Comparative Life Cycle Assessment of Single-use and Reusable Face Masks Type I | Review

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

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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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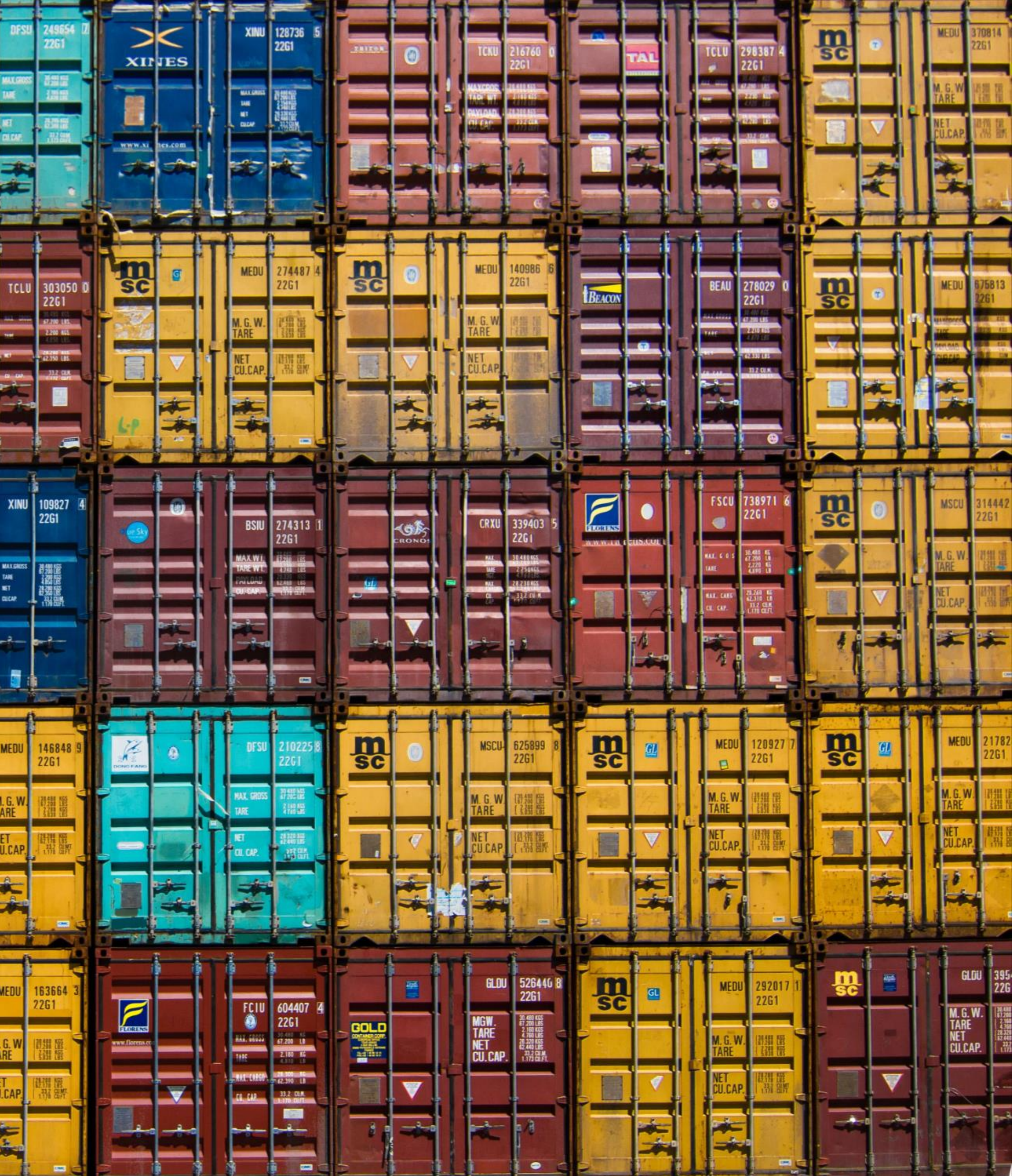


Acknowledgement

The findings from this analysis are based on two existing LCA on face masks, performed by *Tabatabaei, M. et al* and the other by *Cornelio, A et al*. The LCA 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.

Contents

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 **single-use face masks** adapted to the humanitarian context.
- To analyse the environmental impact of the product's life cycle and identify key levers for impact reduction through a comparison with **reusable face masks.**

Scope & System Boundary:

- **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.

*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.

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

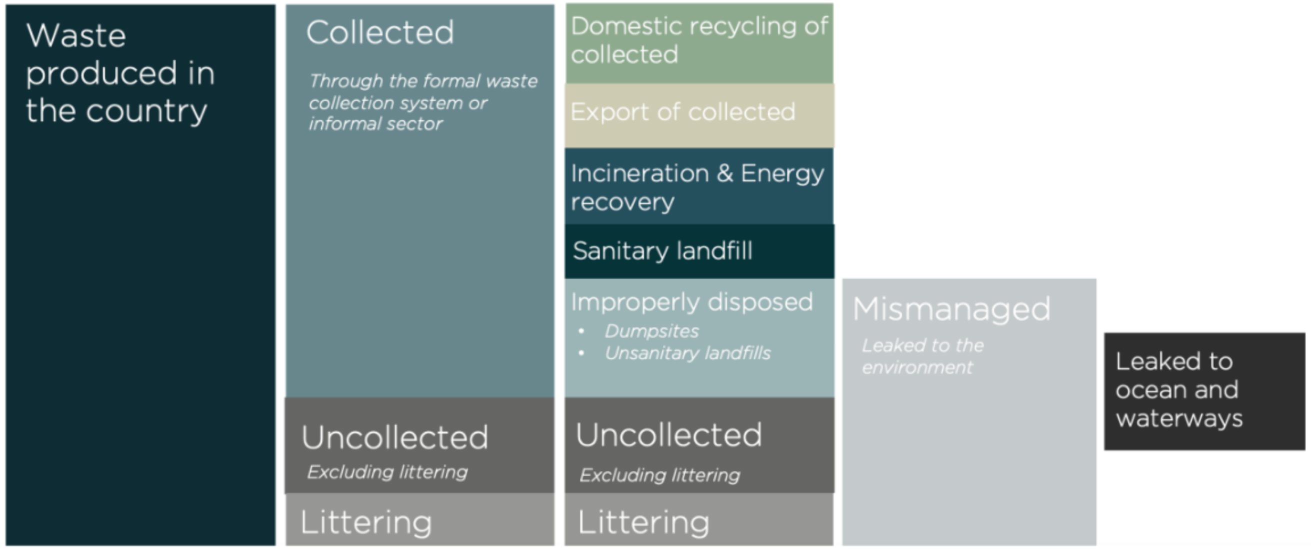
Since the face mask is classified as infectious waste at its end-of-life, only open burning is modelled, reflecting the disposal practices observed in the areas of intervention.

Plastic leakage

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

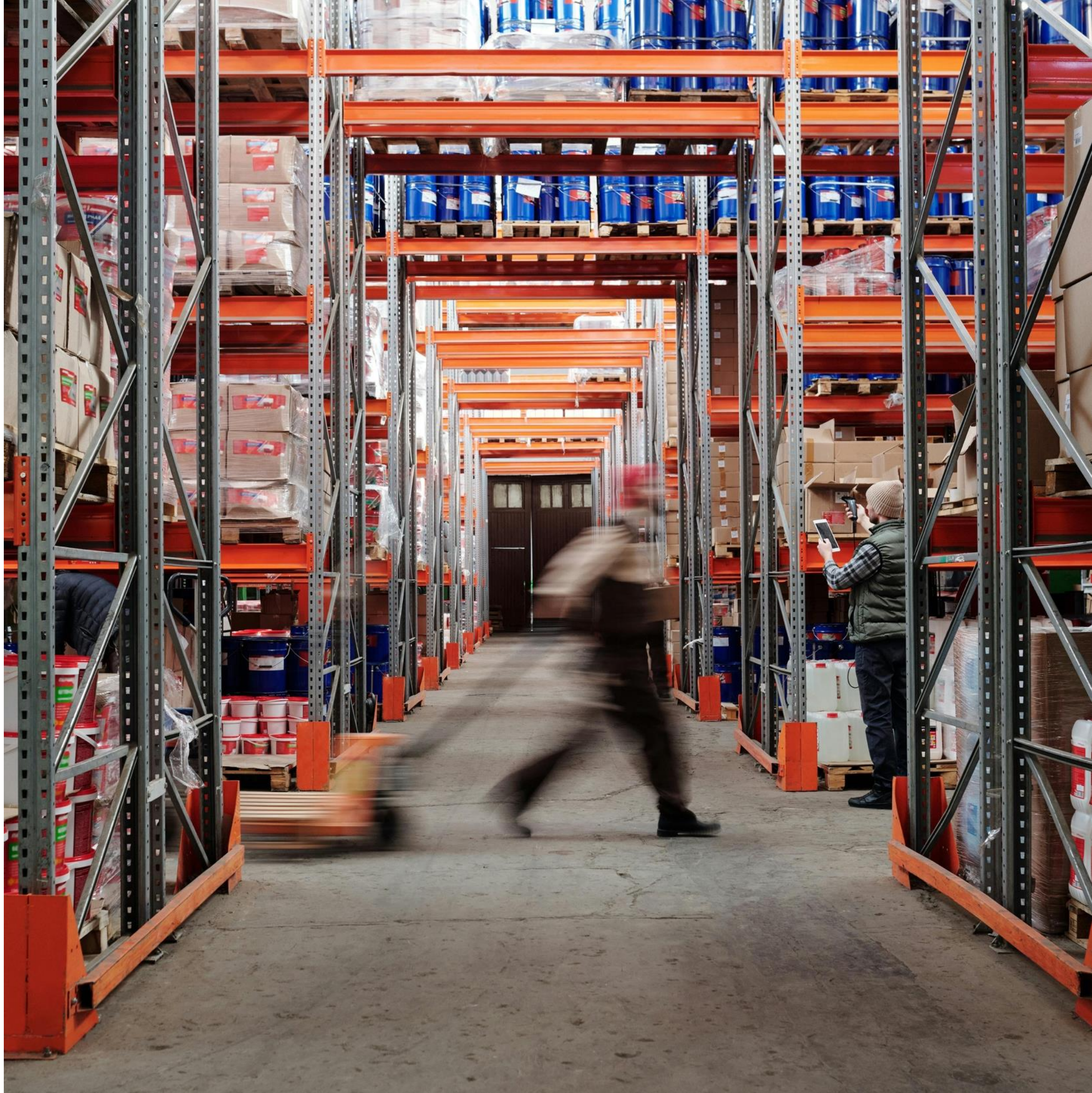
The modelled scenarios are analysed for plastic leakage by selecting the waste management method that is modelled and calculating the projected leakage (or lack thereof) due to the same.

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



Source: EA – Earth Action

LCA Results



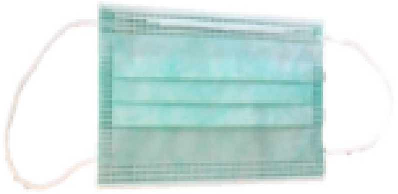
Key Product Parameters & Assumptions

LIFE-CYCLE STAGE	PARAMETER	DESCRIPTION OF MODEL
GENERAL	Field Context	5g polypropylene single use face mask (Type II) compared to a 110g cotton face mask (Type I). Both masks are intended for use in a Type I-compliant context, i.e. by patients or other individuals, rather than by healthcare professionals in medical settings.
Raw Material	Bill of Materials	Polypropylene, polyester and aluminium for single use and cotton, polyurethane and polyester for reusable one.
	Packaging	Neglected
Production	Manufacturing Location	China
	Manufacturing Processes	Modelled using energy use only (Literature)
Supply & Distribution	Transport Chain	TRUCK transport of materials to factor SEA shipping of product to regional distribution centre TRUCK transport to distribution location
Use	Lifespan	1 use for single-use face mask and 20 uses for cotton face mask.
	Usage Processes	Washing machine and drying (60°C) for cotton mask.
Waste	Product Disposal Method	Open Burning

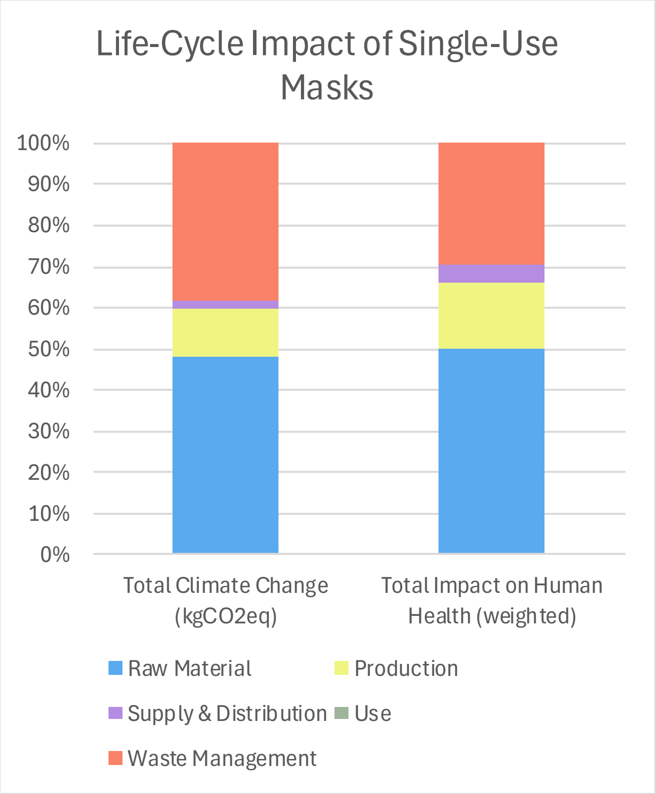
Table 1 — Performance requirements for medical face masks

Test	Type I [a]	Type II	Type IIR
Bacterial filtration efficiency (BFE), (%)	≥ 95	≥ 98	≥ 98
Differential pressure (Pa/cm^2)	< 40	< 40	< 60
Splash resistance pressure (kPa)	Not required	Not required	≥ 16,0
Microbial cleanliness (cfu/g)	≤ 30	≤ 30	≤ 30

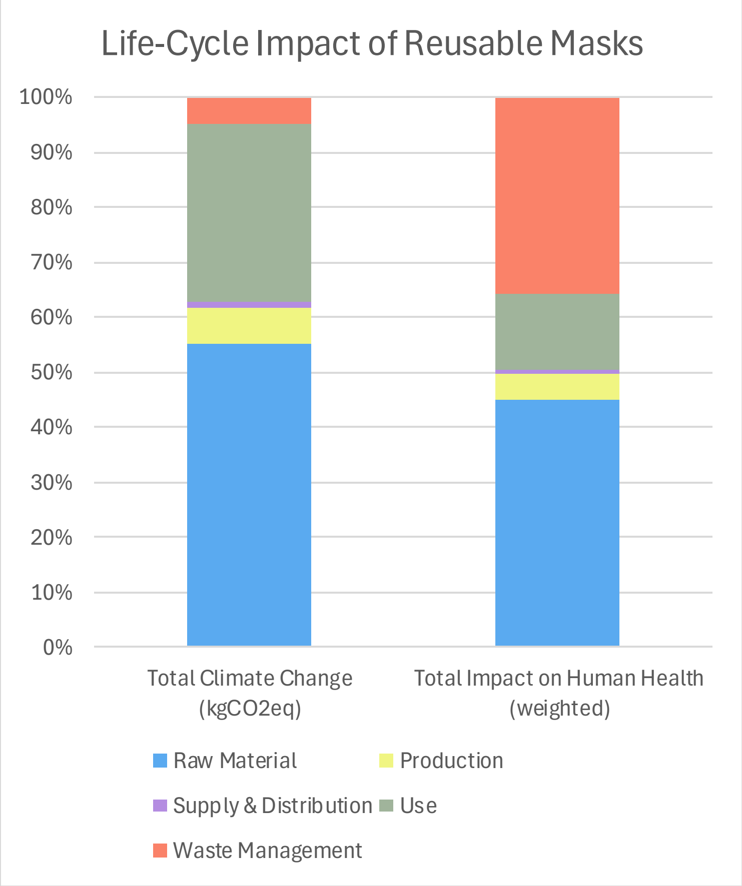
[a] Type I medical face masks should only be used for patients and other persons to reduce the risk of spread of infections particularly in epidemic or pandemic situations. Type I masks are not intended for use by healthcare professionals in an operating room or in other medical settings with similar requirements.



Baseline Results



- The impact distribution of the **single-use face mask** aligns with that of other single-use plastic products, with contributions spread across all life cycle stages.
- In contrast, the **reusable face mask** shows a more concentrated impact: for **climate change**, the main contributors are raw materials and the use phase; for **human health**, impacts are primarily driven by materials and end-of-life treatment.
- The **emission factor of the reusable mask is higher**, largely due to its **greater weight**.
- Plastic leakage: Leakage is avoided via incineration



Emission factors		Unit
Cradle-to-grave	33.2	gCO2eq/unit
Cradle-to-gate	20.0	gCO2eq/unit

Emission factors		Unit
Cradle-to-grave	196	gCO2eq/unit
Cradle-to-gate	121	gCO2eq/unit

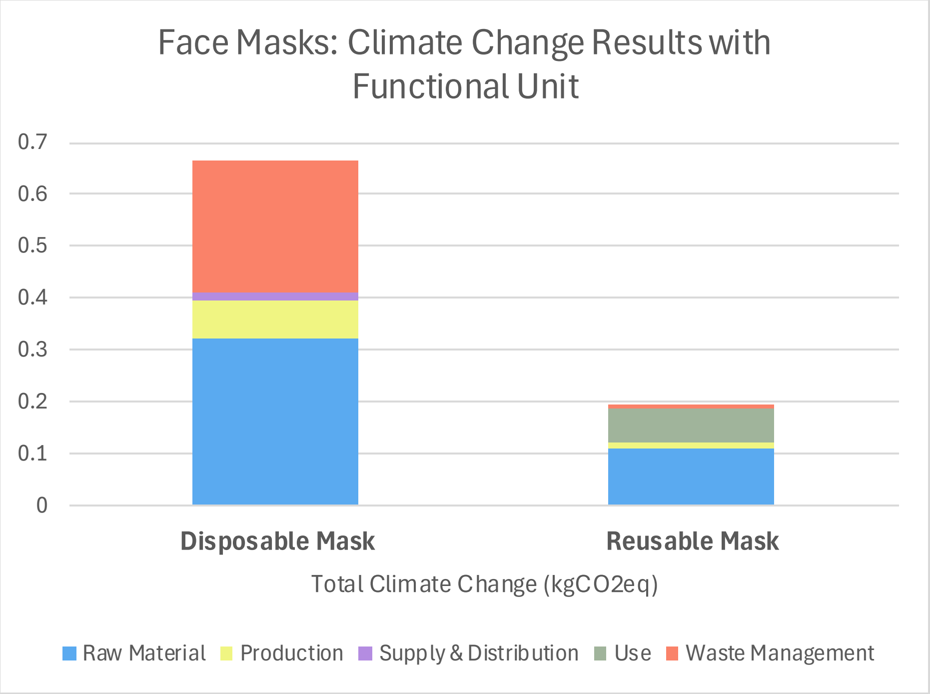
Variations per lifecycle stage

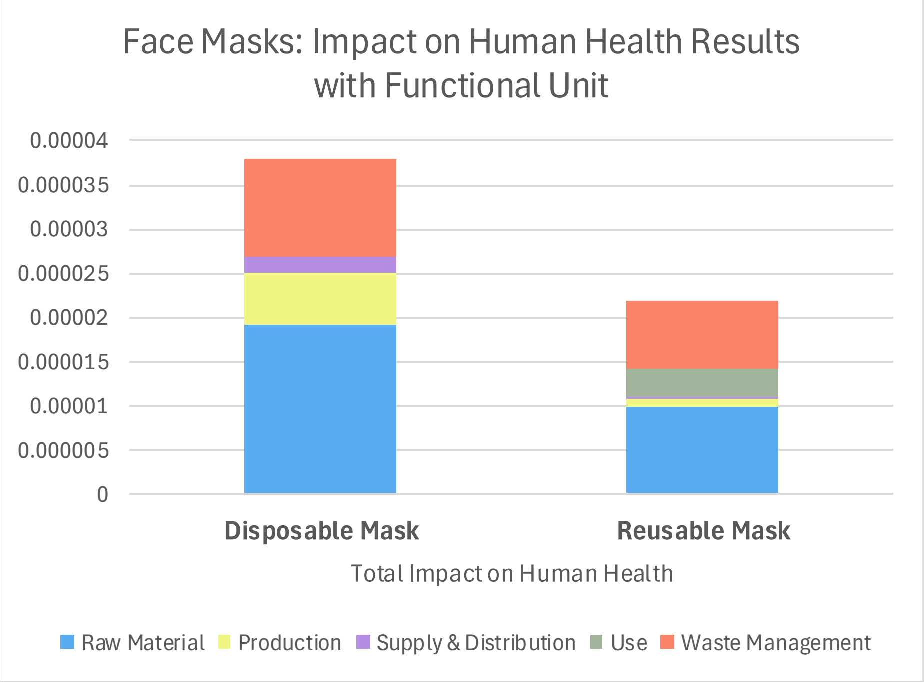
	Raw Material	Production	Use Life	Supply & Distribution	Waste Management
Baseline	Virgin PP materials	Made in China	O	Internation supply from China	Open burning
	Cotton materials		20 laundry washes		

Impact Assessment

- Switching from a disposable mask to a reusable face mask can reduce the climate change impact by **70%,** from about 670 grams of CO2e to 200 grams, to answer the functional unit of 20 uses. The impact on human health can be reduced by **42%.**

This assessment does not cover face masks used in surgical unit or medical contexts by health workers, but for the Type I face mask use case according to EN 14683:2019+AC:2019.





Key conclusions of comparative analysis

- To switch from single-use to multi-use masks can achieve significant impact reductions:
  - ▼ 70% climate change
  - ▼ 42% human health
- This solution applies **only to masks not used by healthcare workers**, where reuse is permitted.
- Deploying reusable masks at scale would require a **logistics system** to **collect, wash, and track** the number of uses for each mask throughout its lifespan.

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Thank you!

Cornelio, A., Zanoletti, A., Federici, S., Ciacci, L., Depero, L. E., & Bontempi, E. (2022). Environmental impact of surgical masks consumption in Italy due to COVID-19 pandemic. Materials, 15(6), 2046. https://doi.org/10.3390/ma15062046

Somatico. (s. d.). Masque MASKO USN1 016899. Somatico.fr. https://www.somatico.fr/pdf/016899.pdf

European Committee for Standardization (CEN). (2019). Medical face masks - Requirements and test methods (EN 14683:2019+AC)

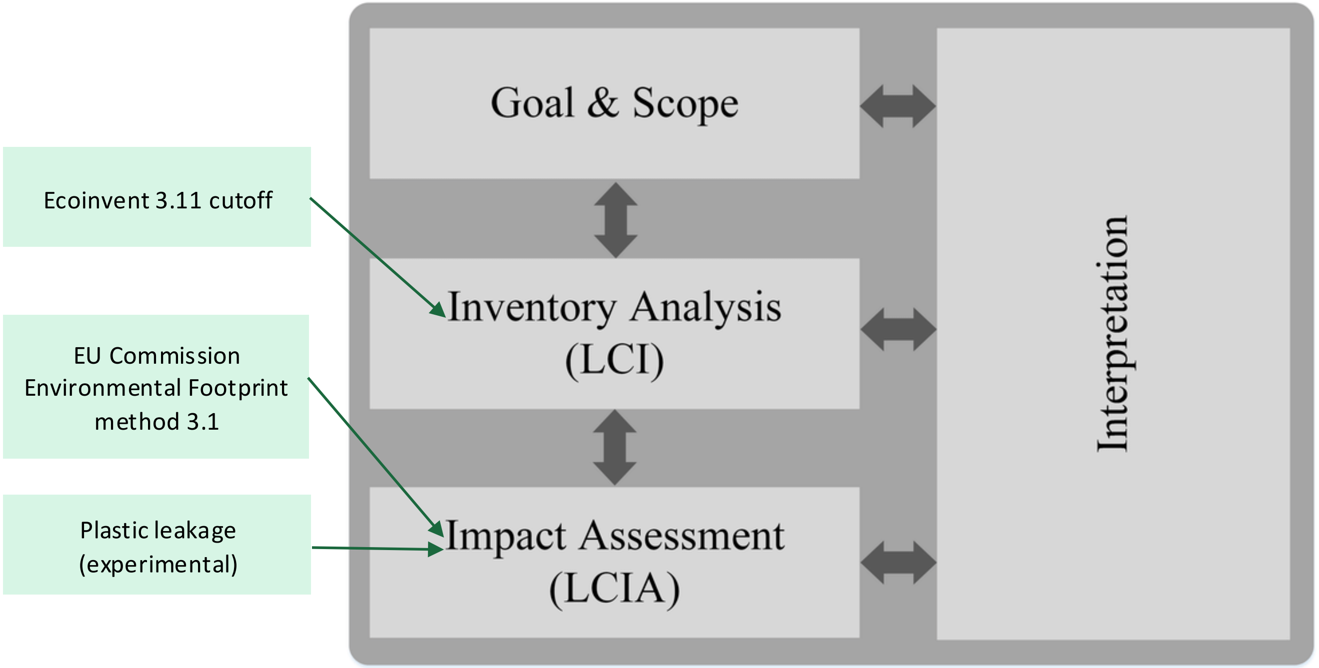
Tabatabaei, M., Hosseinzadeh-Bandbafha, H., Yang, Y., Aghbashlo, M., Lam, S. S., Montgomery, H., & Peng, W. (2021). Exergy intensity and environmental consequences of the medical face masks curtailing the COVID-19 pandemic: Malign bodyguard? Journal of Cleaner Production, 313, 127880. https://doi.org/10.1016/j.jclepro.2021.127880

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/

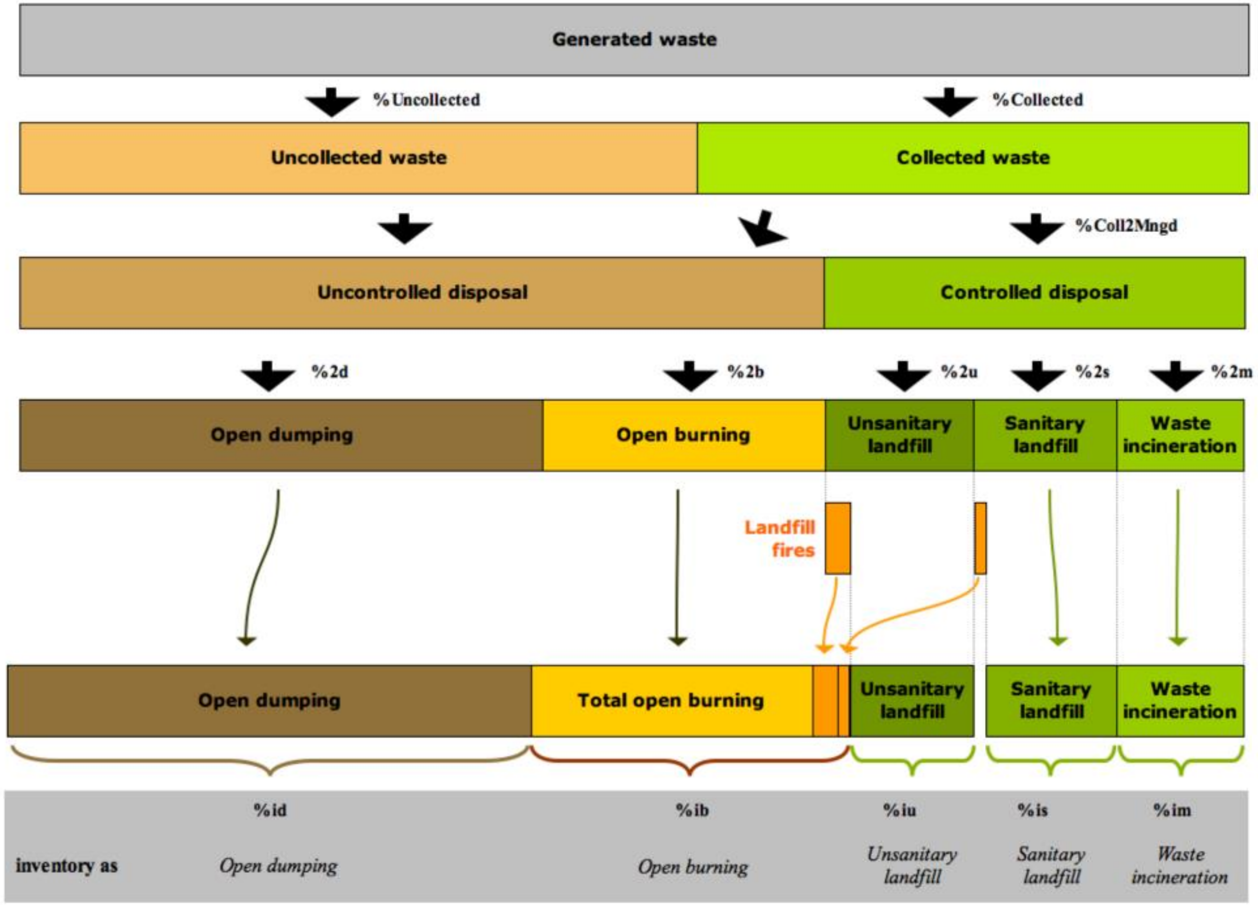
End-of-life waste management

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.