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PEF and sustainability

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The concept of sustainability is based on the interdependence between human societies and the natural environment. Current patterns of economic and social development are placing pressures upon natural resources and may threaten the health and prosperity not only of humans but of life on Earth in general. In recognition of these concerns, the United Nations World Commission on Environment and Development (UN 1987), presented the most often quoted definition of sustainable development as being 'development that meets the needs of the present without compromising the ability of future generations to meet their own needs', particularly with regard to the use and waste of natural resources.

In view of all the media news and natural climate events we are seeing, it is clear that current approaches aimed at reducing existing risks are not enough to avoid the complex problems

that threaten the planet, leading to a depletion of finite natural resources, biodiversity loss and climate change, putting current and future generations at risk. A significant transformation of organisations, production and consumption is needed in order to enable continued economic growth and reduction in poverty while, at the same time, protecting those critical environmental resources. Although the UN definition captures the essence of sustainability, it does require some more functional definitions. These are often based on the concept of the 'three pillars' of sustainability: people/social, planet/environment and economic /companies.

Based on the three pillars concept, a sustainability indicator can be defined as a measurable aspect of the pillars or systems that is useful for monitoring relevant changes in system characteristics. When carefully chosen and implemented, indicators can help managers to communicate ideas,

support decision making, formulate strategies, establish improvement goals and track progress, among others. In the three pillars model, one common approach is to select and consider a set of indicators unique to each of the three overlapping domains that, for simplicity, can be referred to as people, environment and companies as shown in *Figure 1*.

Some indicators that reside in only one domain (1D) can be normalised to create two-dimensional (2D) indicators that may be more meaningful and comparable. Some 1D indicators can be tracked over time to examine the degree of change relative to either a historical baseline or a future objective. The rate or amount of improvement is a relative measure, indicating whether the system is moving towards or away from sustainability. In some cases, a single indicator can be chosen that provides information relevant to two or three overlapping domains.

Once indicators are selected and

corresponding metrics are identified, criteria must be established and methods (e.g. life cycle assessment) employed to acquire the data for each metric to evaluate the systems under study. The complexity and extension of these topics suggests a need for segmentation and preparation of sequential publications.

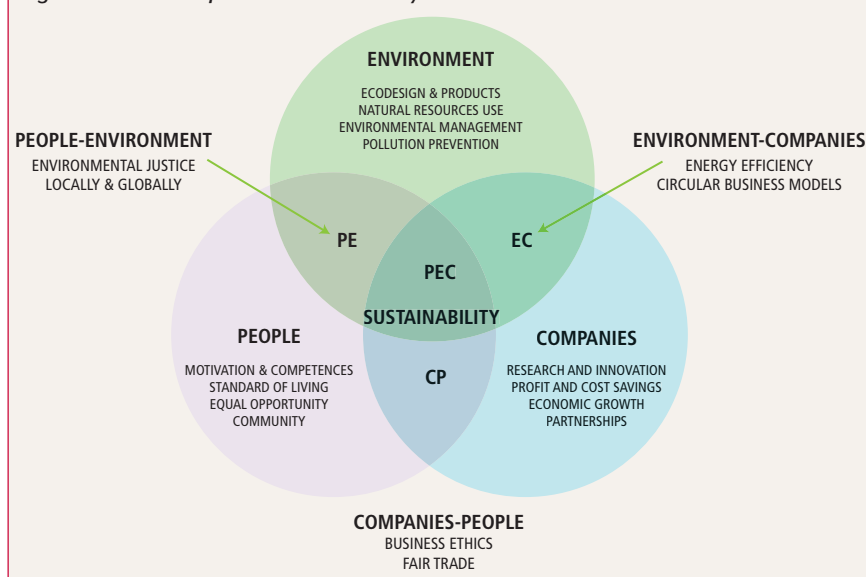
Due to its importance this particular article is dedicated to a product's life cycle sustainability impact.

FOOTWEAR PRODUCT'S LIFE CYCLE SUSTAINABILITY IMPACT

One important step towards sustainability in footwear and allied industries is to measure and tune the environmental impact a product makes throughout its life cycle. By assessing a product's life cycle impact, the footwear value chain can produce footwear more responsibly, economically and in an eco-friendly way by addressing the three pillars of sustainability.

During a product's life cycle assessment (LCA), environmental impacts are evaluated with a holistic view of environmental interactions that

Figure 1: The three pillars of sustainability.



covers a range of activities, from the extraction of raw materials from the Earth and the production and distribution of energy, through the upstream and downstream processes associated with its production (e.g. production of materials), use and disposal phases (e.g. waste treatment). An LCA therefore includes identifying what materials are used, how much material and water a product requires,

how much energy it consumes, how much waste it generates or how it affects climate indicators.

Today, companies that want to communicate the environmental performance of their products face obstacles. They need to choose between LCA methods promoted by public and private entities and pay multiple costs for generating the environmental information.

Figure 2: PEF (Product Environmental Footprint) Impact Categories, including indicators and units.

Impact Categories	Indicator [Unit]
Climate change	Global Warming Potential [kg CO ₂ eq]
Ozone depletion	Ozone Depletion Potential [kg CFC-11eq]
Human toxicity, cancer effects	Comparative Toxic Unit for humans [CTUh]
Human toxicity, non-cancer effects	
Particulate matter/respiratory inorganics	Human health effects associated with exposure to PM2.5 [disease incidences]
Ionising radiation, human health	Human exposure efficiency relative to U [kBq U]
Photochemical ozone formation, human health	Tropospheric ozone concentration increase [kg NMVOC eq]
Acidification	
Eutrophication*, terrestrial	Accumulated Exceedance (AE) [mol H+ eq]
Eutrophication, aquatic freshwater	Fraction of nutrients reaching freshwater end compartment (P) [kg P eq]
Eutrophication, aquatic marine	Fraction of nutrients reaching marine end compartment (N) [kg N eq]
Ecotoxicity freshwater	Comparative Toxic Unit for ecosystems [CTUe]
Land use	Soil quality index [Dimensionless**]
Water use	User deprivation potential [kg world eq. deprived]
Resource use, minerals and metals	Abiotic resource depletion (ADP ultimate reserves) [kg Sb eq]
Resource use, fossils/energy carriers	Abiotic resource depletion – fossil fuels (ADP-fossil) [MJ]

KEY: * Eutrophication – water becomes overly enriched with minerals leading to excessive growth of algal bloom and oxygen depletion.

** Dimensionless – aggregated index of kg biotic production.

Additionally, they may face mistrust from consumers who are confused by the multitude of communication tools with different information that make products difficult to compare. In this context, the European Commission is developing a product environmental footprint (PEF) methodology based on life cycle assessment to provide a harmonised way of measuring a product's environmental impact/performance. A PEF study is essentially a standardised LCA study that aims at ensuring that environmental information is comparable and reliable, and can be used confidently by both business partners and consumers.

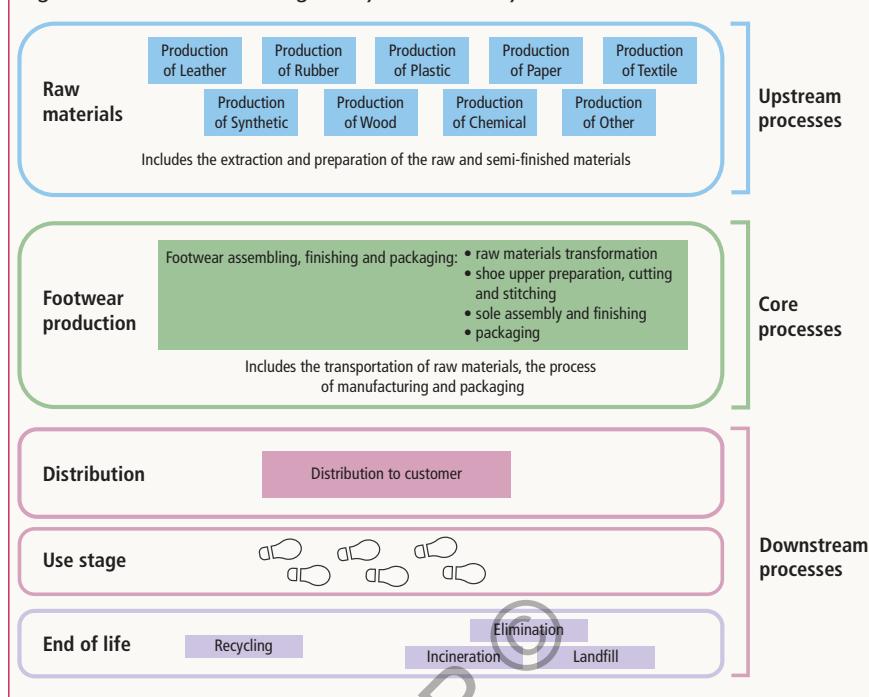
CTCP, the Portuguese Footwear Technology and Research Centre, is leading the European project LIFE GreenShoe4All (LIFE17 ENV/PT/000337) aiming to apply the first pilot PEF methodology to footwear. Maria José Ferreira, the project coordinator, emphasises that, "This method makes it easier to develop and produce footwear with less environmental impact." The method assesses 16 impact categories and indicators as shown in Figure 2 covering for example climate change, acid rain, human and eco-toxicity, and particulate matter as well as impacts due to the use of water, land and resources.

CALCULATING FOOTWEAR ENVIRONMENTAL FOOTPRINT

Applying the PEF methodology to footwear involves essentially five steps.

1. Define the functional unit, e.g. 'one pair of shoes including packaging'.
2. Define the system boundary, e.g. 'cradle-to-grave system boundary'. Figure 3 shows a simplified cradle-to-grave system boundary.
3. Collect data – composition and weight of chemical products, materials and the components employed for the manufacture of the shoes, water and energy consumption, production waste, end of life (EoL), annual total production, suppliers and retailers' locations.
4. Select appropriate PEF models, data sets, modelling and tools.
5. Insert data and calculate values for the 16 impact categories.

Figure 3: Footwear cradle-to-grave system boundary.



PEF results are quantitative and enable companies to assess the full life-cycle impact of a final product, compare different product's environmental impacts and identify what life-cycle stages or production processes contribute the most impact. In the future, performing PEF studies is expected to be a critical step towards product labelling.

ADVANCED FOOTWEAR ENVIRONMENTAL PERFORMANCE

LIFE GreenShoes4All teams are conducting PEF studies in representative footwear models ranging from fashion to safety footwear, with uppers in leather, textiles and/or man-made materials, midsoles in polyurethane (PU) or ethyl vinyl acetate (EVA), soles in rubber, PU, thermoplastics, EVA and others. The results indicate that the following impact categories represent around or over 80% of the total impact; climate change, resource use (fossils/energy carriers, minerals and metals), acidification, water use, respiratory inorganics and eutrophication (mainly terrestrial). Furthermore, climate change and resource use each represent on average, around or over 30% of the total impact.

PEF methodology also makes it possible to identify and quantify the most relevant life cycle stages contributing to these impact categories,

thus helping companies to define how their footwear environmental performance may be improved. Considering some of the shoes analysed, the bigger contributors are raw materials, materials and components acquisition and pre-processing, followed by waste from manufacturing and end of life, and then energy consumption. The creative design phase plays a significant role in footwear life cycle sustainability impact. Selection, based on knowledge (PEF results), the materials to use and the processes that minimise resources consumption and waste generation, is crucial.

More precisely, in order to reduce its PEF, a company's plan could include the following actions: Design its footwear so as to reduce the number of different materials used by making it lighter, more durable and easier to disassemble and recycle; use materials with less environmental impact, reduce its weight and use recyclable and recycled materials among others. Additionally, adopting circular business models, aiming for the efficient use of natural resources powered by renewable energy, will add true value and environmental differentiation to footwear. Using PEF, these and other actions may be evaluated and tuned, enabling sustainable choices to be made and promoting the creation, production and use of 'truly green shoes' in a circular economy. 🌱