Procedia
Environmental Science, Engineering and Management
http://www.procedia-esem.eu

Procedia Environmental Science, Engineering and Management **8** (2021) (3) 639-649

24th International Trade Fair of Material & Energy Recovery and Sustainable Development, ECOMONDO, 26th-29th October, 2021, Rimini, Italy

SUSTAINABLE LEATHER FOR SUSTAINABLE FASHION*

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Abstract

Sustainability has today assumed a centrality in the fashion industry. Conceria Nuvolari is an Italian innovative SME founded in 2009 and specialised in the production and sale of animal leathers. Since 2015 Conceria Nuvolari has been in the search for more sustainable materials, to obtain a leather product that could meet the needs of a transforming market. Indeed, today we observe consumer trends, new technologies and innovative business models helping to lead the future of fashion towards a more sustainable runway. In 2017 Conceria Nuvolari has developed an innovative process to obtain a high-quality leather, named Nature-L®, Chromium free, with low use of heavy metals and biodegradable.
A Life Cycle Assessment in compliance with European PEFCR and a Durability Analysis have been carried out, in collaboration with Politecnico di Milano, Innovhub – Stazioni Sperimentali per l'Industria and Larix Italia. Through Life Cycle Assessment the full list of impact categories in the common context of the European Market for Green Products has been evaluated.

Keywords: Environmental impact, Life Cycle Assessment, Product Environmental Footprint, Leather, Tanning Industry

*Selection and peer-review under responsibility of the ECOMONDO
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1. Introduction

Today, the theme of environmental sustainability in the leather sector is tremendously increased, due to the pressing demand of all operators of the fashion industry for eco-friendly materials, pushed by the environmental regulations and the growing market demand for green products. In particular, in the leather sector the traditional tanning process that converts the protein of the raw hide into a stable material which will not putrefy, has high environmental and human health impacts, due to:

- the heavy use of polluting chemicals and metals: the most commonly used tanning material is hexavalent Chromium. Chemicals are also azo dyes, free formaldehyde, pentachlorophenol, tetra chlorophenols; other metals that are extractable with human sweat are nickel, cadmium, cobalt and lead;
- air pollution due to the transformation process, producing hydrogen sulphide during dehairing and ammonia during deliming, and solvent vapours.

Therefore, the traditional tanning process causes ecological imbalance and the spreading of different kinds of serious and contagious disease among the tannery workers and other individuals involved in the process. When inhaled, Chromium acts as a lung irritant and carcinogen, affecting the upper respiratory tract and obstructing airways. In addition, tanning 1 ton of hide typically results in 20 to 80 cubic meters of waste water with Chromium concentrations around 250 mg/L, and sulphide concentrations at roughly 500 mg/L (Borrely et al., 2018). It is therefore urgent to turn towards leather products and processing methodologies more sustainable and safer for the operators' and people health.

Nature-L® leather is the answer to the compelling needs of the fashion industry for environmental sustainability and is a brand-new alternative business model throughout the leather tanning value chain. Actually, this innovative process is able to obtain a unique certified biodegradable leather according to ISO 14855 (tested by University of Bologna - Dipartimento di Scienze Agrarie in 2018) and to ISO 20136 (tested by Italian Leather Research Institute in 2020), in which high quality hides are tanned using biodegradable, organic elements and without dangerous heavy metals like Chromium. The hides have been tested and passed standard requirements for abrasion resistance, colour fastness, grab strength, and dry and wet crocking for footwear and fashion needs. Indeed, Nature-L® can be used in the fashion industry for footwear and accessories as first market and for clothing as secondary market.

Conceria Nuvolari's business model, based on patent protection and licensing to certified production partners, aims to spread our innovation not only at European level, but also in non-European countries, where damages from environmental pollution can threaten a large number of people. The model Conceria Nuvolari has chosen for their value chain is that of "short-chain", maximising the environmental sustainability of their products.

Naturel-L® responds to the pressing need of greening the leather manufacturing process, coherently with the UN Sustainable Development Goal Number 12 - Ensure sustainable consumption and production patterns, aimed to reduce environmental impact of any human activity. In addition, it responds to the increasing demand of an exigent market, increasingly driven by environment-friendly products while maintaining the highest quality and performance levels.

The main objective of this project has been to fully evaluate all the environmental impacts of metal-free and biodegradable Nature-L® leather (bovine-caprine-ovine), in accordance to the PEFCR – Product Environmental Footprint Category Rules for the production of leather, published in April 2018 on behalf of the European Commission's Joint Research Centre (De Rosa-Giglio et al., 2018).

Another objective has been to carry out the analysis of durability for Nature-L® (Innovhub - Stazioni Sperimentali per l'Industria, 2019), assessing:

- the physical-mechanical characteristics of the leather (maximum strength and stretching with traction according to UNI EN ISO 13934-1:2013, i.e. stress test, colour and temperature resistance test);
- the resistance of the leather to mildew, fungii and bacteria (according to AATCC 30/2013);
- the soil burial test according to AATCC 30;
- aging due to temperature, humidity, light.

This work is divided in two main parts:

- evaluation of all the environmental impacts of metal-free and biodegradable Nature-L® leather (bovine-caprine-ovine), in accordance to the PEFCR. The evaluation has been performed by Prof. Giovanni Dotelli, full Professor of Materials Science and Technology at Politecnico di Milano;
- analysis of durability. The analysis has been performed by Innovhub-Stazioni Sperimentali per l'Industria, Milan.

2. Materials and methods

Every step of the LCA study has been performed as much in accordance to the PEFCR – Product Environmental Footprint Category Rules for the production of leather, published in April 2018 on behalf of the European Commission's Joint Research Centre.

Nature-L® is modelled as bovine or caprine or ovine leather belonging to the Representative Product category RP2 for footwear and leather goods. A cradle-to-gate approach is followed in the study: upstream (farming, slaughtering and preservation) and core (tanning) processes have been identified within the system boundary. The core process has been divided into eight unit processes where the main production phases of Nature-L® are performed.

For every unit process, data about the required material, energetic and logistic input and output flows have been collected and modelled using the PEF-compliant datasets included in the Environmental Footprint EF2.0 database. The obtained information has been processed using the PEF-compliant Environmental Footprint EF2.0 Impact Assessment methods.

The evaluation of the environmental impacts has been mainly based on company-specific data collected from the industrial realities where the leather tanning process for Nature-L® (bovine-caprine-ovine) is performed. Figure 1 illustrates the system boundary for the production of Nature-L® (caprine-ovine) with the main unit processes.

3. Results and discussion

Following the PEF guidelines, the environmental impact of 1 square metre of Nature-L® (bovine-caprine-ovine) is quantified through characterization for every PEF-compliant impact category. However, the PEF Category Rules for leather don't allow the evaluation of the environmental benefit guaranteed by the biodegradability of the product. It is so since leather is an intermediate product and the PEF-compliant cradle-to-gate approach implies a system boundary ending with the production of leather in the industrial facilities, thus not considering downstream processes as B2B distribution, further manufacturing into finished consumer products, distribution to customers, use phase and end-of-life treatment of used products. The results of the PEF-characterization step are illustrated in Tables 1-3.

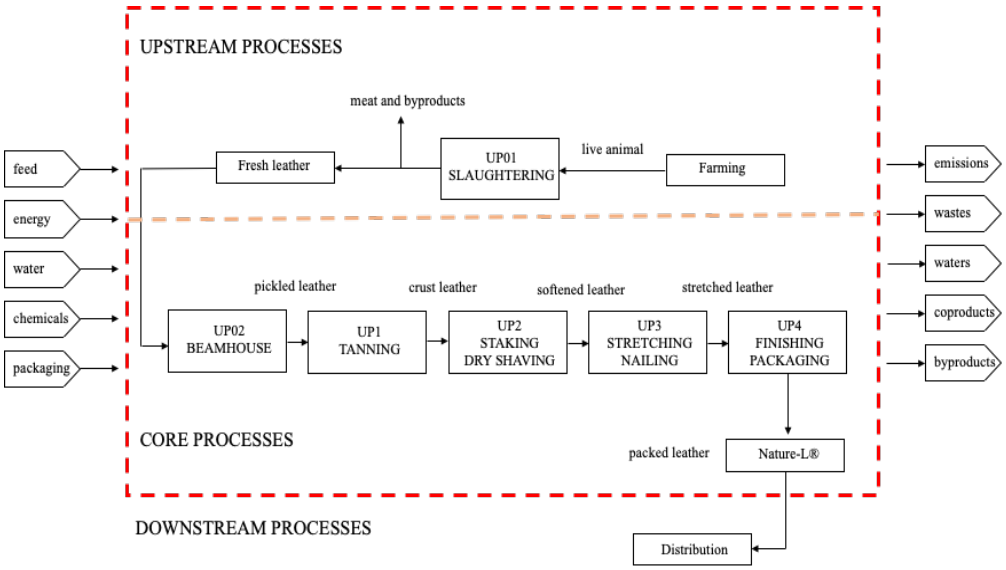

Fig. 1. System boundary for the production of Nature-L® (caprine-ovine) with the main unit processes

The climate change category presented in this study indicates the GWP – Global Warming Potential of the analysed process in terms of fossil, biogenic and land use/transformation contributions. It is expressed in kg CO_2 eq and it's a good measure of the Carbon Footprint of Nature-L® (Bovine-Caprine-Ovine), indicating the quantity of GHG – Green House Gases emitted during the production.

Non-cancer and cancer human health effects belong to toxicity categories, expressed in the study in Comparative Toxic Unit for human (CTUh). This unit indicates the estimated increase in morbidity in the total human population per unit mass of the chemicals emitted. Ecotoxicity freshwater indicates the impact of the studied production process in terms of toxicity in the environmental matrix of freshwaters. It's expressed in Comparative Toxic Unit for human (CTUh). Land use is expressed in dimensionless points. This impact category is related to the soil quality index. Water scarcity is a measure of the user deprivation potential in terms of relative available blue water remaining. It is expressed therefore as cubic meters of water deprived by the studied processes. Fig. 2 compares the climate change impact on wheat bread, beef fillet and Nature-L® leather (bovine, caprine, ovine).

Normalization and weighting are optional Impact Assessment steps; both have been performed using PEF- compliant factors. Normalization is the calculation of the magnitude of each category indicator with respect to the global impact per person considering the world's population. Weighting is used to create a single score value by correlating every impact assessment result with a set of factors that reflect the perceived relative importance of the impact categories. Fig. 3-5 illustrate the results of the PEF-normalization step.

After normalization, the most relevant impact categories are the toxicity ones, represented by "Non-cancer human health effects", "Cancer human health effects", "Eutrophication terrestrial" and "Ecotoxicity freshwater".The most relevant impact categories included in the PEF Category Rules document (as acidification, climate change, terrestrial eutrophication, particulate matter, resource use – fossils and water use) present little normalized contribution for the production of Nature-L® (Bovine-Caprine-Ovine).

Table 1. Results of the PEF- compliant characterization step – Bovine Leather

Impact category	*Unit of measure*	*Total*
Climate change	kg CO2 eq	4.15E+01
fossil		1.72E+01
biogenic		1.56E+01
land use and transformation		8.75E+00
Ozone depletion	kg CFC11 eq	1.86E-07
Ionising radiation, HH	kBq U-235 eq	6.72E-01
Photochemical ozone formation, HH	kg NMVOC eq	6.41E-02
Respiratory inorganics	disease incidence	4.15E-06
Non-cancer human health effects	CTUh	3.11E-05
Cancer human health effects	CTUh	6.48E-07
Acidification terrestrial and freshwater	mol H + eq	5.48E-01
Eutrophication freshwater	kg P eq	4.73E-03
Eutrophication marine	kg N eq	1.54E-01
Eutrophication terrestrial	mol N eq	2.32E+00
Ecotoxicity freshwater	CTUe	1.20E+02
Land use	Pt	3.70E+03
Water scarcity	m3 deprived	2.22E+01
Resource use, energy carriers	MJ	1.73E+02
Resource use, minerals and metals	kg Sb eq	6.33E-05

Table 2. Results of the PEF- compliant characterization step – Caprine Leather

Impact category	*Unit of measure*	*Total*
Climate change	kg CO2 eq	2.02E+01
fossil		9.7E+00
biogenic		9.9E+0
land use and transformation		6E-01
Ozone depletion	kg CFC11 eq	1.69E-07
Ionising radiation, HH	kBq U-235 eq	4.94E-01
Photochemical ozone formation, HH	kg NMVOC eq	2.79E-02
Respiratory inorganics	disease incidence	2.41E-06
Non-cancer human health effects	CTUh	2.21E-05
Cancer human health effects	CTUh	3.68E-07
Acidification terrestrial and freshwater	mol H + eq	3.41E-01
Eutrophication freshwater	kg P eq	9.44E-04
Eutrophication marine	kg N eq	5.89E-02
Eutrophication terrestrial	mol N eq	1.45E+00
Ecotoxicity freshwater	CTUe	3.77E+01
Land use	Pt	2.43E+03
Water scarcity	m3 deprived	5.75E+00
Resource use, energy carriers	MJ	1.01E+02
Resource use, minerals and metals	kg Sb eq	2.42E-05

Table 3. Results of the PEF- compliant characterization step – Ovine Leather

Impact category	*Unit of measure*	*Total*
Climate change	kg CO2 eq	2.21E+01
fossil		1.11E+01
biogenic		1.03E+01
land use and transformation		7.06E+00
Ozone depletion	kg CFC11 eq	1.98E-07
Ionising radiation, HH	kBq U-235 eq	5.89E-01
Photochemical ozone formation, HH	kg NMVOC eq	3.15E-02
Respiratory inorganics	disease incidence	2.56E-06
Non-cancer human health effects	CTUh	2.32E-05
Cancer human health effects	CTUh	3.96E-07
Acidification terrestrial and freshwater	mol H + eq	3.61E-01
Eutrophication freshwater	kg P eq	1.05E-03
Eutrophication marine	kg N eq	6.32E-02
Eutrophication terrestrial	mol N eq	1.52E+00
Ecotoxicity freshwater	CTUe	4.17E+01
Land use	Pt	2.58E+03
Water scarcity	m3 deprived	6.39E+00
Resource use, energy carriers	MJ	1.22E+02
Resource use, minerals and metals	kg Sb eq	2.94E-05

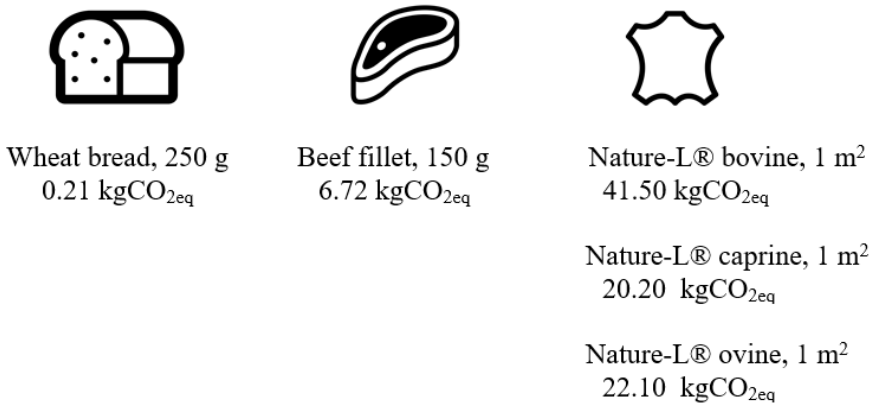

Fig. 2. Climate change impact comparison (LCA Food Database)

The process has been divided into the PEF-compliant sections of upstream and core. Farming, slaughtering and preservation are upstream processes and contribute to the majority of the impacts. Thanks to the specific recipe used in the production process of Nature-L® leather, the core tanning process presents lower impact than the upstream one, as illustrated in Tables 4-6.

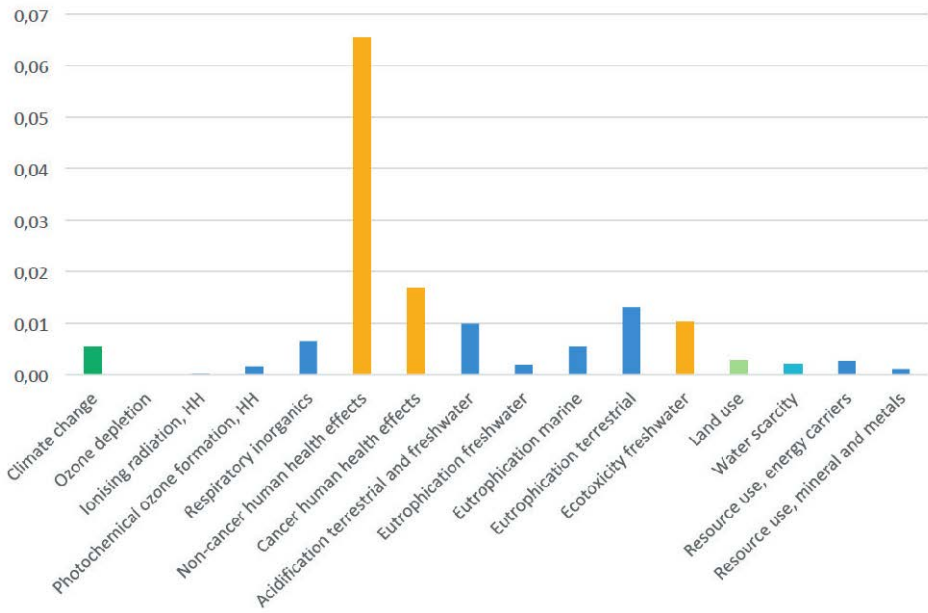

Fig. 3. Results of the PEF-compliant normalization step – Bovine Leather

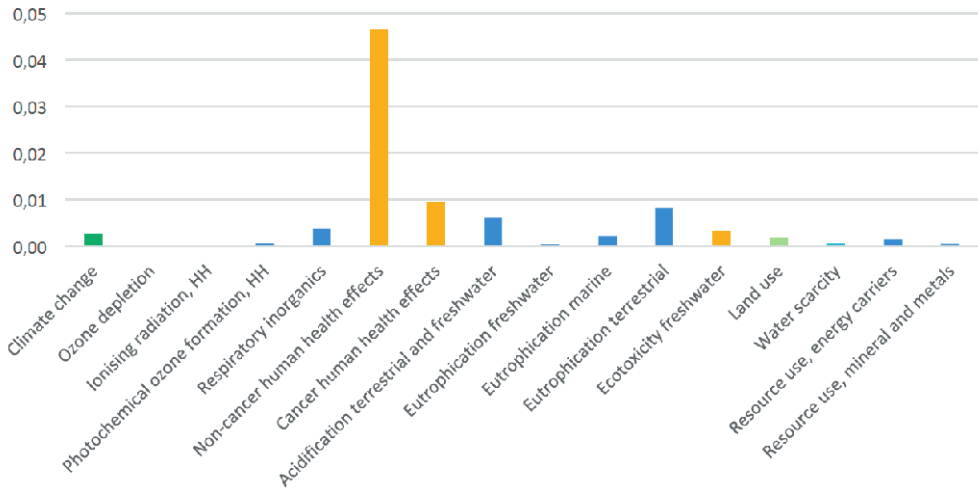

Fig. 4. Results of the PEF-compliant normalization step – Caprine Leather

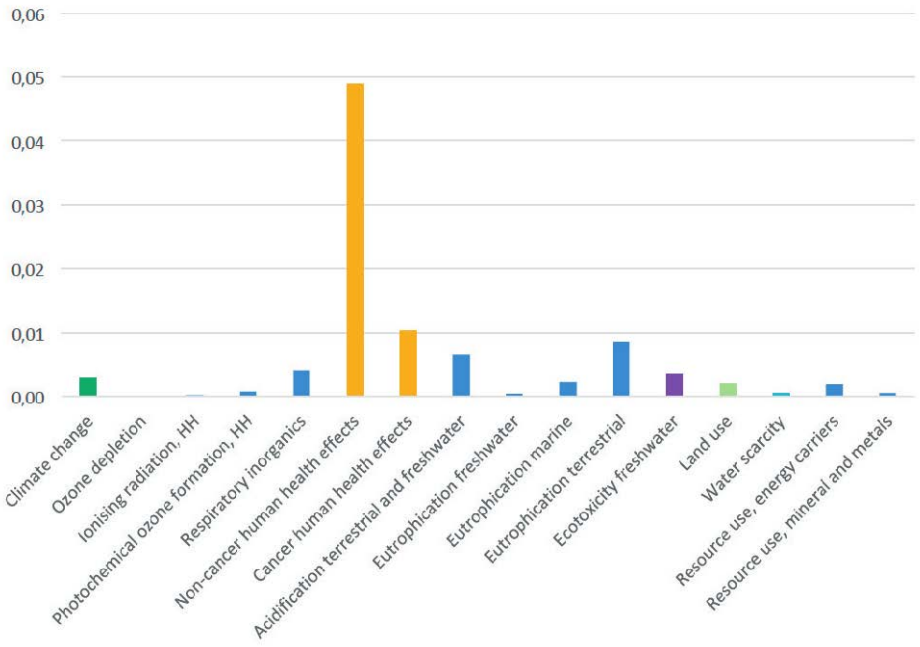

Fig. 5. Results of the PEF-compliant normalization step – Ovine Leather

Table 4. Relative contribution to the characterization and single score weighting results for core and upstream processes – Bovine Leather

	Upstream %	***Core %***
Climate change	89.01	10.99
Non-cancer human health effects	97.34	2.66
Cancer human health effects	91.12	8.88
Ecotoxicity freshwater	92.87	7.13
Land use	95.45	4.55
Water scarcity	71.11	28.89

Table 5. Relative contribution to the characterization and single score weighting results for core and upstream processes – Caprine Leather

	Upstream %	***Core %***
Climate change	71.18	28.82
Non-cancer human health effects	94.84	5.16
Cancer human health effects	80.45	19.55
Ecotoxicity freshwater	65.29	34.71
Land use	88.66	11.34
Water scarcity	25.62	74.38

Table 6. Relative contribution to the characterization and single score weighting results for core and upstream processes – Ovine Leather

	Upstream %	***Core %***
Climate change	67.73	32.27
Non-cancer human health effects	93.91	6.09
Cancer human health effects	77.76	22.24
Ecotoxicity freshwater	61.40	38.60
Land use	86.65	13.35
Water scarcity	23.98	76.02

From the data obtained, farming, slaughtering and preservation phases in the production of raw hides and skins have a higher environmental impact than the core tanning process for the production of Nature-L®: 91.6% of the impacts for Nature-L® Bovine Leather, 81.73% for Caprine Leather, 79.20% for Ovine Leather come from the upstream processes, while tanning activities occurring in Italy accounts for 8.4% (for Bovine Leather), 18.27% (for Caprine Leather), 20.8% (for Ovine Leather) of the total environmental burden. The results of the PEF-contribution analysis are illustrated in Figs. 5-7.

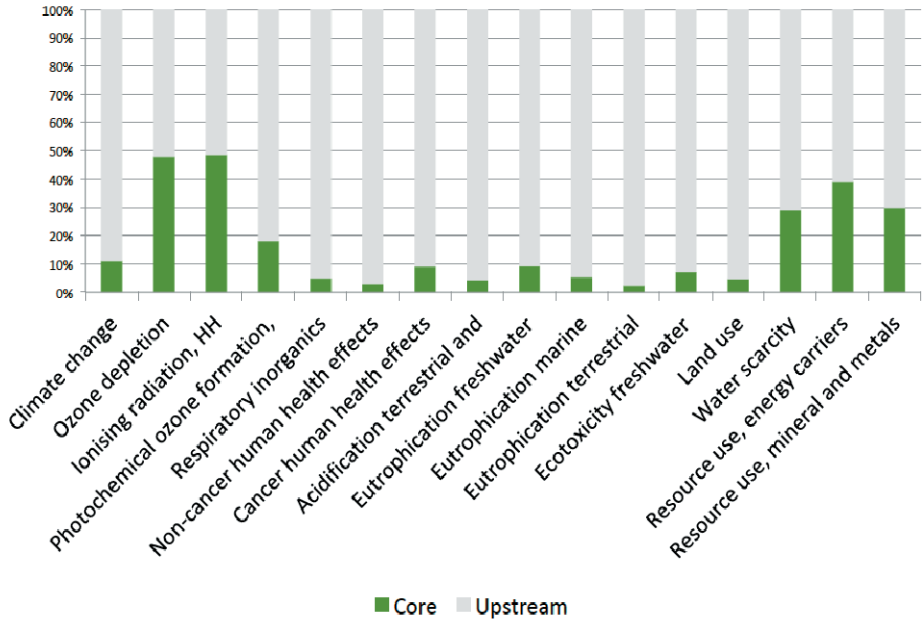

Fig. 5. Results of the PEF-compliant contribution analysis – Bovine Leather

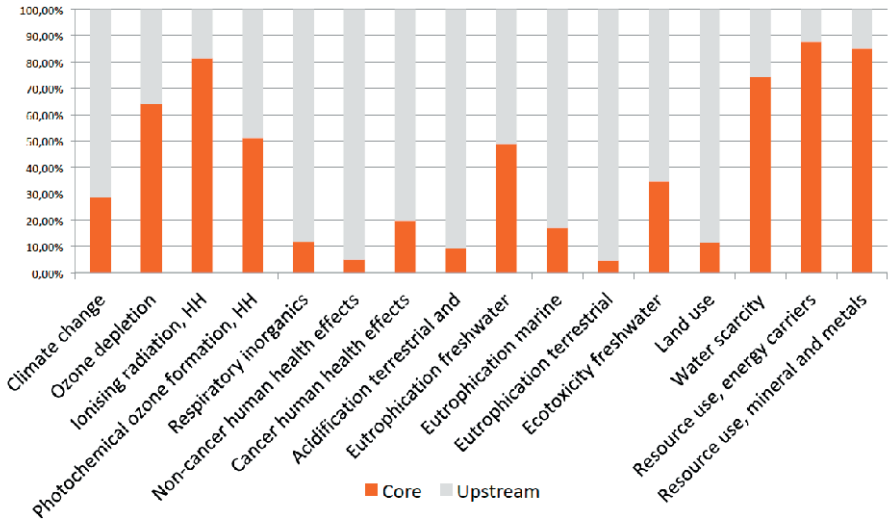

Fig. 6. Results of the PEF-compliant contribution analysis – Caprine Leather

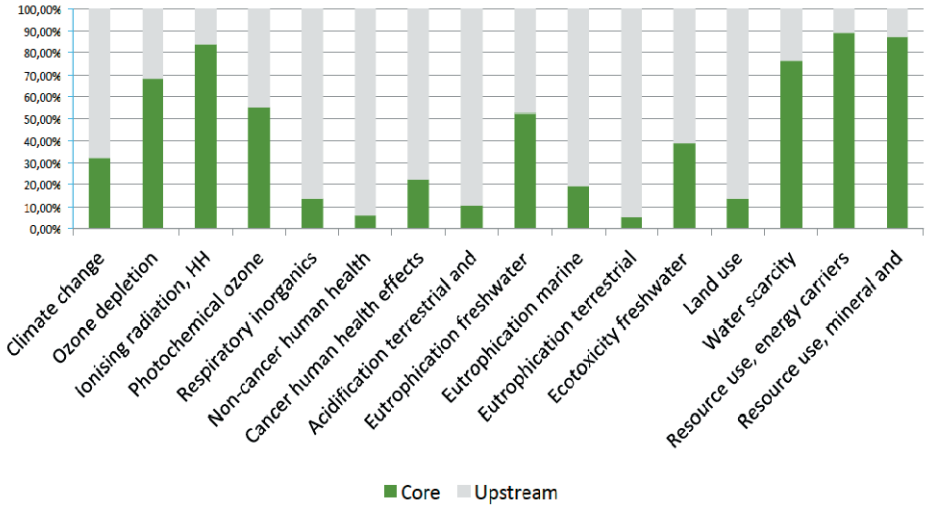

Fig. 4c. Results of the PEF-compliant contribution analysis – Ovine Leather

6. Concluding remarks

Conceria Nuvolari through its metals-free biodegradable leather products contributes actively to support Sustainable Development Goals (SDG): 12 (Responsible consumption and production), 13 (Climate action), and 15 (Life on Land).

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