Life Cycle Assessment of Plastic Mattresses

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

Objectives:

- To establish GHG Emission Factors for **polyurethane foam mattresses** 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.)

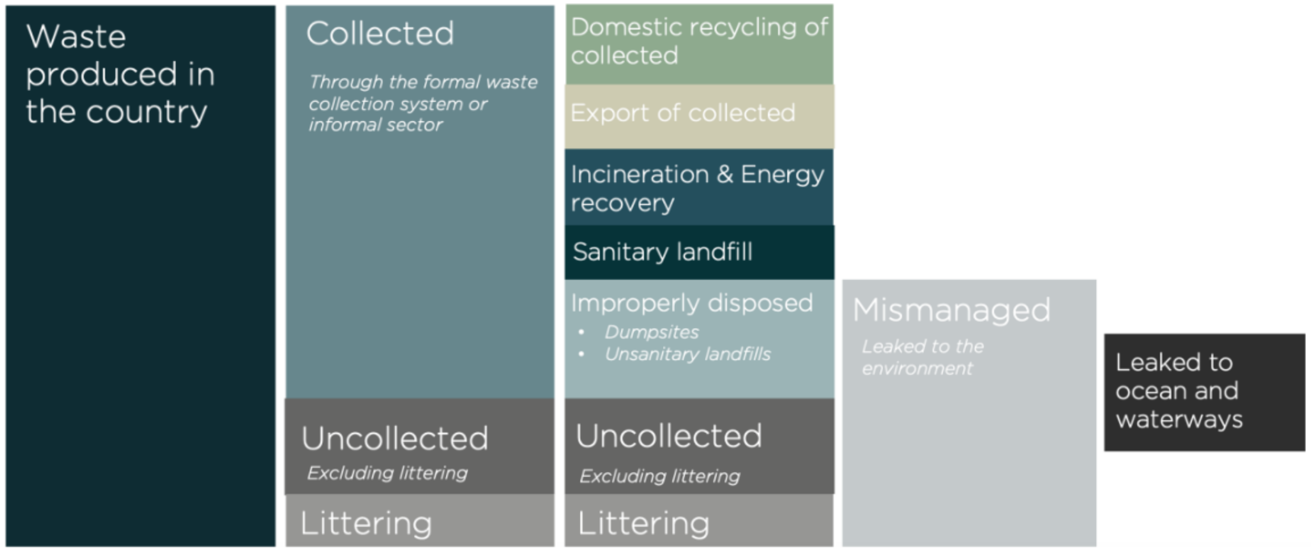
According to the LCA methodology, the analysis of greenhouse gas (GHG) emissions (Global Warming Potential)—is limited to a 100-year timeframe. As a result, any additional impact from plastic degradation in landfills occurring beyond this period is neither measured nor compared to other waste disposal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

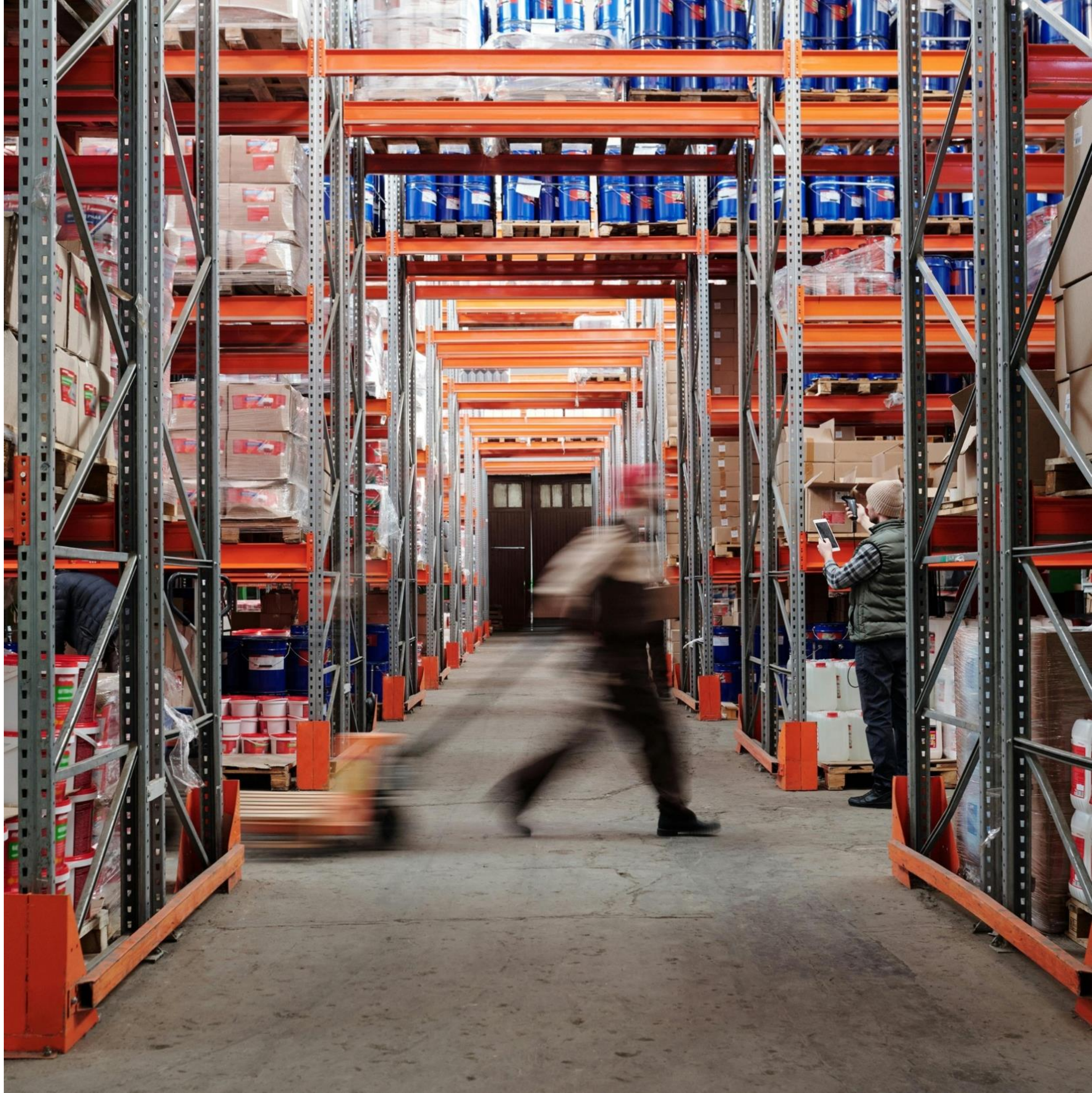
The modelled scenarios are analysed for plastic leakage by selecting the waste management method that is modelled and calculating the projected leakage (or lack thereof) due to the same.

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



Source: EA – Earth Action

LCA Results



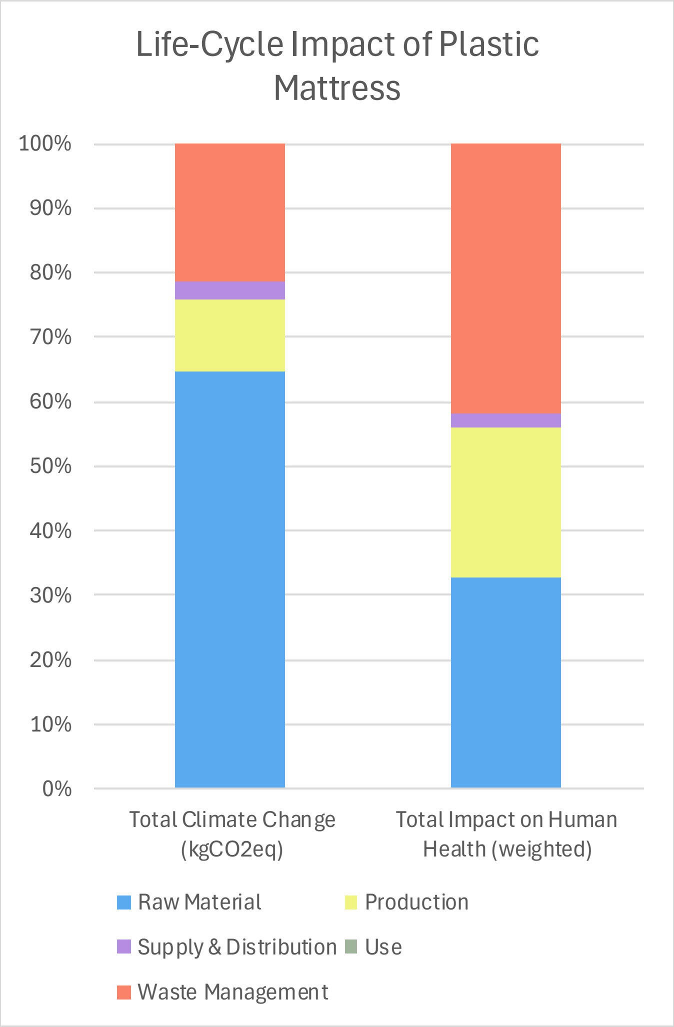
Key Product Parameters & Assumptions

LIFE-CYCLE STAGE	PARAMETER	DESCRIPTION OF MODEL
GENERAL	Field Context	The mattress studied is lighter than the mattresses known in Western contexts (~3 kg instead of the otherwise ~30kg, hence less than 10% of Western data models)
Raw Material	Bill of Materials	High density virgin polyurethane foam (2.80kg net weight)
	Packaging	Plastic, wood, steel and cardboard (total 400g net weight)
Production	Manufacturing Location	Local to warehouse & distribution location (i.e. within 500 km)
	Manufacturing Processes	Standard production
Supply & Distribution	Transport Chain	TRUCK local material procurement (500 km) TRUCK from warehousing to distribution (500 km) TRUCK disposal transport for mattress (100 km)
Use	Lifespan	10 years
	Usage Processes	Assumed to not be washed (field context of resource scarcity)
Waste Management	Product Disposal Method	Open burning
	Packaging Disposal Method	Open dumping

Baseline Results

- Considering a lifetime of 10 years, the raw material of the mattress accounts for **65%** of the total GHG Emissions and **33%** of the total impact on human health
- Waste management has a considerable impact on human health, accounting for **42%** of the total impact, which it is the second largest share of GHG emissions at **21%**
- Plastic leakage
    - It is assumed that the product is incinerated, thereby avoiding leakage.
    - The packaging is dumped/littered causing leakage for all scenarios

Emission factors		Unit
Cradle-to-grave	30.11	kgCO2eq/unit
Cradle-to-gate	22.89	kgCO2eq/unit

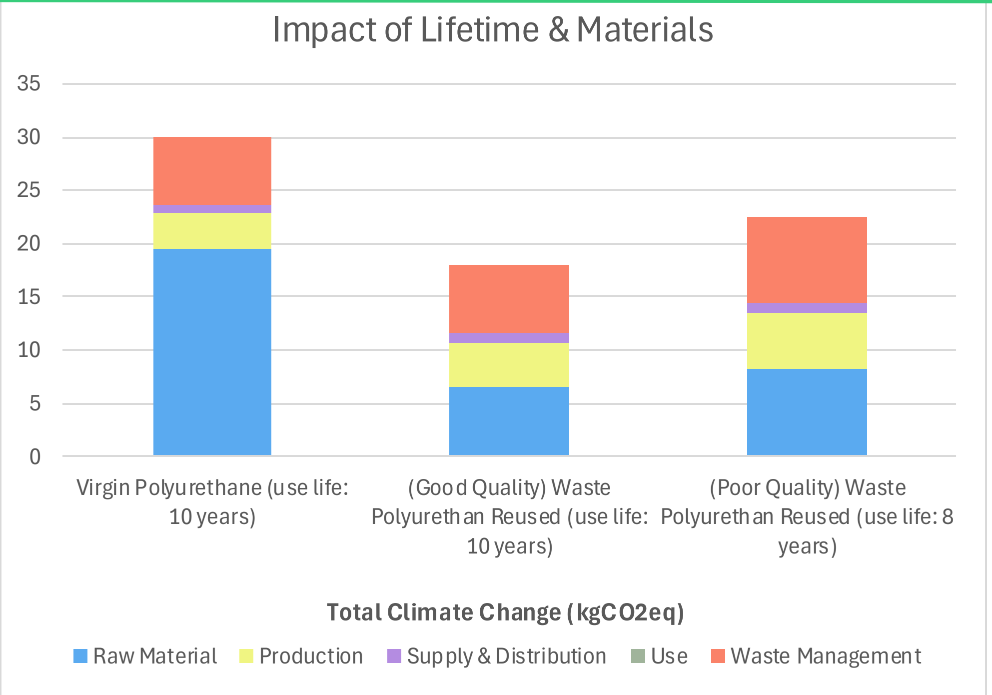


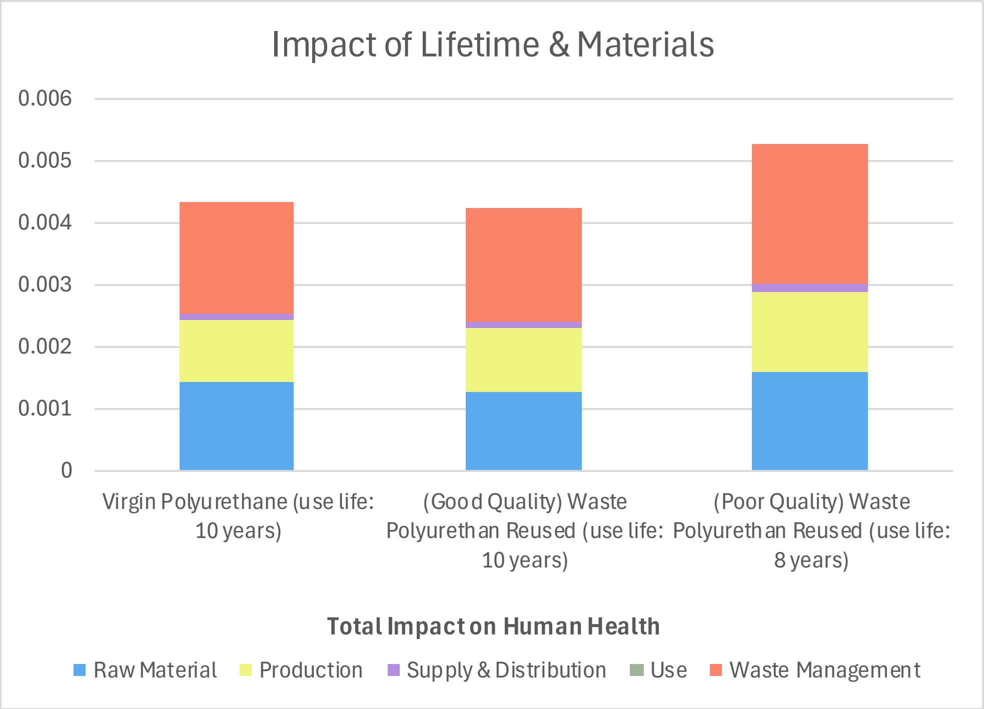
Functional Unit: 10 years of use of a mattress

Variations per lifecycle stage

	Raw Material	Production	Use Life	Supply & Distribution	Waste Management
Baseline	Virgin PU	Average energy mix	10 years (virgin PU)	Local production and supply	Open burning
	Waste PU washed and reused	Electricity derived from solar panels	8 years (waste PU)		Sanitary Landfill
					Municipal Incineration

Lifetime & Materials

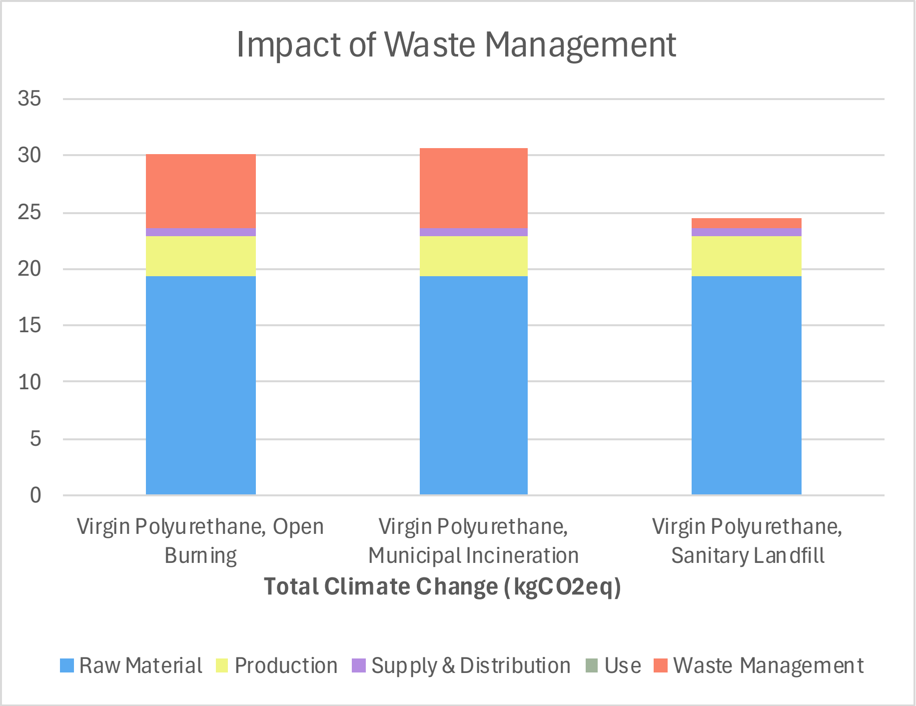


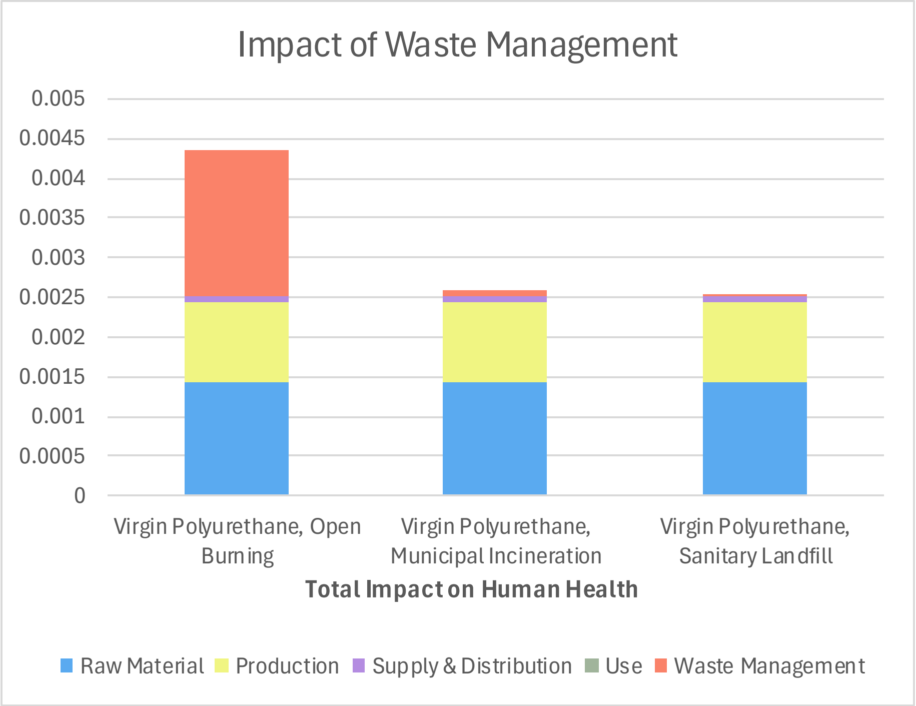


Lifetime and Materials

- This study models scenarios where waste polyurethane foam is used to replace virgin polyurethane foam for the manufacturing of the mattress. Changing this material reduces the GHG emissions at raw material stage by around 65%, but only reduces the impact of human health by around 11%
- The waste foam first needs to be washed/sanitised before it can be used, the modelling of which increases the impact at production, and therefore results in an overall impact reduction of **40%** in GHG emissions and **3%** in impact on human health – if the quality of the mattress is maintained.
- If the mattress has a reduced lifespan due to the use of waste foam – here assumed as a lifespan of 8 years instead of 10 – the overall impact is **25%** lower in GHG emissions, however the impact on human health in this case increases by **21%**

Waste Management

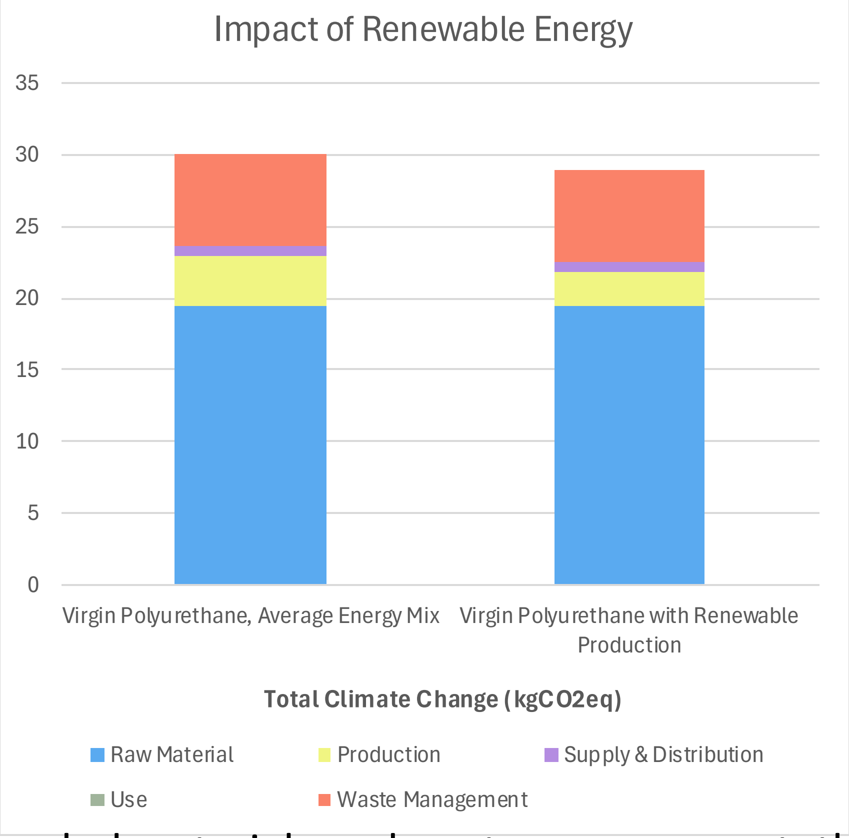


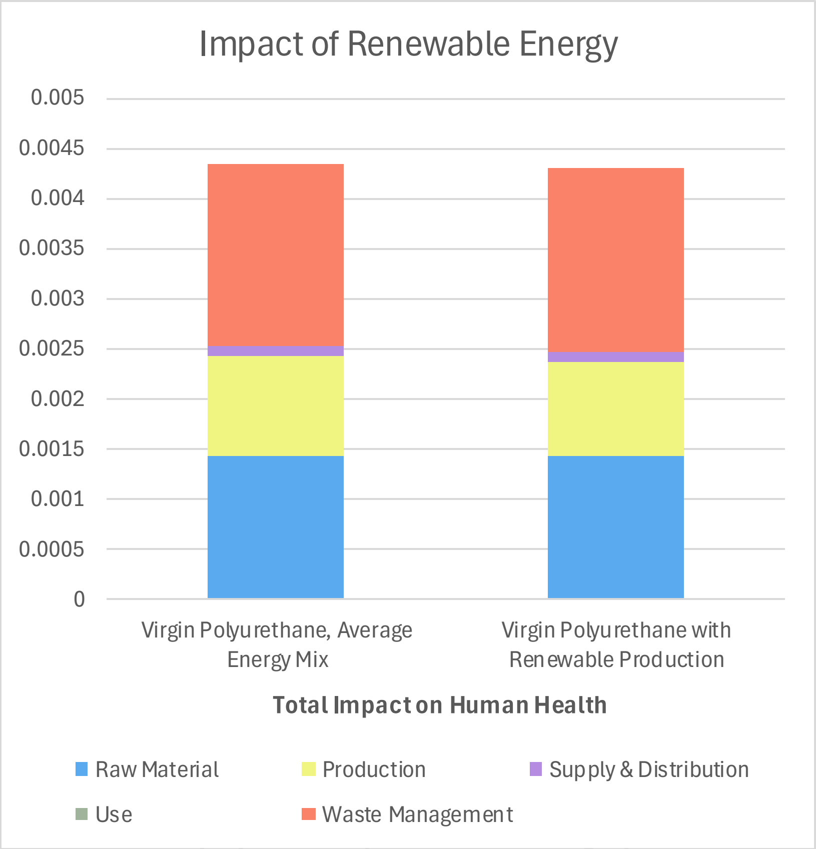


Waste Management

- Burning plastic waste in a municipal incineration plant rather than openly will not reduce GHG emissions but will reduce impacts on human health if the plant has the adequate filters. In this case, GHG emissions actually increase by **2%** when switching to municipal incineration, but the impact on human health reduces by **40%** overall.
- There is a significant reduction in GHG emissions when moving from municipal incineration to sanitary landfill, however the impact on human health is similar. An overall reduction of **18%/41%** in GHG emissions/impact on human health can be seen when comparing open burning to sanitary landfill, making sanitary landfills the preferred waste management method within the scope of the LCA (see slide 6 for more information)

Energy for Production

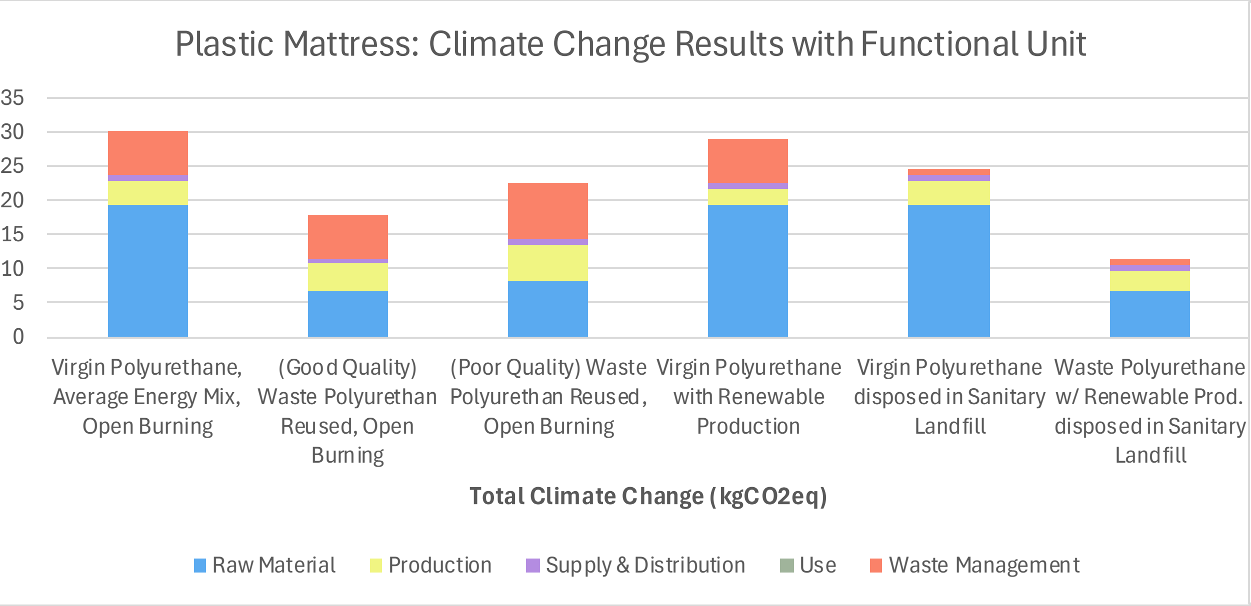


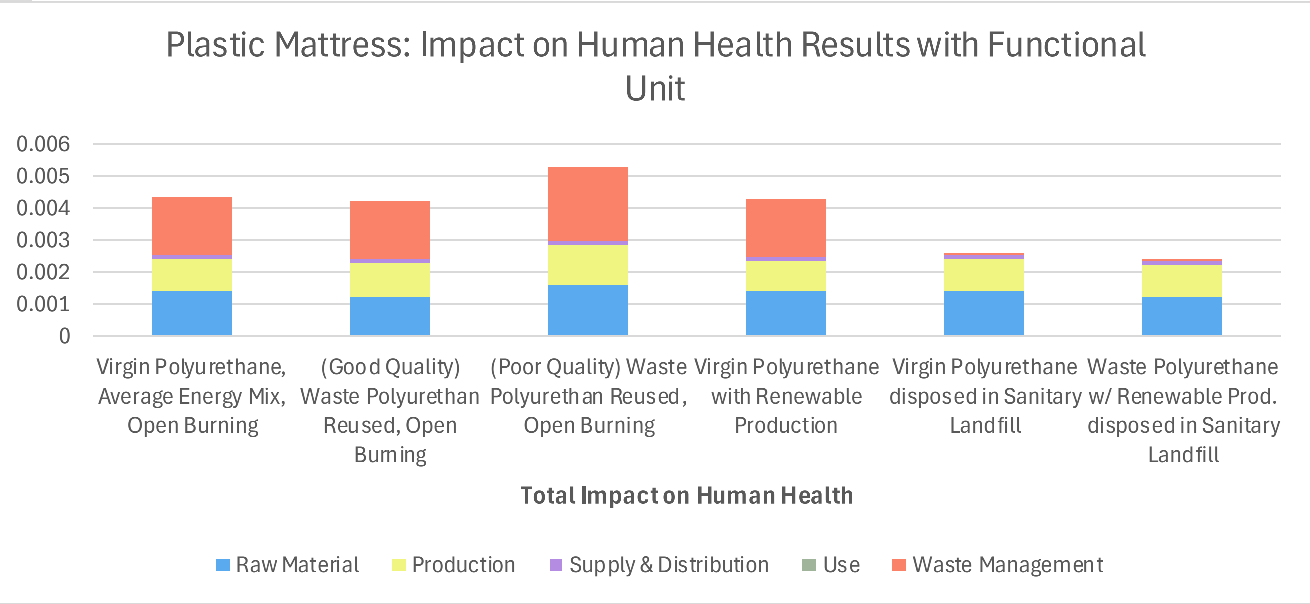


Energy

- Apart from recycled materials and waste management, this study also assessed the replacement of the average electricity mix during production with solar panels. The resulting change in emissions is very small, a **4%/1%** reduction in GHG emissions/impact on human health respectively.
- This is mainly due to the fact that other stages like raw material, are responsible for a very large portion of the overall environmental impact, especially GHG emissions

Impact Assessment: All Results





Key conclusions of comparative analysis

- Recycled materials and better waste management contribute the most to the impact reduction of the plastic mattress, with a strong dependence on quality and durability of the mattress
- For GHG emissions it is more pertinent to focus on reducing the impact on the primary raw material: virgin polyurethane foam
- For impact on human health, the waste management methods make a more significant impact on the overall impact of the mattress
- Combining recycled materials, renewable energy, and better waste management account presents the below impact reduction:
  - ▼ 62% climate change
  - ▼ 46% impact on human health

Email address contact@climateactionaccelerator.org

LinkedIn linkedin.com/company/theclimateactionaccelerator

Website climateactionaccelerator.org

Thank you!

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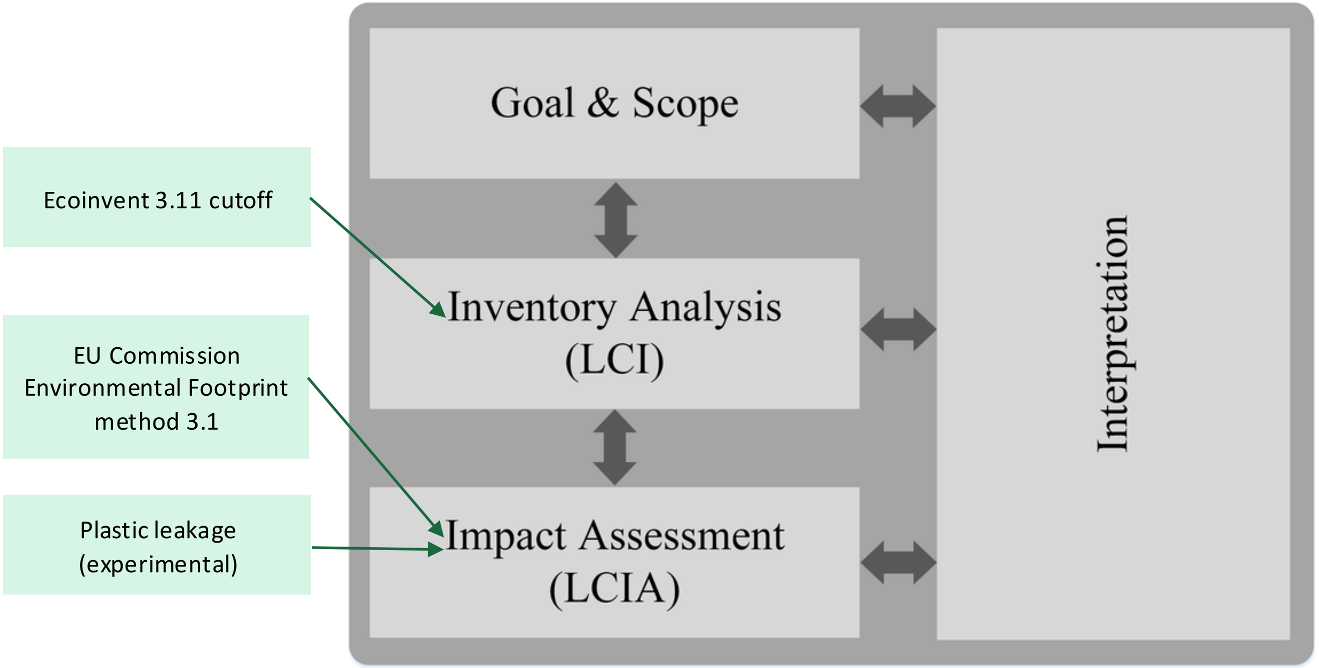
Methodology

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/

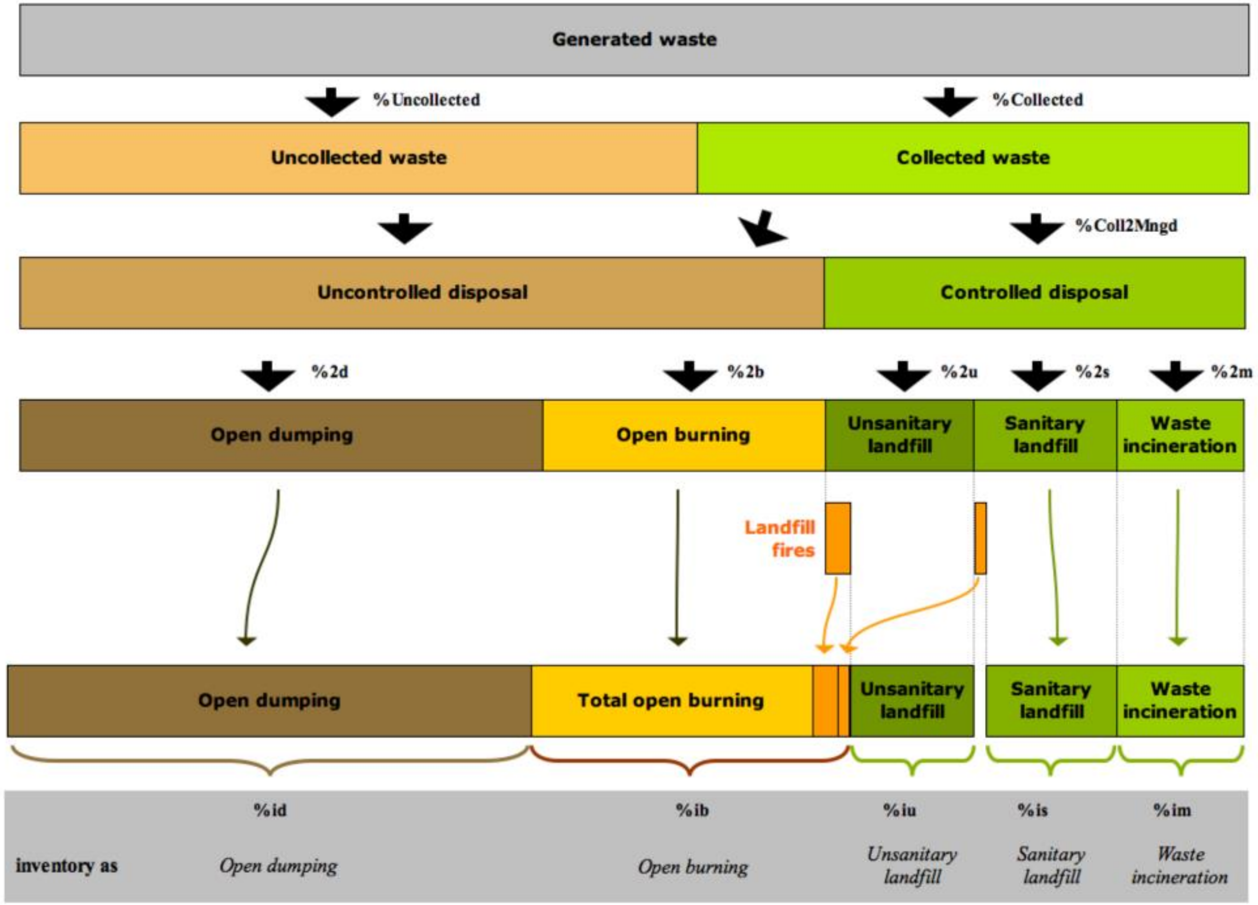
End-of-life waste management

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.