Life Cycle Assessment of Solar Lamps

Project: Accelerating the Reduction of the Environmental Impact of Humanitarian Action

Version 1.0, 20.06.2025

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Science and Technology for Humanitarian Action Challenges (HAC)

Project website: https://climateactionaccelerator.org/accelerating-the-reduction-of-the-environmental-impact-of-humanitarian-action/

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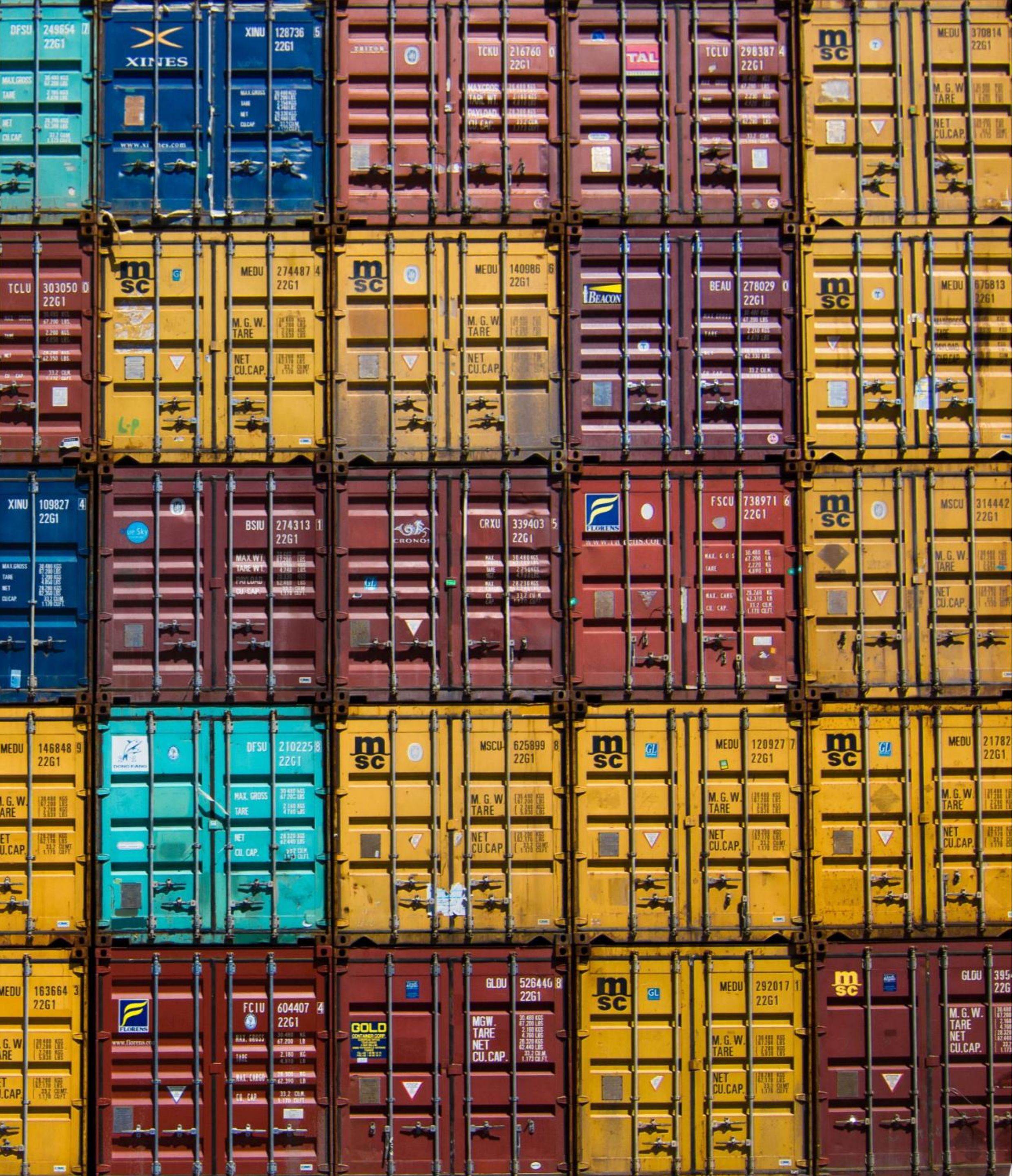

Acknowledgement

The findings from this analysis are based on an earlier study on the environmental impact of solar lanterns conducted by the EPFL EssentialTech Centre as part of a larger project to calculate GHG emissions of activities in displacement settings for the UNHCR. The data was reviewed and adapted in order to align with the streamlined methodology as developed as part of this project.

The content of this document is the sole responsibility of the project team.

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Introduction

Objectives and scope

This analysis aims to enhance understanding of the item's impacts on climate, human health, and plastic leakage. It also identifies potential levers to reduce these impacts. However, assessing the feasibility of implementing these levers falls outside the scope of this project.

By no means is it suggested that life-saving assistance to the most vulnerable populations across the world should be reduced for decarbonisation purposes. Effective emissions and other impact reductions should not result in any reduction in the quality, quantity or timeliness of assistance, but rather should explore ways to reinforce or maintain aid, while identifying low-carbon, sustainable, and resilient alternative options.

Objectives and scope

Objectives:

- Using models of the humanitarian supply chain to identify key levers to reduce the impact of solar lamps (climate, human health, plastic leakage).
- Establishing emission factors for the solar lamps currently in the humanitarian supply chain.

*In life cycle assessment, **cradle-to-grave** refers to evaluating a product's environmental impacts from raw material extraction through manufacturing, use, and final disposal. In contrast, **cradle-to-gate** focuses only on the stages up to the product's departure from the manufacturing site, excluding use and end-of-life phases.

Scope & System Boundary:

- Cradle-to-grave* system boundary for the assessment of impact across the complete life cycle.
- System boundary:
  - The materials, distribution, use and disposal of the product are in scope of our study (see slide 10 for details)
  - The charger for the solar lamp (an external product) is not in scope for this study
  - Impacts of assembly, here assumed to not be critical to the overall impact, are not in scope for this study
  - Any additional processes applied to the product after production are not in scope e.g. unplanned storage, etc.
  - The procurement of the packaging material is modelled, with the upstream activities of the packaging being out-of-scope

Methodology

The results are calculated following the Environmental Footprint 3.1 indicator system in two 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
  - Weighted using the approach detailed in the EF methodology – with a percentage assigned to each sub indicator (see reference)
  - Normalized for one citizen so as to aggregate and represent as a single score for human health

Plastic leakage: Experimental projection of the amount of plastic leaked into nature via mismanagement of waste

References:
"European Platform on LCA | EPLCA.". https://eplca.jrc.ec.europa.eu/EnvironmentalFootprint.html
Joint Research Centre (European Commission), Alessandro Kim Cerutti, Rana Pant, and Serenella Sala. 2018. Development of a Weighting Approach for the Environmental Footprint. Publications Office of the European Union. https://data.europa.eu/doi/10.2760/945290

End-of-life

This study aims to model the impact differences between various waste management methods tailored closer to humanitarian contexts. The following end-of-life options were modelled in the analysis, as appropriate:

- **Open dump** (unmanaged)
- **Open burning** (unmanaged)
- **Unsanitary landfill** (minimal management)
- **Sanitary landfill** (managed site)
- **Municipal incineration** (managed plant)
- **Recycling** (as modelled)

For plastics, the differences in measured impact between each end-of-life scenario are similar. (For more info on the impacts and sources of end-of-life impact measurement please see annex.)

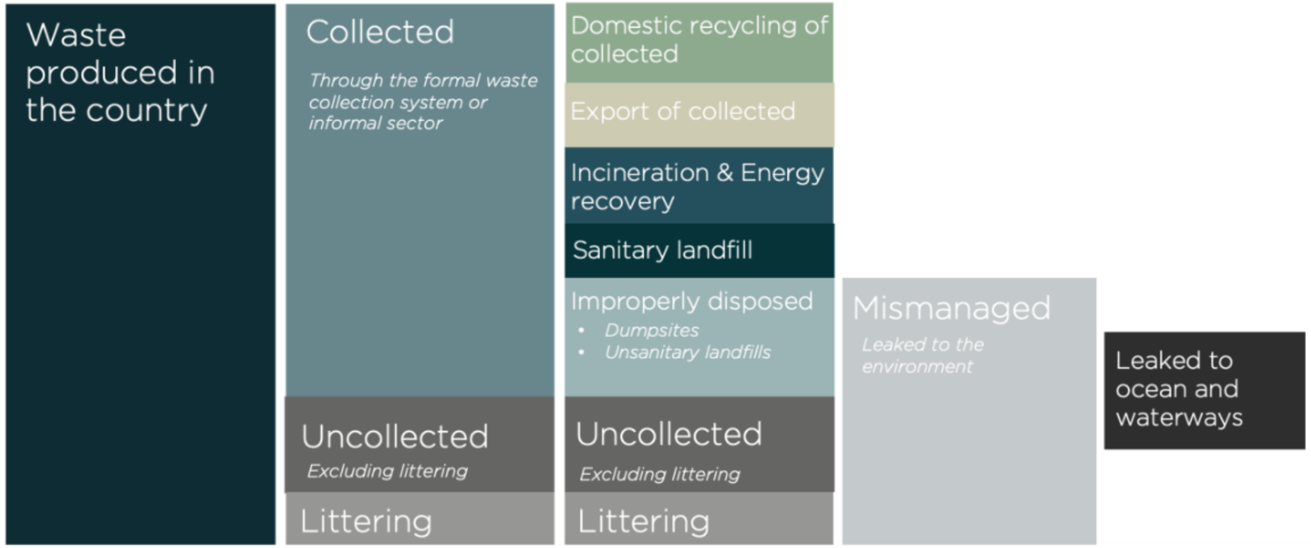
According to the LCA methodology, the analysis of greenhouse gas (GHG) emissions (Global Warming Potential)—is limited to a 100-year timeframe. As a result, any additional impact from plastic degradation in landfills occurring beyond this period is neither measured nor compared to other waste disposal methods.

Plastic leakage

This project aims to estimate the mismanaged waste that may occur at the end of life of products distributed by humanitarian organisations.

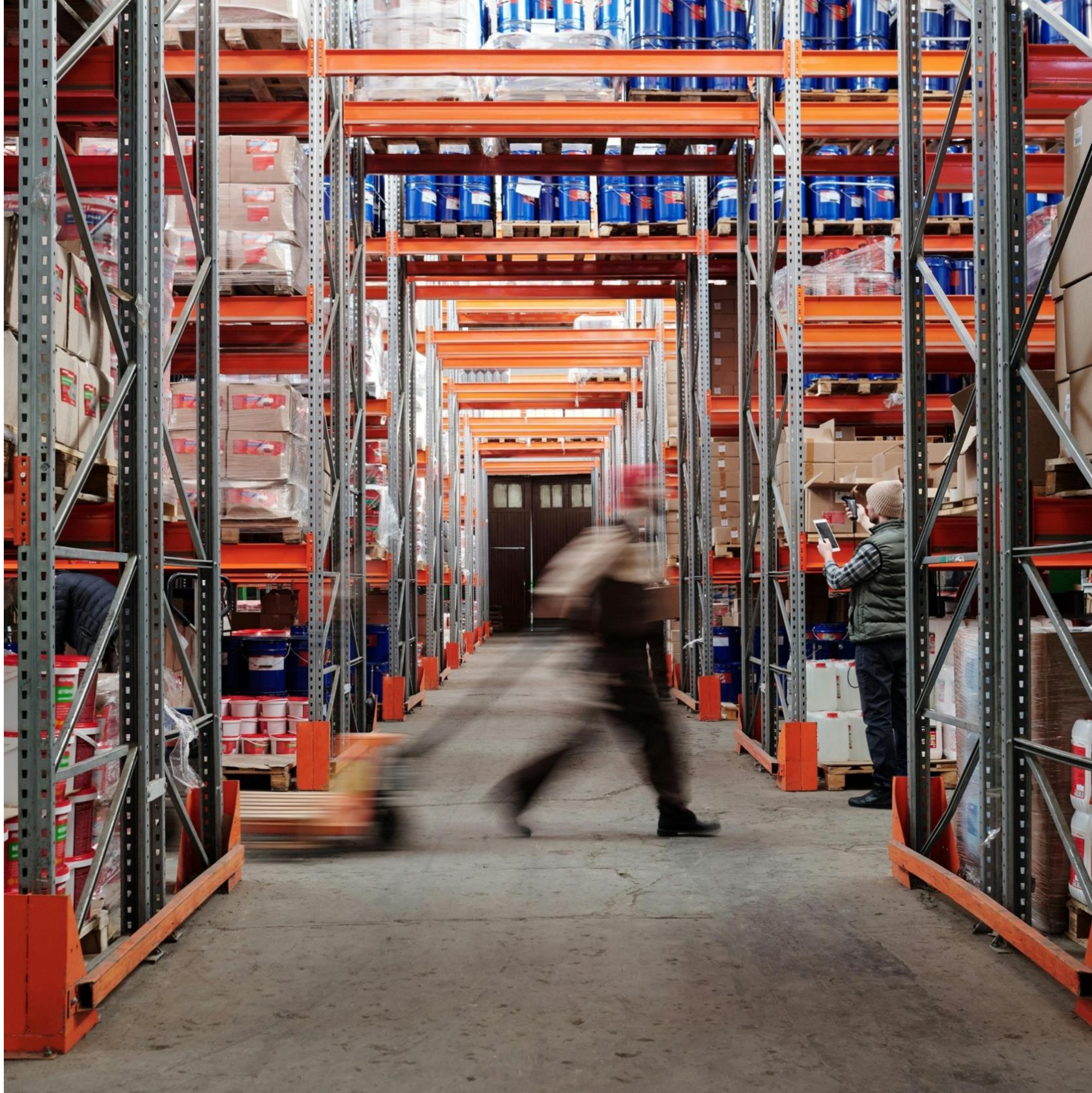
The modelled scenarios are analysed for plastic leakage by selecting the waste management method that is modelled and calculating the projected leakage (or lack thereof) due to the same.

For more information, please refer to: "Global Plastic Environmental Analytics Platform." Plasteax. https://plasteax.earth/.



Source: EA – Earth Action

LCA Results



Key Product Parameters & Assumptions

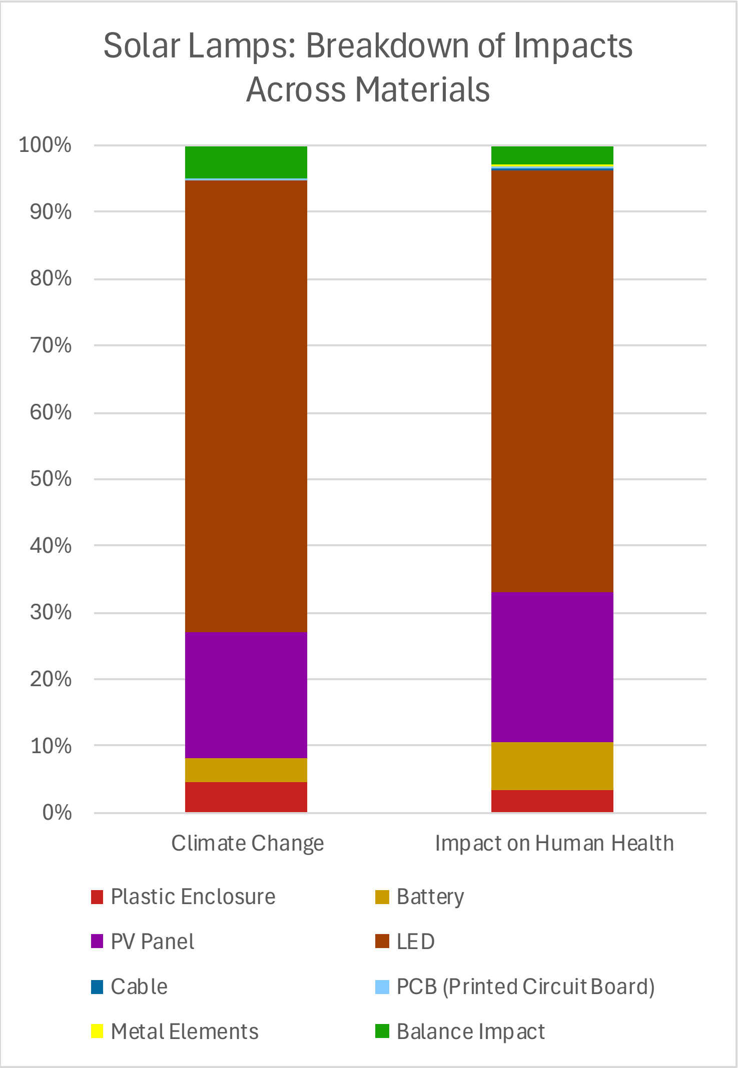
LIFE-CYCLE STAGE	PARAMETER	DESCRIPTION OF MODEL
GENERAL	Field Context	The comparison of the older and newer models of the lamp aim to study the environmental impacts of the reduced volume and weight that has been achieved with higher lifespan.
Raw Material	Bill of Materials	Old lamp: 670g net weight; New lamp 564g net weight Polypropylene, PV Panel, LED, PCB, Metal Frame, Wiring, etc.
	Packaging	Cardboard box, paper wrapping
Production	Manufacturing Location	China
Supply & Distribution	Transport Chain	Trucked to port (500 km) Shipped to African DCs (10,000 km) Trucked for warehousing (500 km) & distribution (1500 km)
Use	Utilization	N/A
	Usage Processes	N/A
Waste Management	Product Disposal Method	Unsanitary Landfill
	Packaging Disposal Method	Open Dumping

OLD

NEW

Baseline Results

- Raw materials account for **95%** of the total GHG emissions and **97%** of the total human health impact associated with the solar lamp.
- Among these materials, the LED component contributes disproportionately to the impact—**68%** of total climate change impact and **63%** of human health impact—despite weighing only 47g out of the total 564g. This is due to the impact-intensive production process of the LED.
- The second-largest contributor is the photovoltaic cell of the solar panel, responsible for **19%** of GHG emissions and **23%** of the human health impact.
- **As there was a very slight shift in net weight between the old and new lamp, the impacts remain very similar when compared without a function.**



Emission factors (OLD)		Unit
Cradle-to-grave	17.48	kgCO2eq/unit
Cradle-to-gate	16.55	kgCO2eq/unit

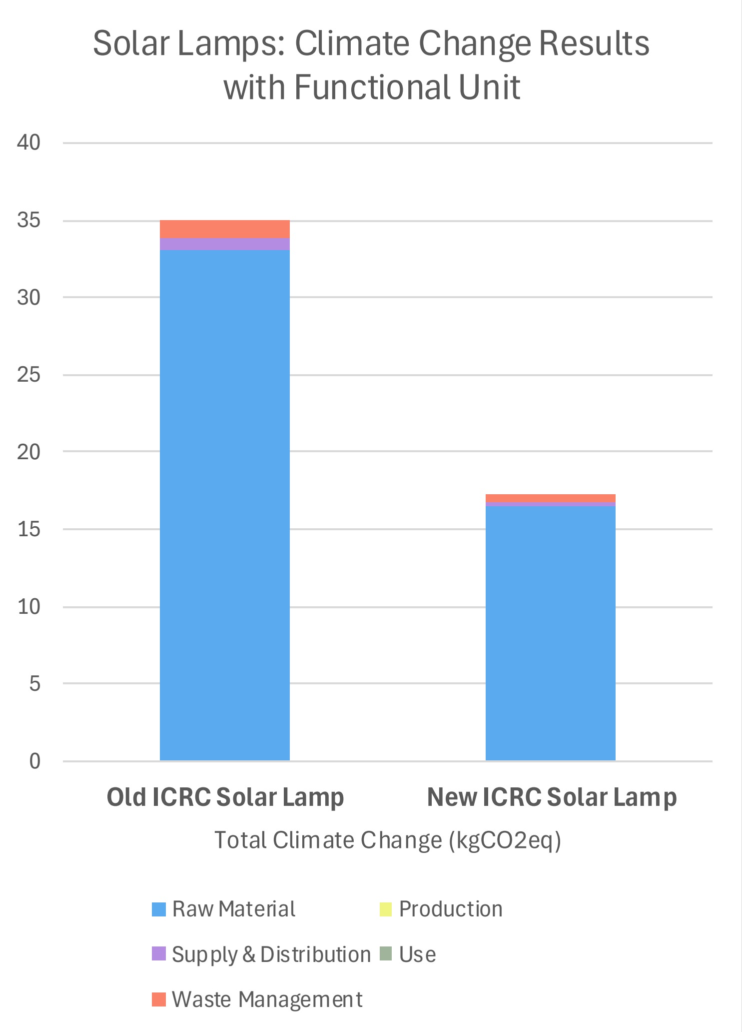
Emission factors (NEW)		Unit
Cradle-to-grave	17.27	kgCO2eq/unit
Cradle-to-gate	16.50	kgCO2eq/unit

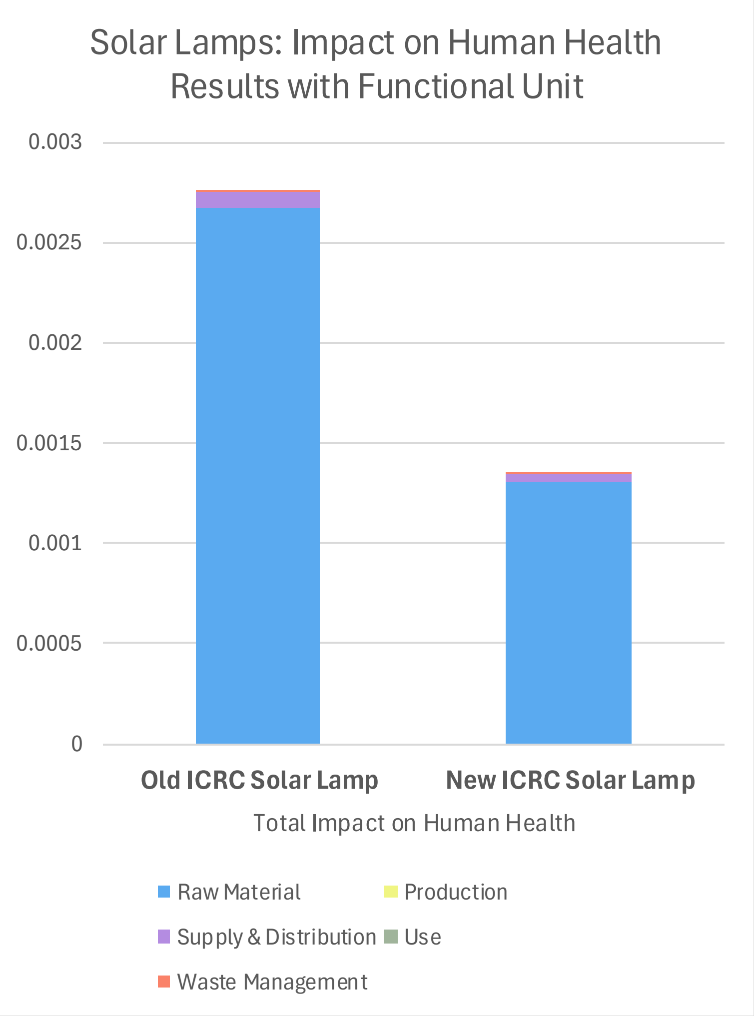
Lifetime & Materials

- By improving the **durability of key components**, such as the battery, and **doubling the lifespan** of the solar lamp, the environmental impact is **linearly reduced** when evaluated against the function of providing household lighting for the same duration.

- Using a **functional unit of 6 years**, the previous solar lamp model—which lasts only 3 years—has **twice the impact** of the new, longer-lasting version.

- More precisely a **50.61%** reduction in climate change and **50.80%** reduction in human health.





Key conclusions of analysis

- By increasing the durability of the components and extending the lifespan of the solar lamp, the impact of the solar lamp reduces linearly as the durability is increased. In this case, doubling the lifespan results in reduction of
  - ▼ 50% climate change
  - ▼ 50% impact on human health
- The impacts to local environment due to the disposal of the components must be further studied to expand on this result.

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Thank you!

The greenhouse gas emission calculator – an introduction UNHCR. Available at: https://www.unhcr.org/media/greenhouse-gas-emission-calculator-introduction

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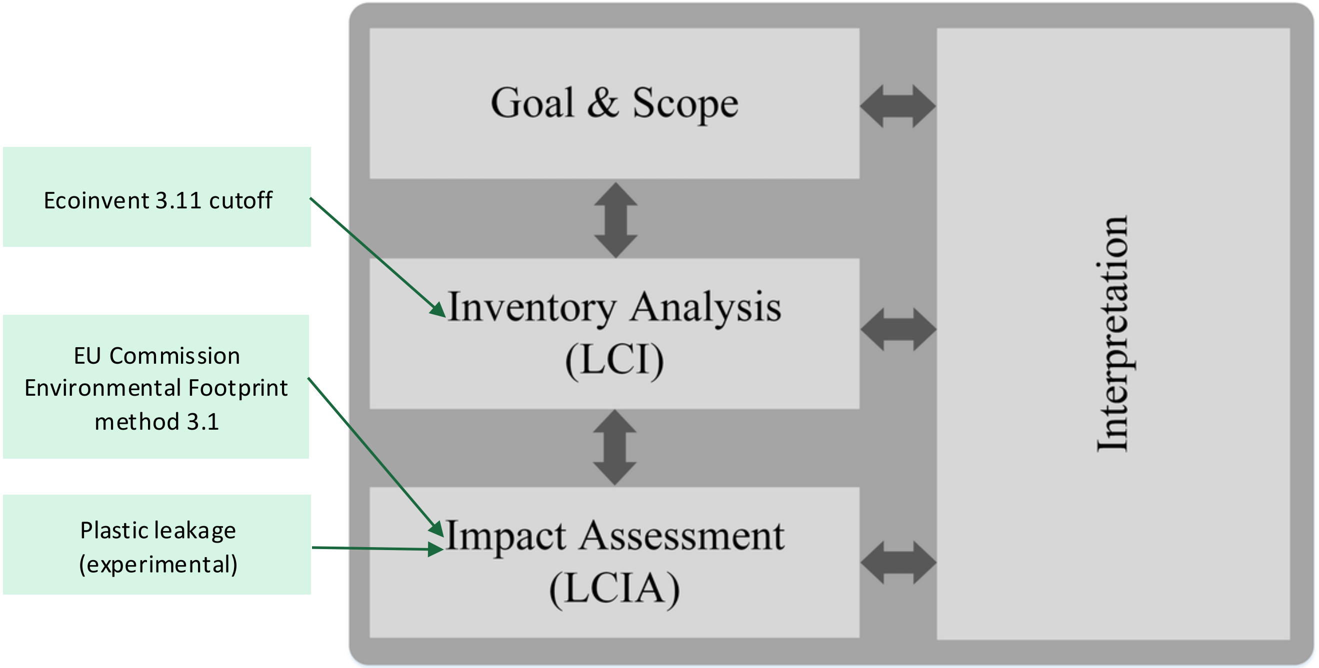
Methodology

The primary database used is Ecoinvent 3.11

The studies utilize the data from the **cut-off system model which allocates the entire impact of the material to its primary user** without any ‘rewards’ for its potential for being recycled.

Consequently, any recycled materials do not carry the burden of the impact of the primary use of the material and rather track the impacts from the recycling process onward.



Life cycle assessment (LCA) steps according to ISO 14040, 14044, and 14067.

References:
“Ecoinvent v3.11.” n.d. Ecoinvent. https://ecoinvent.org/ecoinvent-v3-11/

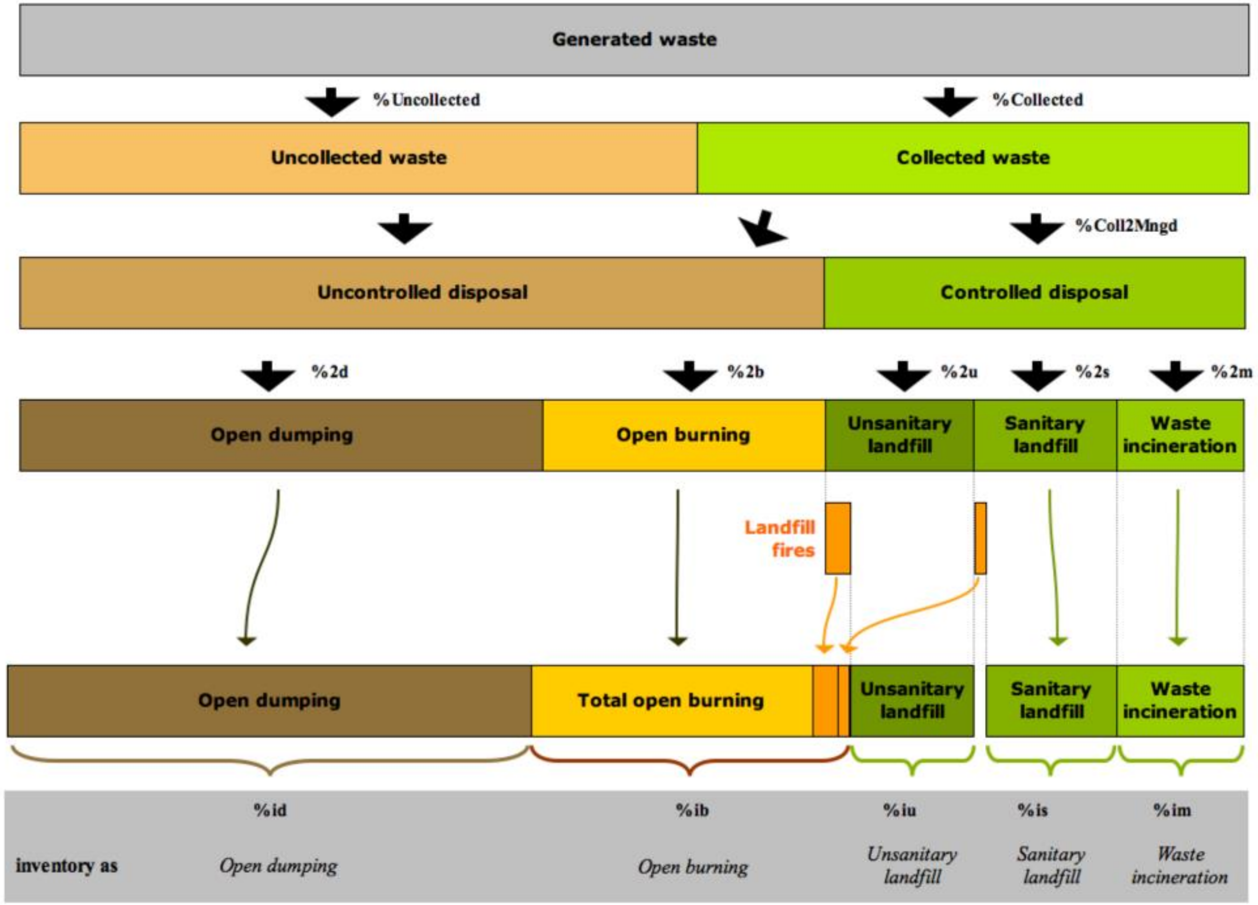
End-of-life waste management

This study aims to model the impact differences between **managed and mismanaged** waste tailored closer to humanitarian contexts.

The end-of-life impact for *a mix of plastic waste* reduces as below:

Method	GHG Emissions	Impact on Human Health
Open Burning	~HIGHEST~	~HIGHEST~
Municipal Incineration	-2.60%	-96.03%
Unsanitary Landfill	-93.80%	-99.40%
Open Dumping	-95.50%	-99.87%
Sanitary Landfill	-96.22%	-99.06%

Open burning creates maximum impact for both categories, but beyond that there are differences between climate change and human health on the specific magnitude of reduction.



Doka, G., 2018, Inventory parameters for regionalised waste disposal mixes

This study uses values for specific types of plastic wherever necessary, however the proportions of impact follow similar trends across the types of plastic product. This is therefore the standard impact implication for plastic products at end-of-life. Whenever possible, recycling is also modelled as a waste treatment option within the scope of the study.

NOTE: The methods listed above have differences in how long it takes for the plastic to be removed. It is part the LCA methodology that measurements are limited to a 100 years, therefore any further impact due to the degradation of plastic in landfills is not measured or compared with other methods of disposal.