Life Cycle Assessment of Plastic Floor Mats

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

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Authors: Ashima Rajput, Dr Cara Tobin Greene, Sonja Schmid

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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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:

- To establish GHG Emission Factors for **plastic floor mats** adapted to the humanitarian context.
- To analyse the environmental impact of the product's life cycle and identify key levers for impact reduction by studying potential variations.

Scope & System Boundaries:

- **Cradle-to-grave** system for the assessment of impact across the complete life cycle.
  - The materials, production, distribution, use and disposal of the product are in scope of the study
  - Any additional processes after production are not in scope e.g. unplanned storage, etc.
  - The procurement of the packaging is modelled, upstream activities related to the packaging are out-of-scope
  - The study focuses on one unit of the product and does not include larger-scale supply activities i.e. shipping per container, etc.

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.)

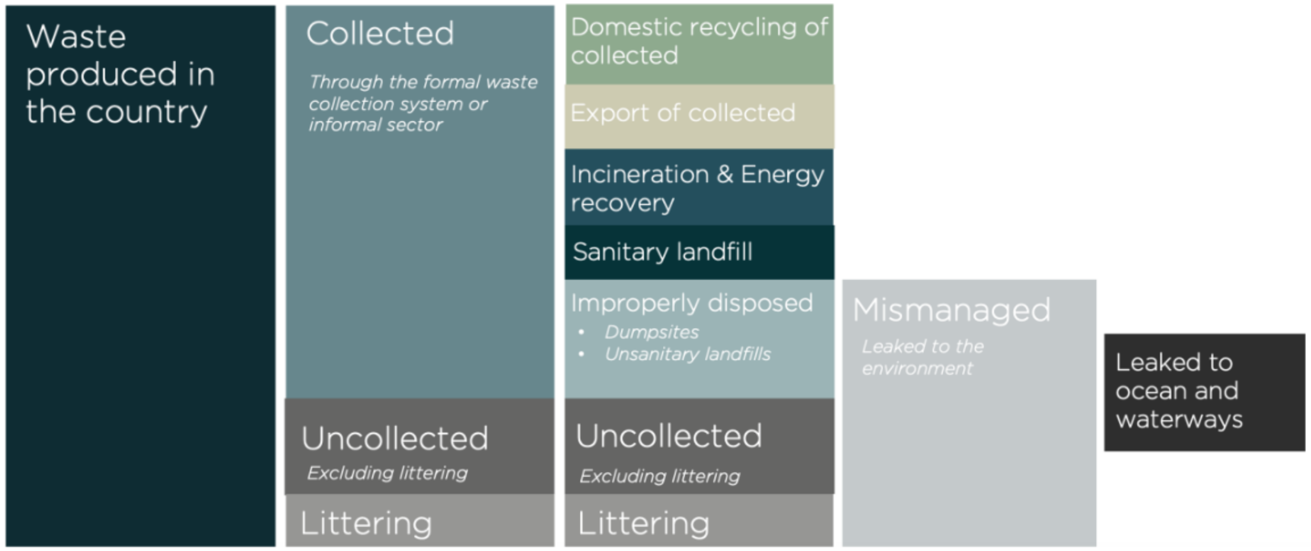
According to the LCA methodology, the analysis of greenhouse gas (GHG) emissions (Global Warming Potential)—is limited to a 100-year timeframe. As a result, any additional impact from plastic degradation in landfills occurring beyond this period is neither measured nor compared to other waste disposal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

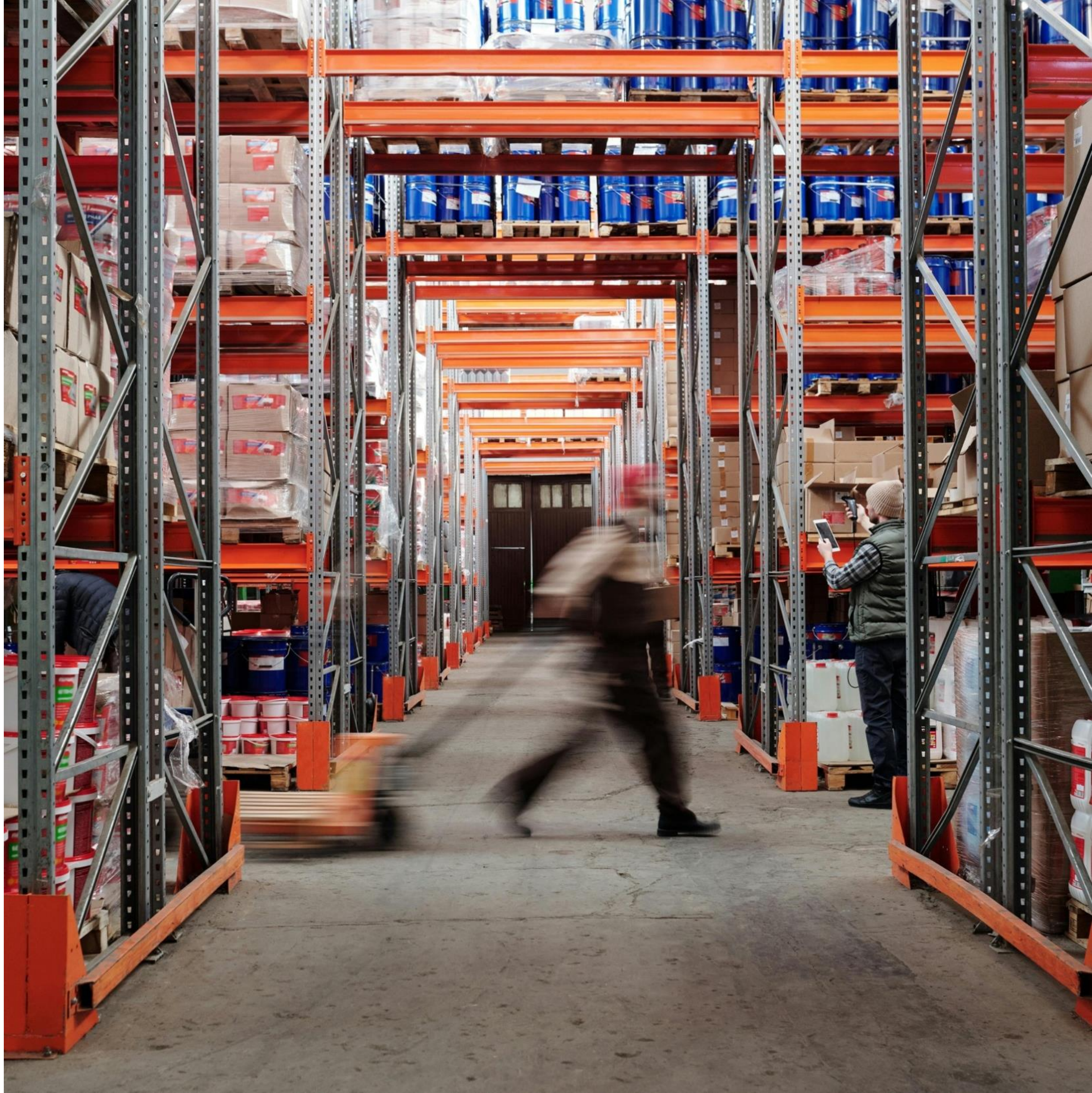
The modelled scenarios are analysed for plastic leakage by selecting the waste management method that is modelled and calculating the projected leakage (or lack thereof) due to the same.

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



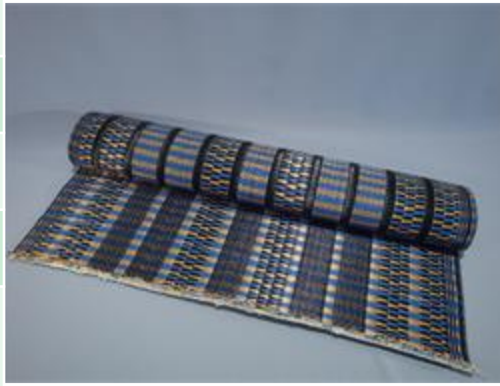
Source: EA – Earth Action

LCA Results



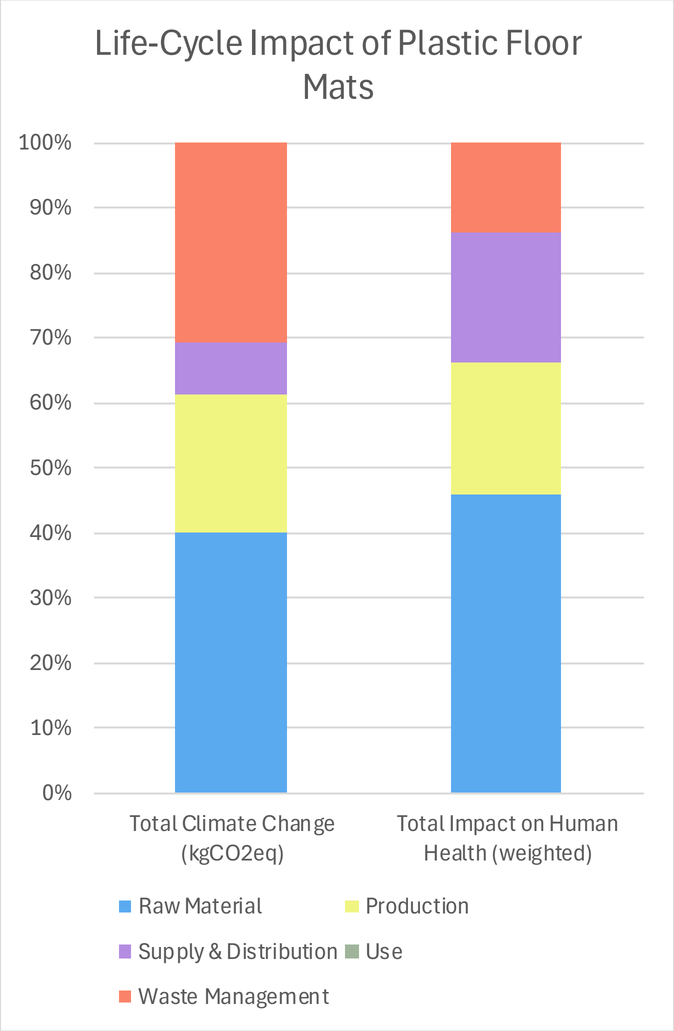
Key Product Parameters & Assumptions

LIFE-CYCLE STAGE	PARAMETER	DESCRIPTION OF MODEL
GENERAL	Field Context	Plastic floor mats are preferred in humanitarian contexts as mats made from natural fibres tend to rot and degrade faster than synthetic mats.
Raw Material	Bill of Materials	Pure virgin polypropylene (860g net weight)
	Packaging	LDPE Packaging Film (100g per mat)
Production	Manufacturing Location	Aurangabad, India
	Manufacturing Processes	Polypropylene fibre production & synthetic weaving
Supply & Distribution	Transport Chain	TRUCK – SEA – TRUCK (to DC) TRUCK from DC to distribution No disposal transport
Use	Lifespan	2 years
	Usage Processes	Assumed to not be washed, only wiping or dusting
Waste Management	Product Disposal Method	Open burning in pits (no transport)
	Packaging Disposal Method	Open dumping (no transport)



Baseline Results

- Considering a lifetime of 2 years, the raw material accounts for nearly half of the impact on human health **(46%)** and is also the main source of GHG emissions **(40%)**
- Open burning at end-of-life is the second largest source of GHG emissions **(31%)**, it's share of emissions being higher than that of producing the mat **(21%)**
- However, in terms of human health, the production phase **(20%)** and supply and distribution **(20%)** have a larger impact than open burning **(14%)**
- Plastic leakage
  - It is assumed that the product is incinerated, thereby avoiding leakage.
  - The packaging is assumed to be dumped/littered causing leakage for all scenarios



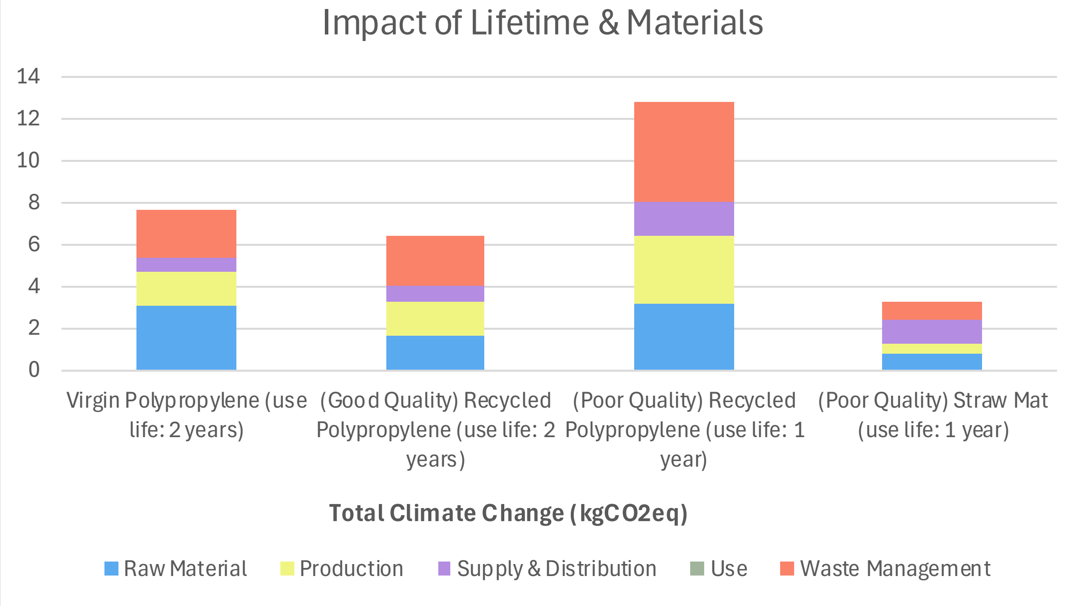
Emission factors		Unit
Cradle-to-grave	7.68	kgCO2eq/unit
Cradle-to-gate	4.69	kgCO2eq/unit

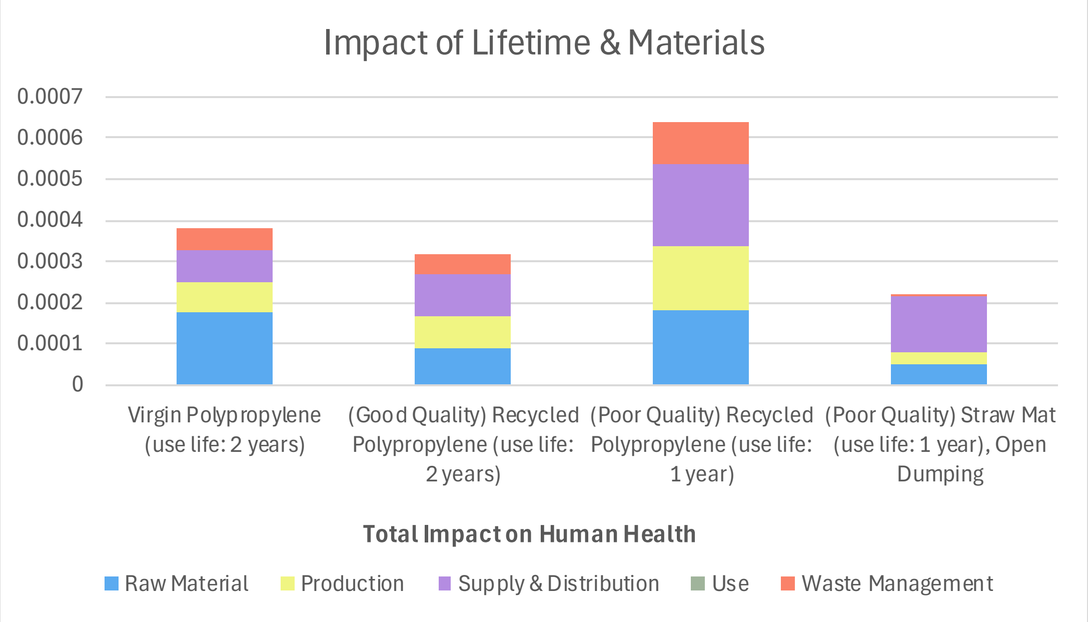
Functional Unit: 2 years of use of a floor mat

Variations per lifecycle stage

	Raw Material	Production	Use Life	Supply & Distribution	Waste Management
Baseline	Virgin PP	Average energy mix	2 years, no washing	International supply (via sea) and sourcing	Open burning
	Good quality recycled PP	Electricity derived from solar panels	1 year (poor quality PP and straw), no washing	Import of Recycled PP, international supply (via sea), and sourcing	Sanitary Landfill
	Poor quality recycled PP			Local production and supply	Municipal Incineration
	Straw				Biowaste (straw mat only)

Lifetime & Materials

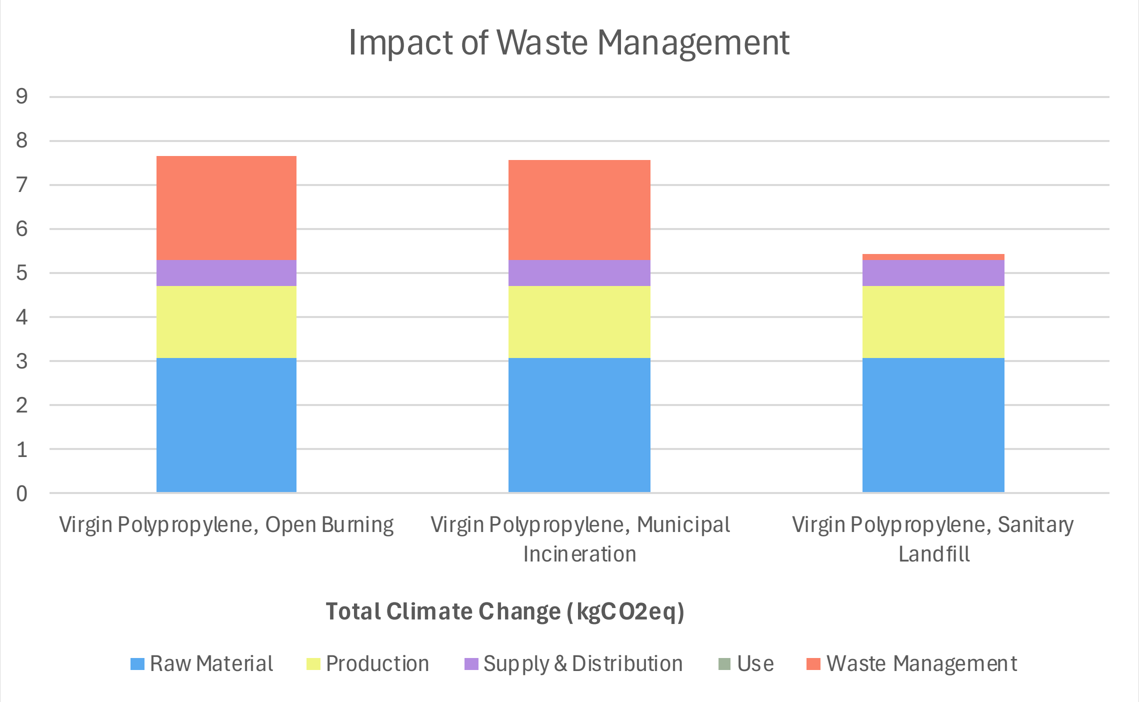


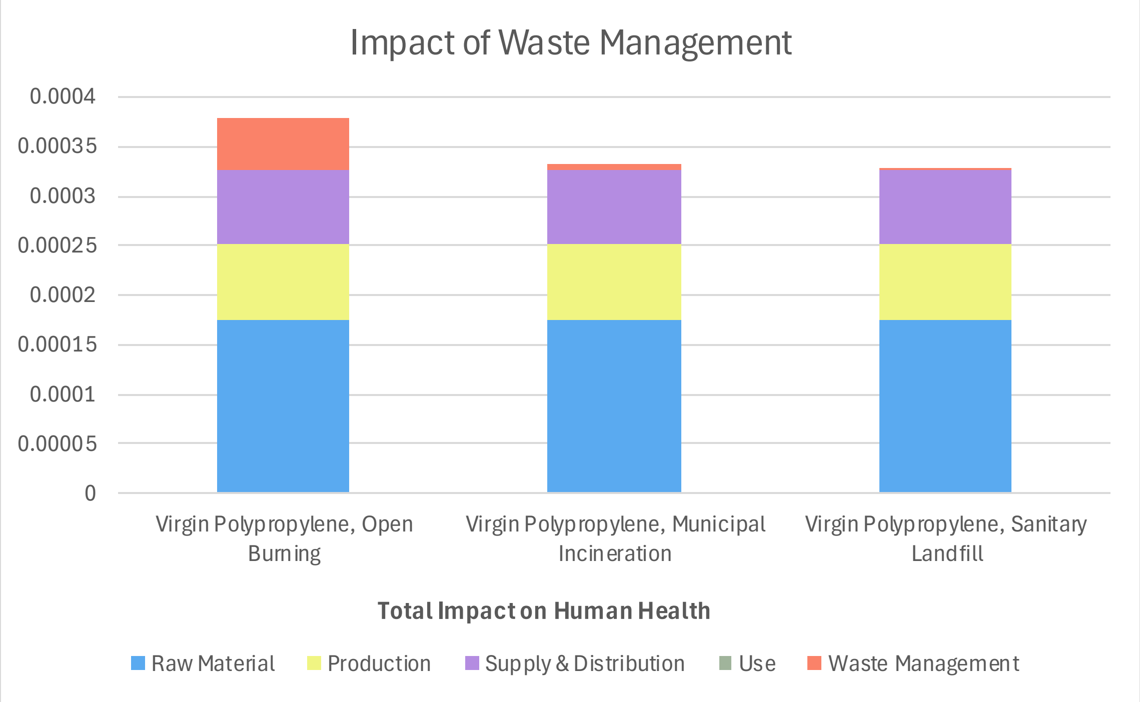


Lifetime and Materials

- Extending the lifetime of the product can lead to a significant reduction in environmental impact, which can be accomplished by improving product quality (by eco-design, etc.) and maintaining the product during the use phase.
- Using recycled polypropylene instead of virgin can reduce the impact of the raw material stage by 50% – however since the recycled PP has to be imported from Europe, the overall reduction is approximately **16%/17%** in both climate change and impact on human health.
- **If the lifespan of the recycled polypropylene mat is shorter** (here assumed as 1 year instead of 2 years), the impact on climate change and human health increases by approximately **67%** and **69%**, respectively, due to the higher number of mats required to meet the 2-year functional unit.
- Using straw as raw drastically reduce the overall impact (**57%/42%** lower GHG emissions/impact on human health than baseline), yet assumptions regarding the lifespan of straw mats are uncertain and would need to be further studied in field contexts, together with feasibility.

Waste Management

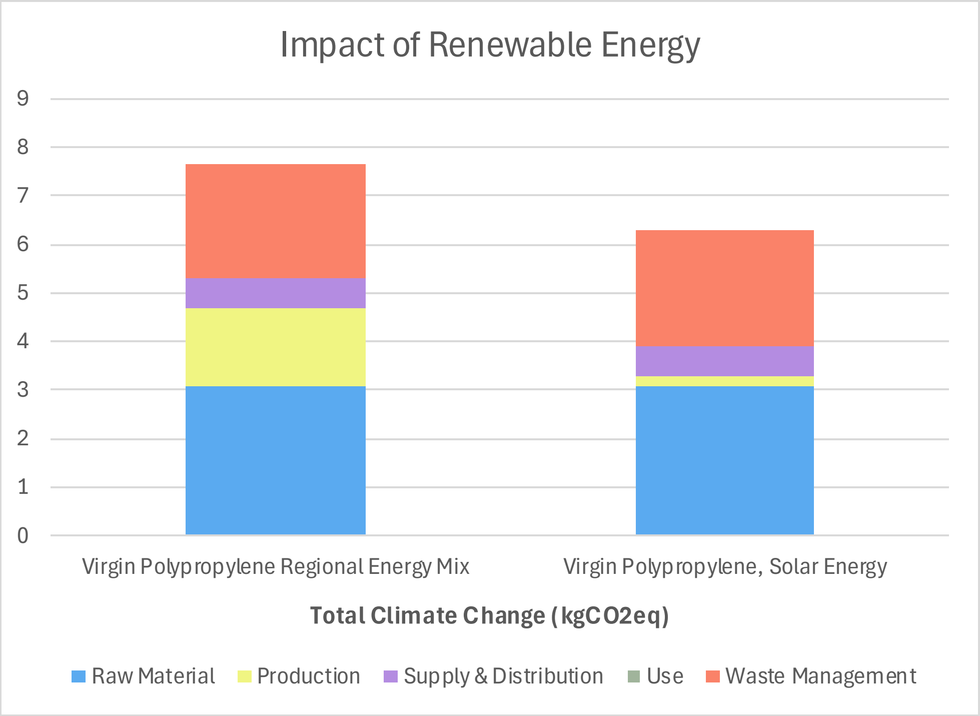


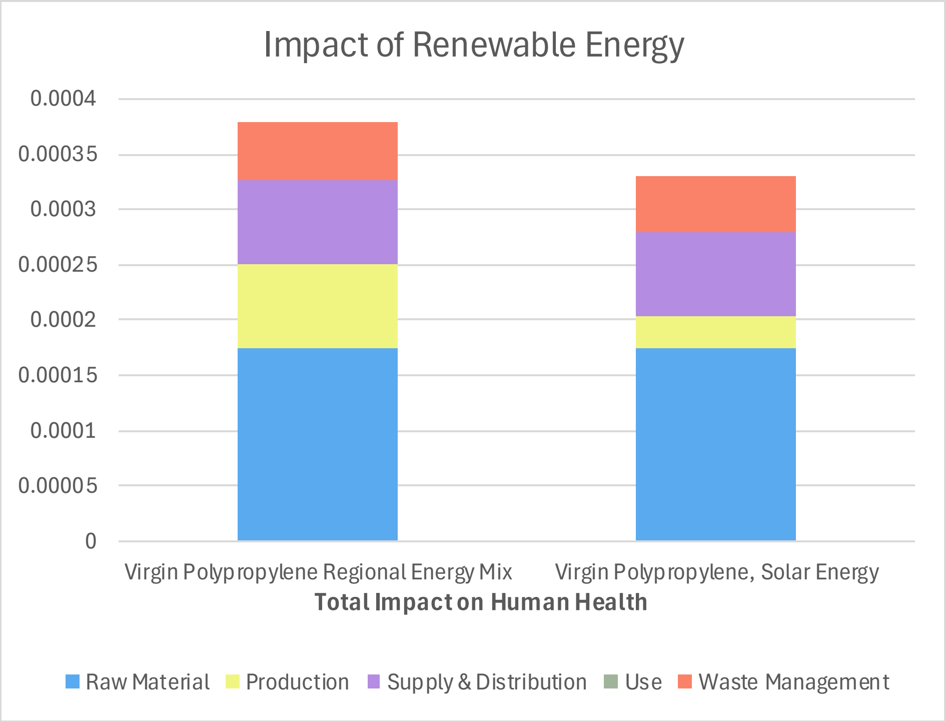


Waste Management

- Burning plastic waste in a municipal incineration plant rather than openly will not reduce GHG emissions by much but will reduce impacts on human health if the plant has the adequate filters
- There is a small improvement when considering municipal incineration for climate change **(1%)** but larger for human health **(12%)**.
- A sanitary landfill achieves a greater reduction in climate change **(29%)** and has comparable reduction in human health to municipal incineration **(14%)**, making sanitary landfills the preferred waste management method within the scope of the LCA, however any additional impact from plastic degradation in landfills occurring beyond this period is neither measured nor compared to other waste disposal methods.

Energy Supply

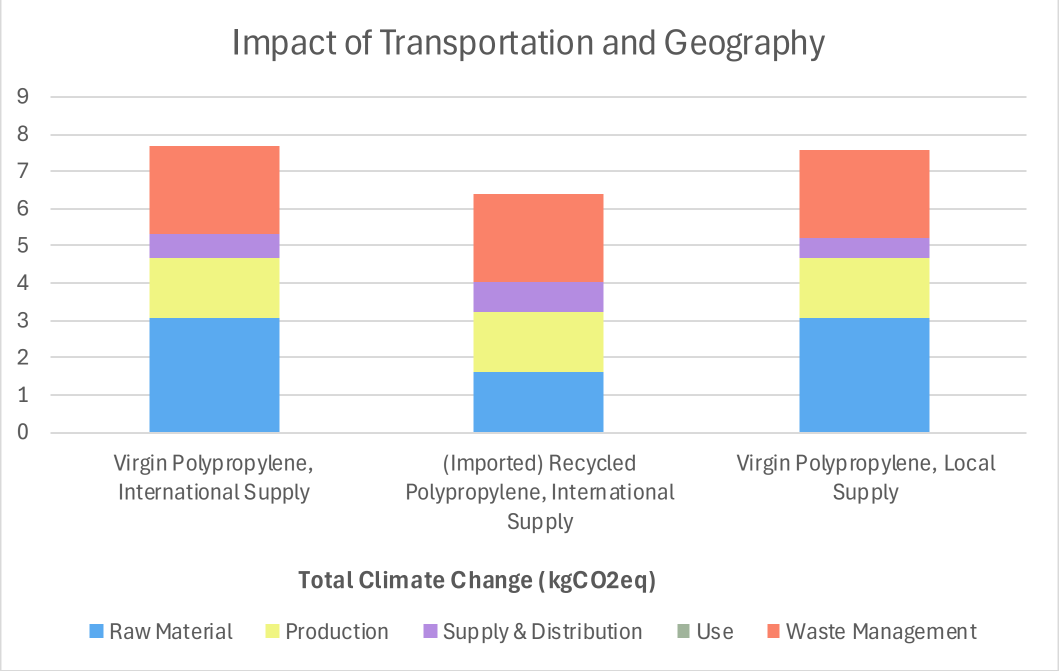


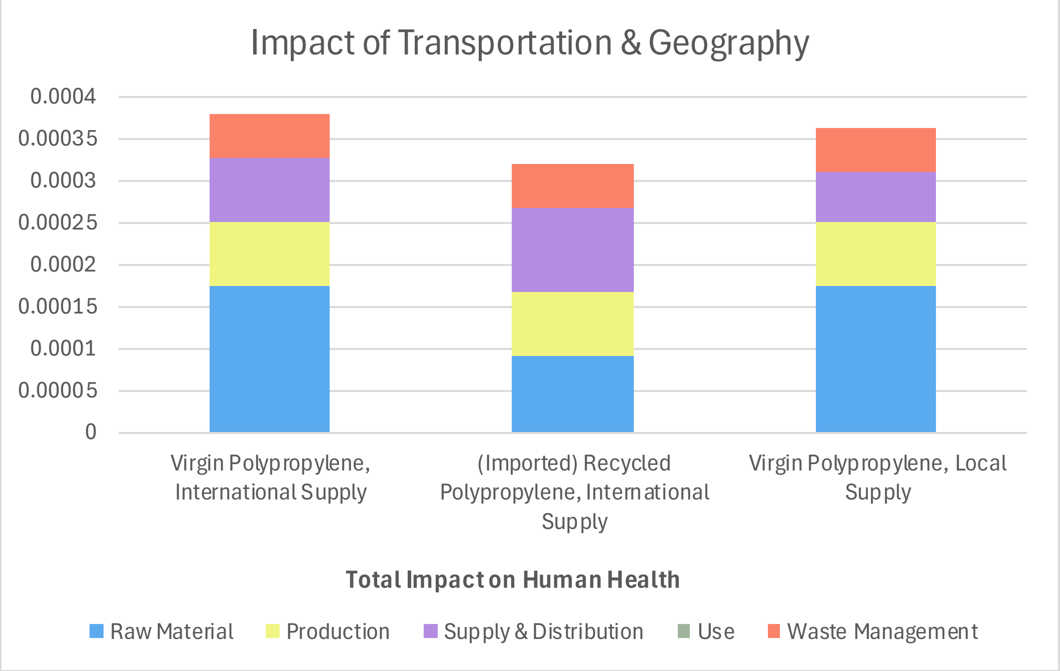


Energy for Production

- Switching the energy source used for electricity or heat during the production phase can significantly reduce environmental impacts – especially when fossil fuel-intensive sources are replaced with low-carbon alternatives.
- Producing mats using solar electricity from an on-site photovoltaic (PV) installation, instead of the average Indian electricity mix (which consists of approximately 75% coal), reduces production-phase impacts by 86% for greenhouse gas (GHG) emissions and 62% for impacts on human health.
- Across the full life cycle, this results in an overall reduction of **18%** in GHG emissions and **13%** in human health impacts.

Transport & Geography



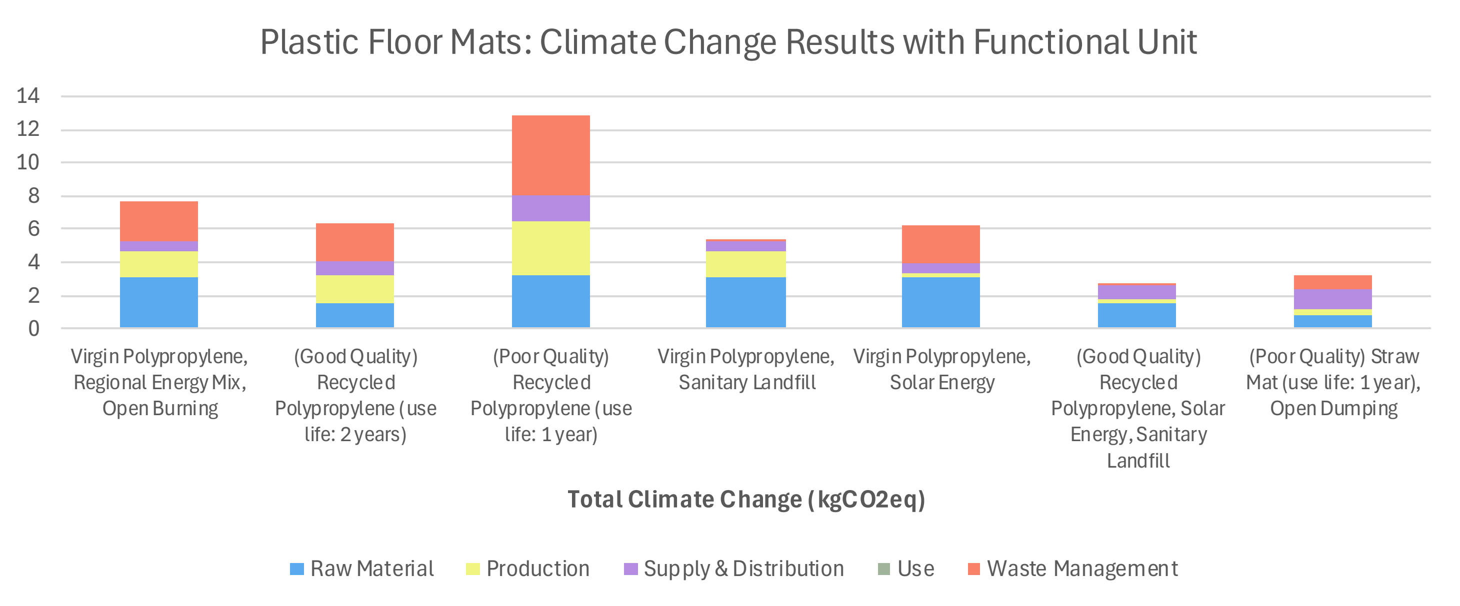


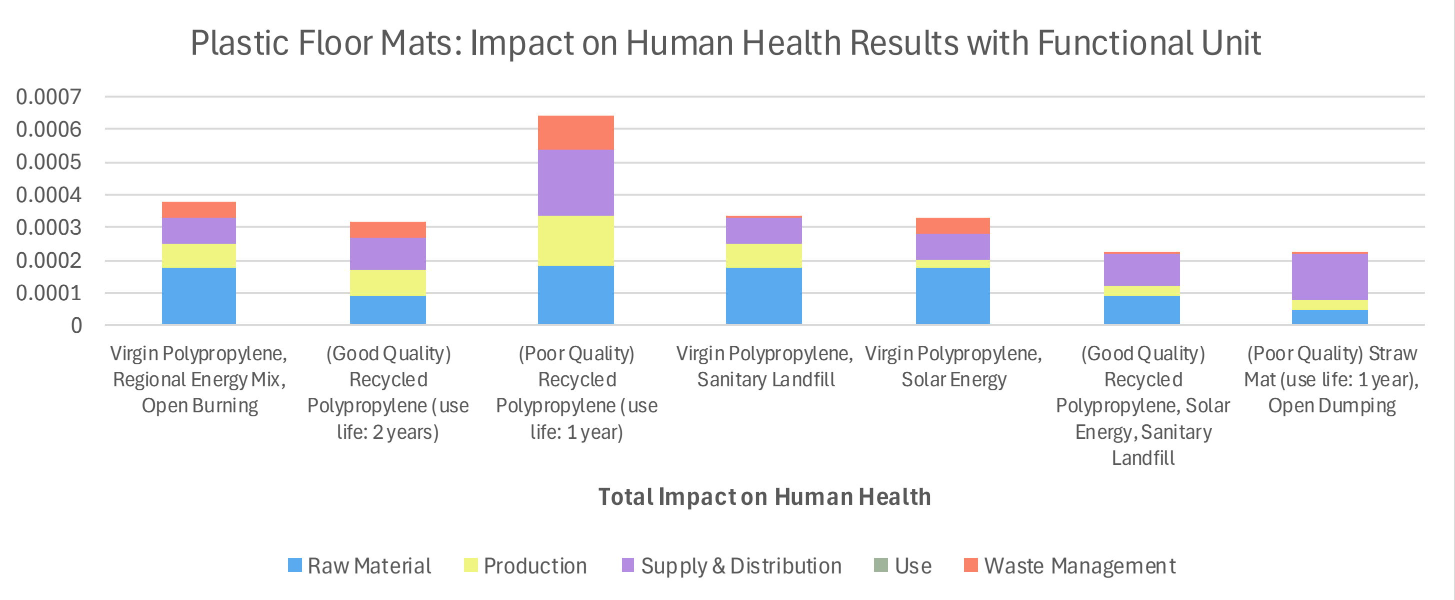
Transportation & Geography

- The plastic mats are made in India and shipped to Sub-Saharan Africa via maritime transport. While the transport contributes relatively little to GHG emissions—typically between 5% and 15%—its impact on human health is comparable to that of production, accounting for approximately 20% for virgin polypropylene (PP) mats.
- The recycled PP material is modelled to be imported from Europe – this additional sourcing increases the impact of the supply & distribution stage by 32% compared to the virgin PP mats. Despite this increase, the overall impact of recycled PP mats is approximately **15%** lower than that of virgin PP mats (*as long as the lifespan of the mats is maintained*) due to the significantly lower environmental impact of recycled PP as compared to virgin PP in the material stage.
- By contrast, producing virgin PP mats directly in Sub-Saharan Africa would only yield a modest reduction of **2%** in GHG emissions and **4%** in human health impacts over the product's life cycle.

Impact Assessment: All Results

Functional Unit: 2 years of use of a floor mat





Key conclusions of comparative analysis

- The modelled scenarios show the following impact reductions (GHG emissions & impact on human health):
    - Virgin to good quality recycled PP: ~16%
    - Average energy mix to solar for production: ~15%
    - Open burning to sanitary landfill: 30%/13%

Therefore, combining recycled materials, renewable energy, and better waste management account for the impact reduction of the plastic floor mat, with the below results

- ▼ 64% climate change
- ▼ 41% impact on human health

Straw mats, despite lasting shorter in our model, comparatively reduce

- ▼ 57% climate change
- ▼ 42% impact on human health
- However – the assumption of poor-quality straw mats lasting 1 year is circumstantial and could change based on ground realities, therefore the reduction potential would have to be confirmed by additional studies on the lifespan of straw mats in field settings.

Email address contact@climateactionaccelerator.org

LinkedIn linkedin.com/company/theclimateactionaccelerator

Website climateactionaccelerator.org

Thank you!

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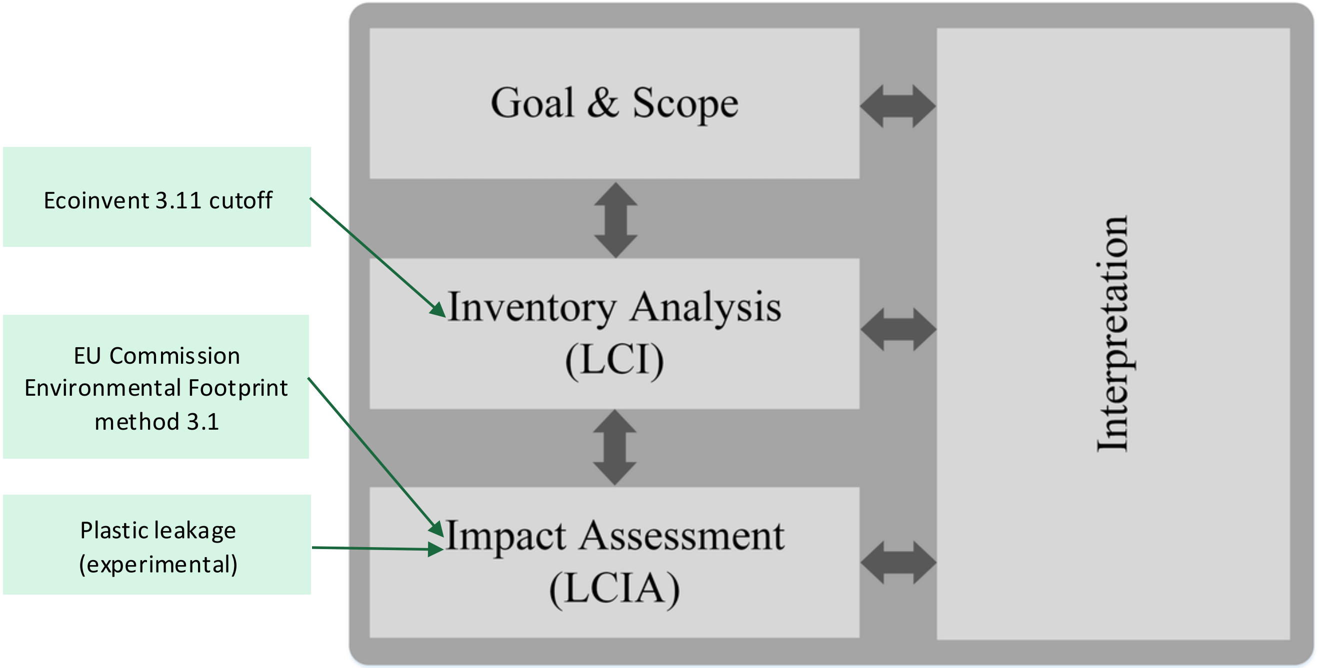
Methodology

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/

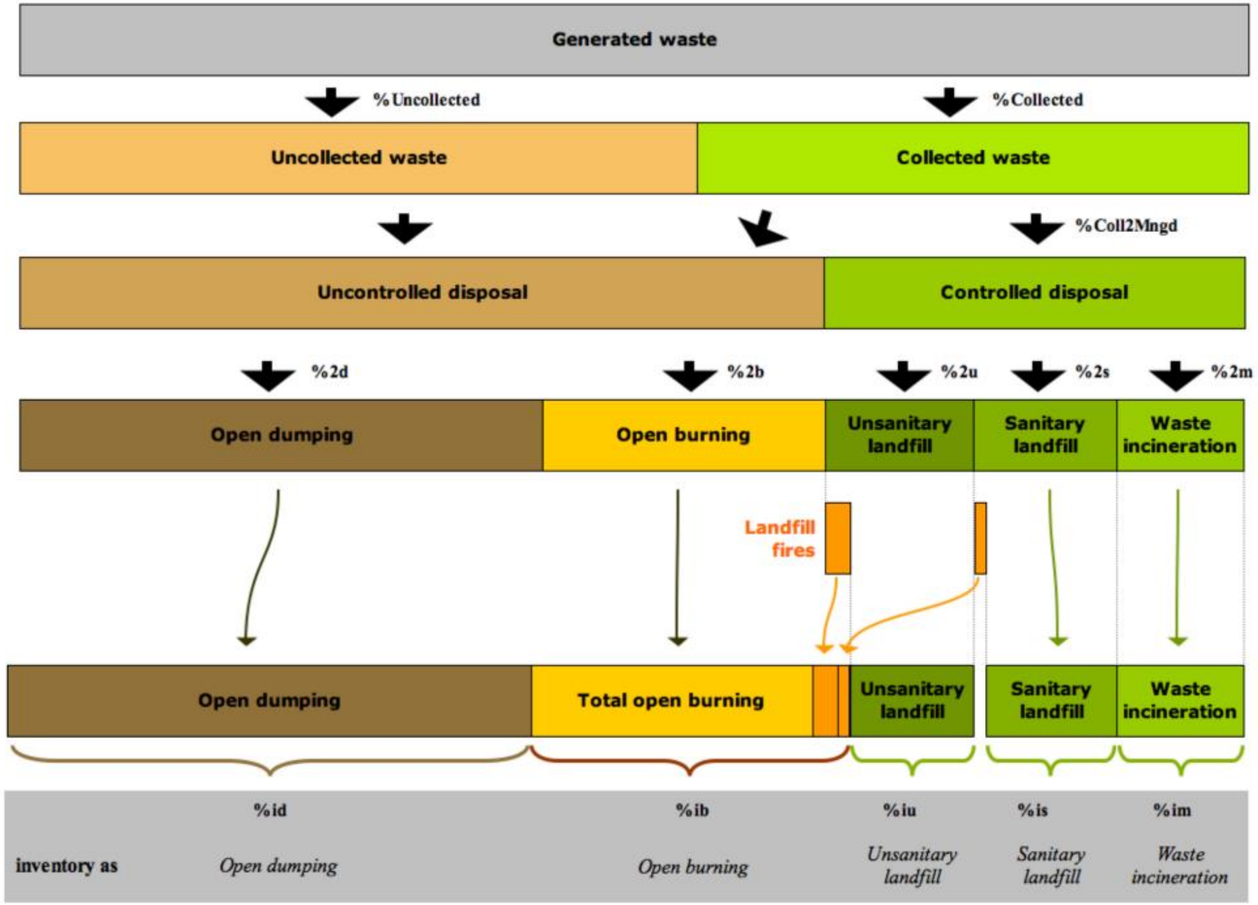
End-of-life waste management

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.