Technical Appendix: Life Cycle Assessment of Body Soap Bars

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I. Description

This study's objective is to identify key levers to reduce the environmental impact of body soap bars and analyse potential product variations accordingly, as well as establish emission factors for soap bars adapted to the humanitarian sector. Soap bars are one of the most ordered items in the humanitarian supply chain by quantity. They are purchased as a stand-alone item as well as inside hygienic parcels of various sizes that are distributed in the field.

Given their essential role in household hygiene and frequent inclusion in the initial phase of aid responses, soap bars are purchased in bulked and stored in warehouses or regional distribution centres. The purchases are often manufactured locally to the region distribution, but field data suggests that the base oils of the soap are imported from overseas. This study takes this factor into account to map the transportation emissions of the product.

Additionally, other studies calculating the impact of soaps do not take into scope the water usage during the use phase. In humanitarian contexts, water supply could be precarious and high-impact, therefore this study takes into account the use of water to formulate the cradle-to-grave factor for soap.

The functional unit of this study is 1 soap bar of 260g.

II. Methodology

Life Cycle Assessment is a standard methodology used to estimate the potential environmental impacts linked to the entire life cycle of a product or system (ISO 14040, 14044, 14067). The scope in this study is a cradle-to-grave system boundary for the assessment of impact across the complete life cycle named as follows:

- Raw Material
- Production
- Supply & Distribution
- Use
- Waste Management

To perform these studies, data from the Ecoinvent 3.11 cut-off system model is used, which allocates the entire impact of the material to its primary user without any ‘rewards’ for its potential for being recycled. The results are calculated following the Environmental Footprint 3.1 indicator system in the below categories:

- Climate Change: Global Warming Potential (GWP100)
- Impact on Human Health:
    - Human Toxicity: Carcinogenic and Non-carcinogenic
    - Ionising Radiation
    - Particulate Matter Formation
    - Photochemical Oxidant Formation

The impact on human health results are weighted using the approach detailed in the EF methodology – with a percentage assigned to each sub indicator, as well as normalized for one citizen so as to aggregate and represent as a single score.

III. Key Parameters & Assumptions

The parameters of the soap bar considered in this study are as follows

LIFE-CYCLE STAGE	PARAMETER	DESCRIPTION OF MODEL
Raw Material	Bill of Materials	Crude Palm Oil, Sodium Chloride, Sodium Hydroxide (0.26 kg net weight)
	Packaging	PE film (10 g)
Production	Manufacturing Location	Local to warehouse and distribution location (i.e. within 1,500 km)
	Manufacturing Processes	Standard saponification
Supply & Distribution	Transport Chain	International oil procurement (10,000 km by sea) TRUCK for procurement of other materials (500 km) TRUCK to warehouse (1,500 km) & distribution (1,500 km)
Use	Lifespan	50 uses with 10 litres of water per use
	Usage Processes	-
Waste Management	Product Disposal Method	Wastewater generation (cubic m of water used)
	Packaging Disposal Method	Open dumping

IV. Scenario Rationale

a. Raw Material

Soap can be made from various types of oil, however the most popular – and the most frequently purchased due to cost-effectiveness – types of soap have been included in this study to keep the scenarios close to reality for humanitarian contexts. The baseline product is made of *100% crude palm oil* with variations for 100% refined palm oil, palm kernel oil, and coconut oil. All scenarios retain the same weight of the oil, sodium chloride and sodium hydroxide as inputs, with the exception of coconut oil which also requires fatty acids for saponification (proportions taken from the respective Ecoinvent soap production process).

A final scenario is added for 100% crude oil soaps with no packaging added, to inform practitioners on the resulting change in impact.

b. Production

Soap production is a heat-intensive process, therefore to model potential changes in production impact, a baseline scenario of heat from natural gas was compared to the improved scenario of heat from a municipal incineration planet, a highly sustainable method of heat production.

c. Use

At baseline, the water supply assumed is “tap water” i.e. inclusive of electrical transmission, with figures used from South Africa, a country both close to the key distribution locations and with a coal and oil-based energy mix, which is likely to be the case in the field.

To model potential changes, the “best case” water supply of rainwater harvesting was used as a scenario to map the potential changes in impact from this phase.

Note: it is known from field data that the water supply can be even worse than the assumed baseline, i.e. using trucking and diesel pumps. However to create a more standardized emission factor, a more moderate option of tap water was chosen.

d. Supply & Distribution

No scenarios are studied for this stage, with all cases using the assumptions mentioned in the table.

e. Waste Management

No scenarios are studied for this stage, with all cases using the end-of-life options mentioned in the table.

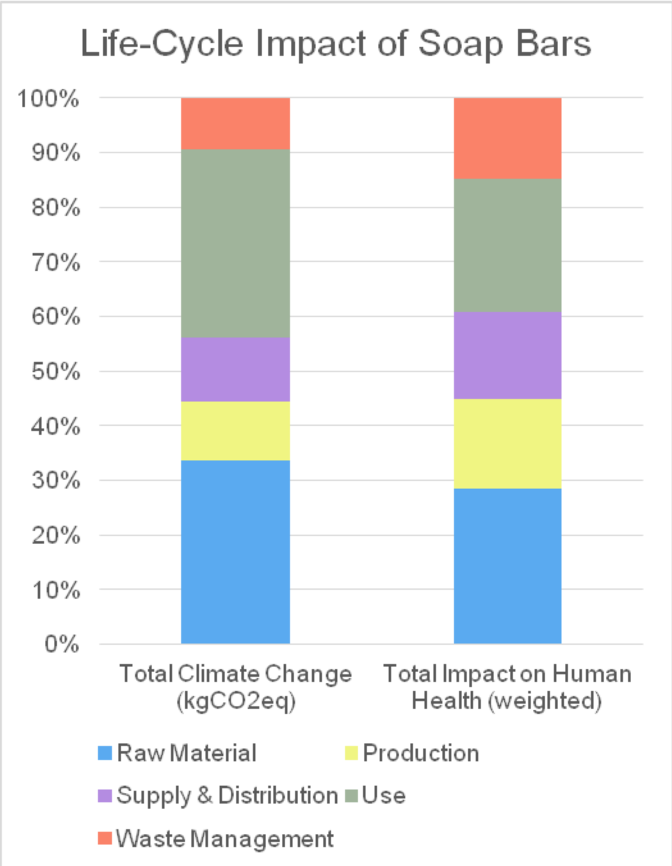
Note: The amount of wastewater calculated in m3 (which is the unit of measurement for the process in Ecoinvent) is considered to be equal to the weight of water in kg calculated in the use phase.

V. Results & Discussion

From the baseline results of the study it can be seen that raw material accounts for 34% of the total GHG emissions and 29% of total impact on human health. The largest share of impact for GHG emissions comes from the use of tap water during the life of the soap bar 34% while for impact on human health it is the second largest share of impact 24% after raw material.

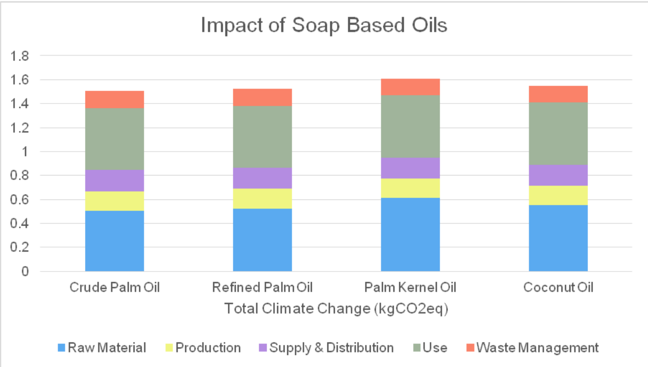
Greenhouse Gas (GHG) Emission Factors

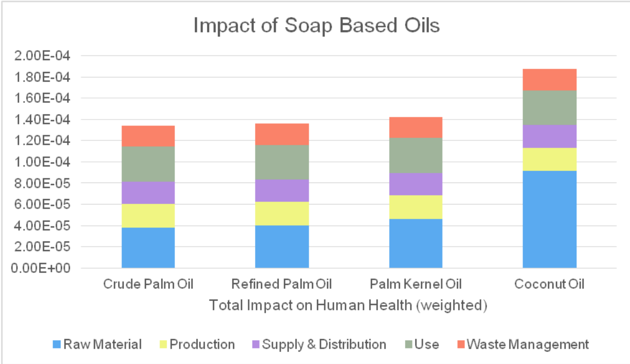
Name	GHG Protocol Category	kgCO2eq/unit
Cradle-to-grave	N/A	1.50
Cradle-to-gate	3.1 Purchased Goods	0.67



V..Results By Category

Raw Material

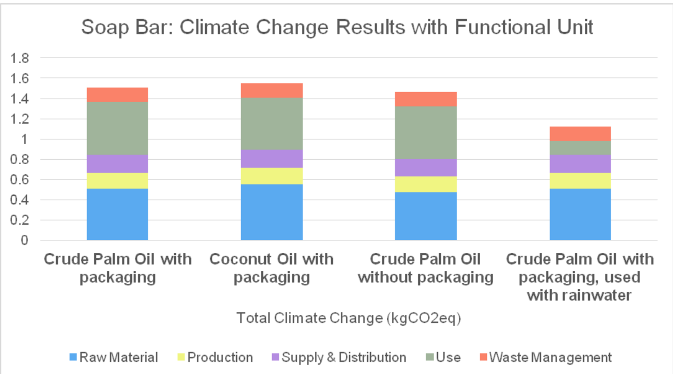


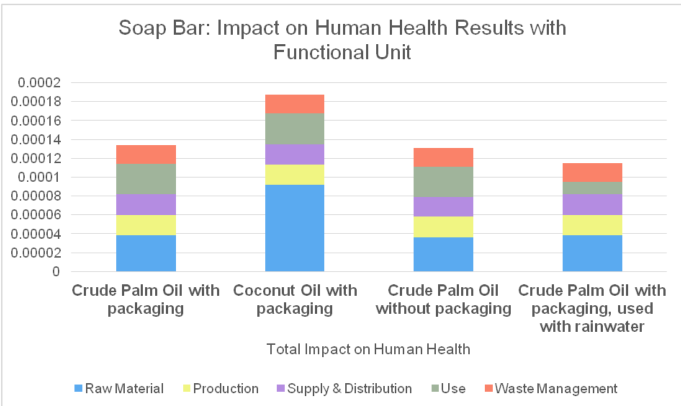


This study revealed that varying the type of palm oil used – crude palm oil, refined palm oil, palm kernel oil – did not affect the impact of the soap bar significantly, with all scenarios changing the impacts between 1-7% in both impact categories.

However, replacing palm oil with coconut oil sees an increase in impact that is vastly different between the two categories – coconut oil (and the additional fatty acids added to the materials for its formulation) -- increases GHG emissions by 3% but also increases impact on human health by 40%.

Water Supply

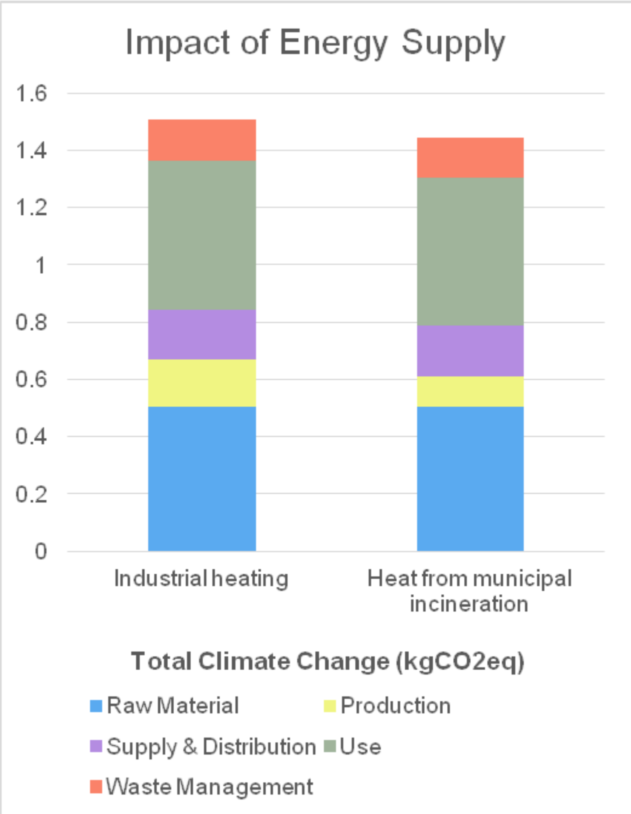


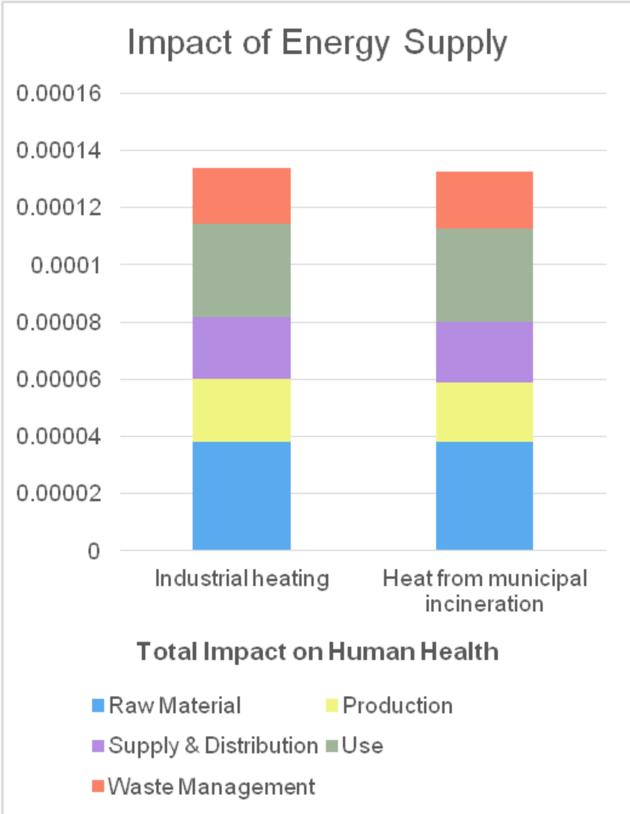


Water use alongside soap contributes significantly to the overall impact in both categories. In the model using 'tap water', a substantial portion of this impact stems from the energy and resources required for water pumping, treatment, and distribution.

To assess a scenario where water supply activities have a lower environmental burden, this study compares tap water (used in Scenarios 1, 2, and 3) with harvested rainwater. The latter results in a 26% reduction in the soap's GHG emissions and a 15% decrease in its impact on human health (Scenario 4).

Energy Supply





This study modelled a standard combined saponification and neutralisation process that is not electricity-intensive (i.e. 0.05 kWh needed for every 1 kg of soap produced) -- therefore moving to solar panels for the electricity requirement has a negligible impact on the product life-cycle

However, a fair amount of heat is needed to produce soap. At baseline, the study assumes a market mix of natural gas and other industrial heating processes for the soap production. Changing this to a market mix of heat derived from waste-to-energy processes (e.g. municipal waste incineration, biogas, etc) reduces the GHG emissions by 4% and the impact on human health by 1%, which is small enough to not be considered as having impact reduction potential. (Note: Greener sources for heat generation exist, but not at the industrial scale that is needed for this study)

Packaging

Eliminating plastic packaging results in a reduction of no more than 2-3% in impact across both categories. However, this could lead to the soap chipping or depleting more quickly, making it an inconclusive solution.

VI. Conclusion

The water usage during the use phase, as well as the raw material of the soap (i.e. vegetable oils) make up the majority of the impact of the soap.

Improving water supply can lead to:

- 26% lower GHG emissions
- 15% lower impact on human health

While palm oil is commonly used and remains an impact-efficient choice, it is important to consider its significant deforestation effects. RSPO-certified palm oil could be considered; its impacts were not modelled due to missing data on human health impacts.

For a more comprehensive conclusion on types of oil usage, the ecosystem/biodiversity impacts should be studied in further detail.

VII. Bibliography

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