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The XXI century mountains: sustainable management of mountainous areas based on animal traction

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Abstract: According to the Food and Agriculture Organization of the United Nations (FAO), there are around 300 million working animals worldwide. They play a fundamental role in human livelihoods through their contribution to financial, human and social capital, supporting between 300 and 600 million people globally, particularly in poorer areas, where animal energy represents a huge and extremely important sustainable power resource. Yet their recognition remains largely neglected, with animal traction being largely ignored by decision and policy makers and even by civil society at all levels, which compromises a real development and improvement of this technology as well as animal welfare. On the other hand, a collective ecological and economical consciousness and an increasing awareness of public opinion about the need to reduce the excessive industrialization and mechanization of agriculture and forestry has led some sectors of society to consider the (re)use of animal traction as a valid modern source of energy. Indeed, working animals optimally transform the consumed biomass in energy and natural fertilizer, which avoids soil degradation and contributes to a sustainable management of arable lands, forests and sensitive areas. The need to maintain biodiversity, reduce carbon emissions, encourage self-reliance and reduce consumption of resources also contributes to this trend.

Keywords: working animals, animal energy, mountain farming, family farming, sustainable development

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1 Introduction

Mountain regions cover 25 % of the World's land surface and directly support more than 897 million people (around 12% of the world population) living within these areas (Mountain partnership 2014). In the European Union (EU), mountain regions represent around 30% of the EU total area, with large parts of this territory protected within the Natura 2000 ecological network and other types of nature conservation arrangements (European Parliament 2016; Sundseth et al. 2008).

Today, mountain areas and mountain populations all around the world are facing some serious challenges, directly related with the impact of climate change, rural exodus and a remaining ageing population. The abandonment of farmland, together with the loss of traditional knowledge for the correct use and management of the mountain environment may seriously compromise these regions, significantly reducing the resilience of mountain areas (FAO 2013).

Nevertheless, these territories should also be considered as an important part of the solution, due to their unique characteristics based on the immense variety of ecosystems and resources, also playing an important role for the economic, social and sustainable development (Euromontana 2016).

The search for sustainable solutions to these new challenges is somehow in the core of the international

political agenda, and are considered alongside the attempts to tackle important issues such as safeguarding of the environment and development of viable economic activities (e.g. farming, forestry, tourism and energy), gender equity, food security and rural development, among others (European Parliament 2016; FAO 2010a).

All these challenges are also well identified by other important stakeholders, such as Non-Governmental Organizations (NGOs), who are seeking for solutions through the promotion of sustainable models of development, incorporating and adapting (old) new concepts, such as the use of animal traction for the sustainable management of mountain areas.

The aim of this article is to present the growing interest and the importance of working animals in the general awareness for sustainable energy sources, for sound techniques in agriculture, forestry, environment management and mobility. Animal traction is also reappearing in scientific research, in agricultural and forestry schools, as well as in rural and urban development programs. This technology has supported mountain economy since ancient times, and today it can be adapted to perform alongside with and in support to the most modern technical options.

2 From domestication to the use of animal energy

The domestication of several species and their use as working animals (e.g. bovine, horses, donkeys and mules, camels, elephants), in a wide range of geographical areas worldwide, was a pivotal point in human history. These lead to a large-scale revolution in the organization and life-style of cities and pastoral societies, improving transport systems and promoting overland trade and colonization of new regions across the globe (Rossel et al. 2008; Marshall and Weissbrod 2011; FAO 2014a).

In the XXI century, the continuous use of draught animals is still a reality in mountain areas worldwide, being mainly persistent in Asia, Latin America and Africa, where it is still increasing (FAO 2010b). According to the Domestic Animal Diversity Information System of the United Nations Food and Agriculture Organization (FAO), there are 300 million working animals worldwide, including around 50 million donkeys, 11 million mules and hinnies, and 59 million horses (www.fao.org/faostat/home), with the vast majority of these working animals being present in developing countries (FAO 2014a).

These animals play a fundamental role in human livelihoods through their contribution to financial, human and social capital, supporting between 300 and 600 million people globally (Stringer 2014). Animals are relied upon as a major source of energy all over the world, and they play a very important role as a working force in agroforestry and in industry, as well as in the transportation of goods and people (The Brooke 2007; Kugler et al. 2008). Some studies even suggest that animal energy may supply nowadays approximately 50% of the global agricultural power needs (Swann 2006).

3 Mountain farming, family farming and animal traction

There is a direct relation between mountain farming systems and family farming, with the latter being one of the most predominant forms of agriculture worldwide, in both developing and developed countries - even in the EU, where there are about 11 million subsistence and semi-subsistence farms (FAO 2013, Ciolos 2010).

The Committee on World Food Security's High Level Panel of Experts defines family farming as that type of farming using *"only or mostly family labour and deriving from that work a large but variable share of their income, in kind or in cash. Agriculture includes crop raising, animal husbandry, forestry and artisanal fisheries. The holdings are run by family groups, a large proportion of which are headed by women, and women play important roles in production, processing and marketing activities."* (HLPE 2013).

The 90% of the world's 570 million farms are managed by families, with some authors pointing at values as high as 98% of all farms (Graeub 2016). These farms produce over 80% of the world's food (FAO 2016), and occupy around 70 - 80 percent of the global farm land (FAO 2014b). Despite the importance of family farming, for many years the Common Agricultural Policy (CAP) of the EU has ignored the role and functions of small farms, often forcing them either to amalgamate, or to exit the sector via structural change. Family farming has even been perceived as an obstacle in the modernisation of EU agriculture (Hubbard 2007).

Recently, the attitude towards small-scale farming has changed and the integration of forests and husbandry activities, diversification of crops that characterize family-farming, as well as low carbon footprint have finally been recognized as something valuable (FAO 2013), which has contributed to the gradual change of the stereotypical image of family farmers and smallholders over the last years. It was shown that family farming or "peasantry", far from being stagnant and obsolete, is in fact a

Figure 1: Traditional farmers in the mountain areas of the Northeast of Portugal still rely on working donkeys for draught purposes such as ploughing potatoes, as well as helping harvest grapes used for wine production

genuine way of farming that is perfectly able to evolve and adapt to changing conditions (Edelman 2011). Once considered a part of the hunger problem, family farming is now considered central to food security and poverty eradication, representing part of the solution to achieve the Millennium Development Goals (FAO 2013). On the other hand, there is a global and clear perception of the new challenges posed by climate change, that seriously affect these farmers and their low impact production systems, along with the increasing negative environmental image associated with highly intensive farming systems (Silva 2014).

Working animals play a key role in supporting family farmers' communities, particularly in areas of limited income, where they present unique characteristics for sustainable animal production. This sustainability is enhanced by the fact that working animals may be kept with little or no external input (being more accessible to larger sectors of rural people than mechanized power), where they can tolerate extreme weather conditions, and are a source of clean and renewable energy that optimally transforms the consumed biomass in energy and natural fertilizer (Hoffmann 2010; FECTU 2012).

Under such environments, draft animals represent a tremendous contribution for small-scale farming systems (FAO 2014a).

The use of animal energy also greatly reduces the working effort of the family members, mainly women and children, contributing in a decisive way to increase the time available for children education and community involvement for women, raising female status, safeguarding rural social structures and family farming (FECTU 2012; Fernando and Starkey 2004).

4 Working animals in a fast changing global world

Despite the fact that the vast majority of the benefits regarding animal energy are fully valid and applicable in modern societies, this renewable source of energy, as well as human energy, is not usually considered in policy recommendations as well as in academic texts describing renewable energy sources and technologies (Fuller and Ayeb 2012).

Decision and policy makers, as well as other stakeholders such as Universities and International

NGOs often ignore the importance of animal traction as a potential source of sustainable development, excluding it from international development strategies (FAO 2010b), which has contributed to a huge delay in scientific research and in the development of appropriate technology for animal traction use.

Human and animal power have been wrongly regarded as obvious signs of underdevelopment (Fuller and Ayeb 2012), which has been followed by a generally negative perception regarding these sources of energy (www.fectu.org).

Within an economical context, both the industrial and the financial sectors show a total lack of interest regarding animal traction, based on the fact that animal energy cannot be stored, transported, commercialized or mass-produced. Within a social context, the attitude assumed by some organizations committed with "animal rights" tends to systematically depreciate any and all uses of the animals, ignoring the real importance of animal energy worldwide. These organizations may have a great influence in urban environments that are unable to judge the legitimacy of the arguments put forward (FECTU 2012).

All these facts, along with the technology improvement but also their imposition based on subsidy policies in the industrialized countries during the XX century, have led to a gradual replacement of animals by motorized traction in many farming operations, even in family farming, representing a major loss of biodiversity, but also the loss of historic, cultural and genetic heritage (Beja-Pereira and Ferrand 2005; Hodges 2006). The preservation of livestock breed diversity also comprises a sustainability value supporting the local economies and the fixation of human population in mountain areas, as well as an ecological value, allowing the improvement and preservation of agrobiodiversity (Gandini and Villa 2010).

However, in a fast changing world, the public have become aware of the real impact of human activities. A collective ecological (but also economical) consciousness about the need of reducing the excessive industrialization and mechanization of vital sectors in mountain areas such as agriculture and forestry, along with an increased and renewed interest in energy and environmental issues has led some sectors of society to consider the reuse of animal traction as a valid modern source of energy. The need of maintaining biodiversity, reducing carbon emissions, encouraging self-reliance and reducing consumption of resources also contributes to this trend (FAO 2014a).

Figure 2: Modern use of draught horses in an integrated organic farm in Germany. The need to avoid dependence on fuel fossils led many farmers to reintegrate animal energy in the production models, as well as other renewable sources of energy such as solar energy (photo courtesy of Erhard Schroll)

5 The Potential of the modern use of working animals

This new approach to the modern use of working animals started in the early 90's of the XX century, with such technology being used primarily by young people in Northern and Western Europe (with many modern users based in mountain areas) who showed interest mainly for horse-based technology. At the same time, the growing importance of animal traction as an alternative or complementary option to mechanical traction has led to the simultaneous emergence of several NGOs across Europe, currently organized in a European Federation – FECTU[1] (www.fectu.org).

A growing number of small and medium farms across Europe have already understood the potential of using working animals in order to achieve their daily work needs, as well as other sectors such as forestry. In purely energetic terms, several studies point to the efficiency of animal traction in relation to the so-called conventional production models. When comparing energy efficiency between working horses and tractors, even with this latter fuelled with the proclaimed ecological diesel (biodiesel), differences are clear. Studies pointed out that the amount of biodiesel required by a 35 horse-power tractor to work one hour per day throughout the year, would occupy 5 hectares, whereas 1.5 ha of arable or grass land are enough to feed a horse used throughout the year for 5 hours per day in order to perform the same work (Herold et al. 2014). In terms of pulling efficiency, a recent study performed by Johansson et al. (2013), in a Swedish small-scale integrated organic farm, demonstrated that the efficiency of a draught horse is 17%, meaning that 17% of the fodder intake is convertible in tractive power. The same study pointed lower efficiency values for biogas (6%), due to the big losses as heat during the biomass conversion process (Johansson et al. 2013).

When comparing both technologies again, another study showed that when relating farming systems based on local renewable energy sources, farming with tractors was based on only 9%, while draught horses were based up to 60% (Jansén 2000). Not only does the energy input derive from the farm itself in the case of the horse (or any other working animals), but the products of the energy conversion also remain on the farm, contributing in a decisive way to close the production cycle in the farm.

Regarding technology, an increasing progress related with working animals in recent years was observed, through a process of improvement and replacement of existing tools and coming from the industrial revolution and subsequent years. This process, developed initially by users in search of answers to the needs inherent to the particular working conditions, is gradually leading to the professionalization of the sector, both in Europe and in the United States, where the larger number of users has boosted a growing market (Herold at al. 2014; Kendell 2005).

Animal welfare appears now in the core of the new technology, with animals being included as an integral part of the work team. A good example of this new paradigm is the technological solution based on electric energy assistance, recently developed in Switzerland (Docker). The energy produced by braking friction on the downhill travel is stored in a battery and returned to the electric motors to assists the horses on the uphill travel or when pulling heavy loads. With this synergy, working animals are not replaced but assisted, reinforced by an engine powered by the kinetic energy produced by traditional horsepower (H. Spychiger, unpublished data).

Other important aspects are also being taken into account in this field, such as reducing the weight of equipment by replacing traditional heavy items (e.g. chains, steel cables, swingle trees, collars) with newly developed synthetic materials.

In technical-scientific terms a significant increase in the transfer of knowledge has occurred by those stakeholders responsible for the current state of the art (mainly FECTU members and American and Canadian counterparts), through the promotion of national and international events, professional workshops, practical courses, congresses, conferences and other related activities, as well as through scientific studies (www.fectu.org).

On their part, some universities and scientific institutions have produced a number of very interesting studies that demonstrate the potential use of working animals in mountain productive areas in the agroforestry sector, but also very important indices of sustainability even for developed countries (Rydberg and Jansen 2002; Morrissey 2009; Gantner et al. 2014).

For woodland soils it has been established that draft animals cause little ecological impact during logging operations (Voßbrink 2005). Preliminary results obtained by García Tomillo et al. (2016) also pointed to a small impact on the soil physical properties when comparing effects of tillage treatments performed with animal traction (García Tomillo et al. 2016). In relation to the development

1 The FECTU (*European Draught Horse Federation*) is an international umbrella-organization committed to encourage modern, effective and well-managed use of animal traction, always based on a responsible use of animals in terms of respecting their physical limits and their dignity.

Figure 3: Demonstration of new agricultural implements specially designed for vineyards on a trellis, presented during the *Trait Comt'Est 2016* (France), one of the most important European events of the sector in 2016

Figure 4: Logging operations using horses, during intermediate cuttings of immature pine trees in a forest managed by the Municipality of Vimioso, Northeast of Portugal. Animal traction has gradually been recognized as a very interesting tool for sustainable management of woodlands

of plants, young vines growing in a vineyard worked only with horses are claimed to start to fruit between one and two years earlier than those growing in soils compacted by tractors (Cannelle 2002; Scharnhölz 2009).

In forest management of mountain areas, comparative studies have found that the percentage of damaged trees drops to half and damage severity to one third when animals are used instead of tractors. However, the benefits can also be financial and not just environmental, because horse skidding is shown to be 30% cheaper than tractor skidding if the extraction distance does not exceed 100 m and the cost of opening a tractor trail is included in the calculation. The cost efficiency of horse skidding is significantly increased by detaching two horses per driver, since the additional cost of the second horse is lower than the additional productivity it generates (Magagnotti and Spinelli 2011a; Spinelli et al. 2013). Another study shows that teaming horse and tractor is a very effective strategy. If the horse pre-bunches for subsequent tractor skidding, total extraction costs become half as high as if extraction was performed exclusively by horse, and three times as low as if extraction was performed exclusively by tractor ((Magagnotti and Spinelli 2011b).

Even if the presented results are promising and demonstrate the potential use of working animals, either independently or in synergy with conventional techniques, more studies are needed, both in the engineering area for the technology development, but also in the agricultural sciences, allowing the collection of evidence-based scientific data that reinforce the potential of the animal energy.

6 Conclusions

Development is now ruled by economic as well as environmental and social principles, where a balance is sought between the economic growth of the regions, the improvement of the quality of life of the populations, but also the creation and implementation of an integrated and sustainable territory.

Mountain areas are perceived as open spaces of an incredible potential, and therefore, systems that must be valued in a perspective of sustainable production of the agroforestry sector, integrating and respecting the local culture and traditions, while valuing and enhancing the endogenous resources, in a search for the correct and careful management of natural resources, including soil, water, landscape and native genetic resources (plants and animals) for the benefit of this and future generations.

Modern animal traction may play a key role in the pursuit of such goals and must be included as part of the global solution for a sustainable management of mountain areas, contributing to the improvement of the livelihoods of mountain communities.

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