System Boundaries, Functional Unit, Calculation Methodologies and Indicators as Fundamentals for Life Cycle Assessment and Carbon Footprinting in Leather Making

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Abstract. Several approaches have been applied in the calculation of leather environmental profiles through traditional Environmental Impact Assessment methodologies (LCA and PCF). Particularly a key driver seems to be the involvement of the upstream processes within the leather life-cycle-inventory. In this paper an analysis on key elements for a proper approach is presented in order to detail the ISO 14067 indication to the leather sector and to adopt a shared and comparable approach during different LCA and PCF studies on leather.

Keywords. Leather, Product Carbon Footprint, Life Cycle Assessment, Independent information modules, Green Supply Chain Management,

1 Introduction

Concern over climate change has stimulated interest in estimating the total amount of greenhouse gasses (GHG) produced during the different stages in the life cycle of goods and services — i.e. their production, processing, transportation, sale, use and disposal. The outcome of these calculations are often referred to as Product Carbon Footprints (PCFs), where carbon footprint is the total amount of GHGs produced for a given activity and product is any good or service that is marketed. PCFs are thus distinct from GHG assessments performed at the level of projects, corporations, supply chains, municipalities, nations or individuals.

Life Cycle Analysis or Assessment (LCA) is the basic method used in carbon footprinting. LCA "studies the environmental aspects and potential impacts throughout a product's life cycle (i.e. cradle-to-grave) from raw material acquisition through production, use and disposal" (ISO, 2006), therefore, to find out where the environmental performance can be improved.

A number of private schemes have emerged in the last years that offer methodologies and expertise to footprint products and companies activities. In many cases these standards also provide guidance to reducing these footprints as well as procedures for certification and labelling against standards.

Through these schemes, manufacturers (and retailers) have calculated and sometimes displayed the carbon footprints on a few thousand products. In most cases these initiatives were not launched primarily to increase market share through product differentiation, but as part of a general effort to demonstrate commitment to climate - change mitigation to consumers and stakeholders.

Particularly, such schemes could promote eco-efficiency efforts in the leather based sectors, aiming at improving process efficiency and recycling processes in production and reduce natural resources, chemicals and energy consumptions. Such efforts need to be validated by a quantitative basis in order to foster green competitiveness of tanneries.

2 Scientific Background : common approaches in the leather environmental impact assessment

According to the examined literature, different approaches can be used for environmental impact assessment both in terms of general methodological approach and in terms of rules specification within the same methodological area. The scientific focus of such survey is to identify which are the common features in such label schemes and the similarities in the current studies on leather life cycle inventory.

- **Methodological approaches** are different in different label criteria. The main standards are all focused on the life cycle approach by producing, at the same time, different key parameters for final evaluation and comparison. Successively to ISO 14044 (Environmental management - Life cycle assessment – Requirements) which defined the basic framework for LCA studies, different approaches have been proposed to further detail such approach (ISO 14025, International Reference Life Cycle Data System). In parallel, new methodological approaches involving different assessment parameters like Ecological Footprint and French Environmental Footprint (BPX 30-323) have been introduced. Gas emission based protocols have been included the Product and Supply Chain Standards Greenhouse Gas Protocol (WRI/ WBCSD) and the UK's Product Carbon Footprint (PAS 2050) and the general ISO 14067 (Product Carbon Footprint).
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  Figure 1 shows the analysis summary on 105 Eco-labels schemes suitable for the leather industry extracted from of 435 eco-labels of 25 industry sectors which are available at global level (197 countries).

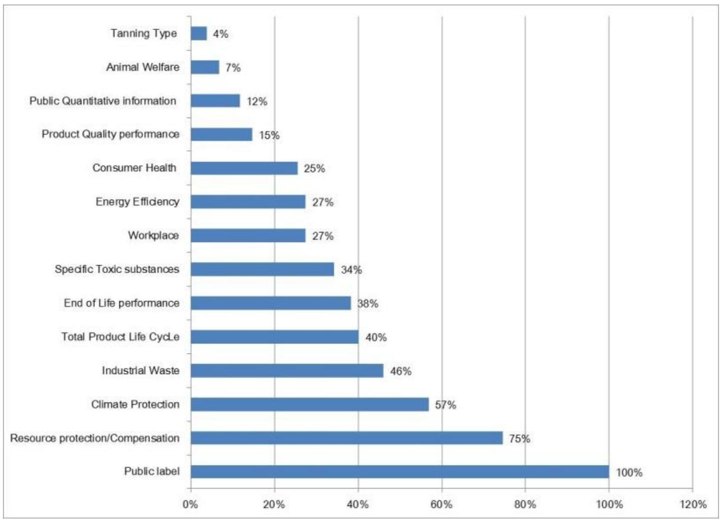

Fig 1. Percentage subdivision of leather eco-label schemes according to focus area

Classification of such standards has been carried out both in terms of information reported in label schemes and of methodology used to assess the environmental performance of companies and products. The outcomes seem to indicate a rapid increase of new kinds of label which are focused on quantitative criteria to assess green competitiveness. In addition, almost 40% of green labels are awarded on a Life Cycle Assessment basis while 57% of label schemes provide indications to consumer in terms of Climate effects or compliance to Climate standards.

On the other hand, the rapid proliferation of private schemes (almost 15 for the PCF) raises two issues of concern. One is that the application of multiple schemes in the marketplace may lead to confusion in the market about what information is relevant and useful and thereby diminish confidence in such information. A second, related, concern is that as such schemes proliferate one may become the de-facto standard and thereby create a market access barrier for products using new carbon-footprinting schemes and for product performance comparison. According to different surveys the fragmentation may constitute a burden on businesses, especially small and medium-sized enterprises (SMEs).

- **Rules specification** concerns the amount, quality and type of data required to build and to validate scientific studies/reports within a standard methodological approach. Different definitions of the boundary of the LCA, in terms of which life cycle stages, emission sources and GHGs area considered, can produce very different results (Büsser et al., 2008). An analysis on current studies carried out in the leather sector show that there is no single approach on Life cycle assessment of products and of company performances that is universally agreed upon and therefore no agreement is currently reached internationally on PCF calculation methods. Common weakness in LCA studies are related to data comprehensiveness, data reliability and source heterogeneity. In addition Carbon footprint studies seem to be rarely accompanied by detailed methodological accounts.

  Figure 2 shows the results of a survey on main literature, reporting the boundary selection for different Life Cycle assessments on leather and leather products. Particularly, 34 studies from literature reporting analysis to minimize the environmental footprint of leather have been examined.

A limited number of available scientific studies try to assess the quantitative environmental footprint on the basis of the entire life cycle tracking. First studies seem particularly focused only on the tanning process, while the recent ones have been shifting the inventory focus on other life cycle phases like leather final disposal and auxiliary materials production.

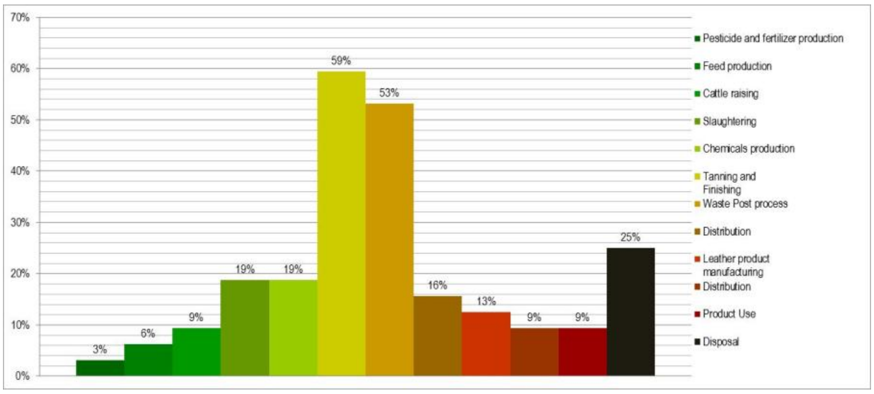

Fig 2. Literature percentage according to the examined phases of leather Life Cycle

The lack of alignment of such studies in terms of system boundaries implies a serious difficulty in finding uniformity, with particular reference to upstream processes. While Puig and al. (2008) and Brugnoli (2012) start their analysis from the slaughtering process, Kurian and Ninthya (2009) include also pesticide production and cattle raising while Kapilkumar and al. (2011) together with other authors tend to include cattle raising phase.

Studies are therefore difficult to be assessed by third parties or to compare with the footprints of like products. The inherent complexity and lack of exactness of carbon footprint analyses contrasts with the need to communicate the results in a simple, clear and unambiguous way to other businesses along the value chain and, ultimately, to consumers. A range of factors may account for this diversity: differences in ambition, technical competence and access to external support; differences in economic resources, different country and business contexts, and the absence of a dominant PCF-LCA standard. It seems clear the importance of harmonizing all the standards schemes and practical experience on the market today and get a unique and direct methodology recognizable by the market.

3 Key elements for standards rules definition in the Leather studies for Carbon Footprint Assessment and Life Cycle Assessment

The chosen standards, publications and application represent an heterogenic scenario of quantitative Environmental approaches, to have different points of view on the same subject. The need of proper comparison between different studies can be seen as strategic element for competition in the "green product" market. According to literature analysis, hereafter are reported common key areas allowing a proper comparison of different results coming from different studies.

Functional unit definition:

Among the different methodologies analysed, there is a convergence in the use of specific functional units. Carbon footprint were mainly built using LCA principles and, as so, recognize the interest in defining a functional unit. Establish a commonly agreed definition will allow to evaluate a service provided by the product. It enables to ensure that products will be compared on a similar basis.

In general terms, the functional unit shall correspond to the basic unit that the tannery uses for trading the finished leather it produces. For a wider application, due to the fact that worldwide finished leather trade is mostly done on the basis of the surface, the proposal is to use, as functional unit, 1 m^2 of finished leather. A reference should be added on standards used for measuring the surface of leather (i.e. ISO 11646 " Leather - Measurement of area", UNI 11380:2010 "Guidelines for surface measurement of leather trough electronic devices").

The particular case of Sole Leather production shall be considered, due to the fact that the products are sold by weight. In this case, even with limited applications, the functional unit proposed is 1 kg of sole leather.

System boundaries definition

The most important difference, both in terms of approach and of quantitative implications, is represented by the inclusion/exclusion of some processes of the Upstream Module, with particular reference to agriculture and animal farming. There is therefore a specific need for defining a harmonized approach, which can ultimately be used for future follow up actions. The first consideration that shall be applied refers to the nature of raw hides and skins, as starting material for the leather making process.

Different literature documents support the conclusion that raw hides and skins have to be considered as a waste of the milk and meat industry. This implies that agriculture and animal farming, as processes of the upstream module, shall be excluded from System Boundaries of LCA studies on leather.

We shall also consider the case in which raw hides are to be considered as a by-product or co-product of the milk and meat industry. According to Weidema et al. (1999, 2001) only one determining product at any given moment is able to affect the production volume of the process by determining economic allocation of co-products.

Under these circumstances, using a conservative approach, in line with the indications of the most relevant laws and regulations at international level, we can consider raw hides and skins coming from animals which have been farmed mainly for other human consumption purposes (meat and milk production) to be non-determining co-products that are not utilized fully, being slaughtering the intermediate process to which Weidema refers to. In both the cases, for the specific aims of the present work, the system boundaries can be considered to be starting in the Slaughterhouse, where activities and treatments are carried out in order to prepare the hides to be used for tanning (e.g.: conservation of the hides and skins by way of cooling systems or salting).

On the basis of what has been explained agriculture, animal farming, leather use by downstream sectors have been excluded from system boundaries, which now start from “Cradle” (the slaughterhouse), to “Gate” (that can be considered as the finished product warehouse of the tannery). In this context, all kind of transportations (represented in the figure by the arrows) should be always included in the System Boundaries.

Final quantification and LCI aggregation

The final aim of the process is to quantify the CPF of the product leather, which is defined in ISO 14067 as the “sum of greenhouse gas emissions and removals in a product system, expressed as CO_2 equivalent and based on a life cycle assessment”. The CO_2 equivalent of a specific amount of a greenhouse gas is calculated as the mass of a given greenhouse gas multiplied by its global warming potential.

In order to be able to quantify the CF defined above, the ISO 14067 the unit processes comprising the product system shall be grouped into life cycle stages; e.g., raw material acquisition, production, distribution, use and end-of-life. Partial CFPs may be added together to quantify the CFP, provided that they are performed according to the same methodology”. According to such “Modular approach” described before, the methodology lies in the quantification CO_2e content of all the different products and material entering the tannery (Upstream Processes), summing them to the CO_2e produced in the tannery itself (Core Processes), and the CO_2e produced for water purification, waste recycling/disposal and air depollution (Downstream Processes). Being the different contributions assessed separately such approach can rapidly solve the lack of system boundary overlapping in the comparison of different LCA-based studies. Modular approach can in fact introduce a methodology to rapidly limit the study area to a minimal common area.

4 Conclusions and recommendations

In this work a preliminary analysis on major eco-label schemes suitable for leather products has been carried out together with relevant scientific literature based environmental impact assessment of the leather life cycle. Then a requirement identification for a harmonized Carbon footprint and LCA in the leather sector has been carried out. The methodology presented in the present document has followed the requirements provided by ISO 14067 and it has been based on the analysis of the existing scientific knowledge. Secondly a critical analysis of the different approaches and a stage for independent review enabled a conceptual aggregation of main similarities.

Particularly Weidema approach appeared as decisive in boundaries determination for leather life cycle inventory referred to animals which have been raised for human consumption purposes different from leather production.

ISO 14067 builds largely on the existing ISO standards for life cycle assessments (ISO 14040/44) and environmental labels and declarations (ISO 14025).
New modular approach seems promising in terms of comparability between contribution of single Life Cycle stages or single relevant flows which can contribute to leather and leather-based products.

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