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Palm Oil's Carbon Footprint in Skincare: A Lifecycle Assessment for Sustainable Formulations

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1. Abstract

The analysis evaluates the carbo-footprint of palm oil in skincare on the basis of lifecycle assessment. It shows the results that through deforestation and use of peatlands in palm plantation, the emissions are vastly elevated. The type of surfactant, packaging and distribution are the other big contributors to the environment. Sustainable sourcing and formulating decisions can have large repercussions to the ecological footprint of skincare on your part.

2.Keywords: Sustainability, Palm Oil, Lifecycle Assessment, Carbon Footprint, Skincare

3. Introduction

The palm oil has influence on the sustainability of skincare procedures closely connected to upstream procedures of agriculture and surfactant manufacturing. Its lifecycle emissions may be too high even in the context of small quantities when it comes to land-use change. The key elements that have to be improved in terms of environmentally friendly skincare products are the choice of reducing the impact biosurfactants, packaging optimization, and supply chain transparency.

4. Previous Works

4.1 Palm Oil's uses

The use of palm oil and palm-oil derivatives, especially Refined Palm Kernel Oil (RPKO) have been adopted into the modern skincare formulation as they possess the emollient qualities; they are major sources of Palm-oil, making it highly available. They have however been scrutinized on their environmental footprint mainly when looking at Life Cycle Assessments (LCA).

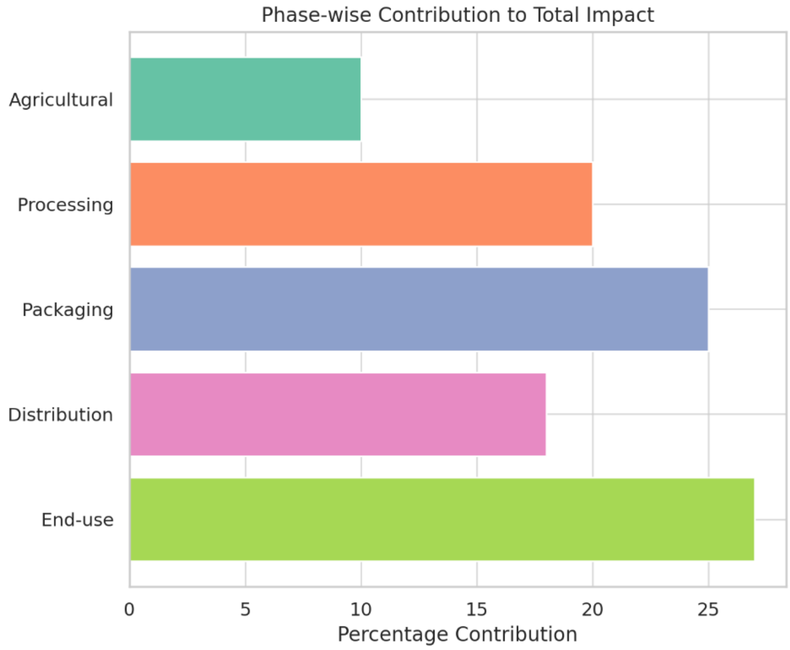
Martinez and colleagues (2017) claim that palm oil agricultural stage produces significant carbon footprint of skincare products, especially in cases of ineffective land-use measures in form of deforestation, peat soil cultivation, etc. In a best-practice scenario RPKO does have minimal impact, but when land-use transformation was in play, then the Climate Change impact category rose by 9.5 percent, and incredibly, the Land Use metrics increased by 938 per cent as a result of peat soil transformation. Such results highlight the environmental burdens that are actually hidden in the palm oil derivatives which could dominants the environmental legacy despite the minor quantities associated with cosmetics conditional in the source and process of the palm oil derivatives.

According to Guilbot et al. (2013) they found that materials and ingredients like alkyl polyglucosides (APG) where the ingredient is frequently based on palm-based feedstock, the material can have a low environmental contribution when well formulated (e.g., 5% concentrations) but its carbon footprint is very susceptible to cultivation regimes and processing decisions.

As an example, the mode of land-use change varied the APG carbon footprint between 1.9 and 49.8 t CO_2 eq/t, with respect to the mode of land-use change. Even subparts such as cetearyl alcohol which is obtained out of palm oil and which constitutes 80 percent of the APG in terms of weight was found to possess significant environmental ramifications. Those results add weight to the idea that the list of ingredients alone is not sufficient in LCA-based sustainability analysis, and the entire cradle-to-grave consequences must be taken into account.

4.2 Land Use Change

Land Use Change (LUC) especially deforestation and the indirect land use change (iLUC) are some of the big factors that account to the carbon footprint of palm oil in skincare. Bausano et al. (2023) emphasized that palm oil usage in the biggest EU nations has prompted huge embodied deforestation and CO2 emissions where only about one-quarters of the rise in demand to oleochemical and biofuel can be credited to the oleochemical and biofuel sectors.



This change of consumption pattern has put more strain on the tropical ecosystems in Southeast Asia. In more than 20 years, the imported palm oil footprint became four times bigger considering the land area in which it operates. It has also up to 445 kg CO2 emissions per capita through LUC emissions in European economies. Although these statistics are related to larger facets of the economy, they give insight toward the systematic impact of the overall use of palm oil in skincare and cosmetics into which the demand, as great as it may be, but not volumetrically, promotes, the chain of international trade in palms oil.

Similar results described by Bunchai et al. (2017) proved that greenhouse gas (GHG) emissions produced as a result of palm oil production may be a difficult issue to assess. In their analysis, they determined that emissions may vary considerably to meet decisions on processing (wet or dry), plantation management (utilization of firewood or recycled fronds) and accounting strategies. iLUC was identified as the major source of emissions, whose savings were up to 274,774 t CO2 eq/year according to optimization of the process. Such cost savings may be directly transferred to reductions in carbon footprint in the downstream industry such as skincare manufacturing in case such best practices are incorporated into the supply chain.

According to Fogliatti et al. (2014) it was investigated how the use of palm or coconut oil as alternative to petroleum-derived surfactants such as linear alkylbenzenesulfonate (LAS) successfully reduced carbon emissions by up to 50% because the origin of the product was changed. dLUC is the condition on which they have their positive effects hence they underline that the bio-based alternatives are not necessarily green unless they are produced in a responsible way.

4.3 Biobased Surfactants

The emerging models of biosurfactants production, which have in recent times considered palm oil production, can be an opportunity in minimizing the environmental effects of skincare products. Charoentanaworakun et al. (2023) said that they came up with techno-economic and environmental parameters on various palm biosurfactants produced by palm fatty acid distillate, among them being methyl ester sulfonate (MES) and alkyl carboxylates.

This research concluded that MES scored the greatest net present value and alkyl carboxylates the most excellent environmental result with a CO2 emitting rate of 1.92 t/ton, performed better than the other palm-based alternatives and petroleum-based ones too. Palm oil-based sulphate surfactants had higher emissions of 2.88 t CO2 /ton, which is even more than regular sodium dodecylbenzenesulfonate (2.46 t CO 2 /ton). This implies that the sustainability of the products of palm oil is very much related to the particular chemical transformation processes followed.

It cannot be neglected that there are packaging and consumer behavior lifecycle effects. According to Guilbot et al. (2013), packaging accounted to a maximum of 51 per cent of the environmental impact of cosmetic cream products in all the impacts that were measured, whereas the end-use stage (mainly distribution and consumer recycling/purchase behaviour) contributed to a maximum of 77 per cent.

The analysis yielded the result that sourcing of raw materials and packaging of detergents takes up the majority of carbon footprint with the largest contributors being palm-based fatty alcohol sulphates (Villota-Paz et al., 2022). PET packaging raised the total CO2 emission by additional 12.2 percent but a change to HDPE may minimize the freshwater eutrophication. This consideration is directly applicable to skin care where one can find the same packaging and use of surfactants.

In various surveys, the compliance of palm oil in the environment of its lifecycle in skin care does not corroborate with its addition to skin care formulations, but rather depends on the upstream agricultural activity, land use change, chemical processing and packaging input. Green innovation demands thus include supply chain transparency, land use literacy and the eco design as essential elements of sustainable formulation effort so that significant carbon footprints are achieved.

5. Key Findings

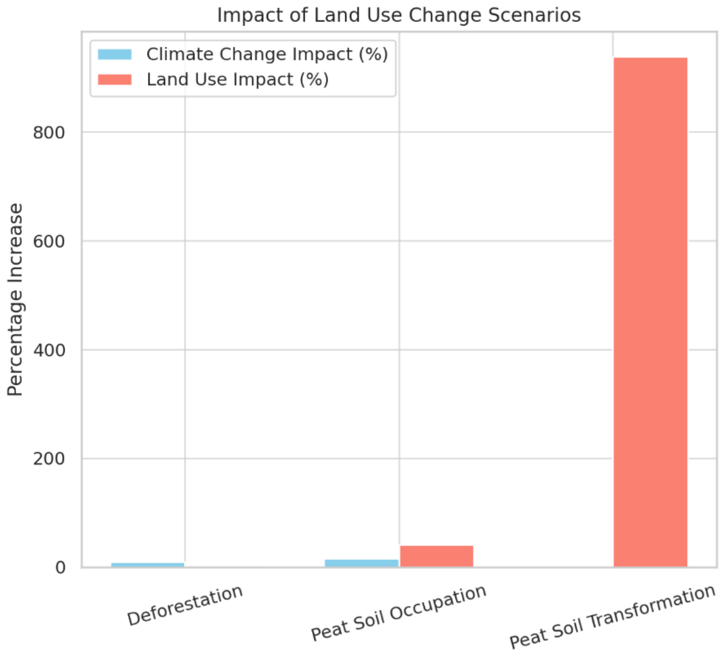
The lifecycle analysis (LCA) of palm oil-based skin care products used shows that there are some significant environmental effects that are focused during the extraction of raw products, land use and change as well as the packaging. The upstream processes such as the use-phase, the quantity of palm oil in the formulations will not primarily cause greenhouse gas (GHG) emissions; rather it would be in the upstream processes; specifically on the land-use change (LUC), conversion of Peatlands and deforestation in palm planting countries, like Malaysia, Indonesia and Papua New Guinea.

Even in the best-practice farming conditions, Refined Palm Kernel Oil (RPKO) constitutes only a small percentage of carbon emissions of the cosmetic cream as a whole. Nonetheless, the impact of climate is raised by as much as 25 percent once deforestation and mechanized drying of the peat soil comes into play (Martinez et al., 2017). Further, the carbon footprint of biosurfactants produced, including alkyl polyglucoside (APG) presents an outrageous difference according to the type of land converted into 1.9 to 49.8 t CO 2 eq./ton, respectively (Guilbot et al., 2013).

The impact of land-use changes on the emission of GHGs and land occupation has been laid down as follows in the table given below:

Scenario	Climate Change	Land Use
Deforestation	+9%	+3%
Peat soil occupation	+16%	+41%
Peat soil transformation	—	+938%

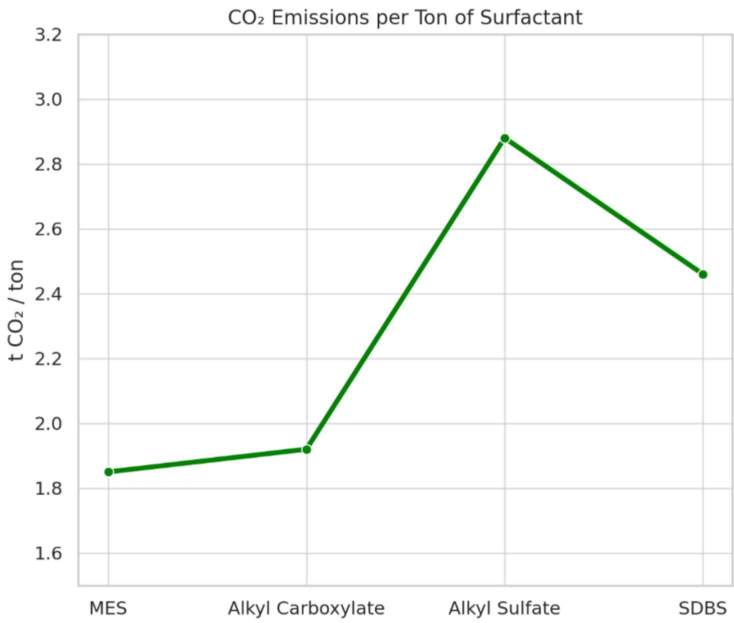
Along with the phases of agricultural activities, the form of production of the surfactants also impacts a lot on the performance of environmentally friendly production methods.



Well, as indicated in the table below, methyl ester sulfonate (MES) and alkyl carboxylates perform better in terms of CO 2 emission in a ton product when compared with sulfate or petroleum-based sodium dodecylbenzenesulfonate (SDBS):

Surfactant Type	CO_2 Emissions
MES	1.85
Alkyl Carboxylate	1.92
Alkyl Sulfate	2.88
SDBS	2.46

The findings also highlight how much packaging and consumer transport can provide the environmental burdens which can reach a limit of up to 77% of the burden depending on the material and consumer behaviours (Guilbot et al., 2013). PET was found to perform inferior to glass in terms of environmental performance because it was more toxic and less recyclable.



These results indicate that factors such as cultivation methods, chemical processing pathways, and product design options like packaging are very important because they highly influence the lifecycle emissions of palm oil despite its possible small-scale use in skincare. Therefore, the supply chain needs to be intervened with the aim of minimizing the overall carbon footprint of cosmetic products that contain palm oil as one of the active ingredients.

BASF's Approach

The Palm Sourcing Policy developed by BASF is quite a comprehensive statement of how it plans to source palm oil, palm kernel oil, and derivative efficiently and responsibly with environmentally sustainable ethics. Respecting both the crop, with its high land-use efficiency, and the issues on which it is implicated, both related to deforestation and social concerns, BASF resolves to enforce change in transforming the palm oil supply chain, which is geared to provide sustainable palm oil.
It is a policy which is formulated on three main pillars:

1. Forest Conservation
BASF requires high standards of "No Deforestation, No Peat, No exploitation (NDPE). The suppliers have to prevent the creation of High Carbon Stock (HCS) forests, High Conservation Value (HCV) lands and putrid soil development. Land burning ought to be discouraged. New developments should adhere to the international best practice, namely, HCS Approach and the RSPO criteria. The rehabilitation of peat, as well as sustainable management of the current plantations is promoted.

2. No Exploitation
BASF ensures there is high human rights and labor standards in line with international conventions. Suppliers should get rid of forced labour, child labour, prejudice, and unjust remedy to employment. Equality of workers, indigenous communities land rights, and gender equality have to be taken care of. Any development is preceded by the focus on free, prior, and informed consent (FPIC) and social impact assessments by the company.

3. Transparency
In a bid to foster responsibility, BASF demands complete traceability of supply chains of the palm, i.e., qualifying from plantation to refinery. All policy violations have to be reported by the suppliers, and they should be able to deliver detailed information about traceability (e.g., GPS coordinates, Unified Mill and Refinery IDs). BASF too holds the right of randomly organizing third party audits and site visits to countercheck this.
By effectively partnering with suppliers, BASF plans to improve productivity, safeguard the biosphere and contribute to smallholder farmers as well as develop a transparent and sustainable palm oil sector.

6. Conclusion

It is quite clear that the use of palm oil in skincare is interconnected with the nature of upstream agricultural activities and the chemical production of surfactants. In spite of the small amounts, it has a large lifecycle emission because of land-use change. Choosing less intensive biosurfactants, better packaging, and more supply chain visibility are the steps relevant to eco-friendly skincare products formulation.

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