2009)	Lambing period 2009
Clannish	2	++ (350–400)	A ++ / S +
Centered on traditional sheep farming	4	+ (220–250)	A +++
C1: change of period or type of product	2	= or + (150–210)	S +++
C2: stopped or high sheep farming reduction	4	-- (0–30)	

* A: autumn; S: spring

■ DISCUSSION

In these farms, we found the long-term action logics also met in other livestock farming situations (Begon et al., 2009; Lemery et al., 2005; Levrouw et al., 2007) with the notable exception of logics based on increasing herd productivity by incorporating technology. Expansion *vs.* herds maintained at sizes that promote controlled management of natural resources, diversification (more streamlined than before) *vs.* specialization, investment in equipment with loans *vs.* financial autonomy remained main lines for diversity of logics as reported in other studies. On the other hand striving for productivity proved to be too demanding and far removed from the sort of pastoralism practiced locally. Changes related then more to the choice of products: although a 14–18 kilogram lamb was still the dominant production, various production or marketing strategies had been emerging.

The permanent characteristics of the Cévennes territory influenced the options selected (difficult terrain, precarious but inexpensive access to land). The diversity of logics, specific to individuals, then came within a set of constraints and options which were closely linked to these permanent characteristics but also to the dynamics of the territory. Demographic dynamics such as the reduced number of farms meant that new pastoral areas had opened up. Land dynamics competing with touristic or crop activities, such as the production of PDO sweet onions on the rare grasslands where machinery can be used and on productive terraces, meant that even fewer areas could be mechanized for hay. Radical choices had to be made: either search for land outside the region (i.e. at least beyond 40 kilometers) or abandon the practice. Local

politics, in particular the retention of the local slaughterhouse ran counter to the general policy concentrating slaughterhouses and made it possible for some farmers to launch out into lamb production for the Aïd festival.

■ CONCLUSION

Cévennes sheep farming systems have changed very little in 30 years and remain very similar to those in the 1980s. But livestock farming is still under pressure from other users of the area. Tourism and town planning have had a powerful effect on basic grasslands but the situation has somewhat settled down. Onion cultivation on terraces has been supporting some livestock farms as another source of income but in one case it restricted the area used by the ewes causing a reduction in the flock. The hunters must still be accounted with and contacted for space use. In one case, cohabitation with other users degenerated into conflict until the livestock farm disappeared. Lastly, the necessity of shepherding the flock because of the predominant way of using land (verbal authorization) questions the young generations: to be a shepherd is to have a very specific occupation, a pastoral skill, and a relationship with the animals and the flock. But it is also a lifestyle out of step with today's living trends.

Acknowledgments

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Résumé

Dedieu B., Pailleux J.-Y. Les chemins pour durer en élevage ovin pastoral des Cévennes

Quels sont les chemins pour durer dans un contexte d'incertitude sur les conditions du futur ? Les logiques d'action sur le long terme sur lesquelles les éleveurs s'appuient pour développer ou adapter leur ferme dans leur contexte propre ont été décrites. Ces logiques renvoient à des choix relatifs au dimensionnement de l'activité agricole, à la spécialisation, aux choix techniques et commerciaux, au rapport à l'endettement et à l'incorporation de technologies. Les données provenaient d'élevages ovins des Cévennes, région pastorale méditerranéenne du sud de la France, à partir de relevés de trajectoires d'évolution des familles, des activités agricoles et de la conduite du troupeau ovin sur 30 ans (1982–2012). Si l'élevage ovin n'a pas vraiment changé dans ses dimensions techniques pendant cette période, trois logiques d'action sur le long terme ont été distinguées : une logique clanique qui donne l'opportunité d'une installation des enfants dans la ferme ou à proximité d'elle ; une logique centrée sur l'activité ovine avec un agrandissement du troupeau ; et une logique multiphase avec l'exploration successive de deux ou trois formules de conduite du troupeau ou de combinaison d'activités du ménage. Les logiques d'action identifiées ont été semblables à celles décrites dans d'autres études, si ce n'est qu'elles n'ont pas mis en avant de logique fondée sur l'accroissement de la productivité du troupeau avec incorporation de technologies, option trop éloignée du type de pastoralisme pratiqué dans les Cévennes.

Mots-clés : ovin, système d'élevage, adaptation, moyens d'existence durables, région méditerranéenne

Resumen

Dedieu B., Pailleux J.-Y. Los caminos perdurables en la cría de ovejas en pastoreo en las Cevenas en Francia

En el contexto de la incertidumbre de las condiciones futuras, cuáles son los caminos perdurables? Describimos los métodos de larga duración en los que se apoyan los finqueros para desarrollar sus fincas o adaptarlas a su medio ambiente. Estos métodos se basan en escogencias relacionadas con aumentar el tamaño de la finca, especialización, técnicas utilizadas, mercadeo, proyección de deudas de producción e incorporación de tecnología. Los datos provienen de fincas ovejeras en las Cevenas, región pastoril Mediterránea del sur de Francia, basados en encuestas de trayectoria de familias, agricultura y manejo de ovejas durante 30 años (1982–2012). A pesar de que la agricultura ovina ha cambiado poco durante este periodo, se han identificado tres métodos de acción a largo plazo: una lógica de clan que permite a los hijos establecerse en la finca o en su proximidad; una lógica centrada en la tradición ovina con un enfoque en aumentar el tamaño del hato; y una lógica multifacética, por ejemplo se exploran dos o tres tipos de manejo ovino sucesivos o actividades domésticas combinadas. Las metodologías de acción identificadas fueron similares a las descritas en otros estudios, excepto que no incluyeron métodos basados en aumentar la productividad del hato mediante el uso de tecnologías, una opción demasiado lejana de la clase de pastoreo practicado en las Cevenas.

Palabras clave: ovino, sistema de explotación, adaptación, medios de vida sostenibles, región mediterránea

Changes in production methods in Tandil area in Argentina

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Keywords

Livestock, farming system, soybean, monoculture, social change, land degradation, Argentina

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Summary

The pampa territorial transformations are focused on changes in rural land use, marked by the decline of livestock, and the frequent replacement of traditional crops by soybean production. Competition with crops contrived livestock farms to move, and the extensive production has been replaced by intensive systems, in relation with the emergence of new actors. The incorporation of technology in agriculture caused socio-territorial transformations that restructured the rural areas. The article shows the scenarios of change in the rural-land uses in Tandil, through inquiries focused on the progression of the intensification of production (soybean, sowing pools, feedlots) and its results: deterioration of natural resources, displacement of production systems, mainly livestock, monoculture hegemony, and expulsion of rural actors. The theoretical framework is based on the analysis of rural areas, built from rural-urban links, to understand these changes and interpret future scenarios. In the methodology we recorded quantitative and qualitative data through non-structured interviews and compared satellite images of census data (1988 and 2008). As a result, when agricultural profitability and the number of soybean plantations were very high, investment opportunities in other economic sectors were less attractive. Financial, non-agricultural and transnational capital thus progressed along the production chains. These investments have been brought *via* pools of seeds and feedlots, which now control the crop and livestock systems. The new intertwining functions, hierarchies and powers positioned themselves in the local production chain, also globalized in time and space.

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■ INTRODUCTION

The global-local processes that motivate actors' adaptation and make a different impact depending on the identity and specificity of the areas (Santos, 1998) have been determining factors of fragility and disparity in the rural spaces. Since the 1990s, the political and economical context has led to deep changes in the territorial organization and rural dynamics, and has redefined the functioning

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model of the rural spaces of the pampas. The combined effects of the convertibility law, and of privatizing and deregulating policies deeply disrupted the social, territorial and economical organization of rural spaces. A production model has emerged, which involves much technology and capital, and which is centered on various business sectors (banks, enterprises, industries).

The new rules promote the agricultural expansion and profitability of the biggest companies, which keep expanding by incorporating the lands of medium and small producers. In this context, the rural actors face many difficulties including the need to increase arable areas, competition for land rental, and the deficiencies of public policies, plans and sectorial management. As a consequence, contradictory forces and socio-environmental conflicts increase in the rural spaces of countries such as Argentina; impacts on natural ecosystems emerge and socio-production structures are modified.

The study of territorial transformations in the region of the pampas, with a focus on the analysis of rural spaces, has been included

in research programs, whose objective is to understand the changes induced by the process of production homogenization in the last two decades. Some authors show that the changes in rural land use are marked by the disappearance of some livestock farms, the replacement of traditional crops by others and the expansion of soybean (Barsky, 2001; Paruelo et al., 2006). The competition with livestock breeding caused also its displacement or replacement, and the extensive livestock production has been replaced by a more intensive one (Barsky and Dávila, 2009; Rearte, 2007; Arceo and Basualdo, 2006) in association with new production actors, such as big companies and “pools of crops” (Reboratti, 2006). The incorporation of technological changes in agriculture caused social, economical and territorial transformations, which were exacerbated by the rural exodus (Sili, 2005) and the restructuring of rural settlements at local and regional levels.

For the last years in the southeast of Buenos Aires Province, investigations related to the transformation of settlements of minor range have been performed, showing the breaking up of the local socio-production fabric and the renewal of urban-rural links (Nogar and Jacinto, 2010). The changes in land uses showed the modalities of the agriculturization process and the displacement of farmers to the southeast of Buenos Aires (Jacinto and Nogar, 2009) and in the rural space of Tandil. The studies show the difficulties that rural actors face from the processes of homogenization and socio-territorial diversification; they emphasize the need to integrate them in future studies in view of developing local territorial management guidelines articulated in a multiscalar form.

This article aimed to show the actual scenarios of change in the uses of rural land by studying the progress of production intensification (soybean crop, pools of crops, feedlots) and its results: natural resources deterioration, displacement of production systems, mainly livestock, predominance of a single crop, and expulsion of rural actors. The study was based on a theoretical framework which started from the analysis of rural spaces, a rurality perceived through the urban-rural links, to understand changes and to interpret future scenarios.

■ STUDY LOCATION, SYSTEMS CHARACTERISTICS, METHODOLOGY

The study took place in Tandil, located in the southeast of the Province of Buenos Aires in Argentina (Figure 1). The production systems that defined the uses of rural land in Tandil up to

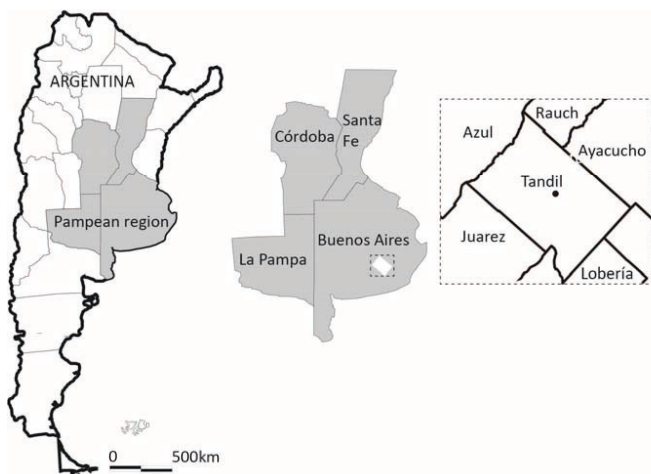


Figure 1: Tandil location in Argentina.

the mid-twentieth century were of the mixed crop-livestock type, which evolved according to national and international demands. The characteristics of the activities and the forms of organization of production determined the pattern of labor incorporation, the rural social structure and the population distribution.

The territory physiography presents hills and plains (Figure 2). Tandil hilly landscape highlights a connectivity and integrity almost natural, based on historical, physio-natural processes, in the social and material networks which make the intraterritorial links viable. Tandil is located at an interfluvial zone, delineating superficial drainage basins such as the upper basin of the streams Arroyos Langueyú and Tandileofú in the southwest, the upper basin of the streams Arroyos Chapaleofú Chico and Grande in the northeast, the lower basin of the streams Arroyo El Perdido and Los Manantiales, and the basin of the stream Arroyo El Rabón toward the northwest.

For the methodology we registered quantitative and qualitative data, through non-structured interviews and compared satellite images of census data (1988 and 2008).

■ CHANGES IN PRODUCTION METHODS

In the last decades, changes in the methods and management of rural spaces of production have been simultaneously continual and intensive toward setting up a model led by innovation and the constant search for competitiveness.

In this scenario, the new agricultural actors and investors aim at profitability in a short time, with a production view encouraged by public policies which give priority to growth and not to development. These actors concentrate the management of the systems by optimizing the expansion of investments and plantations from more production zones to marginal zones with the consequent displacement of producers, mainly livestock farmers. Strategies are based on land rental, the adoption of transgenic technologies that intensify the use of supplies, and new forms of storage, among

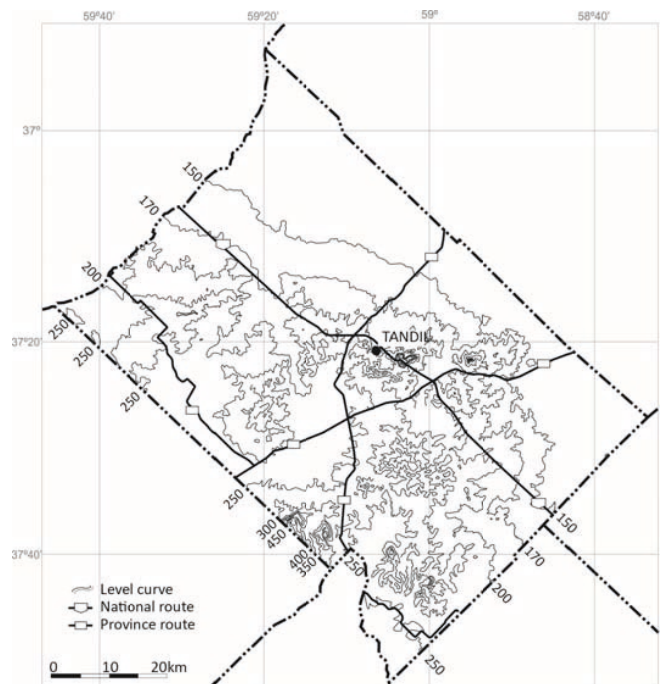


Figure 2: Geofoms of Tandil area, Argentina (Nogar, 2010).

others. As a consequence, the concentration of the economical power is reinforced, guaranteeing the expulsion of actors and systems.

■ CHANGES IN PRODUCTION UNITS

The empiric evidence and field works carried out in Tandil show that, in the last years, deep changes in the structure, function and integration of rural spaces occurred:

- The production farms (referred to hereafter as units, a more general term) smaller than 200 hectares have been converted into land for lease. A key-informant representative from an agricultural cooperative observed: "I believe that today a producer who has 200 hectares cannot make a living and gives up because of the high cost of land rental in relation to what can be obtained from the crops. For us, this is very negative not only for economical reasons but also for social ones".
- The medium-size units presented more resistance, and the owners worked full time in this activity, living in the city of Tandil and making continuous investments.
- A higher percentage of agents have been involved in production methods; the dynamics respond to global and hegemonic trends.

Data from the National Agricultural Census in 1988 and 2002 show that the number of small and medium units decreased and that production units of more than 1000 hectares increased (Table I). Similarly, they show a decrease in land space for rural use from 477,023 hectares in 1988 to 442,390 hectares in 2002.

Figure 3 shows the agricultural expansion from the mid 1990s, explained by an increase in productivity (technological changes, non-agricultural capitals) and in planted areas, by the use of soybean as the leading crop, by an increase in the international demand, and by pools of crops and contractors of production. The synergy between the Roundup Ready (RR) soybean resistant to glyphosate and direct sowing resulted in a technological convergence of high impact that contributed, since the mid 1990s, to expand soybean plantations into marginal zones, erasing rich areas of biological and cultural diversity (Pengue, 2005). Indeed, although the number of soybean plantations and the ensuing profitability have constantly increased since this seed introduction, it has reached new heights in Argentina since 1996 with the launching of transgenic soybeans, in particular, soybean RR. Different sources (SAGyP, FUNTALA, AACREA) show that between the 1998-99 and 2009-10 campaigns, soybean areas increased by 152,000 hectares; this represents more than 35% of the total cultivated area. It is assumed that the disappearance of linen crops, the marked

decrease in corn-planted areas, as well as the fast expansion of soybean caused the appearance of colza, brewer barley, and other crops, which almost allow the performance of the soybean in its early phase.

A relevant actor in this evolution has been the financial capital owned by companies with different social purposes and different economical activities, framed within the agribusiness model, with the aim to ensure higher returns on investment. Its renewed incursion into rural spaces, this time under the physiognomy of pools of crops and feedlots, has given rise to a strong agricultural growth, both horizontal (more cultivated areas) as well as vertical (more agricultural specialization), more animals per surface area, less time for fattening, greater supply resources and capital to achieve scale economies. As Posada et al. (1996) sum it up: "[...] investment funds, managed by firms created *ad hoc* and constituted by non-agricultural investors, who aim at controlling more than 40,000 hectares in a single campaign."

Figure 4 Image 1 shows that the livestock activity in 1988 (represented in black and gray) covered an important rural area in Tandil. However, in recent years the new crops expansion reduced the area destined to livestock and the competition induced the displacement of the dairy- and meat-livestock as well as intensification methods. The analysis of both satellite images (Figure 4) reveals this situation. By comparing the images, it is blatant that crop areas in red and deep pink significantly progressed at the expense of livestock areas (in black or gray), historically located in the northeast, in the lowest part of the district. Besides, according to the observation the agricultural expansion has been encouraged over the entire

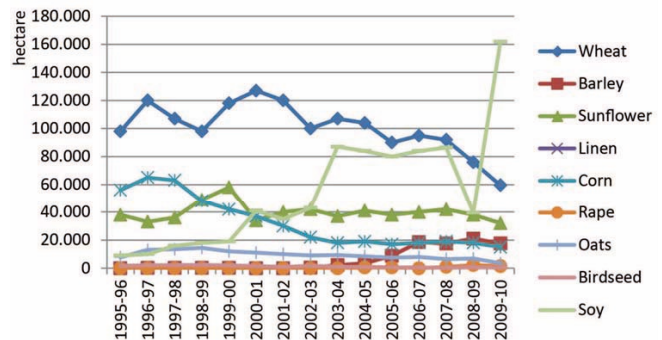


Figure 3: Crop-planted area in Tandil, Argentina, between 1990 and 2009. Based on data from the Ministry of Agricultural affairs (2009), www.maa.gba.gov.ar (consulted 2013).

Table I
Changes in the structure of farms in Tandil, Argentina, 1988-2002

Census	Total	Expansion of farms (ha)				
		< 200	200-500	500-1,000	> 1,000	
1988	Farms	1,095	619	203	154	119
	ha	477,023	48,890	66,309	111,031	249,792
2002	Farms	659	270	147	101	141
	ha	442,390	22,840	47,693	73,612	298,243

Based on data from the National Agricultural Census (1988 and 2002)

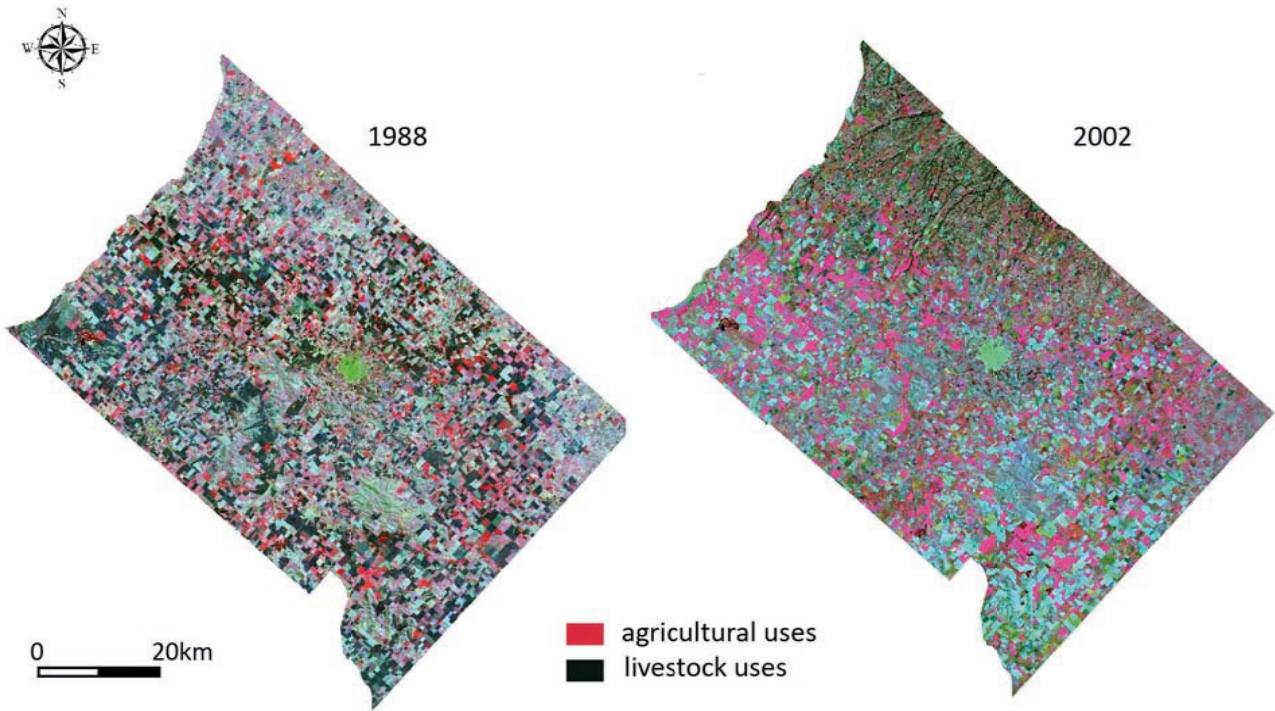


Figure 4: Both images correspond to the last agricultural censuses (1988–2008) in Tandil, Argentina. They were obtained by satellite Landsat 5 and belong to bands 3, 4 and 5. They were treated with ArGis 9.3 and Raster composite band, where the images were entered in the order 4, 3 and 5 so as to obtain the predominant vegetation cover (in red).

area, reaching today beyond the more marginal areas of the north-east and hill slopes (Figure 5).

The beginning of the year 2000 was marked by a socioeconomic and political crisis, and by the suppression of the convertibility system and a devaluation. These measures indirectly accelerated the soybean territorial expansion on the agricultural border and displaced the systems of livestock production. The Fundación Tandil Libre de Aftosa (FUNTALA), an organization in charge of the vaccination against foot-and-mouth disease, reports that extensive meat-livestock units have been receding in Tandil since 1995. Table II also shows that, since 2004, the main local growth was the fattening activity in feedlots, with a high investment in intensification. The loss of surface area and the decrease in livestock-meat production units (Figure 6) intensified pasture destruction and feedlot development. These were

identified as holdings dedicated to the intensive fattening of the owners' animals as well as others', offering a hotel-type charged service. The substitution of the traditional pasture type by stabled production or feedlots has induced an increase in the number of animals per surface unit (Barsky and Dávila, 2008). This strategy has maintained livestock in Tandil in the last years and it represents an alternative to agricultural expansion.

Intensive management had been prompted by the compensating policies implemented by the National Agriculture Department between 2007 and 2010, which subsidized the installation

Table II

Number of cattle head in Tandil, Argentina

Year	Num. of head
1995	357,572
1996	345,256
1997	300,914
1998	–
1999	312,044
2001	349,009
2002	345,898
2003	338,740
2004	361,270
2005	387,560
2006	349,057
2007	343,927
2008	338,538
2009	332,610

Based on data from CO.PRO.SA-FUNTALA



Figure 5: Delocalization of the meat-livestock production systems in Tandil, Argentina.

of feedlots to boost the internal market supply. As a consequence, 27,120 bovine head were registered in Tandil, which thus ranked among the first fifteen departments at national level, with more than 10,000 bovine head distributed in 23 establishments (Figure 7).

Along with new national and provincial regulations, bylaws at municipality level have been adopted. In Tandil since January 2009, a municipal bylaw (No 11,317) specifies environmental requirements addressed to the holdings specializing in intensive livestock breeding in feedlots: “In order to be authorized to settle and manage them, companies must submit an environmental impact assessment to the Environmental Department.”

The system of dairy-livestock production has not been spared from the changes. Mar y Sierras dairy basin consists of different districts⁴ and Tandil ranks first as a fluid-milk producer. Some of the transformations in the dairy production systems have been associated with: i) the increase in production scales, the consolidation

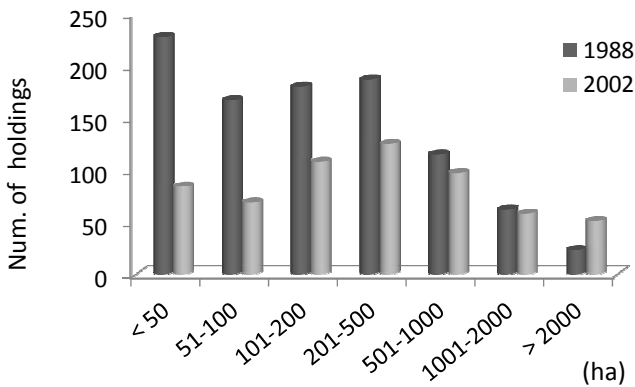


Figure 6: Variations in sizes of livestock farms in Tandil, Argentina, in 1988–2002, based on data from CO.PRO.SA-FUNTALA.

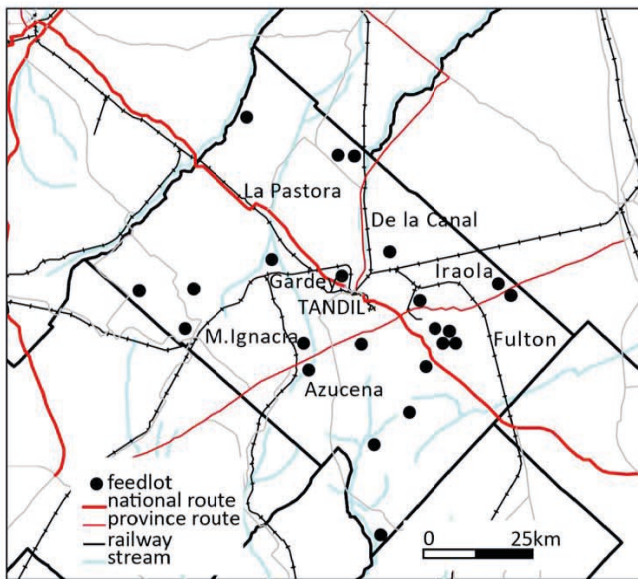


Figure 7: Feedlots in Tandil, Argentina, in 2009. Source: Local Development Department, Municipality of Tandil, 2009, based on data from CO.PRO.SA-FUNTALA.

of medium-size fluid-milk units, with business logic and risk management; ii) the disappearance of small producers; and iii) the displacement of the remaining ones to marginal or poor-soil-quality areas. The result has been the disappearance of the familiar dairy units. According to the Provincial Program of Milk Policies of the Ministry of Agricultural Affairs, between 1970 and 2010, the number of fluid-milk units decreased from more than 400 to 89 (Figure 8). Their disappearance was caused by: i) their small size, ii) their far location from transport and communication networks, iii) the non-incorporation of genetic and technical innovation, and iv) their conversion to soybean crop and/or land rental.

In this transformation process, among the fluid-milk production units 55% were highly efficient, achieved profits and integrated cooperative forms of production with access to marketing, 23% were small and did not operate according to sanitary standards and tax regulations, and 22% invested in fixed capital.

The rural spaces analyzed are structured around enclaves of productivity and growth linked to i) intensive agricultural methods and financial means, ii) an increasing economic competitiveness supported by comparative advantages, making the systems of capitalized production artificial, iii) a high increase in socioenvironmental conflicts, and iv) the absence of territorial-planning policies. These spaces are rebuilding their images through the definition of their scenarios and challenges; it is thus appropriate to refer to them as rural territories in critical adaptation mutation. In these scenarios the fragility-revitalization tension acquires diverse forms of territorial resolution. They all contribute to form a territory or, according to Méndez (2005), a “dual territory” in which the contradictions associated to innovation are emphasized.

When agricultural profitability increased and the opportunities of investments in other sectors of the economy became less attractive, the non-agricultural and transnational financial capital turned to agricultural production chains. These investments were allocated through pools of crops and feedlots, which then began controlling the crop-livestock systems.

The scientific literature reports that business producers and families were displaced by the production homogenization process because of: i) the increasing need of financial capital to reach a competitive scale, ii) the incorporation of technological and agrochemical innovation, iii) the increase in rental prices, iv) the need for new knowledge for a ‘profitable’ action, and v) the pressure of external actors, supplies, and capital.

The soybean system, skeleton of the pools, is complex and imprecise. Big international companies of agrochemicals and

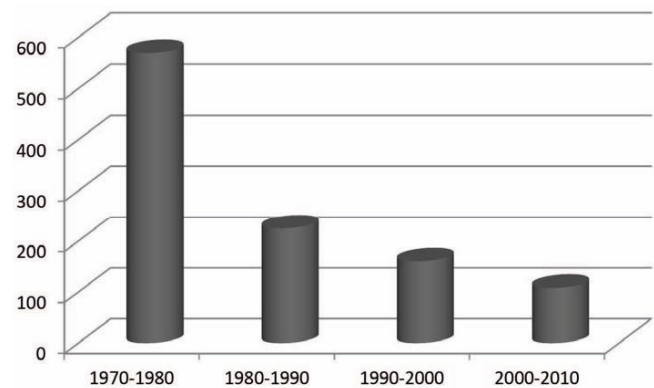


Figure 8: Evolution in the number of fluid-milk producing farms in Tandil, Argentina. Based on data from the Ministry of Agriculture, www.minagri.gob.ar (consulted in 2012).

4. <http://competitividadprospas.net/competitividad/queserotandil>

seeds – signs of cereal exportation –, national and international financial capitals, and big agricultural producers are intertwined, making the limits between actors and territories unclear. Thus, a network system has been developed by owners, production contractors, services (e.g. Agropack) (knowledge and assessment). Agricultural enterprises associate non-agricultural actors who want to make their savings profitable.

Labor reduction is not the only consequence. The expansion of a single crop (soybean) and the development of feedlots impact on environmental sustainability. They cause land deterioration and erosion, loss of soil fertility and land structure, salinization, alkalization, crust, loss of biodiversity, floods, and they impact on aquifer strata.

Among the interviewees, an agricultural producer made a key remark that encompassed the changes that have been occurring in rural spaces: “They have impacts all along the price chain, as the activities displaced are necessarily carried out in less adapted lands, generating higher costs, which result in a significant increase in the final market price. Hence, the pools of crops, not being land owners, ultimately become land users and gain control over the production process.”

■ CONCLUSION

The expansion of the soybean transgenic crop and the adoption of state-of-the-art agrochemical packs drastically transformed the structure of actors and the different management of production units. Their local impacts are so broad and deep that a new complex and contradictory picture emerges, characterized by the deterioration or breaking away from the production networks in place.

In this context, the relationship between society and nature is constrained by the process of production organization at global-local level. For instance, a seed variety has genetic characteristics that lead its development, but its yield and productivity levels will depend on the way the productive-technological process is organized according to the differences between the spaces, as stated by Silveira (2004): “The space is not a fragment, but just the reality in movement, which is affirmed and denied through the event, modeling a subspace in the global space”.

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Résumé

Nogar M.L., Nogar A.G., Jacinto G., Carrizo S. Changements dans les méthodes de production dans la région de Tandil en Argentine

Les transformations territoriales de la pampa sont centrées sur les changements dans l'utilisation des terres rurales, marqués par le déclin de l'élevage et le remplacement fréquent des cultures traditionnelles par la culture de soja. La compétition avec les cultures a obligé les fermes à se déplacer et la production extensive a été remplacée par des systèmes intensifs, en relation avec l'émergence de nouveaux acteurs. L'intégration de la technologie dans l'agriculture a provoqué des transformations socio-territoriales qui ont restructuré les espaces ruraux. L'article montre les scénarios de changement dans l'utilisation des terres rurales de Tandil, par des enquêtes centrées sur la progression de l'intensification de la production (soja, *pools* de semences, lots d'engraissement) et ses résultats : la détérioration des ressources naturelles, le déplacement des systèmes de production, principalement le bétail, l'hégémonie de la monoculture et l'expulsion des acteurs ruraux. Le cadre théorique est basé sur l'analyse des zones rurales, construites à partir des liens ruraux-urbains, pour comprendre ces changements et interpréter les scénarios futurs. Dans la méthodologie, nous avons mené des entretiens non structurés pour relever des données quantitatives et qualitatives, et nous avons comparé les images satellite des données de recensements (1988 et 2008). En conséquence, lorsque la rentabilité agricole et le nombre de plantations de soja étaient très élevés, les opportunités d'investissement dans d'autres secteurs économiques étaient moindres. Le capital financier, non agricole et transnational a ainsi progressé le long de la chaîne de production. Ces investissements ont été apportés par le biais de *pools* de semences et de lots d'engraissement qui contrôlent aujourd'hui les systèmes de culture et d'élevage. Les nouveaux acteurs, puissances et hiérarchies qui s'entrecroisent se sont positionnés le long de la chaîne de production locale, également mondialisée dans le temps et dans l'espace.

Mots-clés: bétail, système d'exploitation agricole, soja, monoculture, changement social, dégradation des terres, Argentine

Resumen

Nogar M.L., Nogar A.G., Jacinto G., Carrizo S. Cambios en los métodos de producción en la zona de Tandil en Argentina

Las transformaciones territoriales pampeanas se focalizan en los cambios en el uso del suelo rural, marcados por el repliegue de la ganadería, la sustitución de importancia relativa de los cultivos y la sojización. La competencia con la agricultura provocó cambios de localización de la ganadería y sustitución de la producción extensiva por sistemas intensivos y asociados a la emergencia de nuevos actores. La incorporación de tecnología en la agricultura provocó transformaciones socio-territoriales, que reestructuran los espacios rurales. El artículo muestra el escenario de cambios en los usos de suelo rural de Tandil, a través de indagaciones centradas en el avance de la intensificación productiva de las acciones (sojización, *pools* de siembra, feed lots) y sus resultantes: deterioro de los recursos naturales, desplazamientos de sistemas productivos, principalmente ganadero, hegemonía del monocultivo y expulsión de actores rurales. El andamiaje teórico parte del análisis de los espacios rurales, construidos desde los vínculos urbano-rurales, para comprender los cambios e interpretar los escenarios futuros. En la metodología se registraron datos cuantitativos y cualitativos, a través de entrevistas no estructuradas, y se compararon las imágenes satelitales de datos censales (1988 y 2008). Como resultados, cuando la rentabilidad agrícola y la siembra de soja se hicieron altamente positivas, las oportunidades de inversión en otros sectores económicos fueron menos atractivos; los capitales financieros, extraagrarios y transnacionales avanzaron hacia las cadenas de producción. Estas inversiones se canalizaron a través de *pools* de siembra y de feed lots, que pasaron a controlar los sistemas agroganaderos. Los nuevos entrecruzamientos de funciones, jerarquías y poderes encontraron referentes dentro de la cadena productiva localizada, simultáneamente temporal y espacialmente mundializada.

Palabras clave: ganado, sistema de explotación, soja, monocultivo, cambio social, degradación de tierras, Argentina

Evaluating grassland feed resource utilization by extensive livestock farming systems

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Keywords

Bullock, sheep, pasture feeding, gross margin, farm system, agricultural economics, Norway

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Summary

The economy of extensive livestock farming systems in rural areas of South-western Norway was investigated by replacing 10% of intensively-fed bulls with steers and expanding sheep production to reduce pasture encroachment. Meat production was kept stable. The analysis followed an approach with simple budgets and case studies. Low costs of concentrate feed and high meat prices favored intensive beef production, whereas the area and grazing premiums favored extensive steer and sheep systems, utilizing outlying and farmland pastures. Costs of concentrates would decrease by € 4.7–4.9 million and rural employment increase by 139–218 standard man years by the examined change. The risk in farming and community income was political as grazing-based systems were more dependent on governmental subsidies. Future development of livestock farming, governmental subsidies and other measures to enhance grazing were discussed in relation to a few policy scenarios for future meat and feed prices.

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■ INTRODUCTION

Norwegian coastal and fjord agriculture is characterized by small farms scattered along the coastline with arable land in-between heath land, small woodlots, hills and mountains. The climate is mild in the winter, and rainfall is between 2000 and 5000 mm. The landscape is diversified and highly appreciated by visiting tourists as well as by locals. Traditionally, livestock farming has been important in the area and grazing by farm animals has contributed to structuring the vegetation, the biodiversity, and to shaping the

landscape. The farming systems that utilize grasslands comprise sheep of the Norwegian white or local breeds, dairy cows of the Norwegian red cattle dairy and beef breed, and suckler cow systems of specialized beef breeds. The largest portion of the beef has been and still is produced on dairy farms where surplus calves are reared intensively for slaughtering, but specialized suckler cow systems have increased in later years.

During the last decade the cattle and sheep populations in the counties along the Southwestern coast (excluding Rogaland) declined by 22 and 14%, respectively (Øvreås, 2012). The open landscapes shaped by centuries of farming are threatened by coniferous plantations and deciduous woods. Their development raises public concern as farming sustains and maintains some of the most species-rich and valuable landscapes in the country. Since postwar, Norway's agriculture has undergone a process of intensification whereby production systems have been depending on purchased energy, fertilizers and feed concentrates which have replaced traditional rural land-use systems. Typically bulls are today reared

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intensively on concentrates and silage and do not use any pasture. Simultaneously, favorable off-farm employment opportunities have facilitated structural changes. However, there are still important structural differences between the smaller coastal farms and the larger inland farms which benefit from more favorable conditions.

An interdisciplinary research project was initiated in 2007 to improve understanding agricultural land-use changes, particularly the roles of socio-economic and biophysical drivers, and examine how extensive grazing for landscape preservation can be promoted. Norwegian farming is conducted within the constraints of the national market and policy-determined premiums. Moreover, import tariffs are applied to keep national prices high for dairy products, meat and concentrates. Special policy measures may be needed to preserve the coastal and fjord landscapes. In the paper we examined the effects of replacing bulls with steers on farm and rural economy, and land use, by increasing the number of steers from 0.5 to 10% of slaughtered cattle, and expanding sheep farming in the area. The measures would promote grazing and lower the use of concentrates while keeping meat production stable. The objective of the study was to explore the economic conditions in extensive livestock farming in a few scenarios and discuss some possible developments of the industry in the area.

■ MATERIALS AND METHODS

The economy of farming systems utilizing pasture in the region was investigated using the farm management approach suggested by Malcolm (2004). Such analysis needs not be complicated, a few disciplines and a few perspectives to explore a few futures would suffice. According to Malcolm, the logic is “what has been and is the situation”, “what is likely to be the new situation if I do this or that, or nothing different”. He claimed that most good answers can be captured with a few key numbers in a few key budgets. Farm management is about making choices of alternative use of resources to achieve a mix of goals of varying degrees in the face of many unknowns. Whole farm budgeting methods that focus on risky elements as well as case studies can be very useful and enlightening. Pressure on profits from rising real costs and falling real prices forces farmers to change the scale and intensity of their business operations. Farmers need to use the resources they control in a way that is sustainable and to be sustainable they have to be profitable. A challenge facing farmers is to be sufficiently flexible, mentally and financially, to adjust resource management to meet both changed economic circumstances and widely varying climatic conditions (Malcolm, 2004).

Data for budget comparisons were collected from the standard gross margin (GM) calculations for Western Norway (Olsen and Knutsen 2009), NILF (2010) and single-case farm accounts collected for the project. The calculations started with a calf owned or purchased, born in the autumn and weighing 100 kilograms at three months of age. For steers pasture constituted 40–45% of the net energy intake, half on farmland and half on outlying rangeland, silage 40–45%, and concentrates 10–15%. Bulls, however, would require about 15% less net energy, no pasture, and about 50% silage and 50% concentrates. Although pasture-based meat may be superior, the same price, i.e. € 5.25/kg, was applied. Intact males produce a higher yielding carcass with less fat and more edible products, whereas steers may have more desirable meat quality, marbling, tenderness and flavor which may also be favorable to consumers. However, the meat price was slightly higher for bulls. This could be due to the rules of classification used in Norway and the fact that steers only constituted 0.5% of slaughtered animals and had not been adequately marketed. The price of concentrates was € 0.42 per feeding unit (FEm)

(1 FEm \approx 6.8 megajoules \approx the net energy in 1 kilogram of barley). The variable costs of self-produced silage was € 0.20 and infield pasture € 0.10 per FEm. Outlying pastures were assumed to be free of charge. For steers the cost of castration was added. Castration had to be conducted early and performed by a veterinarian. Moreover, we used data from the records of two to four low-intensity farms in each of seven coastal municipalities, settled in a way similar to that described in the National Farm Account Survey (NILF, 2008).

■ RESULTS AND DISCUSSION

Since steers grew more slowly than bulls and were slaughtered at 24 months vs. 15 for bulls (Table I), a changeover from 0.5 to 10% steers required 12,600 more animals in the area. The steers required an additional 17–18 million FEm of pasture feed, which corresponded to about 3400 ha of farmland and another 37,800 ha of outlying pastures. By utilizing more productive pasture closer to the farm, total area needed was reduced to about 25,000 ha (Asheim and Rivedal, 2011). Beef production decreased by 378 tons because of lower weights, and the use of concentrate feedstuff decreased by 12–13 million FEm.

The variable costs per animal were € 287 higher for bulls, mainly because of the higher cost of concentrates. Annual GM before subsidy payments was highest (€ 96/ha) for bulls because they were slaughtered after 12 months. Since steers used pasture areas otherwise left unused, annual GM per hectare of silage area was € 75 for steers, which was 22% lower than € 96/ha for bulls. As steers also obtained more subsidy payments for pasturing as well as for area and cultural landscapes, € 933 vs. € 527 for bulls (Table I), annual GM including subsidies was € 240/ha for steers compared with € 268/ha for bulls, i.e. only 10% lower for steers. Steers needed less supervision when grazing, whereas bulls required daily feeding indoors. Moreover the annual fixed costs would be lower for steers due to ease of handling and slightly simpler buildings with alternative use in the grazing period. Assuming only 50% higher costs for steers over 24 months of age compared with 15-month-old bulls,

Table I
Comparing economy of steers and bulls
in Southwestern Norway

	Bulls 290 kg, 15 months		Steers 260 kg, 24 months	
	Total	Per year	Total	Per year
Gross income (€)	1,521	1,521	1,364	779
Variable costs (€)	1,227	1,227	940	537
Gross margin (€)	295	295	424	242
Gross margin [silage area] (€/ha)	96	96	72	41 [75]
Governmental support (€)	527	527	933	533
Gross margin including support (€)	822	822	1 357	775
GM incl. support [silage area] (€/ha)	268	268	229	131 [240]
Fixed costs (€)	693	693	1,048	599
Farm profit (€)	129	129	309	176

the farm profit per year would be better for steers, € 176 vs. € 129 for bulls. However, neither bulls nor steers could sustain high fixed costs, i.e. reasonable investments and use of existing buildings were required to make a profit.

The fencing costs, land degradation caused by trampling in areas with heavy rainfalls or steep slopes, as well as intestinal nematodes had to be paid attention to in steer production; these costs were largely avoided with bulls. The resources of farm pasture, as well as access to outlying pasture and cost of farm buildings were important; however the relationship between the price of pasture and that of concentrates was decisive for the choice. Based on our figures, by increasing the price of concentrates by € 0.1 per FEM, the farm profit for bulls would become negative whereas a similar reduction in the price of concentrates would clearly make bull production more profitable than that of steers. Since bulls and steers eat roughly similar amounts of silage the price of silage was not decisive for the choice. Assuming similar prices for silage and concentrates would make GM before subsidy payments negative for bulls and only slightly positive for steers. Silage in bales could be as expensive as concentrates on an energy basis; however, the silo fixed costs could then be spared.

In a review article Seideman et al. (1982) maintain that the disadvantages of intact bulls compared to steers include undesirable odors, lower quality grade, lower meat tenderness and undesirable meat color. Also heifers produce beef with more favorable technological properties, including more favorable fatty acid composition, and more conjugated linoleic acid than bulls (Weglaz, 2010). Another disadvantage of the intact male is its more aggressive behavior. Castration may be performed to ease handling and improve safety in simpler facilities. In general castration is performed as early as possible out of concern for the animal welfare. However it may be postponed and some farmers reported that castration at less than one year of age may impair their growth (Msanga et al., 2012). Biagini and Lazzaroni (2005) concluded that early and late castrated males showed similar dressing percentages and slaughtering performance for the most important data collected. Bulls were heavier compared to late (+ 50 kg) and early castration (+ 60 kg), however traditional early castration before puberty seemed better because the operation is easier, and stress and disease are avoided. The animals were given the same indoor feeding of hay and concentrates in the experiment.

Intact males grow more rapidly and utilize feed more efficiently which is important for the economy. Steers may be given hormones to stimulate growth when finishing in feedlots in countries such as the United States or Australia. Such systems have not yet become an issue in Norway as the use of growth hormones is forbidden. The natural conditions with a long indoor feeding period, in which expensive harvested feed has to be used, favor bulls as they grow faster and use less feed for each kilogram of weight gain. In areas where the grazing season is longer, utilization of inexpensive pasture feed may well make steers profitable even though weight gains are lower and it takes longer to reach adequate slaughter weights.

Moreover, when the grazing season is short, systems which have two grazing seasons and slaughtering at the end of the season may be advantaged as indoor feeding is kept at minimum. Also twin calving may keep the number of grazing animals high relative to the ones that have to be fed indoors. This is particularly important in suckler cow systems. According to Morris and Smeaton (2009) twinning can be induced by embryo transfer using either two transferred embryos, or one transferred embryo to supplement the natural one produced by the cow. A second round of inducing twinning in cows which return to estrus after the first round is also possible and researchers are working on a vaccine to produce twinning in

cattle. Selection is possible but slow. However, increased calving difficulties, especially in heifers, may be a side effect of increased twinning frequency.

In spite of the short grazing season under Norwegian conditions, grazing as much as possible is preferable and supported by the national government due to concerns for landscape preservation. However, the area and cultural landscape premium was 40% lower for permanent farm pasture than for other farmland. Raising them to the same level would increase GM to € 250 per hectare of silage area for steers which is only 7% lower than GM for bulls. Targeted regional subsidy payment for pasture clearance might also be increased to control pasture encroachment. A calculation assuming € 0.3 lower meat prices showed a decrease in annual profit to € 38 for bulls and to € 130 for steers. Norwegian beef farmers are at risk of lower tariffs and meat prices following more international competition from a new agreement of the World Trade Organization (WTO) or other organizations. Calculation with a € 0.3 per kilogram increase in the meat price revealed that farm profit was rather similar for bulls (€ 220) and steers (€ 222.5). As a risk, increased international prices for beef following higher meat consumption for example in China and India would favor bulls because of the shorter feeding time. However, the road is long before Norwegian beef becomes competitive. In a longer perspective higher beef prices can also be accompanied by higher prices for concentrates.

Data from eight low-intensity coastal sheep farms and 15 medium-intensity regional farms in the region (Table II) were used to

Table II

Average account results of low-intensity coastal sheep farms in Southwestern Norway compared with sheep farms in the region (2007–2009)

Type of farms (num.)	Coastal (8)	Regional (15)
Farm area [hired] (ha)	18 [6.8]	16 [6.4]
Yields of roughage and pastures (Fem*/ha)	1,593	2,231
Num. of breeding sheep [lambs/sheep]	66 [1.17]	102 [1.30]
Meat production (kg/breeding sheep)	20	25
Purchased fertilizers [herbicides] (€/ha)	82.6 [0.2]	120.7 [2.7]
Concentrate feed (€/breeding sheep)	36	33
Total labor input [family] (h)	1,402 [1274]	1,731 [1366]
Livestock products (€)	7,336	14,583
Agricultural subsidy payments (€)	16,343	25,948
Area and cultural landscape subsidy (€)	5,673	7,051
Animals and relief workers (€)	7,511	11,799
Other subsidies (€)	3,158	7,098
Other farming income (€)	1,756	3,789
Fixed and variable costs (€)	20,792	32,558
Net farm income (€) [€/h]	4,643 [3.6]	11,762 [8.6]

* FEM = feeding unit (1 FEM ≈ 6.8 megajoules ≈ the net energy in 1 kg barley)

calculate replacing lost beef with mutton and lamb meat. The farm area of both systems was rather similar, around 17 hectares and used for roughage and pasture. Both farm groups hired between 6 and 7 hectares of farmland. The sheep used outlying pastures like the steers. The yields were 29% lower, the costs of fertilizers and liming of the soils were 32% lower, and the low-intensity coastal farms hardly ever used herbicides. None of the coastal farms were organic but clearly the low-intensity farming systems resembled organic systems.

In comparison to the regional farms, on the coastal farms the number of sheep was 35% lower, they were of a smaller coarse-fiber breed, and the number of lambs per breeding sheep was lower (1.17 vs. 1.30), resulting in lower meat production per breeding sheep. The lambing percentage has gradually increased in Norwegian sheep farming; however, there is space for improvement on both the coastal and regional sheep farms. This would increase in particular feed uptake from pasture.

The income from livestock product sales of the low-intensity coastal farms was nearly half that of the regional farms (Table II) in spite of a similar meat price (€ 3.7/kg). Lower rates of subsidy for permanent pasture negatively affected subsidy payments to the coastal farms with much permanent pasture farmland. The price of wool was also lower, € 3.2/kg on the coastal farms vs. € 3.9/kg on the regional farms. The difference in subsidies for animals and relief work, and price subsidy payments largely reflected differences in flock sizes and productivity. Both the variable and the fixed costs were lower on a per sheep basis in the coastal farm group, but this did not compensate for the lower productivity, wool prices and subsidy payments. The coastal sheep farmers also had lower incomes from other farm and off-farm businesses and wages.

The sheep farmers purchased 4.2 and 3.1 FEm of concentrates per kilogram of meat, respectively, more than that assumed for steers (1.2) but less than that for bulls (4.6). The overall costs of concentrates following the transition to 10% steers would be lowered by € 5.4 million. However, replacing the lost 378 tons of beef with mutton and lamb meat would require an additional € 0.5–0.7 million for concentrates for sheep. Expanding mutton and lamb meat production would require production on an additional 286 low-intensity coastal farms or 148 medium-intensity regional farms. Rural employment would increase by 218 and 139 standard man years (1845 h), respectively, for the two farming alternatives.

There are resources available for increased grazing in the southwestern region of Norway that may be utilized by steers or sheep. The calculations showed a slight increase in farm profit for steers in relation to bulls, however the margins were small. Neither bulls nor steers sustained high costs. Particularly the cost of farm buildings and fences had to be kept at a reasonable level. A scenario with considerably higher international prices for concentrates, because for example of an increased demand, might trigger a transition to steers. The availability of infield and outlying pasture resources on the farm may be decisive for the transition. The pastures must be suited for steers and risks of land degradation from rain or steep slopes, as well as health problems related to nematodes should not be overlooked in this wet climate region. A limited increase in the number of steers might be advantageous for the landscape but one should probably not aim for a huge increase. Feed constraints and availability of cheap concentrates favor bulls whereas ample local pasture resources and a long grazing season favor steers. Slaughtering at the end of the grazing season and increasing twin births are possible ways for Norwegian beef production to increase the use of pasture in cattle meat production.

Steers will also be favored by low meat prices following lower tariffs under, in particular, new international agreements. However, this may depend on Norwegian agricultural policies and whether governmental payments for area and cultural landscape, and for outlying or infield grazing can be kept as green subsidy. Green subsidy can be kept without any restraints but to qualify it must not, or to a very limited extent, impact international trade. Steers are favored if grazing and landscape subsidy payments can be kept as green subsidy. Policy subsidy measures are restricted by international trade concerns and national concern for food prices. Should encroachment in the region be controlled, the special subsidy for outlying grazing could be raised. Similar rates of landscape subsidy scheme for farmland pasture and leys could also be introduced. The rates are currently about 40% lower for pasture land, whereas from a landscape perspective, permanent pasture particularly with grazing animals might be as valuable as leys for silage. Changing the special subsidy for farmland pasturing does not necessarily affect encroachment. Bulls are favored in a scenario with high meat prices because of the shorter time to make them ready, but bulls also depend on low concentrate prices. In a scenario with both high meat and feed prices steers would probably do better and that would also be the case if the market sustained additional payment for pasture-based beef. That may depend upon consumers' preferences.

■ CONCLUSION

The increased use of local resources following a limited 10% transition from bulls to steers on dairy farms would improve self-sufficiency by reducing the use of purchased concentrates by about € 5.4 million. However, if the lost meat was replaced by mutton and lamb meat the net reduction would be between € 4.7 and € 4.9 million. Efforts to lower the use of concentrates for sheep should be given priority if concentrate prices increase. By expanding sheep farming to this extent rural employment in the region would also increase in both sheep farming alternatives. In spite of lower costs of fertilizers and herbicides and lower fixed costs, expanding low-intensity coastal sheep farming would give considerably poorer economic result than medium-intensity regional farms. The result is due to lower subsidy payments, lower productivity as well as lower product prices on the coastal farms. Because of the short grazing season, improved lambing percentage on farms in the region might be a way to enhance the use of pastures by sheep.

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Résumé

Asheim L.J., Haukås T., Rivedal S., Øvreås O.-J. Evaluation de l'utilisation des ressources alimentaires des prairies par les systèmes d'élevage de bétail extensif

L'économie des systèmes d'élevage extensif dans les zones rurales du sud-ouest de la Norvège a été étudiée en remplaçant 10 % des taureaux alimentés intensivement par des bouvillons et par un accroissement de la production ovine afin de réduire l'empiètement des pâturages. La production de viande a été maintenue stable. L'analyse a suivi une approche basée sur des budgets simples et des études de cas. Les faibles coûts des aliments concentrés et les prix élevés de la viande ont favorisé la production intensive de viande bovine, alors que la zone et les primes au pâturage ont favorisé les systèmes d'élevage extensif de bouvillons et de moutons par utilisation des pâturages de l'exploitation et des espaces avoisinants. Les coûts des concentrés diminueraient de 4,7–4,9 millions d'euros et l'emploi rural augmenterait de l'équivalent de 139–218 hommes par an d'après le changement examiné. Le risque pour les revenus de l'élevage et de la communauté était politique car les systèmes fondés sur le pâturage dépendent davantage des subventions de l'Etat. Le développement futur de l'élevage, les subventions de l'Etat et les autres mesures de valorisation du pâturage ont été discutées à partir de quelques scénarios de politique de prix futurs de la viande et des aliments pour animaux.

Mots-clés : bœuf, ovin, alimentation au pâturage, marge brute, système d'exploitation agricole, économie agricole, Norvège

Resumen

Asheim L.J., Haukås T., Rivedal S., Øvreås O.-J. Evaluación de la utilización de recursos de alimentación de pastizales por los sistemas de cultivo extensivo de ganado

Se investigó la economía de los sistemas de ganadería extensiva en zonas rurales en Noruega del suroeste, reemplazando 10% de los toros alimentados intensivamente con novillos y expandiendo la producción ovina para reducir el hacinamiento de los pastos. La producción de carne se mantuvo estable. El análisis siguió un enfoque con presupuestos simples y estudios de casos. Bajos costos de alimento concentrado y altos precios de la carne favorecieron la producción intensiva de res, mientras que primas al pastoreo y por zona favorecieron los sistemas extensivos de ovinos y de novillos, utilizando pastizales en fincas y terrenos circundantes. Los costos de los concentrados disminuirían de 4,7–4,9 millones euros y el empleo rural aumentaría de 139–218 años hombre estándar con el cambio estudiado. El riesgo para la ganadería y el ingreso comunal fue político, ya que los sistemas basados en pastoreo fueron más dependientes de subsidios gubernamentales. El futuro desarrollo de la producción ganadera, subsidios del gobierno y otras medidas para impulsar el pastoreo fueron discutidos en relación con algunos escenarios reguladores de los futuros precios de la carne y los alimentos.

Palabras clave: buey, ovino, alimentación en pastoreo, margen bruto, sistema de explotación, economía agrícola, Noruega

Livestock Farm Networks, a system at the center of French farming development

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Keywords

Farming system, rearing system, livestock management, knowledge organization system, agricultural development, advisory officer, sustainable agriculture, France

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Summary

The Livestock Farm Networks system is dedicated to the development of herbivore farming. As the Networks result from the history of French agricultural development, they are found throughout France and are organized at local level. The originality of the system lies in the partnerships between farmers, chambers of agriculture and the French Livestock Institute, and in that it uses a global approach to take into account the diversity of livestock farming regions and the study of livestock farming systems. The aim is not to be exhaustive, but to be representative of herbivore farming systems based on the selection of the studied systems. The aim is also to assess the evolution of these systems and to disseminate the benchmarks obtained from the monitoring of 1900 farms by 210 chamber-of-agriculture agents, guided by 35 project leaders from the French Livestock Institute, and financed and supported by public authorities and the professional agriculture bodies. The regional and national enhancement of the Networks are aimed at different audiences: farmers, advisers, teachers (for advice or training), individuals or collectives, and local and national decision makers to improve their understanding of livestock farming systems and to measure the impact of new farming policies and lead their implementation. We also show the capacity of the Networks to mobilize themselves on emerging themes. Sustainability, competitiveness, working conditions or even environmental issues have been covered by the study fields of the system, well before sustainable development became a central theme. The Networks as a partnership system are sometimes complex to manage and may appear costly, but the strong and well-recognized partnership has made them a valuable resource and ensures their recognition and legitimacy. The variety of farming productions and the heterogeneous nature of the farming systems are good promoters of innovations and enable French agriculture to adapt to new challenges. The Networks not only enable the observation of these evolutions, but they also act as their catalyst and guide, and help disseminate them.

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■ HISTORY AND TERRITORIAL ORGANIZATION OF AGRICULTURAL DEVELOPMENT IN FRANCE

As early as the 1950s, the organization of agricultural development and advice in France (training, advice, experimentation, dissemination) adopted a very strong collective dimension. Since the 1960s, this organization has been at the interface between public policies and proximity relationships (Compagnone et al., 2009). Relations between the State and the farming profession eventually led to the co-management of agricultural development (1966). Over time the organization of advice inherited from the period of farm modernization and production growth was able to adapt in its methods and intervention themes. It became less prescriptive, and adviser-farmer

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relations became more collaborative. Multidisciplinary expertise was strengthened. The group approach to create a local climate favorable to innovation and to set up projects in common was encouraged even if the demand for more personalized individual advice persisted.

The development structures guiding and advising livestock farmers in their projects were established according to a territorial network based on the administrative departments. Departmental chambers of agriculture, the elected institutional representation of the farming profession and many people active in the rural world, have regularly seen their roles become reinforced. They give direction and leadership to actions of support and guidance as well as advice to farmers for the dissemination of technical and economic innovations in livestock farming. Cooperation and economic organizations are also prescribers of technical and sectorial advice.

The technical institutes carry out functions of applied research, expertise, engineering, training and technical coordination for their sector (the French Livestock Institute for herbivore farming, Arvalis for plant production). Public research organizations, such as the National Institute for Agronomic Research (INRA) are positioned upstream of this system to establish the basic knowledge.

■ COVERING THE DIVERSITY OF MAJOR LIVESTOCK FARMING REGIONS

In Europe, France ranks among the first three countries for the number of ruminants as it has the leading cattle herd (19 out of 89 million head), it is sixth for the number of sheep (8 out of 91 million head), and third for goats (1.3 out of 11 million head) (Eurostat 2008 data). The development of livestock farming associated with agronomic potentialities and climatic constraints has led to a differentiation of production areas. These areas tend toward either dairy or meat, but they are not strictly specialized or limited to regional boundaries.

Faced with this mosaic of geographical, soil, climate and farming specialization, French administrative regions or the simple plain/mountain dichotomy cannot represent this diversity. The French Livestock Institute has devised zoning to present French livestock, understand its functioning strategies and evaluate the impact of political measures at different scales. It also encourages dialog at regional, national or European levels (Pfmilin et al., 2005). Five criteria were selected to classify the areas (Rouquette and Pfmilin, 1995):

- The soil and climate environment with a combination of climate, soil and relief type parameters;
- The physical structure of the farms (e.g. size, field pattern, possible mechanization or not) defining local production and working conditions, including sometimes the local, economic and social history;
- The potentialities for forage crops which influence the choice of animal production (e.g. maize silage possible or not);
- Local demography and land pressure;
- The dynamics of local organizations of production and enhanced value (Protected Designation of Origin, Traditional Specialty Guaranteed).

From these criteria, eight major agricultural regions have been described, of which seven are very important to livestock farming, i.e. the regions of mixed crop-livestock farming, forage farming, intensive farming, grasslands in the North-West, the Center and the East, pastoral farming, wet mountains, and finally high mountains (Figure 1).

This zoning, defined for France and applied to the European agricultural area (with a few adaptations), shows that three of the major areas described (mountains, grasslands and pastoral) represent 60%

of European farms that rear herbivores (Pfmilin et al., 2005). With mainly dairy farming in the North, France is very close to the countries of Northern Europe. As meat and small ruminants prevail in the South, France has points in common with its Mediterranean partners. And as about a quarter of its surface area are mountains, France has the same preoccupations as those of countries in the Alpine Arc.

■ LIVESTOCK FARM NETWORKS, A GLOBAL AND TERRITORIAL APPROACH TO LIVESTOCK FARMING

The result of a long history

The idea of building development projects devised collectively and organized as a partnership has been supported by the State and leading farming professionals since the 1960s. As recalled by Cochard (1974), everything that deals with technical progress and its diffusion must restrict itself to the golden rule of a pragmatism founded on the knowledge of what is real. The idea then emerged of a network permanently collecting global and analytical references both in large numbers and in real size, at a level where it is certain that real problems will have to be faced, i.e. at farm level. There were already some examples of networks in Great Britain: “Low Cost Production” (dairy systems) and the “Meat and Livestock Commission”. In France, many grassroots players had already been working together (chambers of agriculture, farm management centers, and technical institutes). Their partnership had to be encouraged by structuring missions and expectations.

Tried out for some animal sectors and a few French regions by the French Livestock Institute, these monitoring systems took their inspiration from the experience of local development groups in which a group leader and several farmers held discussions about their practices and gave collective thought to solutions adapted to their

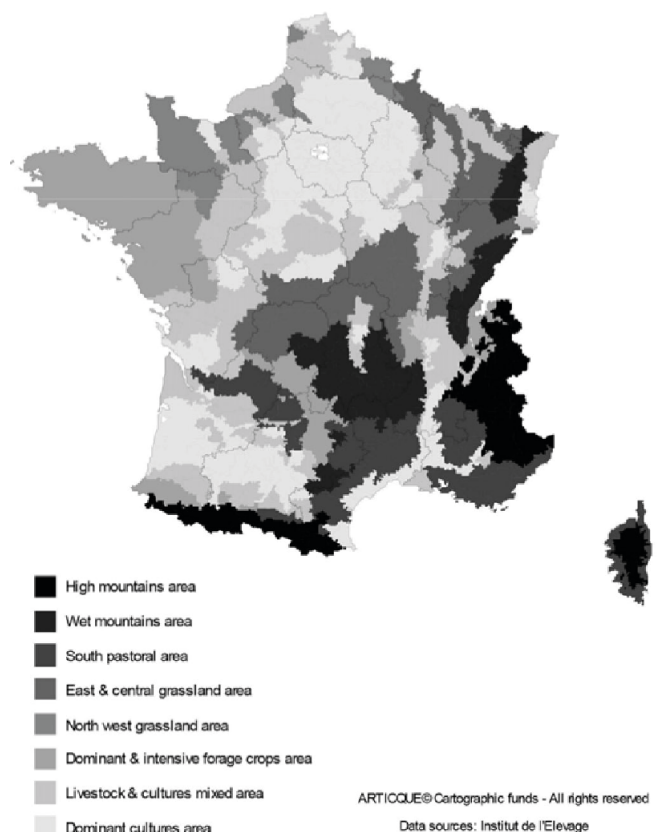


Figure 1: Location of herbivore farming areas (source: French Livestock Institute).

situation. There was a dimension of territorial development in these groups, but there was not very much dialog or transfer of information between the groups or beyond these groups (Compagnone et al., 2009).

With a foresight network created in 1981, regional and departmental engineers monitored efficient and/or innovative and original livestock farms to construct technical and economic benchmarks adapted to regional contexts and transfer these markers to as many people as possible, in order to suggest paths for the future (infancy of the concept of sustainable development). The analysis method was refined (Lebrun, 1991), and monitoring, collecting and centralizing tools were set up (Diapason software). At the present time, this system appears to be original at international level because few similar organizations have been found in our bibliographical research, even though equivalent systems are in place in a few countries (e.g. Parana State in Brazil, Vietnam).

Missions and objectives of Livestock Farm Networks

The system territorial organization and the productions which result from this work are coherent with the zoning previously described. It was given the following three missions: i) observe the livestock farming systems in place in the regions, ii) identify and support innovative systems, and iii) transfer and disseminate the productions in the form of tools, methods, training and publications. To do this, the system is organized so as to describe farm functioning in the form of global references, expressing various possible balances in a defined local context. The detailed and regular monitoring of farms over several years also makes it possible to describe farm evolution patterns and paths of evolution which lead to new balances.

The global and systemic approach, the trademark of Livestock Farm Networks monitoring

The interactions between the biotechnical and human dimensions define the livestock farming system (Dedieu et al., 2008). This systemic vision translates the coherence between herd management and land management, between agronomy and environment, between economic choices and technical choices, between farmer projects and the means to be implemented to achieve them. Communication with the farmers, presenting many viable production systems from the viewpoint of workloads and economic results and accurately describing coherent operational sequences integrating all the units and production systems, are essential parts of the system missions (Delaveau et al., 1999).

Figure 2 shows the livestock farming system concept. The resources mobilized in a livestock farm are described in detail in the main

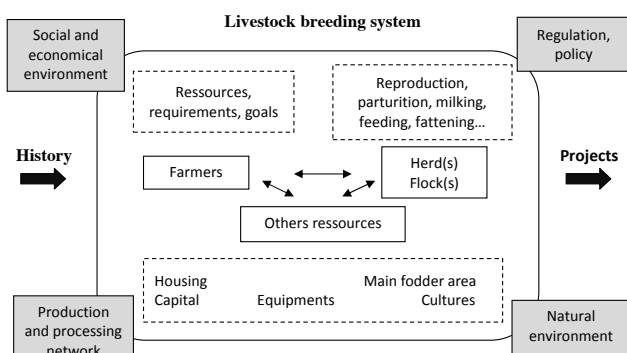


Figure 2: Representation of a livestock farming system and its components (source: French Livestock Institute).

framework and are the basis of the information to be collected in the system. The farm evolution pattern is also studied by monitoring the livestock farms and their evolution over several years. These farms are positioned in a variable social, political, economic and environmental context. Taking these variations into account questions all of the players in agricultural development and determines the direction taken by the work and publications carried out by the system.

■ A SYSTEM WHICH REQUIRES METHOD AND COORDINATION

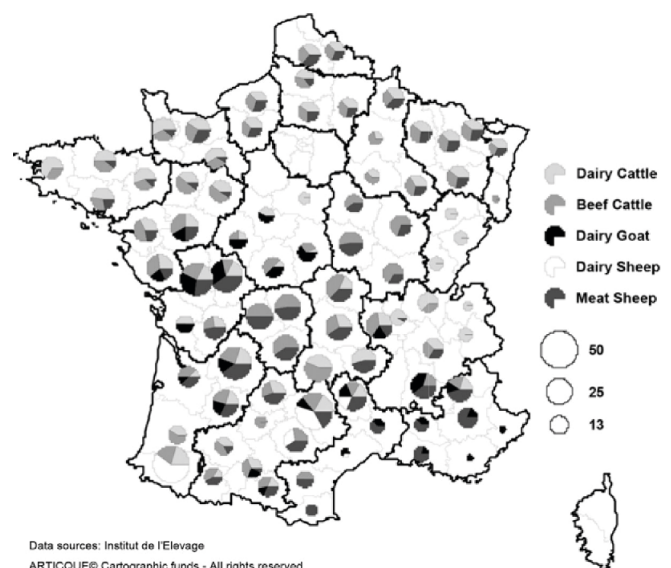
Financial support of the Networks

To be coherent and effective, this system mobilizes many players over several years and requires considerable support, guidance work and farm monitoring. The public administrative establishment, FranceAgriMer, is a major contributor of the Livestock Farm Networks system. Public funds as well as professional farming funds thus finance this system. The financial budget corresponds to five days of work per farm, 50% financed by FranceAgriMer and 50% financed by each structure.

Operational functioning of the system

Such a system involving so many partners requires a lot of coordination to carry out the entrusted missions. The partnership functions very closely between the French Livestock Institute and the 86 departmental bodies. The French organization of agricultural development described earlier makes it easier to set up such an organization because organizations and consultation authorities are already used to working together. Another key point, agricultural development plans are identical regardless of the region. The system thus illustrates the diversity of the systems in France but does not aim at an exhaustive representation of French livestock farms.

The monitoring provides fine knowledge of the functioning and coherence of each livestock farming system. The choice of the systems is made in conformity with the objectives sought by the system and by monitoring the zoning previously presented. Figure 3 and Table I provide information on the farms studied per administrative department and per sector.



Data sources: Institut de l'Elevage
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Figure 3: Number of livestock farms monitored per administrative department and per sector in the Livestock Farm Networks (source: French Livestock Institute).

A regional organization relying on manpower

The system is regionally organized and based on the trio made of the regional organizer, the grassroots technician and the livestock farmer (Table II). The regional organizer coordinates the actions, fixes the methodological framework and provides the monitoring tools. The technician of a chamber of agriculture makes regular visits to the farms at key periods of the year to understand how the farms function (farmers' objectives, past evolutions, projects) and to collect the information necessary to describe the livestock farming system (workforce, production means, technical results, economic results and environmental impacts). The technician-livestock farmer pair functions in an approach of reciprocal dialog. The technician collects information and reproduces it in the form of diagnoses and advice to the farmers (progress approach), who can ask for a study of projects to improve or change their farm. The technicians are more often specialized by sector than by this benchmark activity. They rely if necessary on other technicians with complementary skills (feed, buildings, reproduction) (Dockès et al., 2010).

The regional teams meet regularly to harmonize the collection of data and process the information. The data collected are stored in a national database (Diapason) managed by the French Livestock Institute (Charroin et al., 2005). Nationwide discussions between regional organizers ensure that the work is harmonized and organized all across the country (e.g. surveys).

Products and achievements of the system

Regional and national productions come in the shape of technical and economic benchmarks presented per system (e.g. specialized sheep in the Massif Central, mixed crop-livestock farmers in the

plains of the South-West), syntheses of theme studies (e.g. energy in livestock farming, mechanization) and results of annual surveys or of methods and tools. New themes have gradually been included in the monitoring (e.g. mineral balance, energy, production cost).

The comparison of several farms very near each other makes it possible to describe and build coherent, efficient models of farms observable in the field called "farm typologies". These virtual but functional farms are useful for advisers to simulate farmers' projects and distribute functional markers. Politicians can also use them to study the impact of change in support policies (see below).

Uses and users, individuals and collectives

Monitoring makes it possible to identify, describe and build coherent, efficient production systems adapted to local potentialities and constraints and that the farmers can implement on their farms. As strategic decision-making tools in the individual framework of a farmer-adviser relationship, these technical, economic and thematic methods, benchmarks and markers enable livestock farming advisers to make diagnoses and guide the farmers in their projects (e.g. development of new units, technical reorientation, installation). All these productions and studies make it possible to provide the training and expertise of a body of livestock farming advisers.

The use of these analyses and simulation tools by local or national decision makers improves their knowledge of the production systems present in the entire country (Delaveau et al., 1999). They can test and measure the incidence of new agricultural policies on the different systems in place (Common Agricultural Policy, i.e. reforms influencing the construction of forage systems, influencing support to mountain systems) and thus orientate the final decisions and application methods.

Table I

Monitored French farms

Animal sectors	Num. farms monitored in the Networks	Including mixed systems	Num. professional farms* in 2007
Beef cattle	450		100,200
Dairy cattle	400	Beef and dairy cattle	90,100
Meat sheep	380	Meat sheep and beef cattle; meat sheep and dairy cattle	29,200
Dairy sheep	60	Dairy sheep and beef cattle; dairy and meat sheep	4,800
Dairy goat	130	Goat and beef cattle; goat and dairy cattle	10,400
Total	1,420		234,700

Source: Agreste survey structure 2007, Metropolitan France; French Livestock Institute, Livestock Farm Networks

* The professional farm satisfies two conditions: its economic dimension is greater than the equivalent of 12 hectares of corn; the quantity of work applied to it is at least equal to 0.75 annual work unit (definition of professional farms by Agreste, Eurostat).

Table II

The human means of the French national system

Livestock farms monitored nationally (all sectors)	Agents in charge of monitoring (chambers of agriculture, other bodies)	Project leaders for guidance and use of the system (French Livestock Institute)
1,420 + 500 monitored on regional funds	210, i.e. on average 9 farms monitored / agent	35, i.e. on average teams of 6 agents at regional level

Source: French Livestock Institute, Livestock Farm Networks

■ LIVESTOCK FARM NETWORKS MOBILIZED AND REACTIVE ON EMERGING THEMES IN THE LIVESTOCK FARMING SECTOR

Using selected examples, the following section presents individual and collective uses of the Networks. These examples respond to the three pillars of sustainable development, i.e. economic, environmental and social.

Measuring and strengthening the competitiveness of livestock farms

In a context of global and competitive economy where the market of agricultural raw materials is increasingly volatile, it is essential for the players in the industry to know their production costs. Since 2007, the French Livestock Institute has relied on the technical and economic data of the Networks to propose a national method, compliant with international accounting regulations (International Farm Comparison Network, Agri-Benchmark) and applicable to all herbivore farms. This method made it possible to build benchmarks per production system. It is now a basis for many training schemes for technicians and livestock farmers. In the framework of individual advice, the farmers know their production costs per unit produced (1000 liters of milk, 100 kilograms of meat). By comparing them with the benchmarks, they can identify progress margins.

Through a collective use of production cost calculations, they can share and discuss improvement processes. For elected representatives, observing the areas of production and their differences in competitiveness can help target public support policies at farmers to maintain the activity of farms in less favorable areas.

Preserving the environment and limiting the ecological footprint

Environmental themes are increasingly evoked in demands from European societies. The environmental impacts of farming, and of livestock farming in particular, are regularly discussed (Le Gall et al., 2009). As a consequence, the Networks have integrated methods for measuring impacts on the environment. In recent years, energy consumption and greenhouse gas (GHG) emissions have been measured in all the farms monitored (Hacala and Le Gall, 2006). The Networks make it possible to take on-farm measurements of these criteria to determine the positioning of the livestock farm models in France (Table III) (Galan et al., 2007). Data use has shown how low-consumption farms function with low GHG emissions.

The French Livestock Institute developed in collaboration with the Agency for the Environment and Energy Control and its partners a tool and a method (DIATERRE) to make diagnoses of energy and GHG in farms. At the beginning of 2011, about 300 advisers were trained. They are now using the diagnostic tool and the technical markers obtained from Networks data (Morin et al., 2010), enabling farmers to qualify their energy consumption and reduce it.

Analyzing and organizing work

The discrepancy between the time farmers spend working and the time the active population in general spends working only adds to the preoccupations of farmers about the problem of work. Faced with the legitimate demand for free time, the increasingly complex nature of the work and the evolution of collective work, concrete responses must be provided to ensure that the farming profession can continue to attract prospective young farmers (Calland, 2009).

Table III

Description and environmental performances of the main dairy systems in France

	Systems of forage crops in West France and in foothills	Systems in wet mountains of the Massif Central and Franche-Comté
Number of farms	43,000	16,000
Maize/MFA (%)	20–50	0–5
Dominant type of grassland	Temporary grassland	Permanent grassland
LU/ha MFA	1.4–1.7	0.8–1.0
Milk produced (L/cow)	6,500–8,000	6,000–7,000
Milk (L)/ha MFA	5,000–9,500	3,000–5,500
Organic N pressure (kg/ha spreadable)	100–110	60–80
Nitrogen surplus* (kg/ha)	80–100	30–50
Organic P pressure (kg/ha)	20–22	13–15
Phosphorus surplus (kg/ha)	10	10
Direct and indirect energy consumption (MJ/1,000 L milk)	2,685–4,296	2,685–5,012
Greenhouse gas emissions after integration of carbon storage on grasslands (Eq CO ₂ /L milk)	0.8–0.9	0.7–0.8
Pressure of plant health products (g/ha AA)	800–1,200	0
Biodiversity equivalent area (ares/1000 L milk)	18–22	38–42

Source: Le Gall et al., 2009

MFA: main fodder area ; LU: livestock unit; AA: agricultural area

* Nitrogen balance inputs – outputs at farm scale without symbiotic fixation

The approach to livestock farming work was initiated in the 1990s in the framework of the Networks, which led to the “Work assessment” method in partnership with INRA. This method has been recently applied by other animal technical institutes (pigs and poultry).

Since 2010, new updated national “working time” reference systems, established from surveys carried out in 640 livestock farms which belong for most to the Networks, have been available for seven animal sectors (herbivores and granivores). They are sometimes coupled with more qualitative studies, for example in the dairy cattle sector on essential routine work (Chauvat et al., 2003). Similarly, regional use of these surveys has made it possible to propose markers of working times and annual programming of activities to make work organization easier, as it is the case for meat sheep systems in Auvergne (Servière, 2005).

At the same time, “work” technical support methods and tools have been developed in collaboration with grassroots organizations, making it possible in particular to provide markers for starting up projects, as for example goat farming with the “Conseil Travail Caprin” (Guinamard et al., 2010) or beef cattle farming with Travibov (Sarzeaud and Bisson., 2009).

■ A RECOGNIZED SYSTEM WHICH MUST CONTINUE TO ADAPT

Variety of productions and heterogeneity of farms have long been presented as signs of the backwardness of French agriculture. However, production diversification has also regularly been presented as a necessary condition for the adaptation of farms to market constraints (Colson, 1986). French livestock farms continue to follow two development strategies: specialization or diversification. Regardless of their orientations, the Networks make it possible to study the strengths and weaknesses of these systems, and describe coherent livestock farms, with appropriate choices in the face of present-day issues. This diversity at territory or farm scale, emphasized by the systemic approach, is not seen as a handicap but as a source of system flexibility and adaptation of French agriculture (Dedieu and Ingrand, 2010).

The Networks provide markers, formalize and give guidance to farmers with regard to new themes initiated by the farmers themselves or by technical institutes, agricultural development bodies, society, the market and current policies. The capacity to anticipate is part of the reactivity of the Networks.

Identifying and studying all the technical innovations implemented in livestock farming is not always obvious, all the more as the system, although representative of existing systems, is not exhaustive and compels to make choices. On the other hand, experimenting new approaches (Life Cycle Analysis for example) on well known farms is easier. Sometimes there is still the difficulty of transmitting these new developments to as many people as possible beyond the farms monitored. Dissemination of knowledge and innovation is however one of the system missions. It is made easier when the economic or political context pressurizes the surroundings of the livestock farm to look into it or when complementary projects are set up.

By relying on a strong partnership between a national technical institute for applied research and local development organizations established all over the country, this system has built up its institutional legitimacy and has been able to use the skills and specificity of each organization to make it such a valuable resource. This is strengthened by the women and the men who make up the Networks. The skills in the teams are varied and often complementary (multidisciplinary approach of the advice). The expertise of all these players also makes

it possible to have qualitative elements on the farms and the territory that cannot be proposed by databases.

This system is recognized and supported by farming professionals and public authorities. Its financing is regularly discussed but, and this is a sign of its significance, several farming sectors want such systems to be extended to their own production. As another element of recognition *via* the Programme of Options Specifically Relating to Remoteness and Insularity (POSEI), Europe supports the setting up of these Networks in more distant territories (New Caledonia, West Indies, French Guyana, La Réunion).

This system requires discussions, agreements and steering authorities. The governance method to be implemented is at times complex to manage as it is composed of numerous partners with sometimes diverging objectives which then call for compromises.

A recurrent criticism of the Networks is that their dimension and multipartnership organization can hinder their reactivity. And yet it is this system that the professional steering committees turn to with questions in the news, for example *via* complementary theme investigations.

Satisfying their primary function of forming links between players, the Networks are supports for many multipartnership projects of French and European research, development and innovation, with several partner countries; they also participate in international think tanks (International Farm Comparison Network, Agri-Benchmark).

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Résumé

Jousseins C., Fagon J., Belvèze J., Servière G. Les Réseaux d'élevage, un système au centre de l'évolution de l'élevage en France

Les Réseaux d'élevage sont un dispositif dédié au développement de l'élevage herbivore. Fruit de l'histoire du développement agricole français, ils sont présents sur l'ensemble du territoire national et s'organisent localement. L'originalité de ce dispositif provient de sa nature partenariale entre des éleveurs, les chambres d'agriculture et l'Institut de l'élevage, de sa prise en compte de la diversité des régions d'élevage et de l'étude des systèmes d'élevage à travers l'approche globale. L'objectif n'est pas d'être exhaustif mais d'être représentatif de l'élevage herbivore à travers le choix des systèmes étudiés, d'en mesurer les évolutions, de créer et de diffuser des références à partir du suivi de 1900 fermes réalisés par 210 agents des chambres d'agriculture, encadré par 35 animateurs de l'Institut de l'élevage, et financé et appuyé par les pouvoirs publics et la profession agricole. Les valorisations régionales et nationales des Réseaux s'adressent à différents publics : aux éleveurs, aux conseillers, aux enseignants (pour le conseil ou la formation), aux individus ou aux collectifs, et aux décideurs locaux et nationaux afin de mieux comprendre les systèmes d'élevage, et de mesurer l'impact de nouvelles politiques agricoles et d'orienter leur modalité d'application. Le rôle des Réseaux s'illustre également dans leur capacité à se mobiliser sur des thématiques émergentes. Les aspects viabilité, compétitivité, conditions de travail ou encore enjeux environnementaux étaient inclus dans les champs d'étude du dispositif bien avant que le concept de développement durable ne devienne un centre d'intérêt. Les Réseaux en tant que dispositif partenarial sont parfois complexes à gérer et paraissent coûteux, mais c'est ce partenariat fort qui leur apporte la reconnaissance en tant que ressource clé et qui leur donne leur légitimité. La diversité des productions agricoles et l'hétérogénéité des systèmes d'exploitation favorisent les innovations et permettent l'adaptation de l'agriculture française aux nouveaux enjeux. Les Réseaux d'élevage permettent non seulement d'observer ces évolutions mais également de les catalyser, de les accompagner et de les diffuser.

Mots-clés : système d'exploitation agricole, système d'élevage, conduite d'élevage, élaboration de systèmes, développement agricole, conseiller agricole, agriculture durable, France

Resumen

Jousseins C., Fagon J., Belvèze J., Servière G. Redes de Fincas Ganaderas, un sistema en el centro del desarrollo ganadero francés

El sistema de Redes de Fincas Ganaderas se dedica al desarrollo de la producción de herbívoros. Debido a que las Redes son el resultado histórico del desarrollo agrícola francés, se encuentran en toda Francia y están organizados a nivel local. La originalidad del sistema reposa en la asociación entre finqueros, cámaras de agricultura y el Instituto Francés de Ganadería y por ende utiliza un enfoque global que considera la diversidad de las regiones de fincas ganaderas y el estudio de sistemas de fincas ganaderas. A pesar de no ser exhaustivos, los sistemas estudiados representan los sistemas de fincas de herbívoros. Se evalúa su evolución y se crean y distribuyen puntos de referencia. Estos puntos de referencia se han establecido según el monitoreo de 1900 fincas, por parte de 210 agentes de cámaras de agricultura, guiados por 35 líderes de proyecto pertenecientes al Instituto Francés de Ganadería, y financiado y sostenido por las autoridades públicas y las entidades de profesionales de agricultura. La progresión regional y nacional de las Redes, se dirige a audiencias diversas: finqueros, consejeros, educadores (para consejo o entrenamiento), individuos o colectividades, y líderes a nivel nacional o local con el fin de mejorar la comprensión de los sistemas de fincas ganaderas, así como para medir el impacto de nuevas políticas de producción y guiar su implementación. Mostramos también la capacidad de las Redes para movilizarse en temas emergentes. Sostenibilidad, competitividad, condiciones de trabajo e incluso temas ambientales han sido cubiertos por los campos de estudio del sistema, bastante antes de que el desarrollo sostenible se convirtiera en un tópico a la moda. Las Redes, en tanto que sistema de asociación, puede ser algunas veces complejo de manejar y puede parecer costoso, pero una asociación fuerte y bien reconocida la ha transformado en un recurso valioso y ha asegurado su reconocimiento y legitimación. La variedad de los sistemas de producción y la naturaleza heterogénea de los sistemas de producción son buenos promotores de innovaciones y permiten a la agricultura francesa la adaptación a nuevos retos. Las Redes no sólo permiten la observación de estas evoluciones, sino que actúan como catalizador y guía y ayudan a la disseminación.

Palabras clave: sistema de explotación, sistemas de cría, manejo del ganado, creación de un sistema de organización, desarrollo agrícola, agente de extensión, agricultura sostenible, Francia

Māori livestock farming achieving functional integrity?

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Keywords

Maori, land use, decision making, sustainable land management, New Zealand

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Summary

This paper uses a historical analysis of agricultural development to explore functional integrity of the New Zealand rural landscape arising from a national agenda to pursue greater agricultural outputs. The concept of functional integrity is extended by Māori farming as it introduces a further set of functions related to the aspirations of indigenous landholders. A land-use integrated decision-making framework (IDMF) was developed and applied to four Māori farm case studies that wanted to use land performance to meet their aspirational goals. The IDMF has linked indigenous knowledge with Western science and industry knowledge to form a holistic framework for framing questions, and evaluating and designing land-use options that have the potential to balance multiple outcomes and confer functional integrity. The IDMF provides a framework that will organise multiple activities and coordinate different quantitative and qualitative data sets in a visual format that allows for discussion within a collective decision-making environment. The framework was found to be useful for exploring and making transparent the trade-off between differing functions. This understanding guides the exploration of strategies that will enable the attainment of several functions simultaneously.

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■ INTRODUCTION

The functional integrity view is an approach suggested by Thompson (1997) to analyse sustainability. It views agriculture as a complex system of production practices, social values and ecological relations; the functional integrity of which may be nurtured or disrupted by human practice. The other approach suggested by Thompson is resource sufficiency, which maintains an outside point of view, the viewpoint of the observer. Functional integrity, conversely, acknowledges an inside point of view or the

viewpoint of the player, acting in accordance with certain goals (Alroe et al., 1999). Functional integrity is a dynamic concept that changes depending on the observer's worldview. This paper uses a historical analysis of agricultural development to explore functional integrity of the New Zealand rural landscape arising from a national agenda to pursue greater agricultural outputs. The concept of functional integrity is extended by Māori farming as it introduces a further set of functions related to the aspirations of indigenous landholders. Comparing these two perspectives enables an exploration of the means of achieving a wider set of landscape functions. This in turn identifies lessons to enhance the functional integrity of Western livestock systems. The paper structure addresses: i) the history of New Zealand's rural transformation driven by the economic imperative – this section explores the dilemma facing local development through livestock farming and characterises cooperative arrangements; ii) an analysis of Māori case farm studies is described and our discussion has a focus on the development and application of an integrated decision-making framework to achieve functional integrity; and iii) some questions at the end for further research.

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■ HISTORY

By 1840 the total forested area of New Zealand had been reduced from 85% of the land cover to about 53% (14.3 million hectares) (Ministry for the Environment, 1997). From 1860 onwards there was a rapid increase in the European population seeking to purchase and clear land for farms for development. The resulting impact saw a rapid increase in the area of land in pasture: from less than 70,000 hectares before 1861, to 1.4 million hectares in 1881 and 4.5 million hectares in 1901. From 1890 to 1900, 27% of New Zealand's indigenous forest land was cleared and the number of farms increased eight fold from 10,000 to 80,000 by 1921 when the total occupied area reached its maximum limit of 17.6 million hectares (Ministry for the Environment, 1997). The introduction of the Native Land Act in 1862 saw a rapid increase in European landownership as land previously held by families and clans was traded and at times confiscated under legislation such as the Land Settlements Act in 1863. By the early 1900's over 80% of Māori land was alienated. The current area under collective Māori ownership is less than 5% (Kawharu, 1977).

During the 1960's the government considered that an improvement in export earnings was necessary for long term economic growth. Given the fact that all of the potentially useable land was in farms, it was recognised that to increase export earnings from agriculture, there was a requirement to intensify through use of technology, and that incentives would be required to farmers for them to raise investment levels and create an environment for agricultural expansion. The resulting 1963 budget had three incentives: loans for development, subsidies on fertiliser, and tax write-offs for capital expenditure associated with development. Research and the adoption of technology were seen to be the key to success as a nation. Emphasis was placed on improving soil fertility, introducing improved genetics to plants and animals, improving animal health and optimising farm systems. In parallel with research and development there was the deployment of an agricultural extension service to teach farmers how to implement the new technologies. This protectionism continued into the 1970's and early 80's to retain the prosperity of the 50's and buffer negative external forces such as oil prices. By the mid-1980's the non-sustainability of support was recognised and a major adjustment in New Zealand farming from the removal of incentives and subsidies and the privatisation of the extension service occurred.

■ DILEMMA

Until the 1990's, therefore, New Zealand agriculture was dominated by an economic production imperative with farm practices directed at controlling the inherent system variability and manipulating the inputs to retain states that maximised food and fibre production. During the 1990's there was a realisation, substantially driven from the community level, that the pursuit of production goals had compromised other resources for human well-being, e.g. water quality and biodiversity. This has led to land managers now having to take into consideration the relationship between managing for production gains and providing outcomes more commonly aligned to the public good. Of importance to New Zealand is also the cultural values held by Māori. Cultural values shape the way Māori think about issues, form the basis for decision making, and are fundamental for establishing aspirations, desires, and priorities (Marsden, 1975; Marsden and Henare, 1992). Traditional concepts and beliefs still resonate strongly within contemporary Māori society. Cultural values therefore reflect both the long history and relationship Tangata Whenua (people of the land) have with a given

area, location, catchment, or region and their world view, strongly influencing land-use decisions.

Although the major driver acting to focus on farm functions other than production is local and cultural, international markets are also important to New Zealand. This illustrates that issues are connected in time and space with interactions across scales, global to paddock. Food security, water use, climate change, biodiversity loss, economic well-being and social equity and justice are therefore all tied together in pastoral livestock agriculture.

Today, as a developed country New Zealand has a unique profile in having a high dependency on the agricultural industry for its economic well-being. In the year to November 2010 agriculture made up 44% of merchandise exports which totalled \$43.1 billion (Statistics New Zealand, 2010). In 2005 New Zealand's total land of 26.9 million hectares comprised 11.7 million hectares (43.5%) in sheep, beef and dairy farming (Statistics New Zealand, 2005). Of this, 1.5 million hectares were in collective Māori ownership with over \$1 billion annually generated from the primary industry sectors.

The dilemma that faces New Zealand's society is therefore how to maintain ecological integrity of the resources that underpin agriculture and adjacent ecosystems, while adding value to local and national economic, social and cultural well-being, and delivering ethical goods to international markets. Māori land management provides fertile ground to explore how the twin imperatives of economic development and functional integrity can be balanced.

■ COLLECTIVE ARRANGEMENTS: GLOBAL EMBEDDED IN LOCAL

The cooperative nature of New Zealand's farming industry and Māori landownership offers an opportunity to address the dilemma through balancing functional integrity. Cooperative institutional structures characterise livestock farming in New Zealand with about 95% of dairy production processed and marketed using this type of ownership system. Farmers are also shareholders in fertiliser processing cooperatives and in some instances meat companies. These arrangements mean that individual farmers not only influence local development through their land-use choice and management decisions but also have a direct influence on global provision and thus development.

Māori land today is administered under the Te Ture Whenua Māori Act 1993 and is predominantly under multiple ownership (where there are multiple owners registered against the Certificates of Title). There are approximately 26,480 titles with an average of 73 owners per title and the size of these titles range from 800 m² to 500 hectares. Around 70% of Māori land is administered under a trust or incorporation structure. Many of these organisations have achieved strong viable farm businesses through the consolidation of land and the separation of the business from the provision of social and cultural services. A key characteristic of Māori land is that although the average area per title is around 50 hectares, 50% of these titles are less than 3 hectares and 70% less than 11 hectares resulting in a large number of blocks with small areas of land; many are uneconomic to be farmed on their own. Of the 5,000 trusts (Ahuwhenua Trust) the majority manage less than 5 hectares. Additionally, while there are over 5,000 trusts and 129 incorporations, 40 incorporations control 80% of incorporation land and 100 trusts control around 60% of trust lands (Kingi, 2008; Kingi, 2009a; Kingi, 2009b). This data suggests that there are two distinct groups emerging in Māori land: A small number of large blocks and a large number of small, often uneconomic blocks of land.

While many of these uneconomic land blocks are too small to be run as a viable business, they also lack management infrastructure and skilled personnel. Often farms attempt to service business, social and cultural goals together. Again there is a strong link to local development and community well-being through the flow-on effects of farming and also the strengthening of family ties through *whakapapa* (genealogy) where members of a family will be owners in more than one property.

As agriculture is embedded within local communities the functions acknowledged and managed for will be influenced both by local perspectives and needs, and global viewpoints. The huge contribution from livestock farming is therefore based on socio-ecological systems that include human behaviours co-evolving with ecosystem properties to sustain a particular set of functions. Collective management of farms influences the final decisions taken and emphasises the importance of having a framework to guide decision making that takes into account the multiple functions different stakeholders expect from the land.

■ CASE STUDIES AND METHODOLOGY

We have selected case studies with Māori farms that were all located on the east coast of the North Island of New Zealand. They had as their aim to improve performance from their land to enhance their aspirations. We used these cases to develop and apply a land-use integrated decision-making framework (IDMF) (Figure 1). This was an attempt to integrate socio-cultural imperatives with comprehensive land-resource assessments, complex simulation modelling and a deliberative process to allow future land-use options to be assessed against a range of functions identified by landowners.

Case of Ruawaipu

Ruawaipu is a collective of five Māori multiple-owned farms located between Te Araroa and Ruatoria. All farms run sheep and beef breeding enterprises. Farm size ranges from a total land area of 2,000–3,000 hectares with effective grazing of around 2,300 ha. Total shareholders and beneficiaries exceed 1,000. All farms are governed under the Ahuwhenua Trust structure committee of trustees.

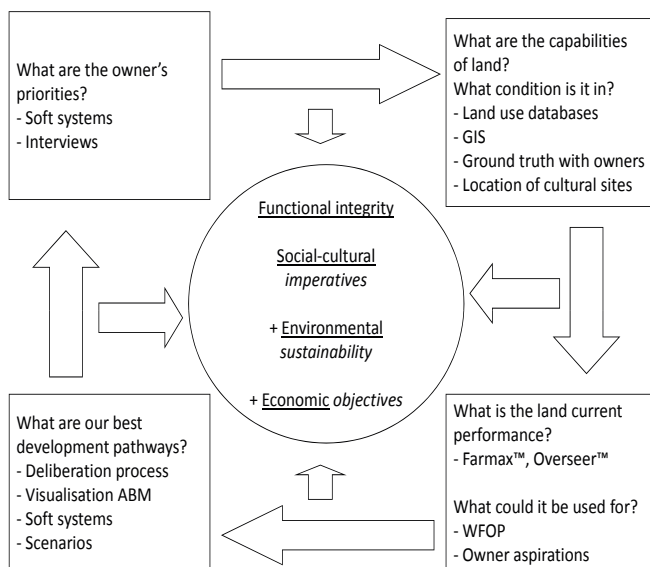


Figure 1: Integrated decision-making framework (IDMF) for delivering functional integrity.

Case of Ngati Hine

The research team engaged with the Ngati Hine health trust on 18,500 hectares of the Ngati Hine Rohe Whenua (tribal region), north of Whangarei, Northland. Their project "Taunaha" is a flagship Māori cultural wellness model combining elements of cultural, social, and environmental aspirations to advance the lives of Ngati Hine people through their connection to the land. Ngati Hine's translation of functional integrity is "*taonga tuku ihoa, nga korero tuku, ihoa*" with Tikanga providing the guidance and policy for implementation. Project Taunaha's paradigm of thinking is around *oranga* (wellness) and *orangatanga* (well-being). Wellness is about the physical condition of a resource or person, the *tinana* (body), and well-being is the natural condition of a resource or person i.e. the spirituality (spirit) and *hinengaro* (soul) (Tipene, 2010).

Case of Waimarama Inc.

Waimarama is one of three Māori incorporations located on ecologically fragile, but highly sought after coastal land, around Waimarama in Hawkes Bay. The incorporation (approximately 2,000 hectares in size) aims to expand its land base through leases with neighbouring blocks and has identified alternative land-use options that will diversify their production base away from the pastoral sector.

Case of Aohanga Inc.

Aohanga farm covers approximately 6,818 hectares of which about 3,039 hectares are used for sheep and beef production. Aohanga, Waimarama and Ruawaipu face increased frequency of summer droughts. Building resilience into their land use to cope with this was for them a key driver.

Methodology

A systems perspective was applied in all case studies to make transparent the relationships between people, natural resources, economics and culture. Interviews were conducted with individual members of the case study organisations to document *matauranga* Māori (indigenous knowledge) about the land and its owners. Workshops using soft system methodologies were held with members of the farm committees to identify their aspirations for the land (Wedderburn et al., 2004a; 2004b; Kingi et al., 2010a). A full description of the underlying soil, vegetation, water and indigenous cultural sites was developed for each of the properties using on ground surveys, land manager experience, land-use databases and historical data (Harmsworth and MacKay, 2010). All the data was placed into a geographic information system (GIS) database. An analysis of the current performance of the farm productive and environmental outcomes was undertaken using Farmax™ and Overseer™ models (King et al., 2010). Farmax is a computer simulation model that allows individual farms to be modelled and enables a wide range of "what if" scenarios to be explored. The programme matches pasture growth data with a livestock system to optimise profit. Overseer models the nutrient balance of a farming system and produces outputs related to environmental emissions (e.g. nitrogen, phosphate, nitrous oxide and carbon equivalents).

Some tools and methods were developed for specific case studies: A whole farm risk optimisation model (WFROP) was applied to Aohanga to assist in the evaluation of land-use options that met their farm objectives and preferences to design feasible farm plans (2). The model generated information that allowed the owners to identify the trade-offs between achievement of different objectives i.e. maximise gross margin while minimising environmental

impacts, e.g. nitrogen leached and greenhouse gas (GHG) emissions. An agent-based model (ABM) linked to a GIS visualisation tool was developed for application to the Waimarama catchment to show the impact on land use when properties network to achieve a range of outcomes (Kingi et al., 2010a). At Ruawaipu the land-use goals had their feasibility tested by researchers and regional advisors evaluating options on key success factors associated with land capability, existing infrastructure and human capital (Wedderburn et al., 2004a; 2004b). All of the information generated through the interviews, workshops, field work and modelling was used to develop a holistic integrated framework that could form the core of a deliberation process. The process was designed to enable alternative future land-use options to be assessed and choices made that take into account and make transparent the trade-offs between different functions.

■ RESULTS

Analysis of the system workshops were collated into the aspirational themes of the owners. Owners used the resource inventory maps and the model outputs to improve their understanding of the state of their current systems before exploring new options and undertaking a deliberation process. These activities tested and addressed the questions posed in the IDMF (Figure 1).

Aspirations

Table I notes the aspirations (functions) that were identified from the workshops held with landowners across the different case studies. The aspirations were formed into functional themes related to natural characteristics, indigenous sites, business viability, land

Table I

Deliberation framework to assess the impact of future land-use options against the functions identified through aspirations and goals of case-study Māori landowners in New Zealand

Aspirations: functions (achieving these would confer functional integrity)	Future land-use option				
	Cultural Tourism	<i>Papakainanga</i> (family housing)	Olives	Biodiversity conservation management	Forestry
Economic					
Providing an income	√				
Self-sustaining community					
Diversity of farm base	√	×	√		√
Economic viability		×			√
Existing market	√		√		√
Land in safe hands for future generations					
To reconnect our people with the land	√				
Cultural					
Kaitiaki					
Turanga Wae Wae					
Tino Rangatiratanga					
Mana Whenua					
Heritage	√	×	×		
Improved cultural identity	√				
Social					
Knowledgeable and skilled people					
Grow <i>whanau</i> opportunities	√	√	√		
Good governance					
Integral part of wider community	√	√	√	√	
Collaboration between landowners	√				
Environmental					
Land-use capability			√	√	√
Protect and preserve environment	√				
No erosion					√
Clean water					√
Biodiversity					
Reduced greenhouse gas emission					√

×: Land use is not suitable to achieve that function.

√: Land use will contribute to achieve this function.

retention in perpetuity, *whanau* (extended family relationships) and cultural well-being. The aspirations were incorporated into the deliberation process of the IDMF ensuring the goals and values of the Trust were included in the assessment of future land-use options.

Understanding your current system

In all instances the Māori landowners were keen to understand the current performance of their existing production systems, how they compared against industry standards and how they could make improvements. For example outputs generated from Farmax and Overseer for Aohanga showed that the current farm system was already well configured for the land resource, and that emphasis should be placed on mainstream livestock activities with an emphasis on further subdivision and water supply. In the case of Waimarama a change in enterprise plus implementing a programme of cost-saving management actions could support existing debt and improve farm profit significantly. The relationship between farm profitability and the ability to run a cultural tourism enterprise and connect with local development was identified through the development of a causal loop diagram outlining the relationships between the factors conferring success to the landowners (Figure 2). Alternative strategies that were explored were the amalgamation of production with other neighbouring Māori land blocks or leasing the land to meet debt and improve profitability. This information was used to guide the decision to employ a farm consultant and to explore networking with other land blocks to confer resilience to the impact of increasing frequency of summer dry conditions that were having a deleterious impact on their farm viability. For both Aohanga and Waimarama the low intensity of the livestock systems meant that the farm systems had a low environmental footprint.

Exploring future land-use options

Land-use options were identified by the different case organisations based on their natural capital and aspirations. Ruawaipu had opportunities for expansion of bee keeping based on the presence of large areas of Manuka trees and a high price premium for Manuka honey. Vineyards had been present in the past and expansion was occurring in the region. Dairying has also occurred in the past and all of the properties had flat areas suitable for dairying. Potential also existed for organic farming especially those farms that had not applied pesticides or fertilisers. Many of the properties had direct access to the coast line and this offered an opportunity for aquaculture. The opportunity for tourism was noted with the advantage of properties along the coast having the capacity to network with each other to provide recreational services. Waimarama

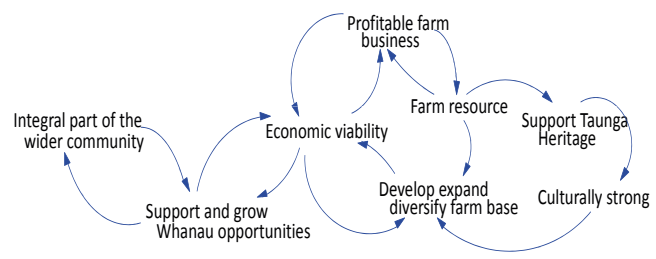


Figure 2: Fragment of a causal loop diagram developed with Waimarama landowners to illustrate the relationships between economic viability, farm business, cultural heritage and local development of the Māori case-study farms in New Zealand.

identified cultural tourism, *papakaianga* (family housing), biodiversity management and olives. Aohanga were keen to explore forestry as a form of carbon farming.

The application of the WFROP model to the Aohanga property enabled the owners to evaluate land-use options that met their farm objectives including: i) maximising farm income, ii) minimising N leached, iii) minimising GHG emitted from the farm, and iv) maintaining the option to trade-in carbon in the future. This model used the base performance of the farm as generated by Farmax and Overseer along with Land-use Capability classes identified from national resource inventory maps and then used development scenarios to optimise the farm for profitability, productivity and environmental impacts. This therefore took the decision making beyond optimising the current land use to exploring alternatives to meet a wider range of functions including a future's perspective that took into account the diversity of the system. The scenario generated by the WFROP that was of most interest to the owners was forestry as it had the highest gross margins, lowest GHG emissions and lowest N leaching.

The use of an expert panel that had knowledge of local development generated a number of key success factors that would be required to enable future land use. These included capital investment, minimum size of economic unit, product quality assurance, local market, infrastructure, and people skill. Within the IDMF, these key success factors are used to test the feasibility of land-use options to deliver to the aspirations.

The Ngati Hine, Ruawaipu and Waimarama cases all introduced the concept of networking farms to realise sustainable land-use profitability. This was explored in depth with the Ngati Hine case where the key leverage points to overcoming barriers to collaboration between the owners of several land blocks were identified, by Ngati Hine, through the development of a causal loop diagram (Figure 3). Four subsystems were identified: clear direction, governance, trust and engagement. The leverage points included: strong leadership, income, building capacity and clear direction that had to be well communicated. Ecotourism was an economic activity identified by Ruawaipu participants that could be enhanced by coastal land blocks working together. Characteristics of the land that lent itself to tourism were i) all properties in close proximity to the sea, and ii) pastoral landscape vista and presence of indigenous bush. The potential to supply readily *kai*

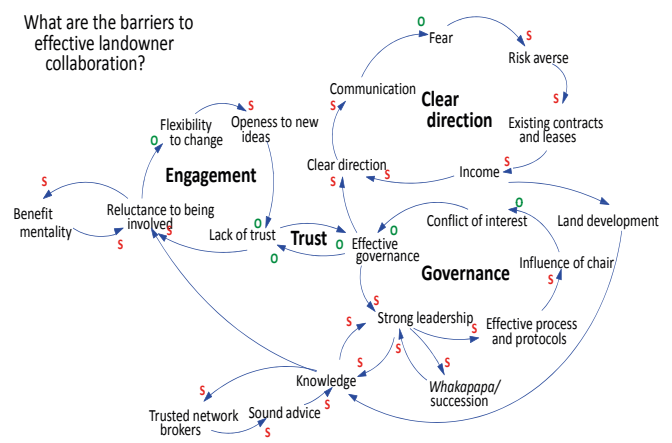


Figure 3: Causal loop diagram representing the system of barriers to collaboration by Ngati Hine networked Māori case-study farms in New Zealand. S on the arrow heads means that the factors will behave in the same direction whereas O means they will behave in opposite directions.

moana (indigenous seafood), and vegetation growing on the farms, e.g. *puha* (water nasturtium) and *pikopiko* (fern shoot growing in a damp shady area of the indigenous forest), to visitors staying on farm and local markets was explored using the IDMF and these activities were identified as opportunities to market test. The products obtained from indigenous vegetation such as Manuka (oil, honey) and flax (oil, cosmetics) have found a ready market and provided local jobs.

Developing these enterprises has the potential to enhance also resource condition as the pressure may be removed from attempting to grow grass on steep hill, low-producing land and use the reverting scrub as a productive source of product while it matures into indigenous bush (forest). A visualisation agent-based model linked to GIS was applied to Waimarama to identify the potential collective outcomes delivered from Māori blocks networked across different land uses. Three scenarios based on land use identified by Waimarama owners included improved pastoral farming, biodiversity priority, and pressure from lifestyle block development. They were modelled and the output measured in relation to the aspiration themes identified through the systems workshops. An example of the results is given in Figure 4 where all values improved (i.e. economic viability) or were not affected (heritage) by the simulated scenario-improved pastoral farming.

Deliberating the choice of land use

The deliberation framework was developed to organise the process of determining and making transparent the consequences of land use across the functions (goals, aspirations) articulated by the landowners and for trade-offs to be identified (Table I). The deliberations were informed to varying degrees by the outputs from the different models that were applied to the blocks. Farmax guided the land-use choice and estimated farm profitability; Overseer produced the data to parameterise the environmental functions; The WFROP model optimised land for a number of uses. Trade-offs between achieving gross margins and reducing environmental emissions were made transparent. The agent-based model linked to GIS enabled trade-offs to be identified when farms were networked. Table I gives an example of the use of the deliberation framework to identify the trade-offs between the functions identified from their aspirations and goals associated with a choice of land use. Figure 4 outlines the trade-offs identified for the farm optimisation scenario for potential networked farms at Waimarama. At all times the researchers and landowners were interacting, with the landowners posing questions and researchers undertaking analysis and reporting back for their consideration.

■ DISCUSSION

We organised our discussion around four themes: i) West meets South when the benefit statement is constructed by science based on using a resource sufficiency view based on the optimisation of a single function (e.g. profit maximisation); ii) South meets West when the benefit statement must align with a functional integrity view with multiple functions as dictated by Māori landowners; iii) the role of farm networking within localised communities to create new trajectories for development that builds resilience within individual farms through the use of human and ecological dimensions of livestock farming; and iv) generic applications of the IDMF.

West meets South

In many instances research and other supporting industries interact with landowners at the stage when the questions asked is

“what is my current performance and how can I improve it?” using the IDMF described in Figure 1. Technologies and models are all aimed at efficiency and optimisation of the current system to achieve the single objective function of farm profitability. Although interactions with Māori landowners illustrate the relationship between farm profit and other aspirations such as *whanau* (family) well-being and ability to undertake ecotourism, this information is rarely relayed to researchers. There will therefore be many instances where a particular financially optimal option will not be chosen because it involves a trade-off with another non-financial function such as risk to loss of land or not providing jobs for *whanau*. This indicates that farm performance has to be measured within a holistic context that includes environmental, cultural, economic and social indicators.

Research and supporting industries can therefore target more effectively their contribution by informing and utilising the decision-making framework in conjunction with landowners. This will offer the opportunity to explore the use of technologies and systems in achieving a balance of functions. The decision-making framework can be used to assist in targeting the questions that the landowners wish to pose and choosing the appropriate analytical tool to allow exploration of the questions. The iterative nature of the process to inform landowner choice requires that the researchers and industry actively engage with the processes embedded in the decision framework and recognise the dynamics of the situation.

South meets West

A combination of *whakapapa*, land-use modelling and customary knowledge is seen as the key to improving the utilisation and sustainable development of Māori land with multiple owners. The IDMF provides a framework that will organise multiple activities and coordinate different quantitative and qualitative data sets in a visual format that allows for discussion and deliberation within a collective decision-making environment. The development and application of the IDMF across a variety of Māori land cases showed the relationship and interactions between the different functions and how not achieving one function had flow-on consequences, intended and unintended, to the other functions,

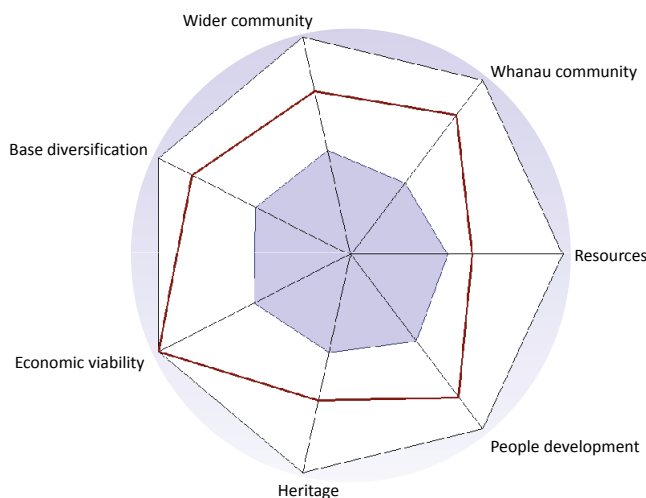


Figure 4: Trade-off analysis for networked properties at Waimarama, Māori case-study farms in New Zealand. Each point represents a collective value, the inside shape is the current status and the red line is the new measure of each value for the improved pastoral farming simulated scenario.

e.g. at Waimarama failing to reach farm profitability impacted on their ability to create opportunities that benefited *whanau* through cultural heritage for use in diversifying economic activities. It also allowed landowners to identify the trade-offs between functions generated by a particular land-use option and to make an acceptance judgement. This understanding guides the exploration of strategies that will enable the attainment of several functions simultaneously. In this way there is a strong opportunity to use the IDMF as a means to guide the attainment of functional integrity.

Networking farms

The concept of *whanau* was an integral part of the research-enabling connections to be made with people and land and gave an entry point into the community. The multiple-ownership structure is based on extended family connections and enables an individual to be connected to more than one property (Kingi, 2009a). This enables the transfer of information between farms and allows opportunity to network physically enterprises as an individual may hold a decision-making role on the governing committee of more than one farm. As shown by Waimarama's case there is a potential for land-use diversification to enable achievement of goals where strategic alliances need to be formed and institutional structures defined for viable business to occur. Amalgamations of Māori land have occurred to increase critical mass thereby enhancing profitability (Vallance, 2003). The work on barriers to collaboration undertaken by Ngati Hine indicates that leadership and effective governance are key leverage points to achieving collaboration. Research and industry support would do well to understand these barriers and design effective interventions and associated action plans in partnership with landowners.

Generic applicability

The IDMF has linked indigenous knowledge with Western science and industry knowledge to form a holistic framework for framing questions, and evaluating and designing land-use options that have the potential to balance multiple outcomes and confer functional integrity. The processes and tools that populate the framework can be applied to a generic audience. A crucial point in the successful implementation of the IDMF is the partnership that is formed between research, industry and landowners particularly as the analytical tools require expert knowledge to operate and interpret. There is a large amount of baseline information required before exploration of future land-use options can take place, and in some instances this may be costly to obtain. We pose a number of research questions for consideration:

- How can the effectiveness of the IDMF as a standalone framework for use by Māori owners be tested?
- Is it possible or desirable to align the formalised decision-making process with traditional decision-making practice, e.g. how effective would this be within a strategic planning exercise?
- How can the IDMF be applied as a guide to achieve functional integrity with non-Māori landowners?
- What are the gaps in the current IDMF, e.g. inclusion of market research, and how can these gaps be filled?

Acknowledgments

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Résumé

Wedderburn M.E., Kingi T.T., Paine M.S., Montes de Oca O.
L'élevage Maori réussit-il l'intégrité fonctionnelle?

Cet article utilise une analyse historique du développement agricole pour explorer l'intégrité fonctionnelle du paysage rural de la Nouvelle-Zélande s'appuyant sur un programme national d'expansion des produits agricoles. Le concept de l'intégrité fonctionnelle est enrichi par les activités agricoles des Maoris car il introduit une nouvelle série de fonctions liées aux aspirations des exploitants des terres autochtones. Un cadre de prise de décision intégrée (CPDI) de l'utilisation des terres a été développé et appliqué à quatre cas d'étude de fermes māoris qui voulaient utiliser les performances des terres pour répondre à des objectifs ambitieux. Le CPDI a associé connaissance indigène, science occidentale et connaissances de l'industrie pour former un cadre global pour la formulation des questions, et évaluer et envisager les options d'utilisation des terres qui ont le potentiel d'équilibrer les résultats multiples et de conférer l'intégrité fonctionnelle. Le CPDI favorise l'organisation de nombreuses activités et la coordination des différents jeux de données quantitatifs et qualitatifs dans un format visuel qui permet la discussion au sein d'un environnement de prise de décision collective. Le cadre s'est révélé utile pour explorer en toute transparence les compromis entre des fonctions divergentes. Cette compréhension guide l'exploration de stratégies qui permettront de réaliser simultanément plusieurs fonctions.

Mots-clés : Maori, utilisation des terres, décision, gestion foncière durable, Nouvelle-Zélande

Resumen

Wedderburn M.E., Kingi T.T., Paine M.S., Montes de Oca O.
La ganadería Maorí logra integridad funcional?

El presente artículo utiliza un análisis histórico del desarrollo de la agricultura para explorar la integridad funcional del paisaje rural en Nueva Zelanda, surgiendo de un intento para mejorar los recursos agrícolas. El concepto de integridad funcional se extiende a la producción Maorí, ya que introduce un conjunto mayor de funciones relacionadas con las aspiraciones de los terratenientes indígenas. Se desarrolló un cuadro de toma de decisiones integrando (CTDI) del uso de la tierra y se aplicó a cuatro estudios de caso de fincas Maorí, que deseaban utilizar el rendimiento de la tierra para alcanzar sus objetivos. El CTDI relaciona el conocimiento indígena con la ciencia occidental y el conocimiento industrial, para formar un cuadro holístico para plantear preguntas y evaluar y diseñar las opciones de utilización de la tierra que tendrán el potencial de balancear múltiples resultados y conferir integridad funcional. El CTDI provee un cuadro que organizará múltiples actividades y coordinará diferentes sets de datos cualitativos y cuantitativos en un formato visual, que permitirá la discusión en un ambiente de toma de decisiones colectivo. El marco fue útil para explorar y elucidar el canje entre las diferentes funciones. Este entendimiento guía la exploración de estrategias que permitirán alcanzar varias funciones simultáneamente.

Palabras clave: Maorí, uso de la tierra, toma de decisiones, ordenación de tierras sostenible, Nueva Zelanda

Extensive livestock farming in Morocco: From marginal territories to major social and environmental roles

Mohamed Taher Sraïri¹

Keywords

Sheep, poultry, dairy cattle, pastoralism, extensive husbandry, product quality, intensive farming, breed, Morocco

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Summary

Recent developments in the supply of animal products in Morocco revealed a sharp decline of the contribution of extensive livestock farming systems. In a context of marked demographic expansion (from 15.3 to 32.9 million inhabitants from 1956 to 2013) associated to rapid urbanization (almost 60% of the population lives in urban centers), consumption habits have changed. There has been a shift from a patriarchal structure of the society, which meant that meals were consumed at home, to more individualistic behaviors. As a consequence, the nature of animal products consumed by large sections of the population has notably changed. Dairy and poultry products appear to be most suited to these changes, as they can easily be used in fast-food preparations. On another hand, the consumption of beef and mutton from extensive systems has been stagnating. Extensive livestock systems, however, still use many fibrous feeds, from rangeland resources to cereal by-products. Traditionally, this has enabled them to ensure strategic functions such as the regional development of marginal areas, natural resource management, efficient water productivity through livestock products in a country experiencing acute water scarcity, and the creation of wealth and job opportunities. The shift of interest from these systems to more intensive ones raises many questions. It puts tremendous pressure on natural resources in areas of intensive production. In addition, the supply of animal products has become highly fragile as it depends on imported inputs, from animal genes to feeds (e.g. soya and maize for poultry). These changes mean that more attention should be given to extensive livestock production systems, as they promote a greener way of production and enhance large rural areas. These systems will hold a strategic position in the near future, when the time comes to face issues such as sustainability of the animal protein supply and natural resource preservation, and to balance the development of the various regions of the country.

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■ INTRODUCTION

Located in the Western part of North Africa, Morocco stretches from the Atlantic Ocean to the Sahara Desert. It presents a wide variety of agricultural ecosystems that include rain-fed Atlantic plains, large scale irrigation schemes, Atlas and Mediterranean mountainous zones, oasis, and desert areas (Figure 1). The country is mainly characterized by its semiarid to arid climate, which constitutes an acute challenge to secure food supply. As a consequence, the country has become a net importer of food, mainly cereal grains: in 2013, more than 2.8 million tons of wheat were imported and cost 990 million US\$ (OCC, 2013).

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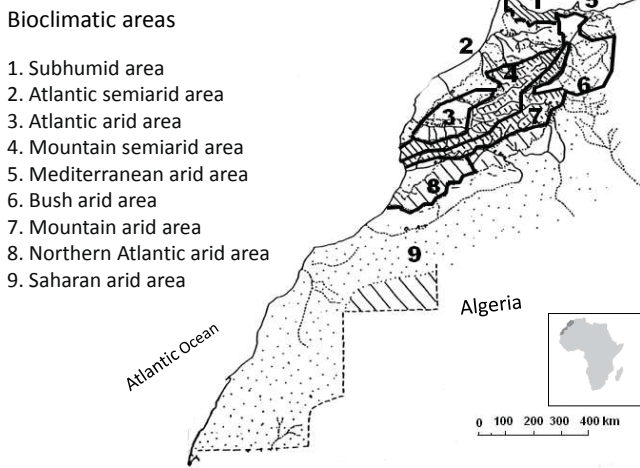


Figure 1: Bioclimatic areas of Morocco.

The wide diversity of agroecosystems promoted the emergence of contrasted breeds of ruminants. Animal wealth has traditionally assumed various vital roles, from the control of rangeland territories to the supply of animal proteins. In fact, as a human society which used to have a strong tribal structure, the livestock has always represented a privileged way of using natural resources (Miège, 1961). During the colonization period, animal products were intensively coveted by ruling powers at a time when Europe was at war. In fact, Morocco was famous for its leather and mutton from extensive pastoral systems (Vaysse, 1952). The country is also the cradle of the Merino sheep breed, which was originally exported during the Merinids dynasty, which prevailed from 1269 to 1465. This breed became popular in Europe and spread worldwide, as it became a major producer of high quality wool (Flamant, 2002).

The original extensive livestock production systems proved their adaptation to numerous vital functions. In the entire North African region, in periods of intense drought or during political unrest, breeders used to keep a limited number of reproductive females to reconstitute their herds after the climatic and/or sociopolitical situation returned to normal (Tillon, 2000).

These strategies seemed well adapted to a context of limited demographic expansion. In periods of intense trouble, such strategies would not however be sufficient to prevent huge mortality rates in herds and animal product shortages (Lakrakeze, 1993). At the end of the colonial episode in 1956, it became obvious that the rapid growth of the human population associated with changing living standards posed a real challenge to secure the supply of animal proteins. Sound policies devoted to livestock production had to be elaborated and implemented.

This paper focused on the consequences of these livestock policies on the supply of animal products in Morocco and their recent effects on traditional extensive systems. An analysis of the evolution of the demand of animal products is presented, the impacts of the adopted livestock policies have been assessed, and the consequences on extensive systems have been detailed.

■ RECENT DEMOGRAPHIC CHANGES IN MOROCCO AND THEIR IMPACTS

Morocco has experienced marked demographic changes during the 20th century. From 1956 to 2013, the Moroccan population

more than doubled (from 15.3 to 32.9 million inhabitants). During the same period, the urbanization rate increased from 27.8 to 55.1% (Catin et al., 2007). This marked increase has created an unbalanced development of the country, with the megalopolis of Casablanca alone concentrating more than 20% of the whole population.

These rapid evolutions have induced new social needs that include food, housing and job opportunities. The rapid urbanization has also brought about changes in traditional living patterns. For instance, the society structure, which can be traced to tribes mainly living on rain-fed cereal crops coupled to extensive sheep production, has shifted to more individualistic behaviors in big cities. Consumption habits have thus changed from collective meals eaten at home (*tajine*), to individual meals often consumed outside. Therefore, the demand for food and its structure have changed noticeably. This has led to the progressive and worrying emergence of metabolic diseases such as diabetes and obesity (Rguibi and Belahsen, 2007). Particularly, mutton, which used to be the most popular kind of meat, has been rapidly losing ground to poultry, whereas beef consumption stagnates (Sarter, 2006). Mutton is being more and more perceived as a source of health trouble because of its high cholesterol content. In addition, mutton and beef prices being more than double that of broiler meat penalize red meat consumption. Finally, mutton does not seem adapted enough for use in fast-food meals such as sandwiches and pizzas. It has gained however the status of a festive meat associated to social and religious celebrations such as baptism, wedding and above all the sacrifice of Prophet Ibrahim's son, Ismail, locally known as the Aïd El Kébir (Sraïri, 2011). The latter imposes to each male adult Muslim to sacrifice once a year a well-conformed lamb. Given the average income of the Moroccan population, the mean annual consumption of animal products remains low with less than 50 kg of dairy products, 28.6 kg of meat (4.9 of mutton and goat, 6.4 of beef, and 17.3 of poultry), with marked individual variations. Therefore, significant increases in meat consumption might be expected in relation with improvements of household incomes.

■ LIVESTOCK POLICIES AND THEIR EFFECTS ON THE ANIMAL PRODUCT SUPPLY

Sudden emergence of intensive poultry

The first measure that increased the animal product supply was the launching of private poultry farms in the early 1960s. These facilities settled near the main port of Casablanca, as the country does not produce maize and soya which are necessary for this kind of business. Imports of maize grain have been increasing rapidly, from 0.1 to 1.8 million ton between 1981 and 2013 (OCC, 2013). In 2013, this gross expense represented more than 343 million US\$. Today, poultry products from modern facilities constitute 58% of total meat and 90% of eggs consumed by Moroccans. Hence, the poultry sector has been in the spotlight to ensure the sufficient supply of animal products following a global trend (Speedy, 2003), unlike the ruminant sector. The modern poultry sector has experienced sustained growth in the production of eggs (from 201 to 4300 million units from 1980 to 2013) and broiler meat (from 70,000 to 510,000 tons during the same period) (FIS, 2008). Poultry products represent a handy source of proteins to a large spectrum of society, as their prices and availability are not affected by climate hazards.

However, the poultry sector in Morocco contains several weak points among which it is highly dependent on imported feeds and genes. It is also highly vulnerable to heat stress which commonly

affects the country during summer. In fact, in such periods locally known as *chergui*, even night temperatures may be above 50°C during two to three consecutive days, causing high mortality rates and decreased animal performances. Moreover, the avian influenza crisis had tremendous effects on the sector, ruining many farmers. Lastly, the vast majority of poultry facilities settled in areas which were engulfed later on by big cities. This causes many problems related to excreta and dead animal management.

Difficulties to implement modern dairying in smallholder farms

The adoption of a 'Dairy Plan' represented another significant step to increase the availability of animal products in Morocco. Such a plan was officially launched in 1975 and relied on several measures: i) the imports of heifers and the encouragement of crossbreeding between local and specialized dairy breeds, ii) the development of fodder crops, iii) the implementation of a milk collection policy to allow smallholder farmers to get a regular income, and iv) the taxation of imported dairy product, to ensure competitiveness of local products. This strategy successfully boosted milk production, which steadily increased from 1970 to 2012 (Figure 2).

However, climatic hazards have affected production, particularly during the drought periods of 1980–82 and 1991–92. Moreover, since the early 1980s, structural adjustment programs affected the State intervention in the dairy chain, which meant the rapid collapse of all kinds of incentives to dairy producers. This rapidly prompted the increase of input prices (feed, but also those of services such as artificial insemination) at a time when the farm gate milk price was stagnating. These changes implied that the dairy activity had to manage growing difficulties, from soaring prices of strategic feeds (above all imported cereal grains and proteinaceous meals) to water stress. Therefore, cattle farmers' average gross margin from this activity has remained generally low (less than 200 US\$ per cow per year, including calf crop sales) and has been very variable, from positive results to deficits (Sraïri et al., 2009b).

The decisive factors which affect the average milk yield per cow in a herd are, firstly, sufficient feed availability (in addition to fodder) and, secondly, its use within balanced dietary rations, as farmers often ignore the principles ruling ruminant feeding. In addition, in a country where water availability is scarce (below 800 cubic meters *per capita* per year), the agricultural sector will have to deal in the near future with enormous challenges to manage this resource efficiently (Blinda and Thivet, 2009). With regards to dairying, water productivity through cattle rearing is

crucial, as more than 60% of total milk volumes originates from large scale irrigation schemes which represent less than 15% of the arable land of the country.

The study of water productivity through the herds constitutes a complex task as it requires analyzing a series of production functions: i) from water volumes entering fodder plots, ii) to fodder quantities produced within these plots, and eventually the amounts of 'virtual water' (Allan, 1998) represented by off-farm feed resources, and iii) to cattle products, which are in the case of the vast majority of farms, both milk and live weight gain, as herds are generally dual purpose (Le Gal et al., 2009). A series of on-farm research was conducted recently in a large scale irrigation scheme in Morocco to assess water productivity through cattle farming. Results showed that almost 1.8 cubic meter of water was necessary to obtain one kilogram of milk, whereas 16.5 cubic meters of water were used to produce one kilogram of beef (Sraïri et al., 2009c). These values were higher than the international standards of water footprint to get milk and meat (Chapagain and Hoekstra, 2004). In the case of Morocco these data however reveal that more attention needs to be paid to that issue, as the water used often comes from groundwater sources, which may be depleted if no regulation mechanisms are adopted to ensure their sustainability (Hammani et al., 2009).

The analysis of the series of production functions to convert water to cattle products revealed that large margins of improvement existed within farms to increase water productivity. Interventions may target irrigation systems (from gravity systems to drip irrigation), fodder biomass yield (by generalizing sound agricultural practices), fodder species (for instance by replacing alfalfa, which is a perennial crop, with maize, which only has a four-month cycle) and finally animal feeding (the systematic use of balanced dietary rations). All these measures however require sound technology transfer tools to farmers, so that the latter can adopt these changes. During this research, a program tested the effects of monitoring closely the feeding practices of five herds. It showed that the average milk yield per cow could be significantly increased by just providing correct advice to farmers: matching the nutrient supply of dietary rations with the energetic and protein levels needed for the potential production of lactating cows (Sraïri et al., 2011).

Another significant challenge which will affect the dairy sector in Morocco relates to milk quality management. In a context where smallholder farms represent the main contributors to the output, the daily production has to transit through cooperative collecting centers to decrease logistic costs before processing. This two-stage chain shows obvious limitations to assess the quality of each single batch (Sraïri et al., 2009a). In such a system, it is impossible to reward farmers individually for good quality milk and to penalize those for poor one because the costs of analyses would be, for the vast majority of the batches that are delivered daily, higher than their market value as many farmers bring less than ten liters per day to the collection centers. Therefore, milk quality and its fair payment also are a sensitive issue for the dairy chain, as they can cause tension between farmers and dairy processors.

As a whole, modern dairying in Morocco will face many major challenges in the near future, particularly as the country is negotiating free-trade with the European Union. As the pressure on water sources is getting more intense, particularly because of the expected effects of climate change and of the fragmented structure of the chain, targeted measures will be needed to ensure competitiveness. This will require further measures to upgrade the whole dairy chain, from human resources to a fair value distribution chain that will benefit all operators.

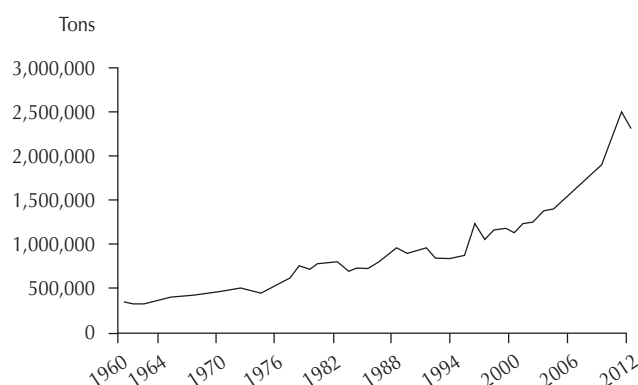


Figure 2 : Milk output in Morocco from 1960 to 2012.

Changes in the traditional livestock systems of marginal areas

Apart from intensive poultry and dairy cattle, animal husbandry in Morocco has always been interested in extensive livestock production. There is a very old tradition of camel, sheep and goat breeding on wide rangelands, whereas cattle are more associated to cultivated areas. Because of the numerous agroecosystems present in the country, there are many breeds of these species that have been naturally selected. Three main cattle breeds (Oulmés-Zaër, Atlas Brown, and Tidili) have been identified and they are all highly adapted to harsh environments (shrinking feed supplies caused by summer droughts) through physiological abilities, but their potential milk yield and growth traits remain limited. Therefore, their main production goal is calf crop, as farmers aim at getting an average of one calf per cow. This is hardly achieved because of common reproduction failures associated to frequent nutritional imbalances in herds, particularly during summer or in periods of drought (Haddada et al., 2003).

Morocco is also known for sheep production, with more than 17.5 million head. The country almost produced 120,400 metric tons of mutton in 2008, and this product ranked seventh among the other agricultural products of the country in term of value, i.e. 238 million US\$ (FAO, 2010). Six endogenous sheep breeds have been identified, each associated to a specific territory with particular feed resources. In addition, there are numerous sheep populations in marginal areas which have not been sufficiently studied yet. This animal wealth represents a crucial asset, as it constitutes the only way to get a source of income from shrubs and poor vegetation. Sheep provide in these regions a vast array of products, not only high quality meat, but also wool which used to represent a high value product as it allowed local handicraft to develop (mainly carpet production), and above all manure, which is important for soil fertility management in systems generally not using fertilizers. Therefore, in high altitude sheep barns, manure is collected throughout the year and transported on mules to villages, where intensive crop cultivation is practiced (Bourbouze, 1997).

Previous works on sheep production in Morocco conclude that three distinct systems may be identified: i) extensive pastoral systems, which mainly depend on rangeland throughout the year, with a very limited contribution from cultivated resources; ii) agropastoral systems, which rely on both rangeland and cultivated resources (cereal straw, stubbles and grains, and sometimes fodder) and even extra farm resources (compound feed); and iii) oasis systems, which use mainly local feed resources (alfalfa, wheat straw and date residues) to raise a famous prolific breed (D'man) within small flocks (less than five ewes with their progeny) as feed availability is limited in such a context (Boulanouar and Paquay, 2005).

Recent developments in sheep production systems in Morocco however recognize that there has been a shift toward two marked changes. The first one reveals that in all the flocks there has been a trend toward increasing cereal grain use because price policies tend to encourage mutton meat production through the import of cheap grains, above all barley (Table I). Such choices have led to a growing animal load in many rangelands, which raises concerns on natural resource management (vegetation and soil erosion) in fragile areas. This is particularly true in the arid areas east and south of the country, which represent the majority of rangeland territories (Chiche, 2008).

The second development consists in the emergence of the religious ceremony of Aid El Kébir as the main market for lambs (Alary and Boutonnet, 2006), as this ceremony concentrates more than

50% of all the sheep slaughtered annually. Therefore, sheep farmers have to adapt to this specific market. Purchases of sheep destined to this ceremony follow strict religious specifications. One key element in families' choice is the exterior appearance of the lamb, which should show a well developed pair of horns. Therefore, strategies for the genetic improvement of sheep should take into account these requirements, particularly breed standards and thus avoid crossbreeding with hornless animals as their products would not be accepted for that specific market.

The previous remarks show that sheep production in Morocco has been facing increasing challenges. On the one hand, it has lost its 'natural' status, as a growing number of flocks rely on off-farm feed resources. This implies growing tensions on rangeland resources, particularly in arid areas. On the other hand, the demand for sheep products has been falling, as it is not competitive anymore with poultry products and beef. This trend is clearly illustrated by the projection of the demand by 2025 (ADA, 2008). These trends show that the levels of mutton consumption are expected to remain constant, and most of the increases in the consumption of animal proteins should come from poultry, dairy products and also beef (Table II).

However, sheep hold a strong identity role, as they are associated to important feasts, mainly the Aid El Kébir. Therefore, sustained efforts to promote sheep production in Morocco are needed. They should primarily focus on capturing consumers' interest by the promotion of their organic and green status in comparison to livestock from intensive systems (dairy cattle and poultry). To do so, traceability will be necessary to reward sheep breeders in remote areas, who have to face harsh conditions in comparison to flocks raised mainly with concentrates in suburban belts. To ensure that traceability and increase the income of extensive sheep systems, an improvement of the whole governance within that chain must be implemented: from input suppliers to breeders, retailers,

Table I

Relationship between the use of cereal grains and mutton and milk prices in Morocco in 2000

Concentrate to total energy intake (%)	Type of concentrate	Price comparison		
		Milk/Barley	Mutton/Barley	Beef/Barley
15	Barley, wheat bran	1.5	30	25

Adapted from Alary and Boutonnet, 2006

Table II

Projected levels of animal product consumption by 2025 in comparison with 2005

Animal products	Consumption levels by year 2025
Milk	Increase by 200 to 300%
Meat (all species)	Increase by 130%
Beef	Increase by 100%
Mutton and goat	Same level
Poultry meat	Increase by 150%

Adapted from the Agricultural Development Agency, 2008

supermarkets and consumers' organizations. This improvement might be the prerequisite to ensuring the sustainability of extensive sheep farming.

■ CONCLUSION

The ongoing changes in the social demand for animal products in Morocco have created a situation in which products from extensive systems appear to be losing ground to commodities generated by intensive systems. In fact, the demand has shifted toward broiler meat and dairy preparations, which are more suited to the offer from fast-food outlets than mutton and goat meat. Therefore, local authorities have promoted several measures to develop intensive systems by helping private poultry operators build modern facilities and implementing a dairy plan in the large scale irrigation schemes.

The initial results have been satisfactory as the output of broiler meat, eggs and milk has increased significantly. However, an assessment of these increases reveals that they rely on intensive imports of inputs, like feed grains and protein meals, and also genes (heifers, chicks, and artificial insemination straws). Moreover, these intensive cattle and poultry systems are concentrated in specific areas, causing serious environmental concerns. For example, dairy farming requires important volumes of water and, therefore, even in irrigated areas it contributes to groundwater depletion in several regions of the country. This is a serious concern in the majority of irrigation schemes located in arid and semiarid areas where water stress is progressively causing the exodus of large dairy farms to more favorable areas in the north of the country. Another concern is the use of pesticides to increase fodder biomass, mainly through maize silage. Pesticide residues contaminate milk but their impacts on consumers, however, seem to be ignored by the operators of the dairy chain, from dairy farmers to milk processors and, above all, consumers themselves.

In order to promote the emergence of environmental issues within animal product supply chains, there must be a change in the methodological approaches used. More systemic methods should be adopted as they would include not only the comparison of animal product prices, but also their environmental footprint (energy and water needs mainly in a country with no fossil oil and with acute water stress), and their social cost. Such a systemic approach might prompt significant changes in the roles of extensive livestock systems located in the marginal areas of the country. Currently they have lost their prestige as they could not meet the growing needs for animal proteins in big cities. However, given the organic status of most products originating from rangelands (above all sheep and goat meat), they could gain ground among well-informed consumers who wish to avoid environmental and health risks associated to products from intensive systems. Such a change could be vital to the resilience of extensive livestock systems, as it would also help increase farmers' income and rehabilitate marginal areas, which face today important challenges such as unsustainable rhythms of resource use (mainly forests and water), pauperization and rural exodus.

To avoid the exacerbation of such problems and promote the harmonized development of rangelands, traceability of their products must be implemented. This will encourage many consumers who have become aware of the benefits of such products to consent to pay higher prices. This should only reward the efforts of livestock breeders in remote areas, who often have to face harsh conditions.

To achieve all these goals and balance the value repartition within the supply chains of extensive livestock systems, the adoption of good governance principles will be mandatory. That could only be

achieved with the responsible implication of all the actors (breeders' associations, retailers, consumers and State authorities), who have to be made aware of the crucial importance of this issue: rescuing extensive livestock systems in order to decrease the dependence on imported inputs and promote a sound social and economic development of the vast pastoral areas of the country. This would also reduce to a certain extent the consequences of recurring food price surges in global markets on the food supply to the population.

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Résumé

Sraïri M.T. Elevage extensif au Maroc : des territoires marginaux aux rôles essentiels socio-environnementaux

Les évolutions récentes de l'approvisionnement en produits animaux au Maroc ont montré une nette diminution de la contribution des élevages extensifs. Dans un contexte de forte croissance démographique (de 15,3 à 32,9 millions d'habitants entre 1956 et 2013) associée à une urbanisation rapide (près de 60 % de la population vit dans des centres urbains), les habitudes alimentaires ont clairement évolué. La structure patriarcale de la société, où les repas étaient consommés collectivement à la maison, a été remplacée par des comportements plus individualistes. Par conséquent, la nature des produits animaux consommés par de grands pans de la population a changé. Les produits laitiers et à base de volaille apparaissent les mieux adaptés à ces changements car ils s'incorporent aisément aux repas rapides. D'un autre côté, la consommation de viande de bœuf et de mouton provenant des systèmes extensifs n'a pas évolué. Ces systèmes permettent cependant de valoriser de nombreux aliments riches en fibres, comme les ressources pastorales et les coproduits de la céréaliculture. Ceci leur a traditionnellement permis d'assurer des fonctions stratégiques comme le développement régional de zones marginales, la gestion des ressources naturelles, la valorisation efficace de l'eau à travers les produits d'élevage dans un pays affecté par des pénuries d'eau aiguës, et la création de richesses et d'opportunités d'emploi. Le fait que ces systèmes d'élevage extensifs aient été délaissés au profit de systèmes plus intensifs soulève de nombreuses questions. Ces derniers ajoutent une immense pression sur les ressources naturelles des zones où la production intensive est concentrée. Cela signifie aussi que l'approvisionnement en produits animaux s'est fortement fragilisé car il dépend d'intrants importés, comme des gènes animaux et des produits alimentaires (soja et maïs pour la volaille). Ces évolutions nécessitent que plus d'attention soit accordée aux systèmes d'élevage extensif car ils assurent un mode de production écologique tout en valorisant de grands espaces ruraux. Ces systèmes tiendront un rôle stratégique essentiel dans un avenir proche lorsque les questions de durabilité de l'approvisionnement en protéines animales et de préservation des ressources naturelles deviendront pressantes, et pour permettre le développement équilibré des différentes régions du pays.

Mots-clés: ovin, volaille, bovin laitier, pastoralisme, élevage extensif, qualité des produits, agriculture intensive, race, Maroc

Resumen

Sraïri M.T. Ganadería extensiva en Marruecos: de territorios marginales a roles sociales y ambientales mayores

Desarrollos recientes en los suministros de productos animales en Marruecos revelaron una disminución aguda de la contribución de los sistemas de ganadería extensiva. En el contexto de una marcada expansión demográfica (de 15,3 a 32,9 millones de habitantes de 1956 a 2013) asociada a una urbanización rápida (casi 60% de la población vive en centros urbanos), los hábitos de consumo han cambiado. Ha habido un cambio de una estructura patriarcal de la sociedad, que significaba que las comidas se consumían en el hogar, hacia comportamientos más individualistas. Como consecuencia, la naturaleza de los productos animales consumidos por largas porciones de la población han cambiado notablemente. Los productos lácteos y avícolas parecen ser los mejores adaptados a estos cambios, ya que pueden ser utilizados en preparaciones de comidas rápidas. Al otro extremo, el consumo de res y ovino provenientes de sistemas extensivos se ha estancado. Sin embargo, los sistemas de producción extensiva, utilizan todavía una vasta cantidad de alimentos fibrosos, desde recursos provenientes de pastizales hasta sub productos de cereales. Tradicionalmente, esto les ha permitido asegurar funciones estratégicas como el desarrollo regional de áreas marginales, manejo de recursos naturales, productividad eficiente de agua a través los productos de ganadería, en un país que experimenta una escasez aguda de agua, así como la creación de riqueza y oportunidades laborales. El cambio de intereses de estos sistemas a unos más intensivos, plantea sin embargo muchas preguntas. Pone tremenda presión en los recursos naturales en áreas donde la producción intensiva está concentrada. Significa también que el suministro de productos animales es altamente frágil, debido a que depende de insumos importados, desde genes animales hasta alimentos (soja y maíz para aves). Estos cambios significan que se debe dar más atención a los sistemas de producción ganadera extensiva, ya que promueven una vía más ecológica de producción y promueve las grandes áreas rurales. Estos sistemas podrían sostener una posición estratégica en el futuro próximo, cuando venga el momento de enfrentar situaciones como la sustentabilidad del suministro de proteína animal y la preservación de los recursos naturales, así como asegurar un desarrollo balanceado de las diversas regiones del país.

Palabras clave: ovino, aves de corral, ganado de leche, pastoralismo, ganadería extensiva, calidad del producto, explotación agrícola intensiva, raza, Marruecos

Rethinking the role of sheep in the local development of Patagonia, Argentina

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Keywords

Sheep, land use, rangeland, desertification, colonization ability, Argentina

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Summary

Patagonia has the world's southernmost rangelands, which are among the last to be dedicated to farming. Commercial sheep herding in the area only started 100–120 years ago and thrived until the 1930 world crisis, triggering the rapid colonization of grasslands of diverse productivity. Besides this agronomic diversity, natural hazards such as droughts or heavy snowfalls associated with the vagaries of economic policies have always made sheep farming in Patagonia a very uncertain activity. Consequently, sheep gradually lost ground as the leading socio-economic activity to oil and gas production, fishing, and lately tourism. Things worsened during the last quarter of the 20th century to the point where the contribution of agriculture to the regional gross domestic product is today less than 5%. However, sheep farming is the only activity that ensures the occupation, even sparse, of the region and, owing to its pioneer character, it still plays a major part in Patagonian identity. Thus, we believe that mutton and wool production still have a role to play in the future of the region, although we argue that this issue would take the form of one of three scenarios that we termed “laissez-faire”, “park” and “sheep” according to the intensity of the decision involved and the funding required. The three scenarios could eventually coexist but long-term sustainability would have the last word.

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■ INTRODUCTION

Patagonia is located between 40° and 55° S, in the westerlies belt, and presents two sharply contrasted faces on either side of the Andes. On the windward side, Chilean Patagonia is a narrow strip of snow-capped mountains, lakes and fjords, with a windy, rainy, and cool climate. On the leeward side, Argentinean Patagonia consists of vast plateaus interspersed with fluvio-glacial valleys; climate is also windy and cool, yet dry because of the rain-shadow effect of the Andean range; annual rainfall exceeds 200 mm only in some favorable locations.

Until the 19th century, because of its austere environment, Patagonia stayed clear of the colonial ambitions of the Spanish and

British empires, although imperial attention was paid to the Falklands and the Strait of Magellan in order to control the transoceanic trade. Once the South American colonies gained independence, the world powers focused on the Argentine pampas and central Chile because of their agropastoral potential. Since 1879, the “Conquest of the Desert” by the Argentine army has appeared to be as much caused by the will of the young Republic to control its national territory as by the British interest to expand sheep farming for the benefit of wool companies already well established in the Falklands and Buenos Aires. A similar process took place in Chilean Patagonia, in Magellan area. The expansion of sheep was carried out at the expense of several thousands of Native Americans, who were killed, reduced to servitude, or scattered on the margins of the “new order”. Patagonia was thus free to be occupied by settlers of European ancestry coming from the Falklands, Buenos Aires, or central Chile, for the greater benefit of British, Flemish or German wool companies (Nouzeilles, 1999; Cibils and Borrelli, 2005).

Sheep numbers peaked in the 1950s when about 22 million animals were recorded. From then on overgrazing became evident, reducing the productive capacity of these rangelands. This, together with difficulties in commercializing wool and meat, led to the adoption of non-sustainable ecological and economic dynamics

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during the recent decades (Ares, 2006) as evidenced by a national stock as low as 10 million sheep in the 1990s.

Depending on the time and region, sheep farming has been carried out very extensively in plots ranging from 10,000 to 30,000 hectares, which would support flocks of 2,000 to 15,000 sheep. These figures were much higher in company-owned ranches. This model was mostly based on those that had built the wealth of the pampas and the Falklands; it only differed in the larger size of the fields. However, less than a century after the beginning of pastoral colonization, it has transformed much of the vast steppes of Patagonia in desert-like areas, especially in its central and eastern parts (i.e. regions with lesser rainfall), to the point that sheep grazing ended in many ranches (between one third and two thirds depending on the area). Some farms have managed to survive with a carrying capacity as low as one sheep per 8–12 hectares (Del Valle et al., 1997).

Other authors (Defossé and Robberecht, 1987; Cibils and Borrelli, 2005) argue that the combination of overgrazing and fire-wood gathering from shrub land (even if the latter was necessary because of the harsh climate) dramatically reduced the shrub and grass cover, leaving the soil unprotected against weather exposure and thus triggering the negative effect of desertification. However, sheep farming continues to prosper in ranches located along the Andean piedmont and in the far south around the strait, since these wetter regions are more productive. Additionally, some farms crossed by a watercourse can irrigate forage crops, mainly alfalfa hay, to supplement their flocks and cope with drought.

At first, the sheep introduced into Patagonia had been nonspecific crossbred, and named after their origin, i.e. Pampa for those that originated from the North and Malvinera for those from the Falklands. Later on, South Patagonia favored the dual-purpose Corriedale breed, whereas the North preferred the Merinos and specialized in wool production. At the beginning wool and mutton (processed in coastal freezing plants) were directly exported to Europe, but after World War II the Argentine meat market started to decline, whereas the wool market (and consequently Merinos) grew. The process is still going on and the Corriedale-Merinos border continues pushing southward (Figure 1).

Desertification in Patagonia would then be a direct consequence of the unwise application in arid rangelands of a productive model designed and adapted to wetter ecosystems such as the pampas or the Falklands. The original overestimation of the carrying capacity of these rangelands led to their overstocking during a century and is considered as the main cause of its current desertification (Golluscio et al., 1998). Since the 1950–1960s, this compelling environmental context has been aggravated by the weakening of the sheep industry in Patagonia, comprising both wool and meat production, and had been negatively influenced by the vagaries of Argentine politics and by globalization, especially from the many variations in the international market for agricultural products. This resulted in the high vulnerability of surviving family farms, especially the smaller ones, which had somehow found ways to adapt their management in order to mitigate declining productivity. The fragile sustainability of these farms led to an unbalanced regional development, with the countryside depopulating and a growing number of rural people being gradually evicted to the suburbs of regional cities and becoming an acculturated proletariat.

Although Patagonian sheep farming has always been an all-man activity, families used to live in the estancias until the 1960s (the children however lived in boarding schools in town during the week and returned home over the weekends or only in summer if the town was far away). This explains why preferred sheep workers are single men and rural areas depopulate. Since in Patagonia

the usual man/sheep ratio is 1/2000, most ranches can be easily managed by one or two men, and very often one of them is actually the owner who lives in town where he has his main job.

Fortunately for the Patagonian economy the collapse of sheep ranching was offset by alternatives such as oil, gas and coal production, and tourism development. Although spatially very concentrated, these activities today support the territorial development as well as increasing metal mining and fishing. Urban centers are now interconnected by networks of roads, cables, pipelines and airports. Therefore, the Patagonian economy can well dispense with the rural sector (which currently only provides 5% of the regional gross domestic product). These changes concern the whole society, including traditional landowner families who have repositioned themselves in the reorganized social networks.

According to our scholar experience in sheep ranching in Patagonia and after discussing with the main stakeholders in the sheep industry there, we were led to rethink the future of Patagonian sheep ranching so as to construct several scenarios, among them three of the most contrasting ones caught our attention. The first one, termed “Laissez-faire”, lets the present situation go on, which entails the development of land speculation on the rural areas and the accretion of bankrupted units into larger ranches, possibly only partly productive and owned by a few major national and international groups. The second scenario, termed “Park”, is based on a decidedly scenic valorization of the rural landscape with the conversion into parks of vast portions of Patagonian ecosystems, once degraded by sheep. Current agrotourism in landscape-favored ranches might indicate an intermediate step in this direction. The third scenario, termed “Sheep”, explores the revival of the

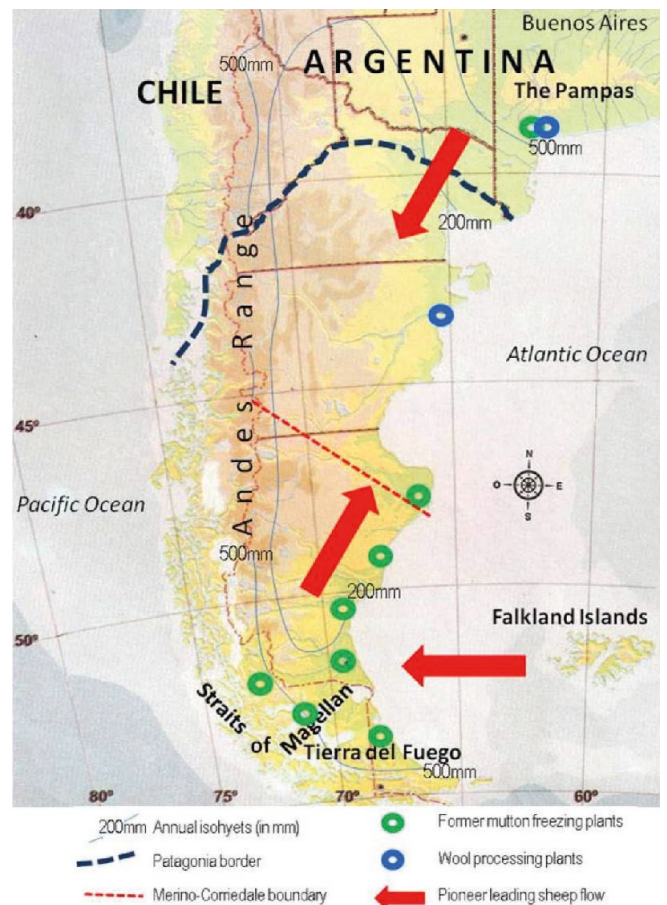


Figure 1: Map of Argentina showing the Corriedale-Merinos sheep border.

sheep-breeding vocation in Patagonia with the restarting of family businesses based on sustainable socio-technological systems that require human and financial resources through public policies (possibly derived from the wealth of the subsoil). The current devolution of large spans of land to Native American communities could contribute to this pastoral perspective but a general zoning system based on land use alternatives would be strongly needed.

■ DISCUSSION

As stated above, the collapse of the sheep farming industry in Patagonia allows us to call it “restarting the system” from 2000 on. Nevertheless, according to current trends the most likely future of Patagonian sheep farming may emerge from the present scenarios sketched hereafter.

Laissez-faire

The very name of the *Laissez-faire* scenario suggests that it would mean a kind of “agrarian inertia”, i.e. the continuation of the general declining trend of wool and mutton production with the laws of the market acting freely in a weakened economy. In this scenario it is possible to imagine a greater concentration of land tenure with the creation of vast ranches of several tens or even hundreds of thousands of hectares. Without surprise, winners would rarely be people with sheep breeding tradition or knowledge, but rather investors, who often are not even from the region.

Mining, from the very simple stone quarry to the sophisticated uranium extraction or polymetallic mega exploitations, will always be a real threat to unsustainable ranches located in exposed-bedrock areas, whereas those in sedimentary tablelands are threatened by oil exploration and exploitation. Regardless of the type of mining involved, some ranches located next to the deposits are already finding a new source of income by providing services to miners.

As mentioned above no alternative activities are needed to quit sheep farming: many ranches that became unsustainable were simply abandoned by their owners, the sheep sold and gates padlocked. Along with social issues, this generates ecological problems such as the proliferation of predators like pumas or foxes that attack the remaining flocks next door (Novaro and Walker, 2005).

There may be conflicts to manage on land ownership between large companies, small farmers, and Native American communities that could claim their so-called ancestral lands. There will necessarily be a deep urban-rural imbalance as this is already observed today.

Park

The Park scenario would boost the tourism economy, in line with the adventurous and ecological side of Patagonia as a trademark and would build on a cultural, environmental, and sustainable development foundation. Agrotourism is already a financial input to an ever growing number of ranches located in scenic areas. The website www.estanciasdesantacruz.com is just an example of the vitality of this initiative. Of course, sheep farming and the traditions related to it are carefully-preserved tourist attractions, especially in ranches less favored by scenic beauty or history.

In this scenario, sheep adopt the role of ecosystem gardeners in largely under stocked paddocks, where they can eventually coexist with guanacos and rheas. These non-domestic species are no longer seen as competitors of sheep but as a natural attraction in the park.

About 95% of Argentine Patagonian land is private property, which explains why the park scenario has already started in private ranches, even if in some cases public reserves have been created too. Pushing this scenario to the extreme, one could imagine an active government commitment in creating national parks (if the area is scenic or worthy of preservation from a scientific point of view) or just national reserves in less favored areas. However, the cost would be high because of the expropriations needed. Arguably the funds collected from mining in other areas, from the fishing industry or from the tourist trade itself could be used to this end.

National reserves in currently unused spaces occupy vast areas in Chilean Patagonia, but are void lands, never occupied before. In Argentina, national reserves in previously grazed rangelands would mean the utter recognition of the failure of sheep farming in colonizing Patagonia. Moreover, mining or great infrastructure works are not welcome in this conception of regional land use, even at current public opinion level. “No dams in Patagonia” and “No to mining” are frequently tagged on Patagonian walls.

Sheep

To recover Patagonia’s sheep-breeding vocation might be the lesser risk from a political, economical and social point of view. Considering the depth of the current depression, sheep revival is a huge task which would require the joint involvement of ranchers and government. Actually, both have recently taken some interesting initiatives; they tend to consider wool and mutton as specialties rather than commodities as it was the case until recently.

Even though diverse official and private efforts to raise production quality start to bear fruit, much remains to be done. Public institutions and private organizations promote shifting to eco- or organic-labeled sheep products which are paid at much higher prices in the market. For instance, the organic-certified wool by the Organización Internacional Agropecuaria brings in 12–15% more than non-labeled wool, bridging to some extent the sheep and park scenarios. Another example of converging scenarios is the synergy between local sheep farming-oriented organizations such as OVIS 21⁵ and international boards such as The Nature Conservancy, which promotes the conservative management of rangelands reserved to sheep in Patagonia that could contribute to improve the landscape⁶.

Agronomic constraints however seem to restrict these encouraging views to favorable areas while condemning others to greater efforts to overcome their geographic limitations. The aqueduct of Trelew-Uzcludun, built by ranch owners in eastern Chubut, is a good example of a private associative initiative to get over production difficulties. On the government side, production credits targeted to specific geographical areas should be preferred to widespread subsidies and compensations. Besides, official technical agencies such as the Instituto Nacional de Tecnología Agropecuaria have active responsibility in improving the production chain both upstream and downstream from the breeding level, with the establishment of sustainable management of rangelands. However, it is suggested that measures to restore and protect Patagonian ecosystems would gain greater acceptance if local producers were seen as equals in the conservation and development process. This could be achieved by replacing the traditional top-down models of policy design by implementing measures based on genuine consultation and participatory community-based approaches to natural resource management (Aagesen, 2000). Table I shows a simplified version of a SWOT (Strengths – Weaknesses – Opportunities – Threats) matrix that summarizes what has been stated above.

5. www.OVIS21.com

6. www.nature.org/ourinitiatives/regions/southamerica/argentina/

Table I

SWOT matrix of the sketched scenarios for the future of sheep farming in Argentine Patagonia

	Strengths	Weaknesses	Opportunities	Threats
Laissez-faire	Currently in force Free initiative Ubiquity	Individualism Imbalances generated (<i>economy, demography</i>) Labor scarcity	Wide reaching Technical support Services provided	Mining Land hoarding Depopulation Land use conflicts
Park	Ecological trademark International support	Some expropriation needed Restricted diffusion Predator Overpopulation	Reassess native culture History rescue	"For export" stereotyping Excessive openness to the outside world
Sheep	International market assured Regional identity preserved	Some areas excluded Restricted diffusion Big investments	New regional productions Widen participation	Separatism Native claims

CONCLUSION

Sheep farming in Patagonia was at its lowest around the turn of last century, closing a cycle started one hundred years earlier, whose heyday (in stock) was reached in about 1950. The depth of the fall was enough to trigger some healthy reactions about how the future of the activity and therefore the future of the region should be, since sheep farming is the most widespread land use in Patagonia and deeply anchored in the regional identity (Coronato, 2010).

In recent years Patagonia's sheep stock has been increasing because of higher international wool prices, favorable domestic currency policies and the adoption of improved production technologies. Even so, this trend is expected to have reached its peak (Villagra et al., 2010) and a generalized recovery of the sheep-breeding industry seems unlikely.

Therefore, no future trend clearly stands out and we believe that any of the three scenarios described above could eventually prevail in the next decades. The more probable future of the Patagonian sheep industry would be a mixed scenario, not only in the involvement of the concerned actors but especially from a geographic standpoint. We believe that a regional land use plan is greatly needed to carry out zoning so as to define (on paper and in government policies) areas where one of the three scenarios should prevail, or at least, areas in which sheep ranching is no longer sustainable. As Noy-Meir (1995) clearly states: "Livestock production from rangeland is now feasible and sustainable only in certain parts of Patagonia; while in other parts there are no feasible solutions or opportunities for either maintaining it, or for re-establishing sustainable production."

Patagonia is large enough to enclose i) areas where no changes to the present situation would be introduced, ii) areas in which scenery or historical facts would justify their conversion into parks

or reserves if they are too degraded (and be eventually sacrificed to mining), and iii) areas whose agronomic conditions are good enough to secure a sustainable (and improved) sheep farming system, producing high-quality mutton and wool.

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Résumé

Coronato F., Fasioli E., Schweitzer A., Tourrand J.-F. Repenser le rôle des moutons dans le développement local de la Patagonie en Argentine

Les parcours de Patagonie sont les plus au sud de la planète et parmi les derniers à se consacrer à l'élevage. La filière ovine s'y est installée depuis seulement 100–120 ans et a prospéré jusqu'à la crise mondiale de 1930, provoquant la colonisation rapide de parcours de productivité diverse. Mise à part la diversité agronomique, les risques naturels comme la sécheresse ou les fortes chutes de neige, associés aux aléas des politiques économiques ont toujours fait de l'élevage ovin en Patagonie une activité très incertaine. Ainsi, cet élevage a peu à peu perdu son rôle d'activité socio-économique principale face à l'exploitation de pétrole ou de gaz, la pêche, et dernièrement le tourisme. La situation s'est considérablement aggravée pendant le dernier quart du XX^e siècle ; la participation du secteur agricole dans le produit intérieur brut régional n'atteint pas aujourd'hui 5 %. Cependant, l'élevage ovin est la seule activité qui assure l'occupation, même faible, de l'ensemble de la région ; cette activité pionnière permet au mouton de conserver un rôle important à jouer dans l'identité de la Patagonie. Ainsi, nous estimons que le mouton, tant par la filière laine que par la filière viande, continue d'avoir sa place dans l'avenir de la région. Nous soutenons que l'avenir du mouton en Patagonie serait dans l'adoption de l'un des trois scénarios que nous appelons « laissez-faire », « parc » et « mouton » en fonction de l'intensité des interventions et des fonds mobilisés. Les trois scénarios pourraient coexister mais la durabilité sur le long terme aurait le dernier mot.

Mots-clés: ovin, utilisation des terres, parcours, désertification, aptitude à coloniser, Argentine

Resumen

Coronato F., Fasioli E., Schweitzer A., Tourrand J.-F. Reevaluación del papel de la oveja en el desarrollo local en Patagonia, Argentina

La Patagonia posee los pastizales más australes del mundo y son parte de los últimos dedicados a la agricultura. La cría comercial de ovejas en la zona se inició sólo hace 100–120 años y prosperó hasta la crisis mundial de 1930, provocando la rápida colonización de praderas de diversa productividad. Además de esta diversidad agronómica, los riesgos naturales, como las sequías o las fuertes nevadas, asociados a los caprichos de las políticas económicas, siempre han hecho de la cría de ovejas en la Patagonia una actividad muy incierta. En consecuencia, las ovejas perdieron terreno gradualmente como principal actividad socioeconómica, frente a la producción de gas y petróleo, la pesca, y últimamente el turismo. Las cosas empeoraron durante el último cuarto del siglo 20, hasta el punto en que hoy la contribución de la agricultura al producto interno bruto regional es menos del 5%. Sin embargo, la cría de ovejas es la única actividad que asegura la ocupación, aunque escasa, de la región y, debido a su carácter pionero, sigue desempeñando un papel importante en la identidad de la Patagonia. Por lo tanto, creemos que la carne de cordero y la producción de lana, todavía tienen un papel que desempeñar en el futuro de la región, aunque argumentamos que esta posibilidad debe incluir uno de los tres escenarios que hemos llamado de « laissez-faire », « estacionario » y « ovejas », según la intensidad decisional implicada y los fondos necesarios. Los tres escenarios podrían eventualmente coexistir, pero la sostenibilidad a largo plazo tendrá la última palabra.

Palabras clave: ovino, utilización de la tierra, tierra de pastos, desertificación, aptitud colonizadora, Argentina

An innovative method to assess the sustainability of pastoral systems in their territories (PSSAF)

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Keywords

Pastoralism, territory, sustainability, assessment

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Summary

The future of pastoral systems and their interactions with territories are the subject of considerable debate in the scientific literature and are still insufficiently documented. Assessing the sustainability of pastoral systems and their interactions with the sustainability of territories is thus a complex task. We proposed in this study a method to assess the sustainability of pastoral systems within their territories. After reviewing the literature, we conducted interviews with pastoralism experts in France and in Africa on the subject of sustainability in general and pastoral systems in particular. We designed our grid according to the principles-criteria-indicators approach and included 10 principles grouped into three major fields: 'Availability of resources in the territory', 'Properties of the system', and 'Extended sustainability'. Understanding the strategies used in pastoral systems enabled us to propose a set of specific criteria per principle. Finally, we compared our grid with other methods used to assess sustainability.

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■ INTRODUCTION

Pastoralism is the use of rangelands through mobility for livestock production (FAO, 2001). Worldwide, pastoralism supports 20 million households and ensures 10% of world meat production (FAO, 2001). Rangelands with spontaneous vegetation are the key resources for pastoralism. This agricultural production system is mainly encountered in areas where cropping is not reliable, such as arid lands or mountains of the Mediterranean basin, the Middle East and sub-Saharan Africa.

In the European countries of the Mediterranean basin, pastoralism is affected by environmental issues. Grazing on rangelands enables open landscapes, including both habitat and biodiversity, and is also one way to control forest fires. In addition, rangelands provide cheap feed and ensure a link with the territory, thus valorizing animal products guaranteeing economic returns to livestock farmers. In this manner, pastoral systems contribute to sustainable development. Nevertheless, the economic viability of pastoral farms is faced with uncertainties.

In arid lands of West and East Africa, pastoralism is not only a livestock production system but also a livestock-based livelihood strategy and a way of life with its own sociocultural norms and values (Ayantunde et al., 2011). Today's changing contexts raise the issue of the sustainability of pastoral systems. They face demographic, economic, sociopolitical and climatic pressures which drive many pastoralists to switch to non-livestock-based livelihood strategies (Barbier and Lopez-Ridaura, 2010). Despite the central function of livestock in reducing poverty and supporting food security in these countries (FAO, 2011), the sustainability of pastoralism is questioned.

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However, assessing sustainability of pastoral systems is still a major scientific issue. Concerning pastoral systems in Africa's arid lands, Ayantunde et al. (2011) stressed the need for a holistic approach to address the sustainability of pastoral systems, whereas many attempts have been made to address it from a single perspective. In the Organization for Economic Cooperation and Development (OECD) countries, many approaches have been developed to evaluate production systems from an environmental perspective, using methods such as the life cycle assessment (Van der Werf and Petit, 2002; Piorr, 2003). Some holistic approaches have recently been developed by researchers, with *ex ante* assessment of projects or scenarios (Terrier et al., 2010), or diagnoses of current situations (Lopez-Ridaura et al., 2002; Ripoll-Bosch et al., 2012).

In France, the IDEA⁴ method was the only multisectorial analysis identified by Guillaumin et al. (2009) in a review of available methods for extension services to evaluate the contribution of ruminant production to sustainable development. This method is based on the attribution of a sustainability score to a set of indicators, combining environmental, social and economic dimensions. The scores are attributed with respect to an ideal mixed crop-live-stock system. But the method is still not entirely satisfactory since it focuses on the farm and the land cultivated around it. Relations between the farm and the pastoral area over which the livestock moves are not taken into account. A diagnosis on the sustainability issues of each pastoral system needs to be performed in order to encourage debate between stakeholders without an *a priori* model of sustainable pastoralism.

The sustainability of a system can be assessed in several ways (Hopwood et al., 2005). Two main approaches are described in the literature. The first uses the definition of sustainability as a starting point for the construction of an assessment grid. In this case, the aim is to define sustainability using the scientific literature, official texts and/or participatory methods, and to use this definition as the basis. The second approach defines the object to be assessed as the basis for constructing the grid (Lopez-Ridaura et al., 2002). It consists in defining the systems, determining their main stakes, constraints and objectives, and using them to build the grid. We combined the two approaches in order to be i) as exhaustive as possible with respect to the sustainability concept, and ii) as close as possible to the specificities of pastoral systems.

Methods to develop a principles and criteria framework

Starting from a review of the literature on sustainability assessment, we built a framework based on 'principles' and 'criteria' that we called the Pastoral Systems Sustainability Assessment Framework (PSSAF), for further development of grids to enable a diagnostic approach of sustainability stakes for pastoral systems in their territories. Principles refer to the main topics that structure our assessment of sustainability. They can be used systematically for all kinds of systems but also reveal our point of view on sustainability (Boutaud and Brodhag, 2006). Given that a grid needs to be system specific, defining the criteria allows the introduction of items that are specific to the systems. In a final step, indicators represent the concrete information and data to be collected. These indicators must be specific to the territory as they depend on the socioeconomic and biophysical context as well as on the availability of data for each territory.

In order to develop principles, we first used knowledge of a pool of experts on pastoral systems. We then confronted our view on

pastoral systems to results/observations on sustainability in various fields in the literature (e.g. animal sciences, economics and social sciences).

To build the criteria, we used the literature and information collected during interviews with experts; 10 interviews were conducted with experts in research or development institutions in Senegal, and 15 in France. We selected the researchers based on their disciplinary approach (to ensure multidisciplinary points of view), and only in the French speaking scientific community (to make sure nuances could be expressed and understood during interviews). We included both private and public development organizations [consulting firms, non-governmental organizations (NGOs), government services] to ensure a wide range of discourse about pastoral systems wherever their location. This enabled us to achieve a high level of understanding of pastoral systems, and their technical, social and economic strategies. The range of experts we interviewed enabled us to highlight crucial strategic elements of pastoral systems, to assess the relevance of the 10 principles, and define the criteria for each principle.

■ RESULTS

Framework of three fields to be analyzed and ten principles

A territory provides certain resources (availability) for farming systems (Figure 1). A system must control access to resources (accessibility), has to cope with external shock (vulnerability), and finally has more or less influence on the territory (impacts). These elements were considered with the aim of maintaining the production system and ensuring its renewal. Moreover the aim of our grid was to enable assessment in the sense of the diagnosis of a system. We defined the main structure by referring to several theoretical corpuses on sustainability assessment through three fields of analysis:

- 'Availability of resources in the territory';
- 'Properties of the system';
- 'Extended sustainability'.

The fields chosen for the assessment grids had the advantage of allowing a transversal approach including the classic three pillars of sustainable development (economic, social and environmental). Within each field of analysis, we defined several principles based on our point of view on sustainability (Figure 2).

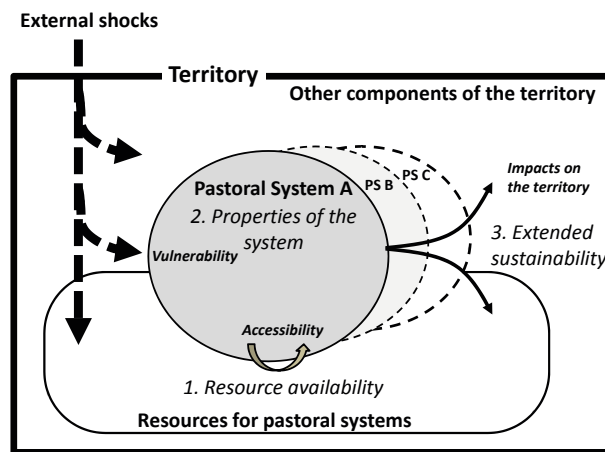


Figure 1: The object to be analyzed: a pastoral system in its territory.

4. Indicateurs de durabilité de l'exploitation agricole, i.e. farm sustainability indicators

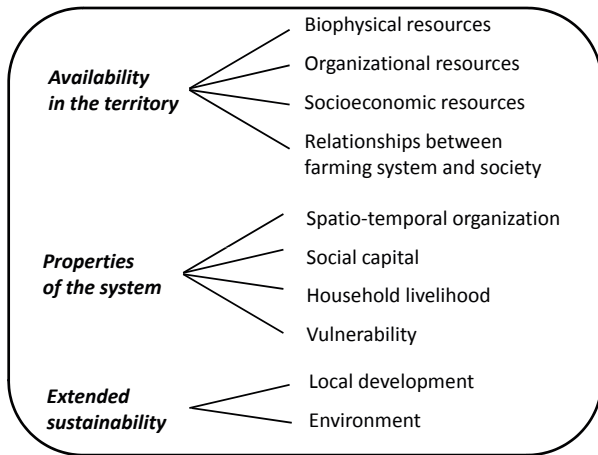


Figure 2: Ten principles grouped into three fields of analysis.

Availability of resources in the territory

Addressing the sustainability of systems at a territorial scale means analyzing factors that enable the renewal of the systems. Natural sciences mainly focus on the links between the human system and the biophysical environment, and consider environmental sustainability as the mainstay of natural capital (Goodland, 1995). In this approach, the environment is viewed as a resource for human systems so that one needs to preserve it. This approach led us to consider several components of the territory as resources for farming systems (Thompson and Nardone, 1999). This may concern the links between a farming system and its biophysical environment (as an ecosystem) but also its links with the territory as a whole, including economic and social interactions. We then considered the productive activity of the systems as well as their social and cultural dimensions. Here we defined a territory as “an area used and managed by human societies” (Brunet et al., 1992). We organized territorial resources in three categories of principles: i) biophysical, ii) organizational and iii) socioeconomic resources. Finally, under Availability of resources in the territory, we chose to introduce the notion of relationship between farming systems and society. Here we stressed the importance of assessing the cultural and political links between a farming system and the society in which the system is embedded.

Properties of the system

In parallel with the concept of resource availability, we analyzed the Properties of the system, firstly on the access to available resources and secondly on the vulnerability of the system. The notion of accessibility is a way of accounting for the capacity of a system to use available resources. Sen (1983) highlighted the need to distinguish between the availability of resources and their accessibility for the systems through system entitlements; individuals' entitlements are the economic, social, political characteristics that determine their access to goods and services (Bertin, 2003); they are also called capabilities by McKenzie (2004). In our approach to farming systems, we defined the capabilities of farming systems and their access to resources through the spatial organization and the economic and social capital. By Properties of the systems we meant the characteristics linked to the management of vulnerability. The vulnerability concept is frequently used to address the issues of sustainability and adaptation to global changes. In addition, it can be used to analyze socioecosystems (Décamps, 2007). The aim was to understand how a system reacts when it is affected by an external shock but also to measure its capacity to adapt to

more regular changes. We believe it is vital to consider this point in a rapidly changing world.

Extended sustainability

Finally, the sustainability of pastoral systems could refer to the balance between the outputs of the farming systems (environmentally and socioeconomically). We applied the concept of Extended sustainability developed by Terrier et al. (2010). We thus considered the different dimensions of how systems could contribute to the sustainability of territories. The field Extended sustainability concerned the assessment of the contribution of farming systems to the sustainability of territories. This implied assessing the contribution of farming systems to the biophysical environment (Zhang et al., 2007) as well as to local development. Determining their influence on local development required assessing their contribution to the conservation of rural life in a given territory, i.e. their social and economic consequences.

Definition and specificities of pastoral systems

To build the criteria associated with these principles, we used the definition of the specific object to be assessed, the pastoral system. We chose contrasted situations as analytical support (the South of France, North Africa, sub-Saharan Africa) and used a common definition of pastoral systems, i.e. extensive production systems based on herbivorous livestock rearing, on spontaneous resources (Daget and Godron, 1995). In sub-Saharan Africa, pastoralists rely mainly on spontaneous resources, sometimes providing cereals as supplementary feed during a drought, or crop residues after harvest (Homewood, 2008). In Mediterranean systems, spontaneous resources are used as often as possible, but during winter forage and cereals are very often provided as supplementary feed (Bourbouze and Lazarev, 1991).

Spontaneous resources vary considerably and are tightly linked to climate conditions. This sensitivity to climatic variations has major consequences for pastoral systems which have to cope with the temporal and spatial variability of resources and are generally organized around the growth pattern of the resource concerned. This means that the system requires large amounts of land if cheap resources are to be exploited all year round and may require two main types of strategies: i) mobility and ii) the management of resources of several different origins that depend on different forms of land tenure. Our aim was to design a grid able to assess pastoral systems using these two strategies.

The first specificity of pastoral systems, mobility, is linked to the spatial and temporal variability of resources. Several schemes have been developed to portray mobility (Adriansen, 1999; Homewood, 2008) in different regional contexts and including a wide range of durations and amplitudes. Regardless of the scale of mobility (within the farm, within the territory or between territories), we considered mobility as a way to cope with unpredictable events (Wiese et al., 2008; Adriansen, 1999). In practice, beyond seasonal variability of resources, extreme variability (for example drought) is often managed by pastoralists through mobility. This temporal and spatial flexibility is an advantage for pastoral systems in unpredictable conditions (Davies, 2008).

The second specificity of these systems is managing a variety of feed resources that differ not only in terms of botanical composition but also in terms of land tenure. The role played by land ownership varies considerably depending on the system concerned. For external resources, a wide range of land-tenure systems exists. Pastoralists have to cope with these different types of tenure (Thébaud and Batterbury, 2001) and they generally maintain long-term relationships with land managers to ensure regular access to the main

resources they need for their animals, but they may also need to develop rapidly other alliances for instance in case of extreme events or in the face of high uncertainty. Then in each social context, pastoralists need to belong to social networks to be efficient. Based on this definition and the specificities of pastoral systems, we proposed a set of appropriate criteria.

Criteria to characterize the three principles of sustainability of pastoral systems

Criteria related to Availability of resources in the territory

The main spontaneous resources for pastoral systems are range-land and water (Table I). They vary in time and space and involve several possible resource tenures. Their availability is critical for the survival of pastoral systems (Bouche, 2011). Among biophysical resources, we include both functional characteristics and resource renewal and their spatial distribution within the territory (Homewood, 2008). This implies assessing ecosystem dynamics (functioning and renewal) and the range of resources available in the territory (Von Wehrden et al., 2012).

Concerning organizational resources (Table I), some are linked with the management of pastoral resources (Thébaud and Batterbury, 2001). Land tenure, access rules, knowledge and social relationships must be considered to assess sustainability. The second part of organizational resources is not linked to the management of pastoral resources but to the variety of professional networks. These networks may be a major component of the sustainability of pastoral systems because of the role they play in day-to-day activities of the systems (health and technical services, marketing) but also their role in the need for change.

Socioeconomic resources were analyzed to evaluate the basic needs of a family (Table I). These included food security as well as quality of life. Unlike studies on food security in the literature, which are mainly based on household or individual food security (Maxwell and Frankenberger, 1992), we assessed global availability at the territorial scale combined with accessibility principles. The quality of life and welfare is far more complex and is specific to local contexts. Consequently, we suggest that grid users select the factors they consider the most important for the territory concerned, which may assess socioeconomic needs (education and health) as well as the quality of the natural environment.

Given that society is increasingly concerned with sustainable development, the relationship between society and farming systems needs to be identified as a precondition of sustainability. We analyzed this relationship as a potential territorial resource for farming systems based on social recognition of the systems and, as a consequence, politicians' commitment to ensuring the survival of pastoral systems in their own territories (Hesse and Thébaud, 2006).

Criteria related to Properties of the system

We addressed here the implicit Properties of the system (Table II), i.e. the accessibility of resources for the system (spatio-temporal organization, social capital, family resources) as well as the ability of the system to cope with uncertainty (level of vulnerability). Access to biophysical, organizational or socioeconomic resources, depends on several principles and related criteria. Maintaining mobility is crucial for the majority of pastoral systems worldwide. The sustainability of mobility can best be assessed by identifying constraints to mobility (access to pastures, family organization). Concerning spatial organization, many pastoral systems are located in remote areas far from resources that are important for professional and personal use. Criteria describing physical links or access to resources were defined here.

We defined social capital as a means of empowering families. Empowerment implies having access to social networks and related goods and services (Adger, 2003). We thus defined a way to characterize the rights of access and the position of the social group.

Table I

Principles and criteria applied to 'Availability of resources in the territory'

Principles	Domain of criteria	Main criteria
Biophysical resources	Vegetation	Functional diversity of spontaneous resources Renewal of spontaneous resources Secure area (spontaneous or cultivated)
	Water	Supply regularity Quality
	Spatial distribution	Existing infrastructures Land occupation Secure areas
Organizational resources	Management of pastoral resources	Access conditions Governance rules Knowledge transmission and renewal Relations between stakeholders
	Professional networks	Network range Dynamics and transformation Access conditions
Socioeconomic resources	Food security	Product range Regularity Price balance Product origin
	Quality of life	Socioeconomic Environmental
Relations between farming system and society	Recognition by society	Recognition of cultural heritage Likelihood of product consumption
	Political commitment	Inclusion of pastoral system in territorial projects Legislative framework Involvement of pastoral system representatives in political networks Support in case of emergency

Table II
Principles and criteria applied to
'Properties of the system'

Principles	Domain of criteria	Main criteria
Spatio-temporal organization	Mobility	Mobility factors Changes in access conditions Match with family life
	Personal and professional activities	Work organization Location in relation to resources Transport means Ability to preserve products
Social capital	Access right	Access conditions
	Social group characteristics	Internal dynamism System legitimacy in the territory
Household livelihood	Self-consumption	Food autonomy Regularity and periodicity
	Income	Income level Income functions Regularity and periodicity Income structure
Vulnerability	Exposure/sensitivity	Level of dependence / factor Fragility of the system Ability to anticipate
	Adaptive capacity	Buffering capacity / factor range Leeway/theme

Next, analyzing households implies assessing the ability of the system to ensure food security and create income. We thus included food autonomy and the regularity of food supply, since some pastoral systems are based on self-consumption strategies. Concerning the generation of income, we identified the different sources on the farm: livestock production and other activities. Multiactivities and complementary sources of income play a role in the accessibility of external resources for the system as well as in the adaptive capacity of the system (Scoones, 1998).

We proposed the principle of vulnerability by referring to the theoretical corpus of knowledge in the literature (Gallopín, 2006; Smit and Wandel, 2006). As a result, we based this principle on three criteria: exposure to disturbances, sensitivity, and adaptive capacity. Exposure to disturbances and sensitivity were treated together as suggested by Smit and Wandel (2006). To assess criteria related to the Properties of the system when faced with external disturbances, we suggested for instance analyzing the strength of the links that connect the system with the external factor concerned (these factors vary with the territory and will consequently need to be defined for

each new application of the grid). To assess the adaptive capacity of the system (Darnhofer et al., 2010) we used the concept of buffering capacity. We hence analyzed the capacity of the system to cope with a range of disturbance, possibly by temporarily modifying its functioning before returning to its original condition.

Criteria related to Extended sustainability

Concerning the impacts of a pastoral system on the environment, first principle in this field, several factors need to be mentioned (Table III). As these vary with the territory concerned, we did not write up a ready-to-use list but instead suggested two domains in which they can be classified: influences on pastoral resources, such as spontaneous renewable resources, and general influences (e.g. water, air). Here the aim was to draw up an inventory of different variables (around a specific topic) for a particular territory (de Wit et al., 1995; Payraudeau and van de Werf, 2005) to analyze their connection with pastoral systems and to classify them according to their domain of influence.

Concerning the second principle in the field Extended sustainability, pastoral systems can influence local development in different ways. The aim here was to evaluate the role of pastoral systems in maintaining rural dynamics in a territory. The evaluation could concern influences related to livestock production but also influences related to the survival of a society in the territory (Manoli et al., 2010). The location of pastoral systems in remote areas logically led us to include the demography issue, employment, and services as factors involved in the sustainability and development of territories. Specifically concerning the influences of livestock production activities, we suggested analyzing both their influence on wealth production and on market chain dynamics.

Table III

Principles and criteria applied to
'Extended sustainability'

Principles	Domain of criteria	Main criteria
Influences on the environment	Influences on pastoral resources	Pastoral resources structure, dynamics and productivity
	General influences	Other resources, dynamics
Influences on local development	Demography	People density
	Employment	Livestock related employment and others
	Services	Livestock related services and others
	Wealth production	Market value Cultural heritage value

DISCUSSION

The approach presented here (PSSAF) has a particular way of addressing the sustainability of systems. The field Availability of resources in the territory describes the territory (its biophysical and socioeconomic dimensions) and its capacity to host pastoral

systems. It is not limited to a stable situation but it assesses the possibilities for renewal based on the organization of the resources by stakeholders. This field has to be filled out only once for any given territory in a given period. The field Properties of the system covers the structural and functional characteristics of a system and its technical and economic performances. It has to be filled out for each system identified in the territory because the systems do not all share the same characteristics in terms of production, social groups and activities. Lastly, the field Extended sustainability specifies the impacts of each system on the territory. At this point, each system is assessed through its (positive or negative) externalities and its relative importance needs to be defined (e.g. number of families, total number of animals).

An original aspect of PSSAF was that we tried to avoid using a normative-technical approach (Barbier and Lopez-Ridaura, 2010). The only technical point concerning the system was the mobility criterion, which we considered to be a major condition for such systems to be classified as pastoral. In the absence of mobility, such systems lost their 'pastorality'. We designed the grid to enable a diagnostic analysis of systems in a particular territory, not to provide a model or to compare systems in different territories. As a consequence, this method allows studying a range of different pastoral systems, highlighting their weaknesses only from the point of view of their sustainability. This resulted in a large number of criteria, i.e. 54 for 10 principles. Its practical implementation is thus more time and labor consuming than IDEA (16 objectives for 41 indicators). But our objective was different: the designers of IDEA provided a more normative method to assess the capacity of farms to achieve the objectives proposed (Zahm et al., 2008). To this end, they established scores for several indicators and could consequently make comparisons. PSSAF is closer to EDAMA⁵ (Terrier et al., 2010) or EVAD⁶ (Chia et al., 2009), which are also time and labor consuming to implement (EDAMA: 32 themes and 61 indicators; EVAD: 13 principles and 81 criteria). The objectives of these methods are closer to ours, i.e. to perform a diagnosis of sustainability.

As a structured list of principles and criteria, PSSAF can be used by several kinds of stakeholders as it stands. Concerning its implementation, we suggested two alternatives, both based on the postulate that indicators need to be specific to the situation to be analyzed. The first is to use the grid containing principles and criteria as a support for discussion between the actors of a territory. Considering the wide range of stakeholders involved in the development of territories (e.g. collectivities, individuals, companies), this could be a very interactive way to encourage actions for sustainable development at territorial level. In this case, the aim is to reach a shared view of the sustainability of a territory and to encourage recommendations that result from actors' discussions concerning the choice of indicators. It is a way of promoting participatory approaches like MESMIS⁷ in the case of natural resources management in Mexican and Latin America contexts (Lopez-Ridaura et al., 2002), or EVAD in the case of analyses of an aqua cultural territory (Chia et al., 2009), which have been successful.

The second alternative consists in a development agent using the grid with its principles and criteria. The agent could be a consultant, or an NGO or administrative agent. In this case, the aim is then to build a set of specific indicators for a particular territory and to use it to perform a territorial diagnosis. A trial was conducted

between Luberon Natural Regional Park (PNRL) in France and the Center for Studies and Realization in Pastoral Mediterranean Alps (CERPAM) to test the ability of the grid to fulfill this function, i.e. perform a territorial diagnosis. PNRL and CERPAM have long been partners in the search to define and implement the best development policies of these areas. Their aim is to promote local development and environmental preservation of zones designated as protected areas (natural regional parks, biosphere reserves, Natura 2000 policies) and they felt that PSSAF was able to help them structure their diagnosis and therefore choose between several policy options. The analyses concerned the Luberon and the Lure mountains, where three pastoral systems coexist: Mediterranean ewes raised for meat, pre-Alpine ewes raised for meat, and dairy goats and ewes. A CERPAM and a PNRL agent started identifying sustainability indicators for their territories (e.g. quantitative or qualitative data, synthetic indicators, expert intuition). The experience confirmed the relevance of the method for expert analysis of sustainability as they were able to propose a first set of indicators after two days of work. Result analysis of this implementation of the grid will be the subject of a future paper.

The present global approach enables multiscale screening of the sustainability of pastoral systems in a given territory. Compared with other methods of assessing sustainability, PSSAF originality lies in the structure of the grid, which is not based on the usual three dimensions of sustainable development but on the relationships and links between the system and the territory, as well as on the properties of the systems. This makes it possible to use a cross-disciplinary approach to assess pastoral activities and their ability to ensure the sustainable development of territories.

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Résumé

Lambert-Derkimba A., Aubron C., Ickowicz A., Touré I., Moulin C.-H. Méthode innovante pour évaluer la durabilité des systèmes pastoraux dans leurs territoires (PSSAF)

L'avenir des systèmes pastoraux et leurs interactions avec les territoires sont au cœur de débats majeurs dans la littérature scientifique et sont encore insuffisamment documentés. Évaluer la durabilité de ces systèmes pastoraux et leurs interactions avec la durabilité des territoires est donc une tâche complexe. Nous proposons dans cette étude une méthode pour évaluer la durabilité des systèmes pastoraux dans leurs territoires. Suite à un travail de synthèse bibliographique, nous avons conduit des entretiens auprès d'experts du pastoralisme en France et en Afrique sur le sujet de la durabilité de manière générale et de celle des systèmes pastoraux en particulier. Nous avons conçu une grille sur la base de l'approche principes-critères-indicateurs, en incluant 10 principes autour de trois thèmes majeurs que sont la disponibilité des ressources dans le territoire, les propriétés des systèmes, et la durabilité étendue. La compréhension des stratégies utilisées dans le cadre de l'activité pastorale nous a permis de proposer un jeu de critères spécifiques par principe. Enfin, nous discutons de cette nouvelle méthode au regard d'autres méthodes utilisées pour évaluer la durabilité.

Mots-clés : pastoralisme, territoire, durabilité, évaluation

Resumen

Lambert-Derkimba A., Aubron C., Ickowicz A., Touré I., Moulin C.-H. Método innovador para asesorar la sustentabilidad de los sistemas pastoriles en sus territorios (PSSAF)

El futuro de los sistemas pastoriles y sus interacciones con territorios son el foco de un debate considerable en la literatura científica y se encuentran aún insuficientemente documentados. Asesorar la sustentabilidad de los sistemas pastoriles y sus interacciones con la sustentabilidad de los territorios es por lo tanto una tarea compleja. Proponemos en este estudio un método para asesorar la sustentabilidad de los sistemas pastoriles dentro de sus territorios. Después de revisar la literatura, conducimos entrevistas con expertos en pastoreo en Francia y África sobre el tema de la sustentabilidad en general y en sistemas pastoriles en particular. Diseñamos nuestra cuadrícula según un enfoque en los principios-criterios-indicadores e incluimos 10 principios agrupados en tres campos mayores: la disponibilidad de los recursos en el territorio, las propiedades del sistema y la sustentabilidad duradera. Comprender las estrategias utilizadas en los sistemas pastoriles nos permitió proponer un set de criterios específicos por principio. Finalmente comparamos nuestra cuadrícula con otros métodos utilizados para asesorar la sustentabilidad.

Palabras clave: pastoralismo, territorio, sostenibilidad, evaluación

Water harvesting model for improved rangeland productivity in Butana, Sudan

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Keywords

Rangeland, biomass, water conservation, rain water management, Spot image, Sudan

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Summary

The above-ground biomass and floristic composition of Butana rangelands in Sudan were assessed in 2006 with field surveys covering 25 sites. The remote sensing data derived from Spot image for the same period was integrated to the field surveys to map the spatial distribution of biomass production (kg ha^{-1}) using the perpendicular vegetation index. A rainfall map of the region was established from the meteorological data of the season and the digital elevation model. The rain use efficiency factor, which is the quotient of the annual primary production ($\text{kg dry matter ha}^{-1}$) of a season by rainfall (mm) of the same season, was used as a rangeland degradation and desertification indicator in Butana. To test the potential of water harvesting techniques on biomass production, two seasons' experiments were conducted (2006 and 2007). Their results were used to simulate the potential of biomass production with water harvesting application through a general model that linked remote sensing output, field measurement and water harvesting results.

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■ INTRODUCTION

Butana spreads across the central clay plains of Sudan. It is located between $14^{\circ} 23'$ and $17^{\circ} 34'$ N, and $32^{\circ} 32'$ and $35^{\circ} 36'$ E, and between the Rahad, Blue Nile, Nile and Atbara rivers, covering a surface area of about $120,000 \text{ km}^2$ (Figure 1). The area is located in the Sahel zone characterized by climatic and ecological transitions from the savannah in the south to the arid Sahara in the north (Akhtar, 1994), with a tropical arid and semiarid climate and a short summer rainy season (Zaroug, 2000).

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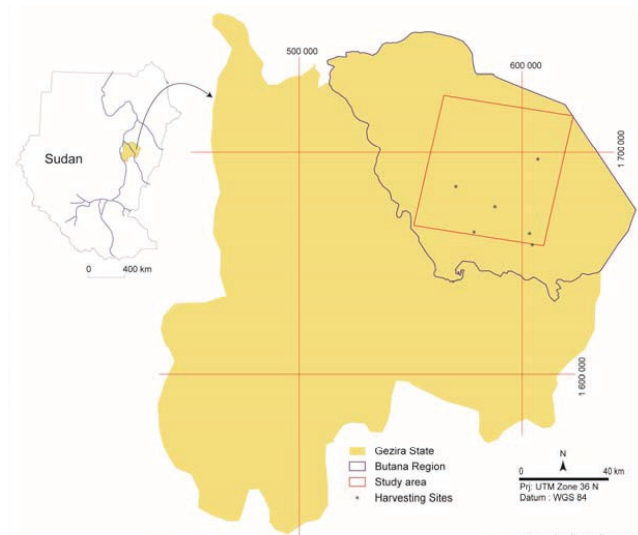


Figure 1: Butana region in Sudan.

Based on long-term averages, the area is marked by annual precipitation from less than 50 mm in the North West to 500 mm in the South East (Olivier, 1965). The extreme spatial and temporal variability of rainfall results from the northward drift of the Inter-tropical Convergence Zone which leads to an unpredictable rainy season and recurring droughts. The high rainfall variability also triggers a natural shift of vegetation formations over several hundred kilometers (Akhtar, 1994). In addition, Pfloumbaum (1994) reports that this high rainfall variability causes considerable inter-annual variations in the dry matter production of natural pastures of Sahelian zones.

Generally rainfall is characterized by an uneven distribution (short summer rainy season) and long dry spells that affect crops and range vegetation at critical growth and filling stages, leading to a significant reduction in the total production and productivity of the area experiencing severe degradation.

With declining investments in irrigation in developing countries, alternative methods, such as soil and water conservation, have increased in importance in recent decades (Turrall, 1995). Water harvesting is one of them and the technology is based on the collection and concentration of surface runoff for cultivation before it reaches seasonal or perennial streams (Reij et al., 1988). In Sudan, where the major parts are located in arid and semiarid zones, different traditional water harvesting techniques and systems have been used for a long time and are still referred to in the literature by their traditional names, e.g. *haffir* and *teru* (Oweis et al., 1999). The objective of this study was to develop a geographic information system (GIS) and remote sensing model to assist in improving the current situation of Butana rangelands, i.e. to increase their productivity and carrying capacity through the application of water harvesting techniques.

■ MATERIALS AND METHODS

This study was conducted in Central Butana rangelands whose areas are about 3600 km² (Figure 1). The current ecological situation of these rangelands was evaluated in 2006 by field surveys covering 25 sites in the region. The above-ground biomass and floristic composition were determined for each site. Remote sensing data derived from Spot image for the same period (Spot View Ortho Basic, date 5/10/2006, columns 7252, rows 6802, projection UTM zone 36 N, datum WGS 84) was integrated to the ground field surveys to create the spatial distribution of biomass production (kg ha⁻¹) by mean of vegetation indices, particularly the perpendicular vegetation index (PVI) (Gintzburger et al., 2005).

A rainfall map of the region was established from the regression correlation between the meteorological data of six stations around the area for the period 1980–2004 and the digital elevation model. The rain use efficiency factor (RUE), which is a quotient of annual primary production [kg dry matter (DM) ha⁻¹] by rainfall (mm year⁻¹) of the same season, was used as a relevant indicator for desertification and degradation in the rangelands of arid zones of the world (Gintzburger et al., 2005; Le Houérou, 1984). A review of the RUE methodology applied to arid rangelands is presented by Saïdi and Gintzburger (2013).

The effect of water harvesting techniques on biomass characteristics in Butana region was evaluated with two seasons' experiments (2006 and 2007) on different sites representing two main vegetation and soil units. On each site four rectangular plots of different sizes and parallel to the flow direction were set up (Figure 2). Their surface areas were 60 x 20 m², 40 x 20 m², 20 x 20 m² and 20 x 20 m² (control), respectively. The first three plots were considered as separate catchments and totally enclosed on all sides by

earth embankment, whereas the last plot was left open as control. Each of the first three plots was divided into two main units representing the runoff area and the biomass harvesting area. Each plot was also crossed by five separate lines from which the biomass was measured and floristic samples were analyzed.

A general model for water management (Figure 3) was designed using the output results of remote sensing data, the ground surveys and water harvesting experiment findings. The aim was to simulate the potential of biomass production in these rangelands. The model linked the final results of remote sensing and GIS, including a rainfall map, PVI, a biomass map, a rain use efficiency map and a drainage map, to the results of the field measurements of water harvesting and of the surveys.

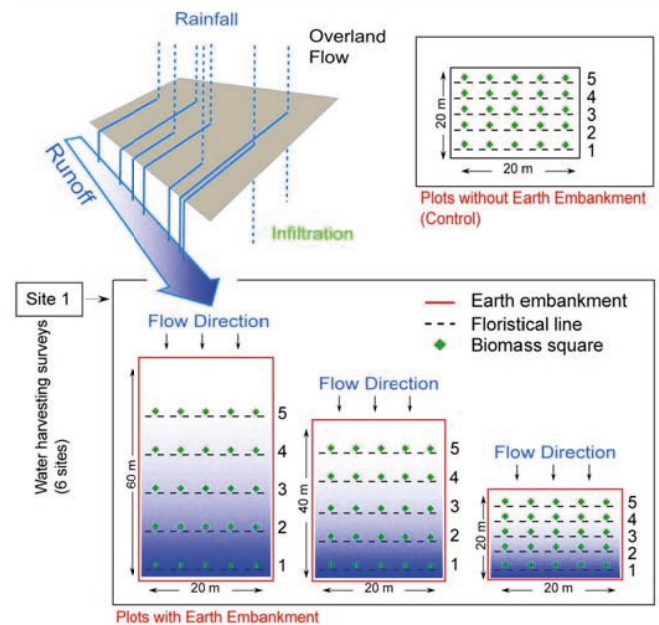


Figure 2: Water-harvesting experiment design (2006-2007).

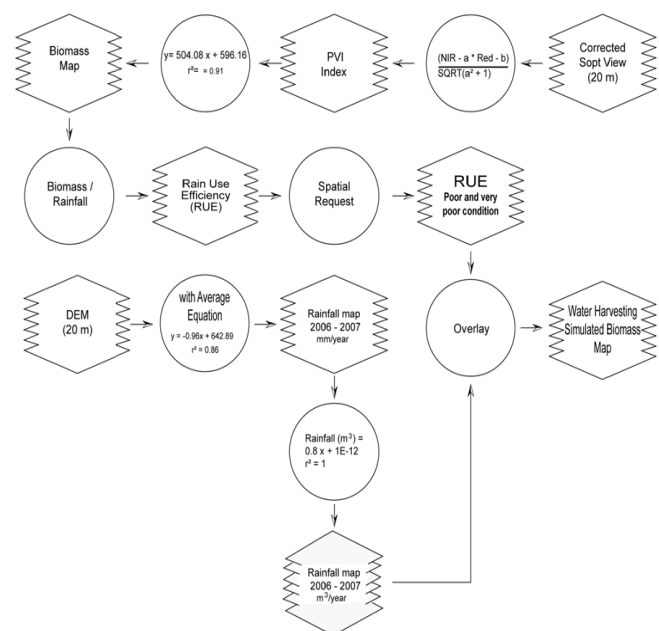


Figure 3: General model of water management used in the central rangelands of Butana, Sudan.

■ RESULTS AND DISCUSSION

The spatial distribution of the RUE factor in Central Butana rangelands (Figure 4) indicated that it was in the range of 0 to 4 kg DM ha⁻¹ mm⁻¹ with an average value of 2.5 kg DM ha⁻¹ mm⁻¹, which agreed with Le Houérou and Hoste (1977) who reported a value of 2.7 kg DM ha⁻¹ mm⁻¹ in the Sahel zone. RUE lowest value was found in the Butana high land in the upper rain-water catchment, where water flows fast to depressions and water courses. In areas grown with sorghum, RUE was higher than 4 kg DM ha⁻¹ mm⁻¹ as farmers tended to maximize water productivity by water management and water harvesting. Figure 4 shows four RUE classes in Central Butana rangelands. In the almost desertified areas which showed no production, RUE ranged from 0 to less than 1 kg DM ha⁻¹ mm⁻¹, in the highly degraded rangelands it ranged from 1 to less than 2 kg DM ha⁻¹ mm⁻¹, in the medium degraded rangelands it ranged from 2 to 3 kg DM ha⁻¹ mm⁻¹, and in the rangelands under good conditions near rain-fed agriculture it ranged from 3 to 4 kg DM ha⁻¹ mm⁻¹.

Results showed that Central Butana rangelands were highly degraded as indicated by the RUE factor map. The situation is the consequence of the high variability of rainfall and the high pressure of animal grazing especially in the rainy season (short summer rainy season). Future development of these rangelands would require the application of many strategies such as soil and water conservation in terms of rain water harvesting to maximize the use of rainfall and hence locally increase rain use efficiency.

Since the main objective of this study was to produce more biomass and maximize water productivity to improve the carrying capacity of Butana rangelands, we found that the production of biomass was a function of the harvested water depending on the size and design of the water harvesting catchment. The biomass produced with water harvesting techniques in the different locations was highly significantly correlated to the harvested water in the two seasons ($r^2 = 0.88$) (Figure 5).

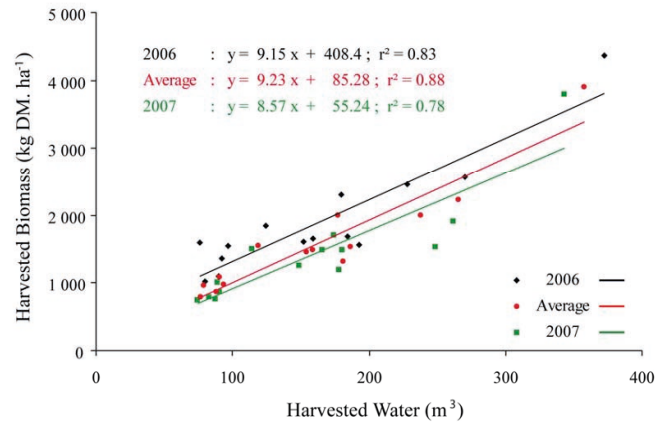


Figure 5: Relationship between harvested biomass and harvested water in the central rangelands of Butana, Sudan.

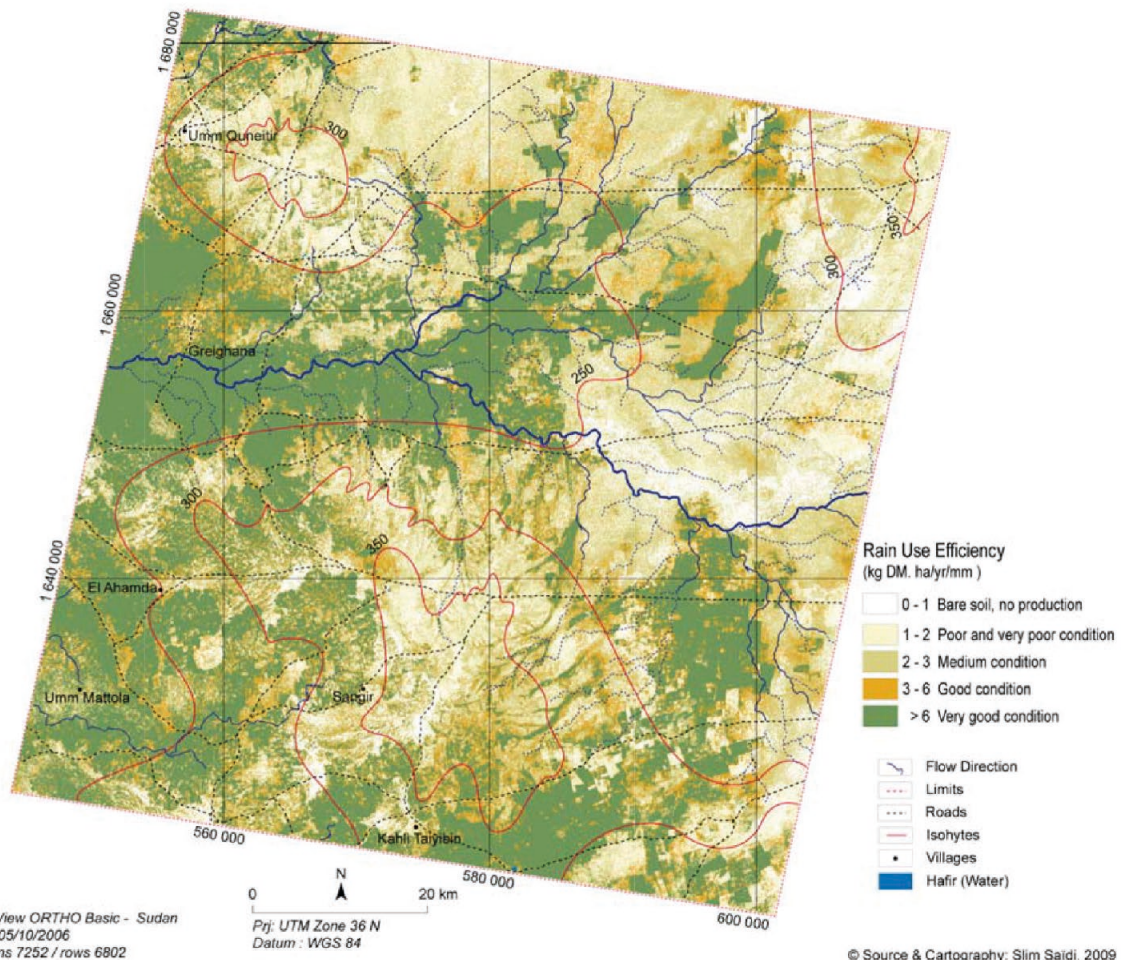


Figure 4: Rain use efficiency map in Central Butana, Sudan.

The following equation was thus written out:

$$\text{biomass (kg ha}^{-1}\text{)} = 9.23 \text{ harvested water (m}^3\text{)} + 85.28$$

The application of this equation to the general model gives the potential of simulated biomass production (kg ha⁻¹) in relation to the harvested rainfall amount. The suitable areas for water harvesting were identified according to the drainage network derived from DEM.

Figure 6 shows the simulation of biomass that can be produced in Central Butana rangelands when applying water harvesting. The western part of the area (in white) is excluded as it represents rain-fed agriculture. The rest of the area was divided into different homogenous simulated biomass according to the rainfall map and potential runoff. The increase in dry matter production (in green) in the most degraded areas of the rangelands ranged from 350 to 650 kg ha⁻¹ yr⁻¹ to 2000 to 2200 kg ha⁻¹ yr⁻¹; the rain use efficiency ratio was thus increased from less than 1 kg ha⁻¹ mm⁻¹ to 8 kg ha⁻¹ mm⁻¹. In some areas near the drainage network the dry matter production peaked at 2400 kg ha⁻¹ yr⁻¹. The RUE factor clearly shows that the degraded areas can be regenerated with rainwater harvesting projects which are already in use in Butana. The drainage and potential runoff maps display the potential catchment characteristics to select the suitable areas for water harvesting (shadowy areas along the drainage network) (Figure 6). PVI was used through the model to determine the land use and vegetation pattern in the area impacted by runoff.

■ CONCLUSION

As reported by Elfaki (2010), the socioeconomic life of Central Butana is affected by water resources. There is a major interaction between natural resources and the socioeconomic life of Butana's population. Sedentary people's lives are controlled to a large extent by available water resources especially rainfall. Rainfall determines the success or failure of the agricultural season besides its effect on livestock through rangeland vegetation and watering points. Transhumant herders' entire lives are controlled by the pattern and distribution of rainfall, as they determine their decision to come to Butana, their movements, the length of their stay, the family income and the date of reverse migration. Indeed all these factors depend on the availability of water resources in the rangelands. To overcome the problem of rainfall variability, this study presents a decision-support model for water harvesting which can help decision makers and stakeholders determine the suitability of rain water harvesting in any selected part of Central Butana. With the appropriate implementation of runoff techniques in the region as well as the support of the present results, it may significantly improve the livelihoods of Butana people and herders' communities.

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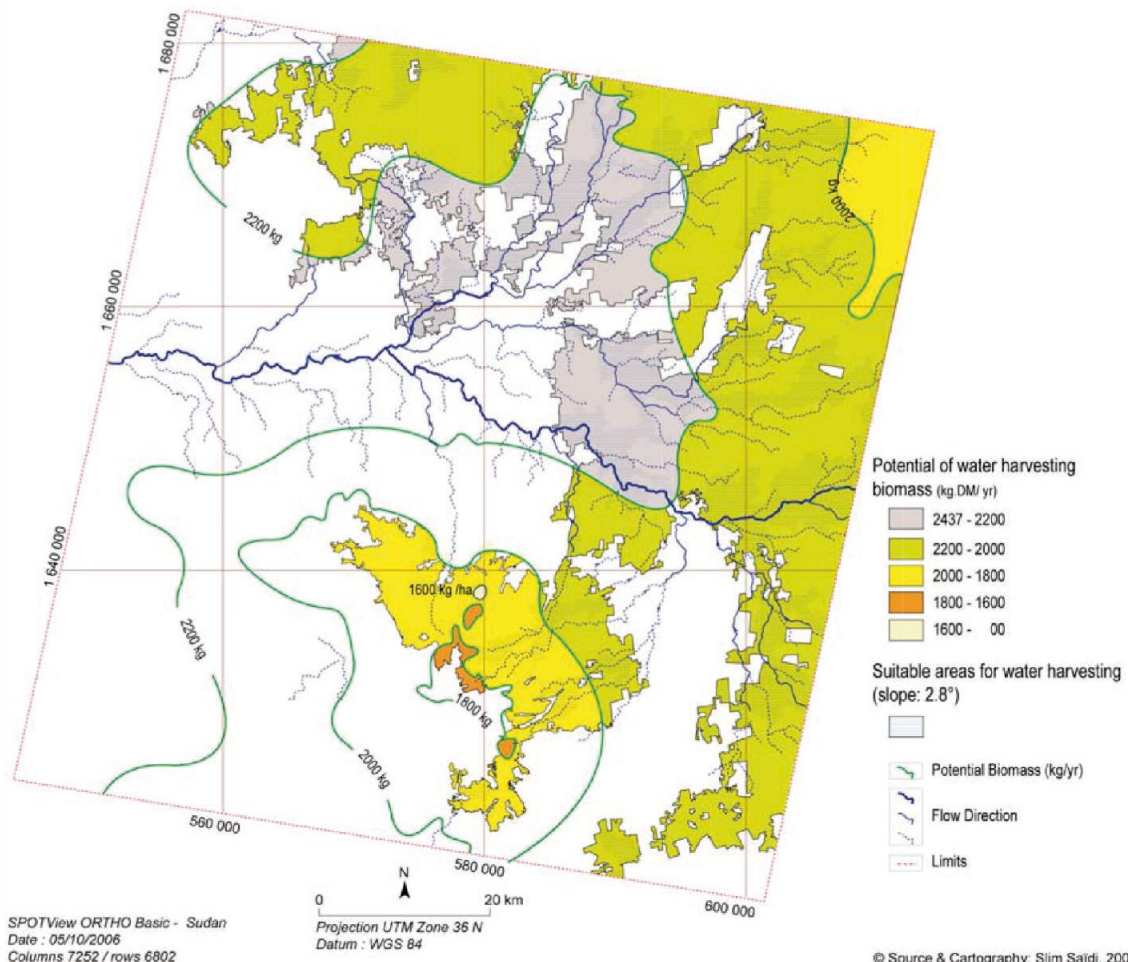


Figure 6: Water-harvesting simulated biomass in Butana, Sudan.

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Résumé

Elfaki E.A., Saïdi S., Adeeb A.M., Ickowicz A. Modèle de collecte de l'eau pour améliorer la productivité des parcours dans le Butana au Soudan

La biomasse aérienne et la composition floristique des pâturages du Butana au Soudan ont été évaluées en 2006 à partir d'enquêtes de terrain sur 25 sites. La mise en œuvre de l'indice perpendiculaire de végétation, issu du traitement de l'image Spot, a été couplée aux enquêtes de terrain afin de cartographier la distribution spatiale de la production de biomasse (kg ha⁻¹). La carte des précipitations de la région a été établie à partir des données météorologiques de la saison et du modèle numérique d'élévation. Le coefficient d'efficacité pluviale de la région, qui est le quotient de la production primaire annuelle (kg matière sèche ha⁻¹) d'une saison par la quantité de pluie (mm) dans la même saison, a été utilisé comme indicateur de la dégradation et de la désertification des parcours du Butana. Afin de tester l'efficacité des techniques de récupération de l'eau sur la production de biomasse, deux saisons d'expérimentation ont été nécessaires (2006 et 2007). Les résultats obtenus ont permis de simuler le potentiel de production de biomasse à travers un modèle général impliquant conjointement les données télédéteectées, les mesures de biomasse des sites de récolte ainsi que la quantité d'eau de surface reçue par chaque site.

Mots-clés : sol de parcours, biomasse, conservation de l'eau, gestion des eaux, eau de pluie, image Spot, Soudan

Resumen

Elfaki E.A., Saïdi S., Adeeb A.M., Ickowicz A. Modelo de recolección de agua para mejorar la productividad de los pastizales en Butana, Sudán

En 2006, se evaluaron la biomasa superficial y la composición florística de los pastizales en Butana, Sudán, mediante estudios de campo que cubren 25 sitios. Los datos de teledetección procedentes de imagen "Spot" en el mismo período fueron integrados a los estudios de campo, para mapear la distribución espacial de la producción de biomasa (kg ha⁻¹), utilizando el índice de vegetación perpendicular. Se estableció un mapa de precipitaciones de la región a partir de los datos meteorológicos de la estación y el modelo digital de elevación. El factor de eficiencia de uso de la lluvia, que es el cociente entre la producción primaria anual (kg materia seca ha⁻¹) de una temporada de lluvia (mm) de la misma estación, se utilizó como indicador de degradación de los pastizales y desertificación en Butana. Para probar el potencial de las técnicas de recolección de agua sobre la producción de biomasa, se llevaron a cabo experimentos en dos estaciones (2006 y 2007). Sus resultados se utilizaron para simular el potencial de producción de biomasa con la aplicación de la captación de agua, a través de un modelo general que vincula la teledetección de recursos, las mediciones de campo y los resultados de recolección de agua.

Palabras clave: tierra de pastos, biomasa, conservación de agua, ordenación de aguas, agua de lluvia, imagen Spot, Sudan

