The multifunctional roles of tropical grasslands

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Key words: grassland, multifunctional, ecological intensification, agroecology, tropics, ecosystem services

Introduction

The challenge to increase food production has become more urgent than ever, with the emerging consensus that the world will have approximately 9 billion people to feed by about 2050 (Roberts, 2011; Guillou and Matheron, 2012). Predictions of future food demand differ, but even the most optimistic scenarios require increases in food production of at least 50% by 2050 (Lal et al., 2013; Gill et al., 2010). Food demands will both augment and shift in the coming decades, with a strong growth in consumption of animal products in countries of the South (120% between 1980 and 2005), compared with that in the North (+7.6% for the same period, FAO, 2012). These changes are occurring not merely because of population growth, but also because economic growth increases consumer purchasing power, especially for meats and standardizes consumption patterns (Horlings and Marsden, 2011). Growing urbanization encourages people to adopt new diets, and climate change variations and events are threatening both land and water resources (Pretty et al., 2010), in addition to 17 billion animals using substantial amounts of natural resources (Herrero et al., 2013).

To follow food production, there has already been an expansion of 9.6% in the world's agricultural area over the last 50 years, in both arable land, permanent crops and permanent meadows and pastures (O'Mara, 2012). However, since 1991, the total area has been stationary, and with discrepancies among various countries of the world. While in developed countries the agricultural land area decreased by more than 34% between 1995 and 2007 (including pastures and permanent cropland), developing countries saw increases of nearly 17.1% (Gi-

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bbs et al., 2010). According to the FAO (2009) projection, global agricultural areas are likely to expand substantially, by about 280 Mha by 2030. However, there is a consensus that increasing yields on existing agricultural land without further expansion is a key component of food security. (Wirsenius et al., 2010).

In the 1960s a 'Green Revolution' has previously allowed an impressive conventional growth of agricultural production, to ensure human food. During the post-war reconstruction, total production and yields were strongly increased through the manipulation of the environment by various means: mechanization, synthetic chemical inputs, genetic engineering, and monoculture. This approach was economically coherent and emphasized the productive function of agriculture. Therefore, compared with 1961, food consumption has increased by 25% per capita in proportion, but with significant variations among the continents (FAO, 2009). But this productivist model supported by the economic viewpoint has induced serious adverse side effects on the environment, with a "boomerang effect" on future food production (Delgado, 2003; Fedoroff et al., 2010). The myth of the efficiency of this paradigm model has been largely discussed and questioned (Altieri et al., 2012). It appears therefore a need to promote a sustainable management of all kind of natural resources. In tropical areas, this objective fully concern the existing land and grasslands, as well as intact forests cleared for grazing (Gibbs et al. 2010).

The general interest for sustainable development gained currency in the 90's with its institutionalization through the Rio Earth Summit in 1992. This new turn promoted sustainable development through collective action but also posited the consistency of local scale to define usage rules for natural resources (Angeon and Caron, 2009). This specific moment has accelerated the recognition of sustainable development in different sectors including agriculture. It enacted the great transformation of agriculture by contrast with the dark sides of the productivist model.

The institutionalization of sustainable development in the 1990s created a window of opportunity for a growing recognition of the other functions of agriculture, both social and environmental which were till then presented as externalities. This sustainable footprint of agriculture legitimized the concept of multifunctionality (Perraud, 2003 ; Caron et al., 2008) which relies on the reconciliation of the conflicting interest between the three classical pillars: economic (production of food and non-food goods and services), environmental (preservation of natural resources) and social (revitalization of rural areas, transmission of natural heritage, aesthetic landscapes). Nevertheless, the difficulty was precisely to make multifunctional agriculture operational by internalizing the externalities provided by the activity. Among the issues raised is the question of how to promote the diverse functions of agriculture by answering how to pay for them? This requires new policies not focused only on the economic production objective but likely to support the overall functions of agriculture.

This gap is intended to be filled with the notion of ecosystem services. Popularized with the Millennium Ecosystem Assessment Report (MEA, 2005), ecosystem services design the services provided by agriculture. A service is an immaterial but intentional production. It is therefore associated to a value and a price. The process of an effective recognition of the services offered by agriculture necessitate to precisely identify them, evaluate their contribution to human well-being and to pay the providers of these services for them. .

In this paper, considering tropical grasslands, we wonder about the ways to promote their different functions by supporting the production of ecosystem services. Tropical grasslands represent major natural resources from which sustainable exploitation is still feasible without any expansion of agricultural land. Such an ambition is possible through appropriate ecological intensification processes, the enhancement of local knowledge which constitutes a potential sink of innovations. In that way, the sustainable management of grasslands may fully contribute to the agroecological transition which is of first importance in these areas deeply affected by global changes.

1. Tropical Grasslands, a major natural and multifunctional biome

1.1. Grasslands are the basis of various farming systems

Grasslands are the basis of pastoral faming systems and represent 26% of the land on the planet; around 47% and 36% of total grasslands are respectively still semi-natural or marginal (Bouwman et al., 2005; van Asselen and Verburg, 2012), mainly in the tropics and developing countries. This suggests that intensification may be possible with no further expansion of agricultural land (FAO, 2012).

Grasslands are associated with different farming system types and products; they may be non-arable areas, or integrated with crops in arable lands, with a low dependence on external inputs (i.e., fossil energy). Hence different products can be obtained at lower cost, with a real improvement of the quality of products that result from the use of grassland, and the perception of "natural" products, which many consumers are willing to pay for (Gracia et al., 2011). Grasslands are able to make use of solar radiation all year round, and support livestock, which can alleviate seasonal food shortage and contribute to food security.

Grasslands represent very flexible agroecosystems, which can help households forestall inequalities in access to food and other products. The world today produces sufficient food to feed its population, but there still remain more than one billion people suffering from food insecurity and malnutrition (Pretty et al., 2010). Moreover, in a more forward looking perspective, one of the major challenges of the 21st century will be to feed an increasing population with declining resources. Given their importance in terms of area and their geographical diversity, grasslands can allow different approaches to intensification for different contexts. Whereas extensive pastoral systems occupy regions where agricultural production is generally marginal, integrated crop-livestock systems are associated with high population density regions (Herrero et al., 2009; Tarawali et al., 2011). All these systems, based on the utilization of grazing areas, can be improved differently depending on local environmental and economic resources, needs and constraints. Grasslands can be used with cattle, sheep and goats, or horses, raised alone or in combination (Dennis et al., 2012; d'Alexis et al., 2013), with ranging intensiveness, partly indoors, and with grazing periods of ranging duration.

1.2. Grasslands have other functions than those related to animal production

Global estimates are that grazing land accounts for about one fourth of potential carbon (C) sequestration in world soils and removes the equivalent of 20% of the carbon dioxide released annually into the earth's atmosphere from global deforestation and land-use changes (Follet and Reed, 2010). Tropical grasslands represent a storage pool of carbon (C), almost twice that of temperate grasslands, mostly sequestered in the soil and a more stable form of storage than the aerial components of forests (Soussana et al., 2010). According to Bagchi and Ritchie (2010), stocking rate and impacts of livestock on vegetation composition are equally important in influencing soil C sequestration in grazing ecosystems. The management of grassland, N fertilization, manure management and grazing pressure are therefore determining in ensuring this C storage (Batlle-Bayer et al., 2010; McSherry and Ritchie, 2013; West et al., 2010), and must be considered in intensifying grasslands for animal production. Currently, further information is still needed on tropical grasslands in order to meet appropriate management options.

Grasslands are also important havens of **biodiversity**, especially in tropical regions, where they are the source of about 50% of all plant species, although they represent only 7% of the land surface (Bond and Parr, 2010). However, this biodiversity is seriously threatened by anthropogenic factors including land clearance, introduction of exotic species or invasion, soil cultivation, fertilizer application and altered fire management (Prober and Smith, 2009). Livestock particularly, as the largest user of grasslands, increases pressure on this ecosystem while being a tool to maintain biodiversity of open landscape (Derner et al., 2009), contributing to aesthetic value and leisure amenity, and even allowing rapid structural regeneration of land (Metera et al., 2010; Maczkowiack et al., 2012). However, there is still a need for comprehensive research to support the development of agro-environmental schemes to protect grassland biocenoses; this will require management tools that operate on an appropriate scale (Boval and Dixon, 2012).

In addition, good use of grasslands must be fostered, as they contribute directly to the livelihoods of over 800 million people (Herrero et al., 2013), while providing income and meeting the socio-cultural needs of many modest smallholders, and being an essential way to retain population in some areas. It has been estimated that about 70% of the 1.3 billion people around the world in "extreme poverty" survive on livestock grazing (FAO, 2009). The statistics also often underestimate the contribution of livestock to regional or national economic development, since they often disregard many non-food livestock outputs (McDermott et al., 2010). These latter are quite often more important and varied in developing economies than in developed ones and constitute an important component of the agricultural economy (Herrero et al., 2013). Livestock reared on grasslands also contribute to the well-being of the breeder, and play a crucial role in social protection for the poor to cope with uncertainties and constraints, such as crop failures and other disasters (FAO, 2014). Livestock also are used for ploughing and transport, provide a local supply of manure, and are of cultural importance for many communities, where cattle are the foundation of many religious rituals (e.g., Godfray et al., 2010; Pretty et al., 2010).

Therefore, in addition to provide livestock products with a market value, grasslands have other roles, in compliance with sustainable development objectives, which need to be highlighted for better management of this particular biome.

2. How to promote the multi-functionality of grasslands?

The importance of this natural biome, the range of fundamental resources it provides and the current global change context (FAO, 2014), highlight how a sustainable use of grasslands is crucial. The international organizations recommendations to boost progress toward "smart agriculture" (FAO, 2010), the growing societal awareness reinforced by the media require strong changes in agricultural practices. The need to increase global agricultural production and simultaneously to care over the preservation of natural resources may result in valuing the services offered by the environment in the agricultural production function. Numerous studies come to the idea that an increase in agricultural output must exclusively result from ecological intensification (IAASTD, 2009; De Schutter, 2011; Altieri et al., 2012), the conventional and productivist model having reached its limits.

Ecological intensification designs the sustainable use of natural processes through the amplification of ecological interactions and biological regulations (Jackson et al. 2010; Doré et al., 2011; Chave et al. 2014). Though there exists a debatable consensus around the notion of ecological intensification - Bonny (2011) shows the difficulty to stabilize the definition of the concept – it is recognized that ecological intensification carries out the modernization of agriculture (Griffon, 2010; Horlings and Mardsen, 2011; Duru et al., 2014).

2.1. By deciding an appropriate ecological intensification

According to Duru et al. (2014), two forms of ecological modernization of agriculture exist (thereafter ecologization of agriculture): the "weak" versus "strong ecologization of agriculture". Both of them intend to reduce the main negative environmental impacts.

The weak form, first form of intensification, is a "low ecological modernization of agriculture". It is based on increasing the efficiency of inputs (water, for example), recycling of waste or by-products of a subsystem for another (Kuisma et al., 2012) by setting implement good agricultural practices

(Ingram, 2008) or technology under precision farming (Rains et al., 2011). It can also match it with new technology transfer as easy to `organic inputs (Singh et al., 2011) and genetically modified organisms (GMOs). Compared to the norms and routines implemented in the conventional production model, the weak ecologization implies few changes in the implementation of agricultural practices. These changes are limited to the implementation of "good practices" that intend to improve the efficiency of chemicals and/or reduce their use by alternative practices such as their substitution by biological inputs. They rely on incremental innovations.

The strong ecologization, second form of intensification, is really the opposite of a productivist based model and corresponds to a "profound ecological modernization of agriculture". It is based on biodiversity providing ecosystem services. For example, in addition to the recycling of resources principles and of control of flows, it is question to use the biodiversity, in order to produce "input service" to support the production (via the availability of water, maintaining fertility, control of pest and disease...), and the regulation of flows (water quality, regulation of biogeochemical cycles...) (Rouxet, 2008; Duru et al., 2014). Strong ecologization requires a paradigm shift and relies on radical innovations. It imposes to "deeply revise farming system, resources management at territory/landscape level, and the agrifood chain" (Duru et al. 2014, p. 85). In addition to the recycling of resources principles and of control of flows, it is question to use the biodiversity, in order to produce "input service" to support the production (via the availability of water, maintaining fertility, control of pest and disease...), and the regulation of flows (water quality, regulation of biogeochemical cycles...) (Rouxet, 2008; Duru et al., 2015).

In matter of ecologization of agriculture, agroecological transition may be considered as a privileged pathway. But we have to keep in mind that both the weak and the strong processes coexist in the ongoing agroecological transition (Angeon and Chave, 2014).

"Agroecology" laid the foundations of "how to sustainably ecologically intensify" agriculture. It thus sets out the basis for operating the agroecological transition. Agroecology is, defined as a way to protect natural resources, with guidelines to design and manage sustainable agroecosystems (Altieri 1989; Wezel et al. 2009). Agroecological principles are providing the scientific, methodological and technological basis for a new "agrarian revolution" worldwide (Altieri et al., 2012). It 'is essential to consider it as a science as well as a practice that allow the intensification of this agroecosystem. The term of agroecology is currently used with quite different meanings, as a science or as practices. Agroecology may also be a movement, as in Latin America or USA (Wezel et al. 2009). Thus, the term of agroecology is currently used with quite different meanings, as a science, a practice and a movement (Doré et al., 2011).

Agroecology as a science, while it presents a large diversity of approaches and definitions in different countries of the world, one of the broadest provided (Francis et al. 2003) is "the integrative study of the ecology of the entire food systems, encompassing, ecological, economic and social dimensions", or more simply "the ecology of food systems". In that way, agriculture should be based on ecological processes that enhance carbon storage, biodiversity, leaching and others. Therefore agroecological intensification should improve biomass turnover, ensure favorable soil conditions for plant growth and minimize losses, promote genetic diversification in time and space and enhance beneficial biological interactions and synergies between elements from biodiversity to highlight the processes and key ecological services (Wezel et al. 2009). In its strong form, ecological intensification must also be consistent with the social contexts and interests of producers and smallholders, including the analysis of their attitudes and practices. It is about emphasizing social processes that promote community participation and empowerment, and also the recognition and conservation of agricultural heritage (Altieri, 2011). This enables social cohesion by promoting a sense of pride and belonging (Koohafkan et al. 2012) and by modifying the relationship between men and their environment.

Agroecological principles can help feed the world and provide a more radical move towards a new type of economy. Economic factors have become the predominant forces in the food system (Altieri 1989), while the relationship between intensification, natural resources management and socioeconomic development is complex. There is a need for not only rethinking market mechanisms and organizations but also for initiating a more innovative institutional flexibility at different spatial scales that brings the farmers closer to the consumers (Abreu et al. 2012).

Considered as a practice, agroecology aims at enhancing the traditional or indigenous agriculture considered as reservoirs of knowledge (Altieri, 2002)., particularly in developing countries. It helps to make agriculture more environmentally friendly (ecological, organic or alternative) and should help better ownership by producers (Wezel et al. 2009). Moreover, traditional practices and knowledge are an important crucible for innovation (Pretty et al., 2010), as they result from a collection of many precious observations and experiences over time. "The eye of the farmer" and the use of various sensors more or less complex may allow more appropriate local interventions and more fine adjustments. For instance the study of the widespread tethering traditional practice in the Caribbean but also spread in various other latitudes (Ghana, Ethiopia, Uganda, Sahel, India or North America,) has highlighted the various alternatives and benefits it provides beyond the negatives a-priori (Boval et al., 2014). Therefore, it was revealed that the practice of tethering, well managed, can truly have a key role for animal production as it is very flexible and still contemporary concerning currently 90% of cattle holders and 60% of goat farmers (Alexandre et al., 2008; Gunia et al., 2010). Moreover this practice presents ecological and environmental benefits (use of natural small areas) as societal and economic perspectives (income for small holders, security linked to diversification). These different outputs intend to reinforce agroecology as a structural societal movement.

The principles of agroecology, thus introduced, appear particularly well suited to promote grasslands. Their multifunctionality can be then addressed adequately.

2.2. By innovating, in order to promote natural grasslands and their multifunctionality

Many studies have been carried out on intensification of grasslands, mainly for animal production, and have been reviewed successively (Minson, 1990; Humphreys, 1991; Poppi, 1997, Lemaire, 2009). But the most studied strategies are not necessarily innovative from an agroecological point of view. It is difficult to quantify the effectiveness of a given strategy for a specific context due to the wide range of conditions of the various studies published as well as the wide range of criteria used to assess those strategies.

Most of the studies carried out in grazing conditions had indeed the priority to increase the outputs of animal products by having as a reference the animal production in intensive conditions (i.e. stall-fed conditions) with a key objective to achieve the highest possible intakes of metabolizable energy (ME). But the financial costs (cost of buildings and concentrates, cost of labor for mowing and harvesting cultivated forages), or environmental costs (due to fertilization or soil compaction) have often been neglected. Also the qualities of the products have been rarely considered as well as their diversity. Yet some forms of animal production (leather, manure, and fine wool) do not require necessarily high intakes of ME. By another way, grassland exploitation may contribute indeed to other services than the provisioning of animal products, which deserve to be better valued.

The most striking fact is that a recent quantitative analysis of the literature (Agastin et al., 2014), making better use of existing knowledge, showed that equivalent animal performances may be obtained whatever the feeding environments (in stalls or at pasture) provided the complementation practices are the same. Indeed, the main factor that explains the differences often reported in the literature is the use of concentrates in stalls, which is rarely the case at pasture. By another way, it has been demonstrated that animal products obtained at pasture is of better quality, as recently reviewed (Reddy et al., 2015) showing among others, better ratios of polyunsaturated fatty acids when animals are finished at pasture.

Thus, the first fundamental step in order to be more innovative and better valorize grassland ecosystems is to change the thought patterns. This means considering other goals than mainly the individual animal performance, and highest intakes of ME, by being aware in considering various scales (the short-term vs long-term and sustainable performance) and various dimensions (integrating financial, labor and environmental costs), to support breeders.

Furthermore, the inclusion of relevant criteria for assessing a management strategy adapted to a given context is also essential (Boval and Dixon, 2012). Therefore the methodological work needs to further advance to facilitate the measurement of relevant criteria and providing tangible information in a given context. These methodological works must assist in the dissemination of simple, effective and measurable criteria to support rangeland managers in choosing their strategies. In this respect, the SPIR progress with portable devices, that allow now evaluation in situ situations, is to note (Liu et al., 2014).

Nevertheless, there are lock-in and path dependency that prevent new innovations trajectories (Vanloqueren and Barret, 2009). Promoting production methods once launched are difficult to change. A simple way to improve animal performance may be for example the appropriate choice of the stage of regrowth of pasture, being equivalent to the frequency of grazing on a same site. This single elementary strategy, if well adapted to the local forage species, can indeed really change the diet of grazing animals (Gulsen et al., 2004; Boval et al., 2007) and consequently the growth performance while enjoying the subsequent regrowth of the forage and the sustainability of the pasture and of its supply function for livestock. It is a key elementary strategy to maintain a balance between the utilization and the short-term and long-term viability of the pasture (Laca, 2009).

Also by changing the combination of elementary strategies may be sufficient to improve the overall efficiency of the management strategy implemented, for example, by changing the grazing period at one site and the grazing frequency (Boval and Dixon, 2012)

Besides, already known practices can be revisited/modernized and be very effective. For instance mixed grazing can be considered as an illustration of a strong agroecological strategy to improve individual growth and per hectare, valuing complementarity of feeding behaviour among animal species and reducing the impact of gastrointestinal parasites for small ruminants. Mixed grazing is a relatively old practice (Nolan and Connolly, 1977; Nicol, 1997). Until recently, breeders, each with a small number of different species of animals, fed them regularly together. But with the development increase of the size of farms and the productive specialization that increasingly marked operating systems during the last half century, breeders began to graze separately the different livestock species. Some drifts specialized farming systems and the spread of supplementation with non-herbal food and deworming induced addition grassland degradation, the development of residual biomass used poorly and the emergence of parasites resistant to many chemical anthelmintics (Kaplan, 2004). Mixed grazing systems then appeared as an appropriate strategy to increase meat production on pasture and thus increase the growth performance of animals but also individually per hectare while reducing parasitism (Hoste et al., 2010, Jackson et al., 2009). For sheep, a meta-analysis of the literature highlighted individual weight gain of 15 g / animal / day, which varies depending on the physiological stages (lactating, pre- or post-weaning) and a 29% gain per hectare in mixed grazing compared to grazing of sheep alone (d'Alexis et al., 2013). For goats, an experiment during two years in tropical pastures revealed an individual gain of 14 g body weight / animal / day, and an overall gain per hectare doubled or even more if we consider the biomass presents better exploited in mixed pasture. For cattle driven mixed, the benefit is less clear, fluctuates between studies but individual growth is at least equivalent to that recorded for cattle grazing alone (d'Alexis et al., 2014). In addition to the interest for animal production this strategy promotes ecological diversification, the turnover of biomass reducing production costs and the use of conventional anthelmintic favorable for products of good quality without chemical residues.

Also the much known practice of composting, since centuries, has been used to maintain soil fertility and plant health while the mechanisms by which diseases are controlled by composts are just now being elucidated (Hoitink et al., 2004). But using this practice, involving the action of earthworms to obtain a vermicompost, may contribute to strong ecological intensification of grassland. Besides the fact that this practice makes it possible to achieve a proper recycling and recovery of various manure (Sierra et al., 2013), it improves the quality of organic soil, the nutrient bioavailability, and grassland biomass while having a nematophagous action, beneficial to a lesser gastrointestinal parasitism of small ruminants at pasture (d'Alexis et al., 2009). The biological and financial advantages of this practice in the longer term and their use to various grassland systems must be further quantified. Considering the important bright effects of strong ecological intensification processes, the main question to answer is how practically engage farmers so that this intensification is being effective?

3. Ecosystem services as supports for ecological intensification of grasslands

As evoked above, the implementation of the agroecological transition requires ecological intensification. It depends on the sustainable management of natural resources that enhances the multiple functions of agriculture. In this section, we analyze ecosystem services (ES) as key contributors that help to make operational the multifunctionality of agriculture through the amplification of ecological intensification process. Assuming that the construction of multifunctional agroecosystems goes through the preservation and the development of ES (Vereijken, 2002), it is worth shedding light on their identification especially for tropical grasslands. We will also discuss other related concerns like the question of their value and the payment for the benefits they generate.

3.1. ES: what is at stake?

The notion of ES was first introduced in the field of scientific ecology at the end of the 70's. The term was mobilized to explain the different processes that intervene in the functioning of the ecosystems and to alert on the negative impacts of human activities on these functioning. Since the 90's, ES are becoming increasingly popular both in academic sciences and on the operational fronts (Fisher et al., 2009; Froger *et al.*, 2012 ; Méral, 2012). They were placed on the political agenda since the seminal contribution of the Millennium Ecosystem Assessment (MEA, 2005). The results from The economics of Ecosystems and Biodiversity (TEEB) report confirmed the growing international concerns for the value of nature with their presentation at the Conference of the Parties of the Convention on Biological Diversity (Nagoya, 2010). The Intergovernemental Platform on Biodiversity and Ecosystem Services (IPBES) established in 2012 also reinforces this interest. It aims at demonstrating and assessing the values of nature and seeks to encourage policy-making that recognizes ES.

Combining economic and ecological approaches and necessitating systemic reasoning to grasp the functioning of ecosystems and their interactions with human activities, many authors attempt to clarify the notion of ES. ES are more often defined as: “the terms and processes, through which natural ecosystems and the species that make them up sustain the human life” (Daily, 1997), “the benefits derived human populations, directly or indirectly, from ecosystem functions” (Costanza et al., 1997) or “the benefits that people obtain from ecosystems” (MEA, 2005). ES thus design the ability of the ecosystems to provide goods and services on which human well-being depends. They describe the set of benefits derived by people from ecosystems that positively contribute to human well-being.

Though their importance is recognized and their empirical identification is considered as necessary, ES raise numerous questions.

It is to note that because the state of an ecosystem determines its ability to provide various ES, biodiversity is considered one of the main determinants of ES, even if knowledge of the interactions between biodiversity, ecological processes and SEs are still very incomplete (Cardinale et al., 2012). ES produced by agroecosystems rely on the enhancement of biodiversity which generates commodities and marketable outputs (i.e. the 4 Fs: Food, Feed, Fibers, Fuel) and non-commodity outputs (i.e. environmental benefits, landscape amenities and cultural heritages) that are not traded in organized markets. These multi-outputs may be joint goods or services (bundled goods or services) and some of the non-commodity outputs may exhibit the characteristics of externalities. For the latter, markets are inexistent or inefficient (they function with failures and are not able to send reliable price signals for such goods). Therefore, as asserted by the neoclassical welfare economics, the main challenge is to determine the cost (in case of negative externalities) or the benefits (in case of positive externalities) provided by the production of these outputs. This consists in the internalization of externalities.

ES entail transactions between the providers and the beneficiaries of the services offered. The precise identification of the beneficiaries is crucial (Huang et al., 2015) but also the allocation of economic value to the provided services. There is benefit when « the point at which human welfare is directly affected and the point where other forms of capital (built, human, social) are likely to be needed, to realize the gain in welfare » (Fisher et al., 2009, p. 646). The value of the benefits depends upon their use and may be dependent on local or external market prices. This value depends on the satisfaction of the beneficiaries' targets (Van Oudenhoven et al., 2012) knowing that these stakeholders are embedded in their social and cultural contexts (Sagoff, 2011).

Given that many ES are unique and irreplaceable, estimations of socioeconomic benefits and costs of agriculture should incorporate their value (Costanza et al., 1997). Understanding the dynamics of ecological processes relative to ES is essential in orienting economic decisions. An especially challenging aspect of this process consists in the interpretation and the use of ecological information collected from one spatial-temporal scale to another.

As a result of the foregoing, the identification of ES allows integrating the economic value of ecosystems and intends to guide public and private actions in favor of ecosystems and biodiversity for life and human interests. Promoting ES, to enhance the awareness of citizens and decision makers about their value and the services they provide, when they are in good condition, is a way to maintain natural ecosystems in the heart of the concerns. Therefore, in order to promote ES, the benefits and observed costs should be identified considering the categories of actors, the concerned ecosystems, the local or global dimension of the ES assessed as well as their potential marketable value. The lighting of different ES and their possible evaluation on the more or less long term can then better inform about the gains and losses related to the policy options implemented for a better long-term adjustment. Also special attention should be paid to distinguishing between ES at different scales. Besides, the possible interactions between ES must be characterized and analyzed specifically.

3.2. ES for grasslands in the Tropics

Since the MEA (2005), ES are classified in four utilitarian functional groups: (i) supporting (i.e. soil formation, nutrient cycling), (ii) provisioning (i.e. food, freshwater), (iii) regulating (i.e. climate and disturb regulation) and (iv) cultural (i.e. recreation, aesthetic). From these four categories of ES derive five well-being constituents (Figure 1).

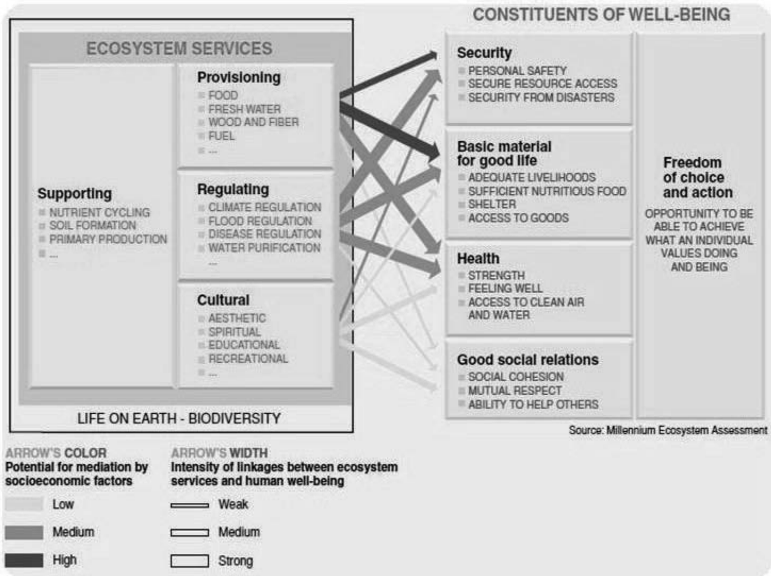

Figure 1. MA (2005) distinguishes four major types of ecosystem services, which derive five "elements" that make up the well-being of humans

If we consider the activities related to an agricultural system based on the exploitation of grasslands, many services are offered, in addition to provisioning which often appear as the first objective of the farmer.

Provisioning services are for instance meat productions which may be different according to the animal species considered and their rearing conditions (alone or mixed). Provisioning services can also refer to milk, cheese and other products more or less transformed. For all these products a market value can be defined quite easily, and the identification of the service and its possible payment for the farmer appears fairly obvious. However in addition to the quantities of the various products, should be highlighted the value of the quality of these products.

Numerous studies show the link between the quality of animal products and farming systems based on pasture (Reddy et al., 2015; Agastin et al., 2013).

These farming systems evoke for consumers the well-being of animals and consequently a healthy diet for themselves and their families. Publicity knows how to enhance this statement which should benefit more directly to producers. Other outputs as the manure need special attention. Indeed the services provided via compost or vermicompost for example, should be well determined, as they influence the value of the supply of manure. If compost may help for improve the organic matter of the soils, as well as interfere with nematode of crops (Arancon et al., 2002; Foley et al., 2014) or even for gastro-intestinal nematodes of animals grazing on grasslands (d'Alexis et al., 2009), that implies a strong added value for the manure supply. Note that some products such as leather will have various uses depending on the local context, and therefore a different value. In temperate regions, if animal skins are mainly used for making coats, jackets or various other leather products, in the tropics, in the Caribbean for example, goat skins are primarily used in the manufacture of drums which have a very strong cultural role in the area. Thus even provisioning services, which seem obvious to promote at first sight, need to be properly assessed, and fit in local contexts.

Beyond provisioning services, grasslands are also from an ecologically point of view ecosystems which have a strong link between herbivores and floral diversity (Gliessman, 2009). Therefore grasslands when well-managed, may provide ecological and regulating services, notably to maintain and restore biodiversity of the open landscape (Ma and Swinton 2011, Metera et al. 2013), for pollination and against erosion and leaching. The evaluation of the various regulating services and the process implemented should be studied, according to the various grazing ecosystems. Grasslands can also potentially offset a significant proportion of global greenhouse gases emissions and the extent of storage may be increased via appropriate strategies of management such as stocking rate and grazing pressure (Allard et al., 2007; Ammann et al., 2007; Soussana et al., 2013). Besides, animals are essential actor on regrowth of grass, contribute to improving the quality of the grassland, and act in soil erosion and the processes of infiltration and water retention (Gliessman et al., 2009). Thus, Koocheki and Gliessman (2005) consider the pastoral nomadism as a complex set of practices and knowledge which ensure the long-term maintenance of a sophisticated "triangle of sustainability" which includes plants, animals and people. The evaluation of different control services and processes implemented must be studied according to different grassland ecosystems concerned.

Beyond the regulating services, natural resources and landscapes may provide numerous social, cultural, recreational, and aesthetic services which satisfy human needs and well-being and must be considered and valued (Ma and Swinton, 2011; Zhang et al., 2007). In this sense, most traditional agroecosystems have remarkable characteristics regulated by strong cultural values and collective forms of social organization including customary institutions for agroecological management, normative arrangements for resource access and benefit sharing, value systems, rituals, etc. (Altieri, 2011). The livestock production systems based on grasslands therefore has great potential for social equity, the poverty alleviation, risk reduction and gender equality (Gliessman, 2009) in compliance with the Millennium Development Goals Objectives and the post-2015 Development Agenda.

This is precisely the case of the traditional practice of tethering in some tropical areas, as previously described above. This practice provides indeed income to a wide range of breeders (including pensioners, women and youth), via an efficient conversion of biomass into animal protein at low cost on any non-arable land. The animals, when they are well reared by this way, regularly visited and watered, contribute in addition, to shape the landscape and maintain the state of local savannas. By driving individually the animals, the adjustments of stocking rate by the owner may prevent overgrazing (Boval et al., 2014). However for these services, though essential, determining a value in use is laborious and requires the establishment of evaluation methods involving various disciplines experts.

The production systems based on grasslands also enhance the short circuits reducing the cost of food distribution. The development of such local food chains seems to renewal the meaning of farm work, helps reinforce social links and reduce energy consumption (Mundler and Rumpus, 2012).

Conclusion

While agriculture is a great contributor to most of the critical problems human societies faced nowadays (soil impoverishment, pollution, loss of biodiversity, emerging diseases, deterioration of health etc.), it can also play a major role in their resolution. Therefore, agriculture generates negative but also positive externalities. The focus on the positive externalities invites to operationalize the multifunctional facets of agriculture by the promotion of ES. This supposes that ES are likely to be identified, evaluated and paid for. This approach is of first importance for orienting policies and developing incentive measures for a real appropriation of ES by farmers. More widely, this objective necessitates supporting a strong agroecological transition. This implies to abandon the ongoing production model (i) to achieve a more rational and efficient use of all natural resources, including the solicitation of natural regulations (climate, ecosystems) and resilience weather conditions for the territories, ii) to adopt a new economic and social rationale that renews ways to consume, to produce, to work and to live together. This goes through the redefinition of a societal pact that necessitates federating all the stakeholders around an agroecological project. It calls for the development of convenient tools and methods to develop radical innovations and more widely to collectively think and organize the agroecological transition in its strong form. This is of first importance especially in vulnerable areas like the Tropics in order to increase their long-run resilience.

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