EIP-AGRI Focus Group
Permanent Grassland

Life cycle assessment: evaluation of the environmental impacts of grassland-based systems

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Evaluation of the environmental impacts of grassland-based systems using Life Cycle Thinking

Main question

Which is the environmental value of grassland-based product estimated by a Life Cycle Thinking (LCT) approach?

1. Valuation of ecosystem services as key-factor for the full profitability of permanent grasslands.

As production systems' eco-sustainability, biodiversity and climate change mitigation are on top of the European agenda (new PAC conditionality/greening), minimizing the ecological impacts of farms represents a key factor for farmers to obtain public incentives and for enhancing the multifunctionality of agricultural systems expressed as services to society. Therefore, the assessment and valuation of environmental performances could be a crucial factor to improve competitiveness of grassland-based farming, in particular when located in marginal lands or within protected and HNV areas, whose products are receiving increasing interest in local and international markets. For this purpose, it is essential to assess the environmental performances of the grassland-based livestock systems in an innovative way, following a Life Cycle Thinking (LCT) approach and exploring evaluation methods that gather and quantify the complex and multifunctional character of these systems. Moreover, a relevant aim to be reached indirectly by this way is the quantification of ecosystem services provided to the society by grassland-based farms.

Functional products from grassland-based systems represent a key factor of multifunctionality as a dominant paradigm for farm management, having reached the goal of maximizing outputs as common goods and its benefits for human health (Fig. 1). Several experimental results show that less intensive production schemes based on pasture or grass feeding have marked positive direct effects (e.g. higher carotene content improves milk, butter and cheese colour) and indirect effects (e.g. the concentration

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of proteolytic enzyme influences cheese maturation and texture) of several traits on animal products (Coulon and Priolo, 2002). It could be relevant to assess the real role of functional products within the scenarios of agro-ecology and sustainable production processes (relevance for rural community, policymakers' recognition of rural economy, importance for the agri-food market, etc.).

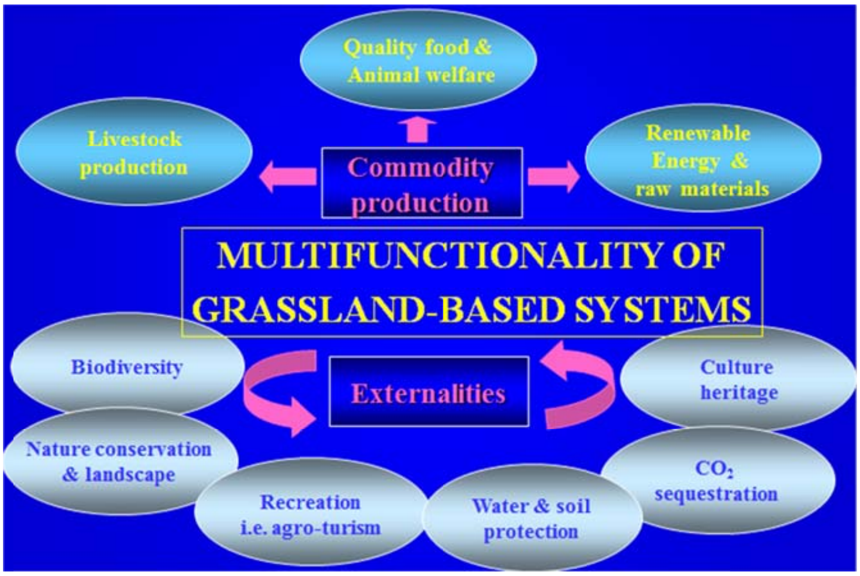

Figure 1 – Main commodity products and positive externalities in a well managed grassland-based system (Porqueddu *et al*., 2003).

Grassland-based farmers' activity also provides beautiful rural landscapes and traditions which attract tourists and visitors to countryside, mainly some landscape features that are associated to the production system, including woody vegetation. Their land management produces a number of positive effects, contributing to reduce environmental risks. mitigate climate change damages, carbon sequestration and improve biodiversity, etc. For example, in northern Spain the majority of protected areas (including national parks) fall within territories where active traditional grazing systems usally linked to agroforestry are maintained and the resulting "green paradise" attracts tourists. Ironically, the persistence of those areas depends on the continuance of the traditional activities which are under risk of extinction. A remarkable example is given by the production of unique cheeses, most of them with Protected Designation of Origin (*PDO*) status. The quantification of the ecosystem services should represent the starting point to assess more clearly the EU strategy of CAP subsidies' eligibility of permanent grasslands, comprising wooded pastures, grazed forests, silvopastoral systems, that are currently still excluded from the first pillar payments in some EU regions (e.g. Sardinia).

Moreover, it is necessary to assess if grassland-based farming systems achieve lower costs and higher quality products than systems that are intensive, and more dependent on external inputs. On the other hand, bearing in mind that extensive systems are characterized by lower productivity levels, their economic sustainability strongly depends on diversification of incomes (eco-tourism, etc.).

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The promotion of farming systems based on permanent grazed grasslands, increasing the extent of grazing in terms of both surface area and season, could be explored not only to reduce feeding costs but also to meet consumer expectations on animal welfare. Animals bred on species-reach grasslands need less chemical treatments against diseases because they have more opportunities for self-medication. Open-air grazing should be fully exploited (Porqueddu, 2007); e.g. in some regions of Southern Europe, it can be practiced all over the year representing a very important intrinsic resource.

2. Life Cycle Assessment (LCA).

The environmental impacts (including greenhouse gas emissions) of animal production systems based on grasslands can be evaluated by using the LCA approach (De Boer, 2003). LCA is a widely accepted, complete and standardized computational tool for providing a widespread knowledge on the environmental aspects associated with products or production processes (Hayashi et al., 2006). It represents also the first step towards sustainability of production systems, identifying where environmental impacts and damage take place (Chen et al., 2005). The role of LCA in the context of research priorities has been recently discussed by Soussana (2014). According to this author, bridging nature capital and health issues, with the assessment of the life cycle of products and systems may lead to breakthroughs in the sustainability assessment of food systems. However, when applied to agriculture, the method presents some challenges due to the intensive nature and limited availability of the required data, and the multiple-output nature of production (FAO, 2010). In particular, we highlight the need for improving the following points: i) definition of both the functional unit (ha, DMY, MJ, kg meat/milk/cheese/wool) and impact allocation criteria in coherence with the complexity of the various functions offered by grassland-based systems; ii) definition of the systems boundaries in order to include all the processes that determine the environmental value of grassland-based products and services along their life cycle; iii) selection of the most appropriate evaluation method in relation to comprehensive assessment of land use, C-sink activity and biodiversity relationship.

According to the European Animal Task Force white paper (www.animaltaskforce.eu), a model based on LCA needs to be developed to determine the trade-offs in environment-socio-economic impact when decisions are taken on the use of co-products and alternative resources. It is reconized that Life cycle and system analysis are sound methodologies for a complete chain analysis and focus on a set of environmental impacts.

3. List of existing projects and results.

Several LCA studies have recently been conducted on dairy cow production systems in Europe to compare different farming strategies (Corson and van der Werf, 2008; Thomassen et al., 2008; Alig et al., 2011; Penati et al., 2013), while very little research has been conducted on the environmental implications of dairy goat and sheep productions (Vagnoni et al., 2014).

LCA analysis can be an efficient tool to understand comprehensively the environmental implications of production cycles, thus counteracting some widespread wrong ideas that persist on animal productions in the media and the society. The following statements can be cited:

'Red meat production requires 7 kg grain per kg meat, pork 4 kg and chicken 2.5 kg'

Actually,

- Red meat production may require a lot of grain but grass-based meat requires very little cereals and other grains.
- Factory production of pork and chicken meat always requires a lot of grain.

'Red meat production requires 15,000 l water per kg meat, pork meat 4,000 and chicken 2,000'

Mekonnen & Hoekstra (2010) compared LCA of water consumption for beef and dairy cattle, pigs, sheep, goats, broiler and layer chickens, and horse productions. They considered three categories of water consumption ('Water Footprint'): blue, green and grey[1]. The authors concluded themselves that 'the total water footprint of an animal product is generally larger when obtained from a grazing system than when produced from an industrial system, because of a larger green water footprint component. The blue and grey water footprints of animal products are largest for industrial systems (with an exception for chicken products). From a freshwater perspective, animal products from grazing systems are therefore to be preferred above products from industrial systems'. Mekonnen & Hoekstra (2012) also stated that 'Animal products from industrial systems generally consume and pollute more ground- and surface-water resource than animal products from grazing or mixed systems'.

'**Ruminants have a worst impact on the environment than monogastrics because of methane emissions'**

Actually,

- Pig and poultry factory production probably consumes about 2/3 of soybean imports, they thus have a high negative impact on:
  - the destruction of the Amazonian forest, of the Cerrado and the Pampa, all species-rich ecosystems
  - the emissions of CO2 in South America from forest and grassland conversion to soybean fields
  - the quality of surface and ground water through the effect of slurry (imported N and P pollution) in Europe

[1] The blue water footprint refers to consumption of blue water resources (surface and groundwater) along the supply chain of a product. 'Consumption' refers to loss of water from the available ground-surface water body in a catchment area. Losses occur when water evaporates, returns to another catchment area or the sea or is incorporated into a product. The green water footprint refers to consumption of green water resources (rainwater in so far as it does not become runoff). The grey water footprint refers to pollution and is defined as the volume of freshwater that is required to assimilate the load of pollutants given natural background concentrations and existing ambient water quality standards (Hoekstra et al., 2011).

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- the eutrophication of forest and oligotrophic habitats in Europe by NH_3 emissions
- the destruction of permanent grasslands in Europe which leads to CO_2 emissions and biodiversity destruction
- animal welfare.

'Ruminant production systems have necessarily negative impacts on the environment'

Actually,

- Sheep, goat and cattle systems maintain species-rich habitats in mountain and Mediterranean areas, in wetlands, … (HNV farmlands)
- Without these grazing animals these habitats would be encroached or planted with exotic trees and would lose their biodiversity.
- Are a habitat for soil life (earth worms, insects, micro-organisms)
- Are a feeding ground for farmland birds (skylark, grey partridge, birds of prey) and some mammals (roe deer, badger, hazel).

There are several international and European projects on LCA, some are in the field of agriculture but only a few are concerned on livestock grassland-based systems. There is thus an urgent need of detailed studies on LCA of animal production systems and in general of agricultural systems.

Here is reported a list of the more relevant projects:

- **UNEP/SETAC** - The Life Cycle Initiative (**http://www.lifecycleinitiative.org/**). The project aims to foster the concept of Life Cycle Thinking (LCT) and to harmonize the existing methodologies on LCA at global level. A specific goal is the standardization of biodiversity evaluation methods.
- **SOLID, FP7 (http://www.solidairy.eu/).** SOLID is a European project on Sustainable Organic and Low Input Dairying financed by the European Union. The project runs from 2011-2016. A total of 25 partners from 10 European countries participates in this large project. The project aims to improve the technical performance and economic competitiveness of organic and low-input dairy systems in Europe, while maximising their potential to deliver environmental goods and enhance biodiversity. SOLID will research sustainable organic and low-input dairy production. Organic and low-input dairy farming systems are increasingly noted as delivering multifunctional benefits to the agricultural industry and society but technical and economic constraints prevent widespread adoption. LCA analysis of C footprint of organic and low- input dairy systems at farm and regional scale will be carried out.
- **LEAP-FAO** - Livestock Environmental Assessment and Performance Partnership (**http://www.fao.org/partnerships/leap/livestock-partnership/en/**). The LEAP Partnership was founded in 2012 and involves stakeholders across the livestock sectors, all who share an interest in improving the environmental performance of livestock supply chains. The objective is to develop comprehensive guidance and methodology for understanding the

environmental performance of livestock supply chains. The overarching goal of this initiative is to contribute to improved environmental performance of the livestock sector while considering social and economic viability. The Partnership will contribute towards the achievement of this goal through support to decision-making by providing guidance on environmental assessments (LCA) and their subsequent application. The Partnership promotes an exchange of data and information, technical expertise and research geared towards improving and harmonizing the way in which livestock food chains are assessed and monitored.

- **Specialty Feed Ingredients Sustainability (SFIS)** Project Consortium (http://www.ifif.org/pages/t/Specialty+Feed+Ingredients+Sustainability+(SFIS)+Project). The SFIS project brings together for the first time a consortium of international companies and associations dedicated to reducing the environmental impact of livestock through innovative specialty feed ingredients. The project partners have joined together to measure and establish the role of specialty feed ingredients (SFIs), specifically amino acids and enzymes, on the environmental impact of livestock production and are united in their goal to contribute to the reduction of emissions in the food and feed chain. The SFIS consortium is led by the International Feed Industry Federation (IFIF) and the EU Association of Specialty Feed Ingredients and their Mixtures (FEFANA), and brings together the American Feed Industry Association (AFIA), the Japan Feed Manufacturers Association (JFMA) and the Brazilian Feed Industry Association (Sindirações), as well as companies active in the production of feed and specialty feed ingredients. The results of the study were validated by an independent Scientific Council made up of global experts in the fields of LCA methodology and animal nutrition to ensure scientifically robust inputs in the analysis and prepare the ground for a future peer reviewed publication of the project. The final findings of the SFIS study will be published in Q2 2014.

  PECUS-CISIA, Italian National Project "Integrated knowledge for sustainability and innovation of Italian agri-food sector", coordinated by the Agrifood Sciences Department of the National Research Council (CNR-DAA) and partially funded by the Ministry of Economy and Finance of Italy (MEF). The PECUS project aims to contribute to fill knowledge and data gaps on the environmental implication of small ruminant livestock systems i) comparing the environmental impacts of sheep milk production from different Sardinian dairy agro-pastoral farms at different input levels; ii) identifying the hotspots to improve the environmental performances of each farms, by using an LCA analysis (Vagnoni et al., 2014).

  ATF- Animal Task Force, European initiative on the food chain including a task on LCA for the livestock sector (www.animaltaskforce.eu.). The mission is to foster knowledge development and innovation for a sustainable and competitive livestock sector in Europe. To realise this it is believed we need integrated approaches across the value chain. Knowledge institutes and industry have to collaborate to contribute to the economic, environmental and societal challenges involved in our mission. In addition it is necessary to further develop the relationships with decision making institutions in the EU. Only by starting a dialogue common solutions can be found. The vision is to deliver European livestock systems that are globally competitive and environmentally positive. European farm industries are global players and supply competitive markets, both European and worldwide. The viability of different livestock systems needs to be considered. Only by creating more sustainable and better optimised animal production systems with healthy, balanced and robust animals, we can ensure a steady supply of good quality food and other 'agri-products' for all, while contributing to a better environment.

In the project **AnimalChange** (www.animalchange.eu; an integration of mitigation and adaptation options for sustainable livestock production under climate change) some LCA work is carried out as well. To understand off-farm implications in terms of carbon footprint and GHG emissions, results of current farm models will be coupled with lifecycle analyses (LCA) integrating pre-chain GHG emissions and their mitigation.

IFEU, German National Project "Environmental Performance of Milk and Dairy Products – Status quo and optimisation potentials" coordinated by the Institute for Energy and Environmental Research - Heidelberg (IFEU), in collaboration with IDF Germany (VDM) and the German Dairy Industry Association (MIV) and funded by the Federal Ministry of Food and Agriculture (BMEL). The project aims to i) quantify the environmental impacts associated with the production and consumption of milk and dairy products along the entire life cycle from milk production through processing, packaging and distribution to final use and ii) to depict optimisation potentials. A special focus is laid on the dairy industry, but the report (Müller-Lindenlauf et al., forthcoming) also investigates the environmental impacts of milk production based on grassland and feed produced on arable land, respectively. Moreover, a "Climate and Energy Calculator for the German Dairy Industry" is produced within the project.

Carbon Dairy - LIFE12 ENV/FR/000799, the main objective of the LIFE Carbon dairy project is to promote a milk production approach that is capable of reducing GHG emissions by 20% over 10 years. To achieve this goal, the partners aim to: i) provide livestock farmers and their technical and administrative environment with tools and methods to understand the issue, to guide and modify their technical choices in order to reduce GHG emissions and preserve carbon stored in soils, ii) promote innovative livestock farming systems and associated practices to ensure the technical, economic, environmental and social sustainability of dairy farms, and thus to improve interactions between climate change and livestock production, iii) launch a national campaign to demonstrate to livestock farmers and agricultural advisers the interest and feasibility of a 'climate roadmap' for milk production; and Develop this 'roadmap' for milk production with carbon action plans adapted to each production system and a relevant partnership strategy implemented at the national level. The project is conducted in six representative dairy regions of France and investigations concern a sample of 3 900 farms located across the six regions to enable the large-scale assessment of carbon impact.

4. Research needs.

Well managed permanent grasslands produce positive externalities (Fig. 1) or public goods or generically environmental services (Porqueddu *et al.,* 2003), since they can play a major role not only on carbon sequestration and biodiversity enhancement, but also on cultural heritage landscapes, farmland biodiversity, water quantity and availability, watershed protection, soil functionality, climate stability, air quality, resilience to flooding and fire, pest control, and pollination, among others. In addition, there are some social public goods, which are impacted by agriculture and forestry such as rural vitality, farm animal welfare and health and food security (Cooper *et al.*,2009, Power, 2010, Hart *et al.*, 2011). Recent contributions by Bateman *et al.* (2013; 2014) have noted the importance of bringing ecosystem services into decision-making. However, these public services do not have a market price, are difficult to disaggregate, are highly interrelated in complex dynamic ways, and therefore are difficult to measure. As a result, they are often ignored in environmental evaluation of animal agriculture, being excluded from the profitability analyses. There are some examples of ecosystem services valuation from a economic point of view on wooded pastures (Campos *et al.*, 2009).

Natural and semi-natural grasslands provide more ecosystem services (provision of animal products excluded) than agriculturally-improved permanent grasslands. Well-managed temporary grasslands produce also positive externalities or public goods, though usually less than permanent grasslands but more than arable land. They can store carbon in the soil, enhance soil biodiversity and fertility, increase clean water provision, protect watershed, increase resilience to flooding, contribute to pest and weed control, and can provide pollen and nectar to pollinators.

In addition, when farmers or forest owners/managers do not receive any type of payment or compensation for the provision of these public goods, they may lack the proper motivations to provide them. Recently Bateman et al. (2013) illustrates the consequence of such incentive misalignment, showing that agricultural policies which try to maximize the market value of farm production without consideration of impacts upon ecosystem services related non-market goods (such as water pollution, biodiversity loss, increased emissions of greenhouse gases and degradation of recreational resources), actually generate overall losses in the net value of land use.

LCA and other LCT-based evaluation methodologies show shortcomings when trying to integrate land use and biodiversity dimensions mainly due to the inherent spatial and temporal heterogeneity. This is also acknowledged by Müller-Lindenlauf *et al.* (forthcoming) who – in addition to the classical LCA impact categories – also discuss aspects such as land use (and quality of this land), land use changes (and associated GHG emissions), biodiversity, water use and animal welfare.

Other studies have shown that when allocated to livestock production only, the GHG emissions per kg of product decreased according to the intensification level (Ripoll-Bosch *et al.,* 2013). However, when accounting for externalities, GHGs emissions per kg of product increased according to the degree of intensification. The strong links between grassland-based livestock production and the provision of diverse ecosystems services, especially in mountain and other marginal areas, need to be considered and integrated into a standard evaluation framework for environmental impacts of agricultural production, such as LCA .

For example, it is important to assess the role of permanent grasslands on i) soil erosion control, ii) wildfire prevention, iii) carbon sequestration, iv) enhancement of biodiversity and v) clean water provision. In order to fill these gaps, it is essential, also at local level, to develop knowledge for improving data inventory (e.g. livestock enteric fermentation during grazing, nitrification and denitrification processes, methane and P balances, etc.). A step in this direction was proposed by Zhang *et al.* (2010) through the development of an Ecologically Based LCA (Eco-LCA) that includes a large number of provisioning, regulating, and supporting ecosystem services as inputs to a life cycle model at the process or economy scale. Including an ecosystem service like grassland soil carbon sequestration into an LCA has led to significant changes in the estimate of GHG emissions from European livestock systems (Weiss and Leip, 2012; Soussana *et al.,* 2014). However, further progress is needed in order to regionalise ecosystem services prior to their inclusion in an LCA framework. Such a regionalisation has already been attempted through the development of a first atlas of ecosystem services at the scale Europe (Maes et al., 2011). LCA requires further development and application to support scientifically-sound methodological choices enabling a harmonised assessment of improvement options for social acceptability of systems. LCA needs to be refined and applied, alongside inventory data and other relevant statistics, to provide robust analyses of current situations and how they have been changing. This includes novel research on the impact of the presence, absence or reduction of livestock agriculture on local/regional rural communities. Moreover, the importance of grassland-based livestock farms for biodiversity should be quantified so that effective grazing strategies can be developed.

5. Innovative actions.

- Rethinking the technical and political solutions to improve livelihood of farmers managing low-inputs grassland-based systems.

- Identifying and maximizing opportunities for multifunctional benefits (overlap of environmental, production, cultural functions).

- Agro-ecology and Agroforestry as means to replace fossil fuel by ecosystem services and to improve the positive impact of agriculture on the environment and human health.
- Promotion of forage legumes (e.g. lucerne and clovers) for reducing energy consumption and protein imports.
- Pasture-based meat and dairy products for reducing impacts on the environment and improving the quantity of functional components in human diet.
- New tools based on LCT (LCA of territories) to manage rural areas (e.g. agro-land care extension service) giving scenario analysis of permanent grassland-based meat and milk production systems in terms of their different LCA and alternative systems.
- Identify and develop new traceability systems and environmental certification systems for grassland-based products accessible to small-sized farms and being able to improve guarantee trasparency.
- Territorial management permanent committees of stakeholders (to empower the farmers) where farmers should participate directly. Where farmers and researchers can establish a direct dialogue, exchanging ideas and experiences with mutual benefit.
- Integrate data sets at local level and implement LCT tools for interconnecting extension services to academic and research centers and obtaining a more timely and accurate dynamic picture of the territorial context.

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