Comparative Life Cycle Assessment of Single-Use vs. Reusable Coveralls

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

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Authors: Paolo Sévègnes, Ashima Rajput, 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 **single-use coveralls** 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 coveralls.**

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

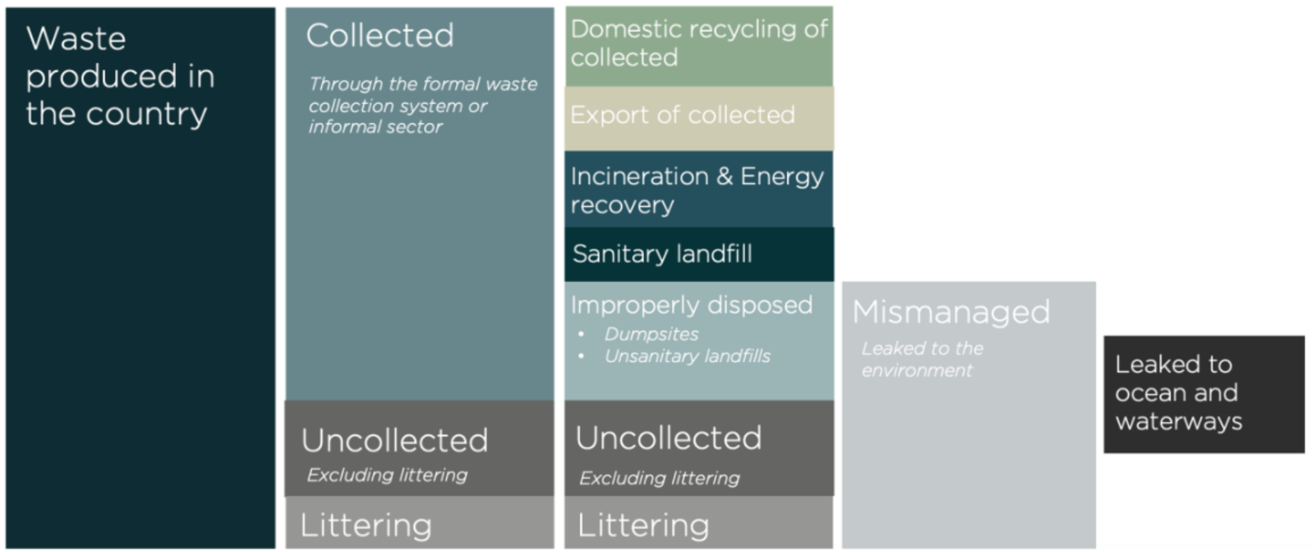
Since the coverall is classified as infectious waste at its end-of-life, only open burning is modeled, reflecting the disposal practices observed in the areas of intervention.

Plastic leakage

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

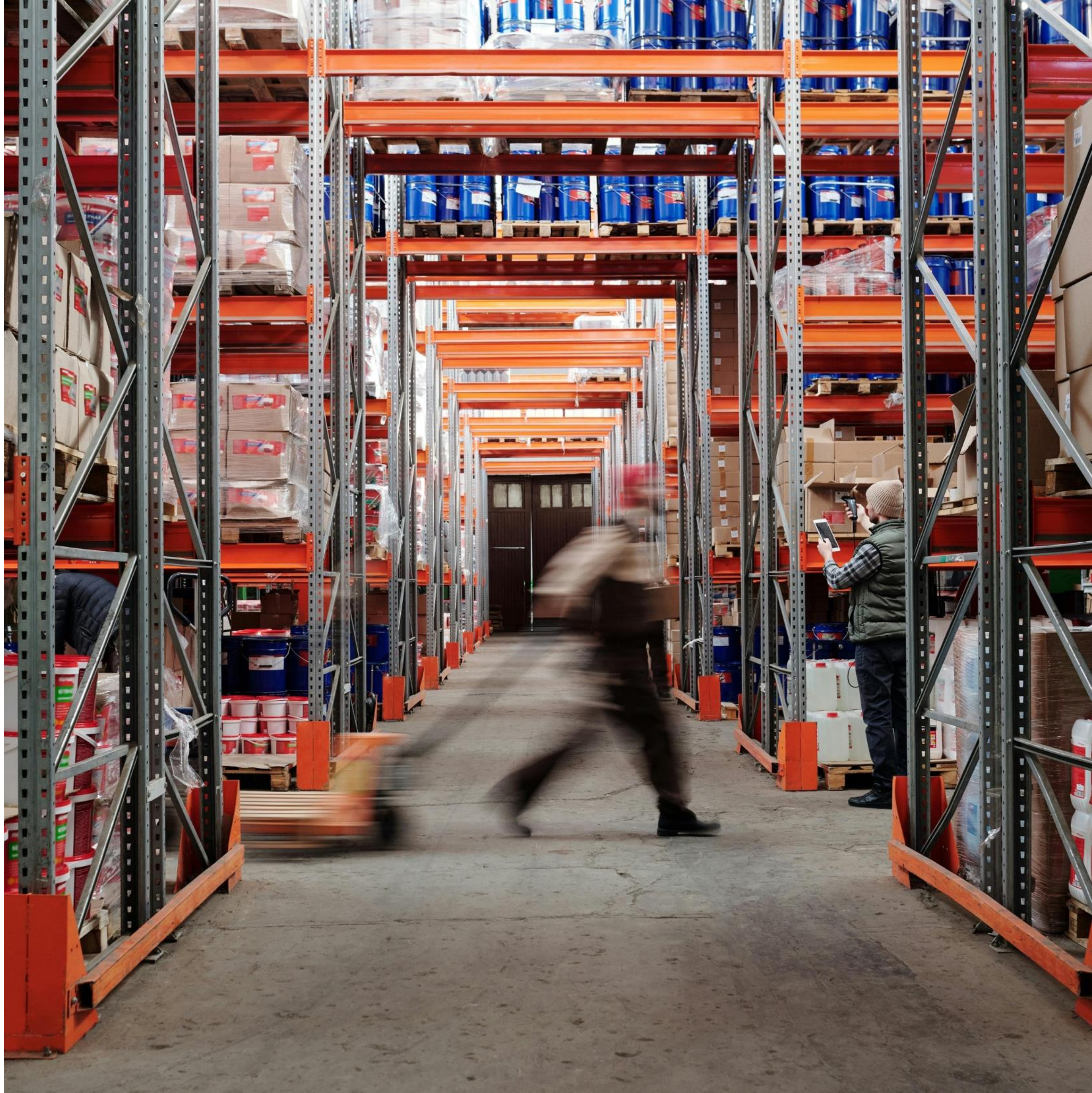
The modelled scenarios are analysed for plastic leakage by selecting the waste management method that is modelled and calculating the projected leakage (or lack thereof) due to the same.

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 Single-Use Coverall	DESCRIPTION OF MODEL Multi-Use Coverall
GENERAL	Field Context	This analysis aims to compare two options for coverall suit for medical interventions –as used in EBOLA context.	
Raw Material	Bill of Materials	Virgin Polyester, Polypropylene, Rubber, PET	Virgin Polyurethane, Polyester, Rubber, PET
Production	Manufacturing Location	Manufactured from locally sourced materials in China and transported to the field by ship.	
Supply & Distribution	Transport Chain	TRUCK SEA TRUCK	
Use	Lifespan	1 use	100 uses
	Usage Processes	None	Washing with tap water, soap and chlorine after each use.
Waste Management	Product Disposal Method	Open burning	Open burning

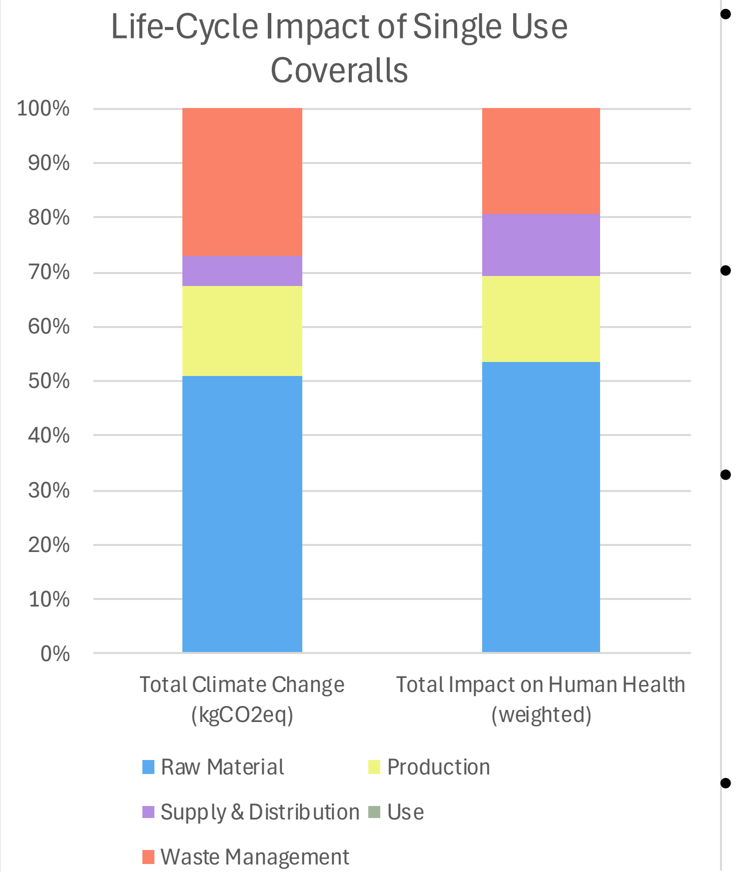
About the Smart PPE – Reusable Coverall

- The product was designed by the **EPFL EssentialTech Centre** and **Médecins Sans Frontières (MSF)** to replace single-use coveralls in the **Ebola response context**.
- This assessment focuses solely on the **suit component** of the PPE, not the full smart PPE system with the integrated air vent.
- The **filtration device** is considered equivalent across both single-use and smart PPE systems, and is therefore excluded from the comparative analysis.
- The **smart PPE** is **not yet available on the market**, but it is **ready for production**.
- Prior analysis has shown that using smart PPE instead of single-use PPE can **reduce the hourly cost of intervention by a factor of six**.
- For further information: https://www.essentialtech.ch/projects/smart-ppe

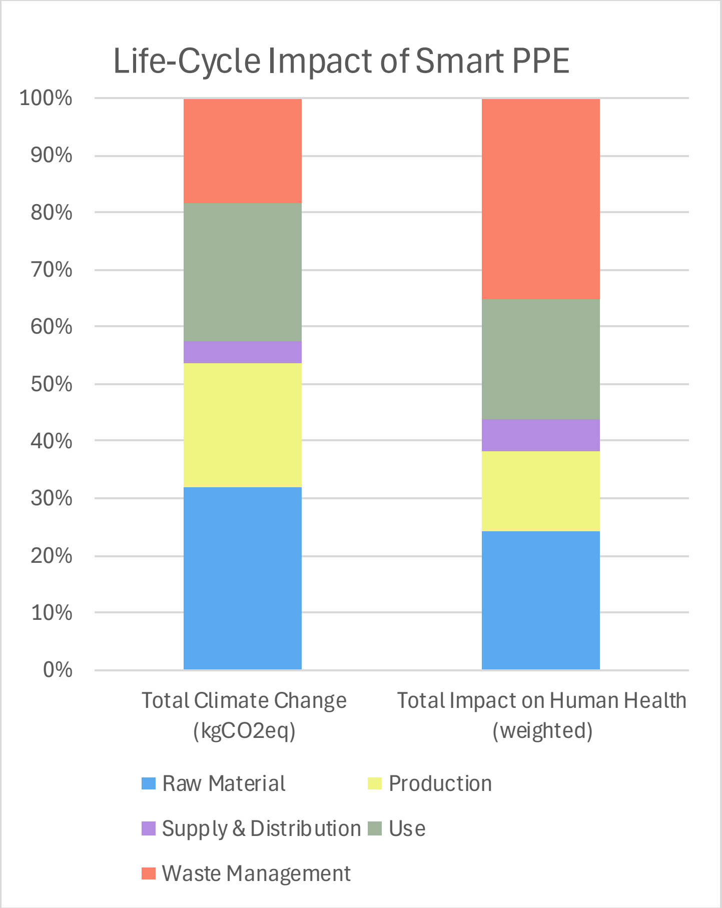
A detailed technical sheet, including a cost comparison with a single-use coverall is available upon request.

Please contact Grégoire Castella (gregoire.castella@epfl.ch) or the Climate Action Accelerator (contact@climateactionaccelerator.org)

Baseline Results



- As both are plastic-based products, raw materials contributes significantly to their impacts, accounting for **50%** of GHG emissions and **53%** of human health impacts in the single-use coverall and **32% and 24%,** respectively, in the reusable coverall.
- The reusable coverall includes a use phase, which contributes **24%** of total GHG emissions and **21%** of the impact on human health—a phase that does not exist for the single-use coverall.
- At end of life, both products are modelled to be disposed of by open-pit burning, due to their classification as medical waste. This accounts for **27%** of GHG emissions and **19% of** human health impacts for the single-use coverall, and **18% and 35%** , respectively, for the reusable coverall.
- Plastic leakage: Leakage is avoided via incineration.



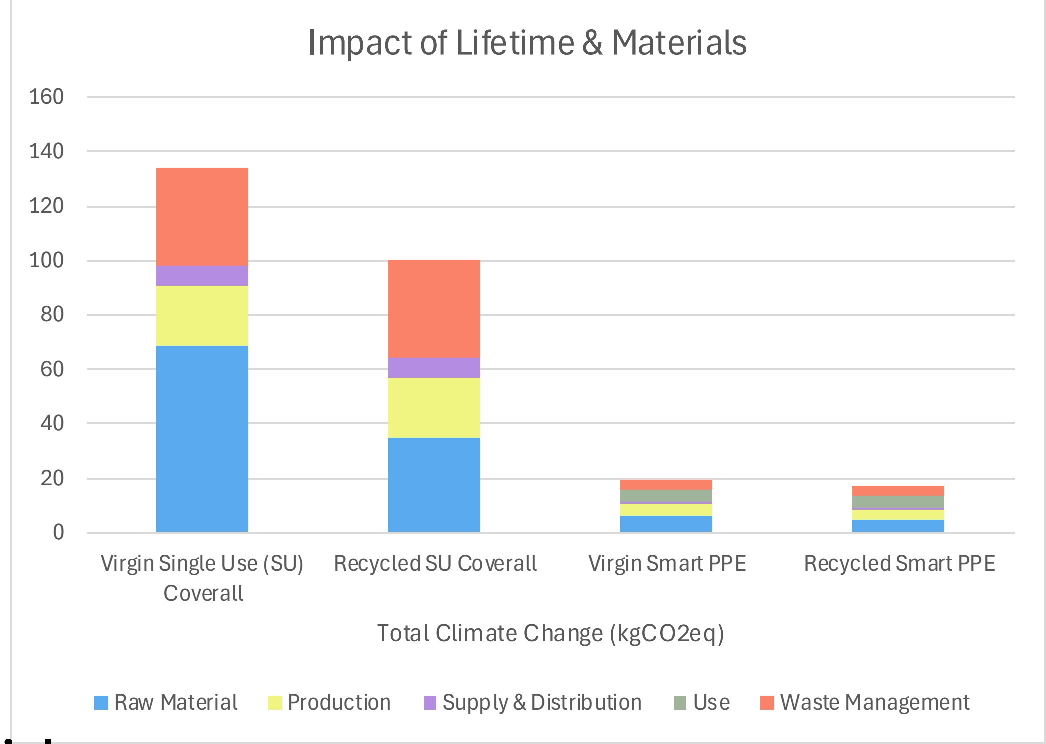
Emission factors		Unit
Cradle-to-grave	1.34	kgCO2eq/unit
Cradle-to-gate	0.918	kgCO2eq/unit

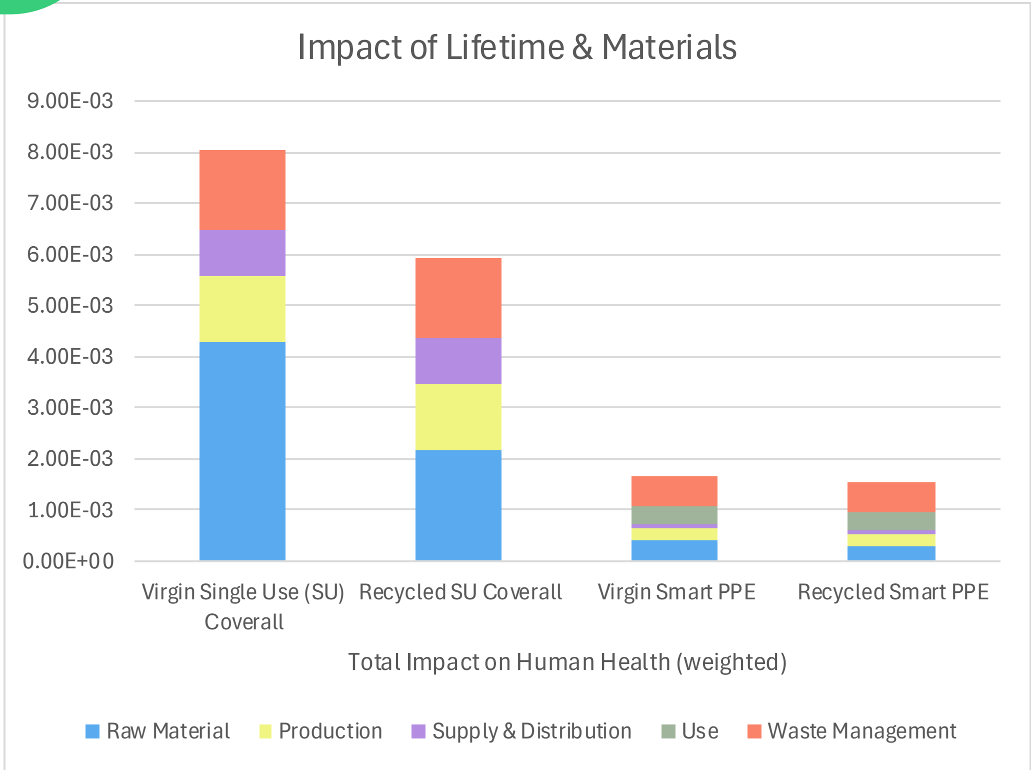
Emission factors		Unit
Cradle-to-grave	19.0	kgCO2eq/unit
Cradle-to-gate	10.3	kgCO2eq/unit

Variations per lifecycle stage

	Raw Material	Production	Use Life	Supply & Distribution	Waste Management
Baseline	Virgin PE Single Use Coverall	Average energy mix	No washing	TRUCK – SEA – TRUCK from China to sub-Saharan Africa	Open Burning
	Virgin PU & PE Reusable Coverall	Solar energy for production	Washing after each use with regular rap water		
	Recycled PE Single Use Coverall				

Lifetime & Materials

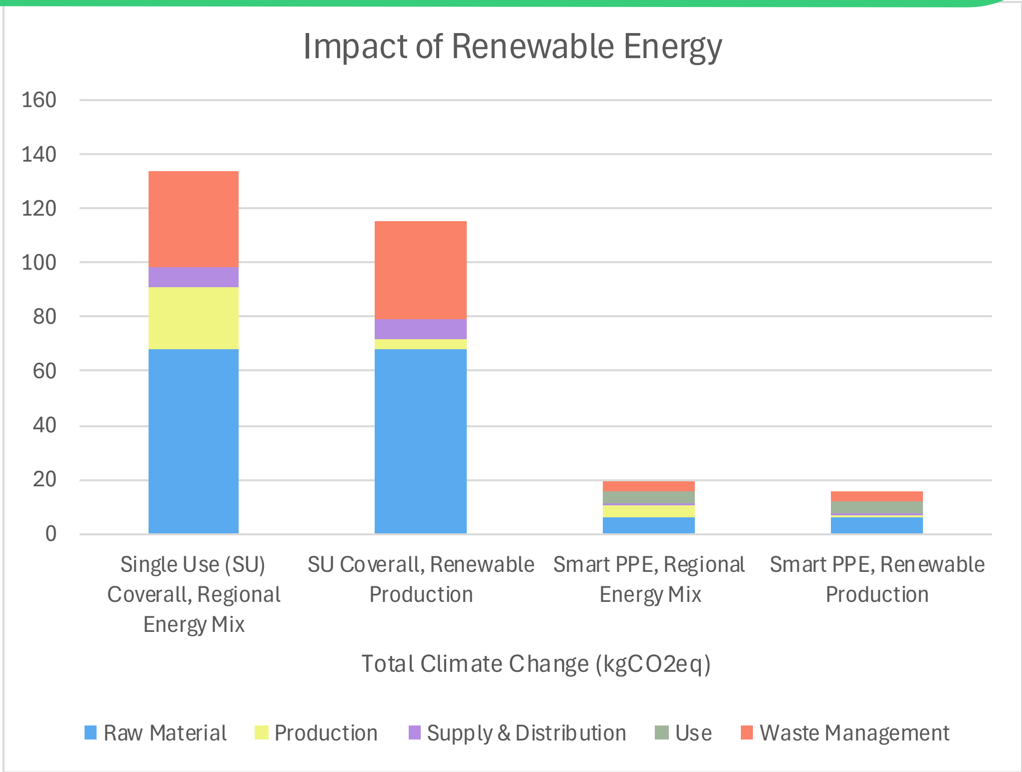


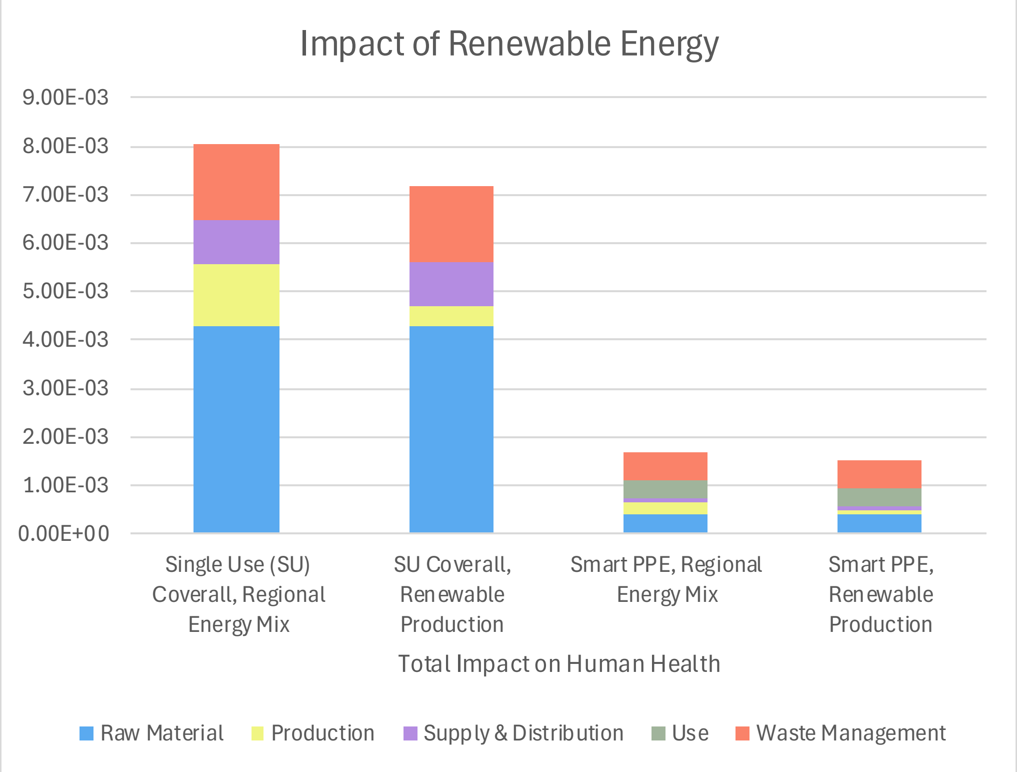


Materials

- When assuming 100 uses, **moving to reusable coverall** reduces GHG emissions by **86%** and human health impacts by **79%** compared to the single-use coverall.
- Substituting virgin material with recycled material for the single-use coverall can reduce impacts by up to **25–26%** in both GHG emissions and human health categories, assuming no loss in material quality and that the same number of coveralls is required to complete the intervention. For a reusable coverall, this would lead to a **9%** of reduction in GHG emissions and a **7%** in human health impacts, as raw materials represent a smaller share.

Energy Supply



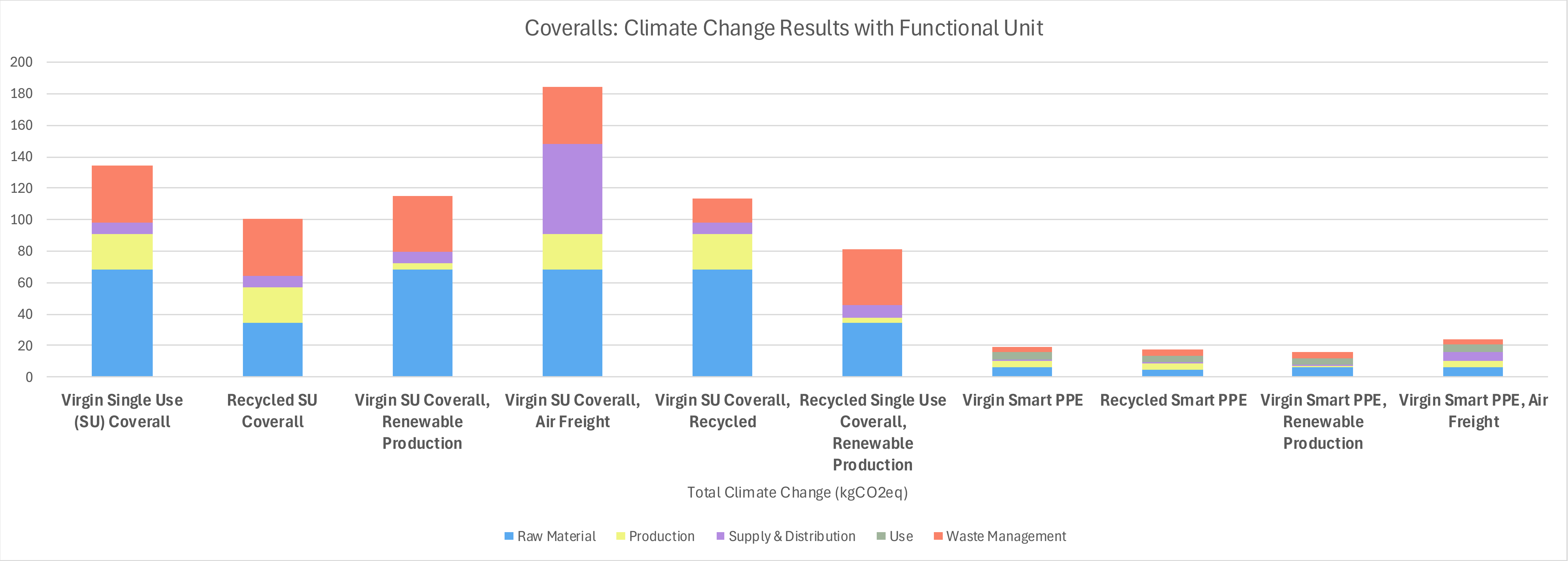


Energy Supply

- Switching the energy source for electricity or heat used during production can significantly reduce environmental impacts, especially when fossil fuel–intensive sources are replaced with renewable energy.
- For the single-use coverall, shifting from the average energy mix to solar energy reduces GHG emissions by **14%** and human health impacts by **11%**.
- When combined with other measures—such as using recycled materials—these reductions can be amplified, further lowering the overall environmental footprint.

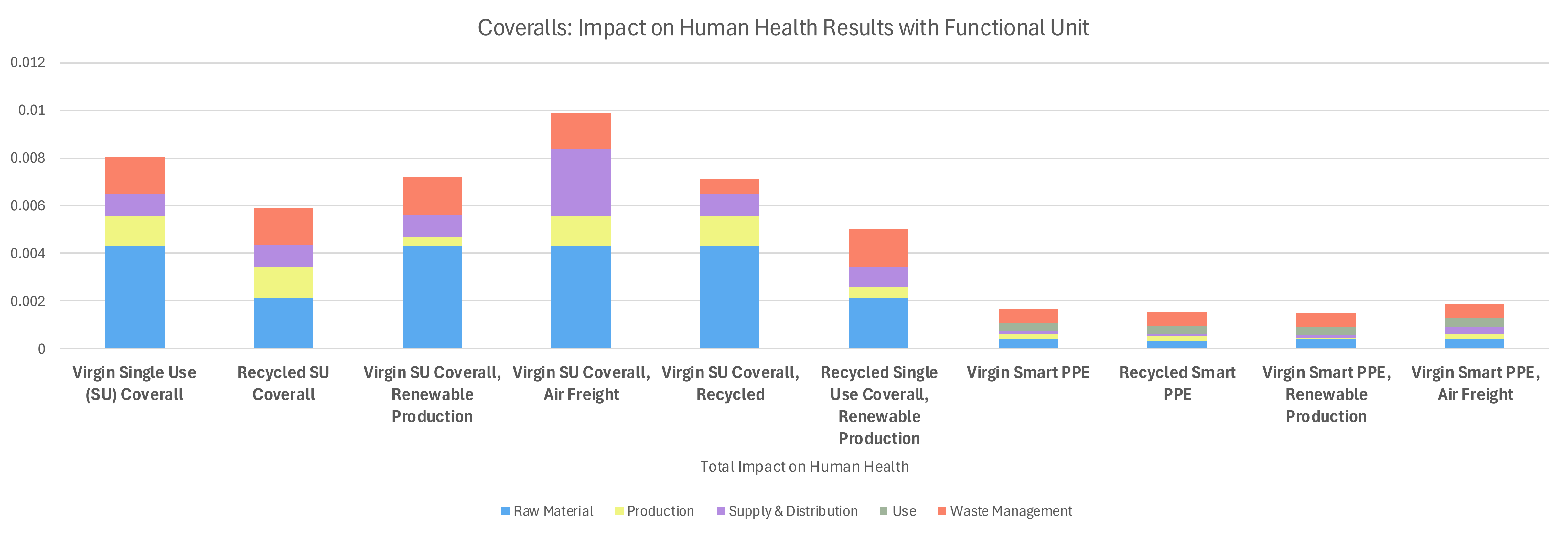
All Results: Climate Change

Functional Unit: 100 uses of coverall
Single use coverall needed: 100
Reusable PPE needed: 1



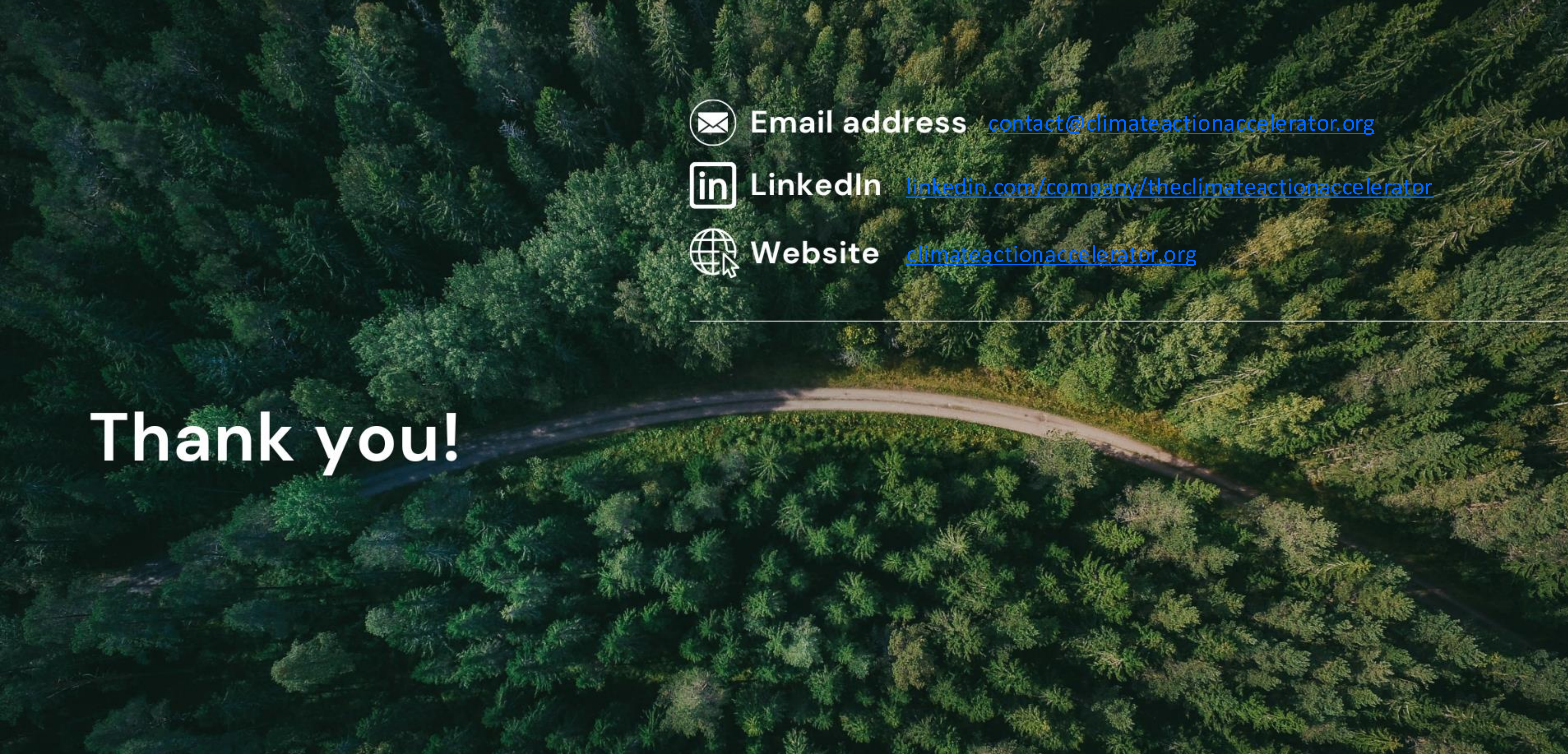
All Results: Impact on Human Health

Functional Unit: 100 uses of coverall
Single use coverall needed: 100
Reusable PPE needed: 1



Key conclusions of comparative analysis

- To reduce the environmental impact of single-use coveralls, significant improvements can be made by focusing on raw materials and the energy used during manufacturing. However, the greatest reductions are possible by switching from single-use to reusable coveralls.
    - ▼ 86% climate change
    - ▼ 79% impact on human health
- It is important to highlight that this study focuses on two main indicators: climate change and human health. Other impact categories, such as ecosystem quality and water usage, are not covered. For example, the reusable coverall requires approximately **1,000 litres of water** for cleaning over its lifespan.



Email address contact@climateactionaccelerator.org

LinkedIn linkedin.com/company/theclimateactionaccelerator

Website climateactionaccelerator.org

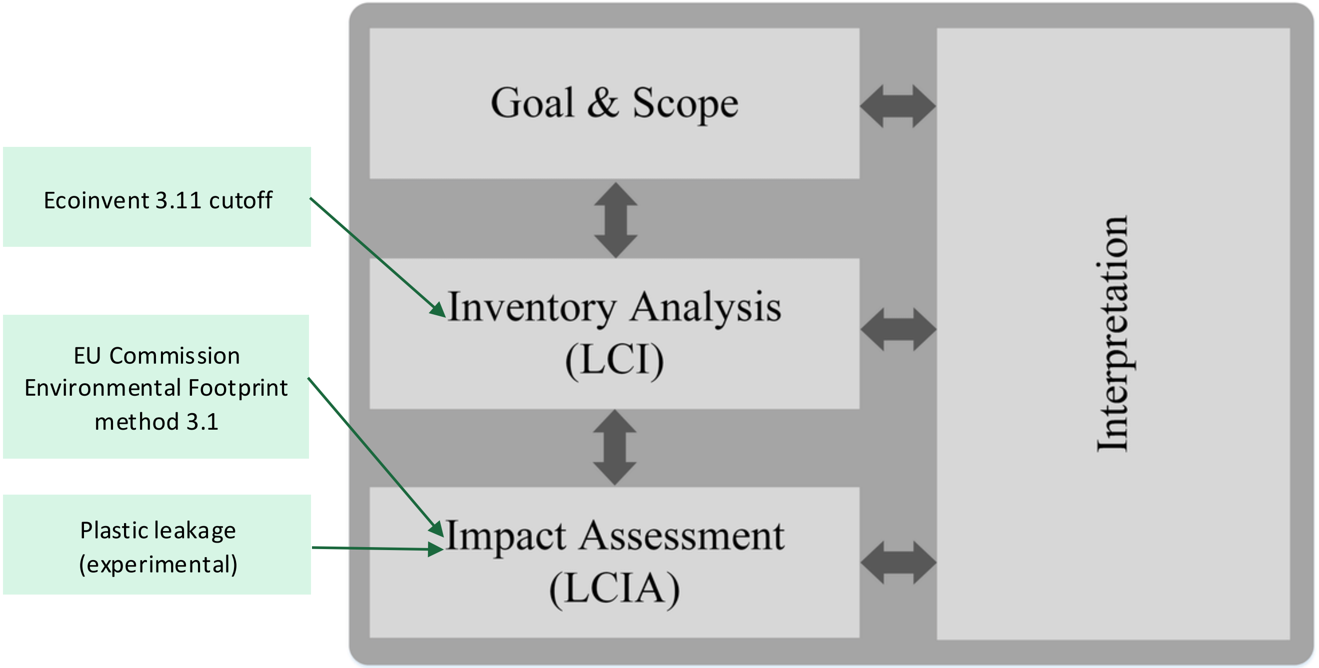
Thank you!

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/

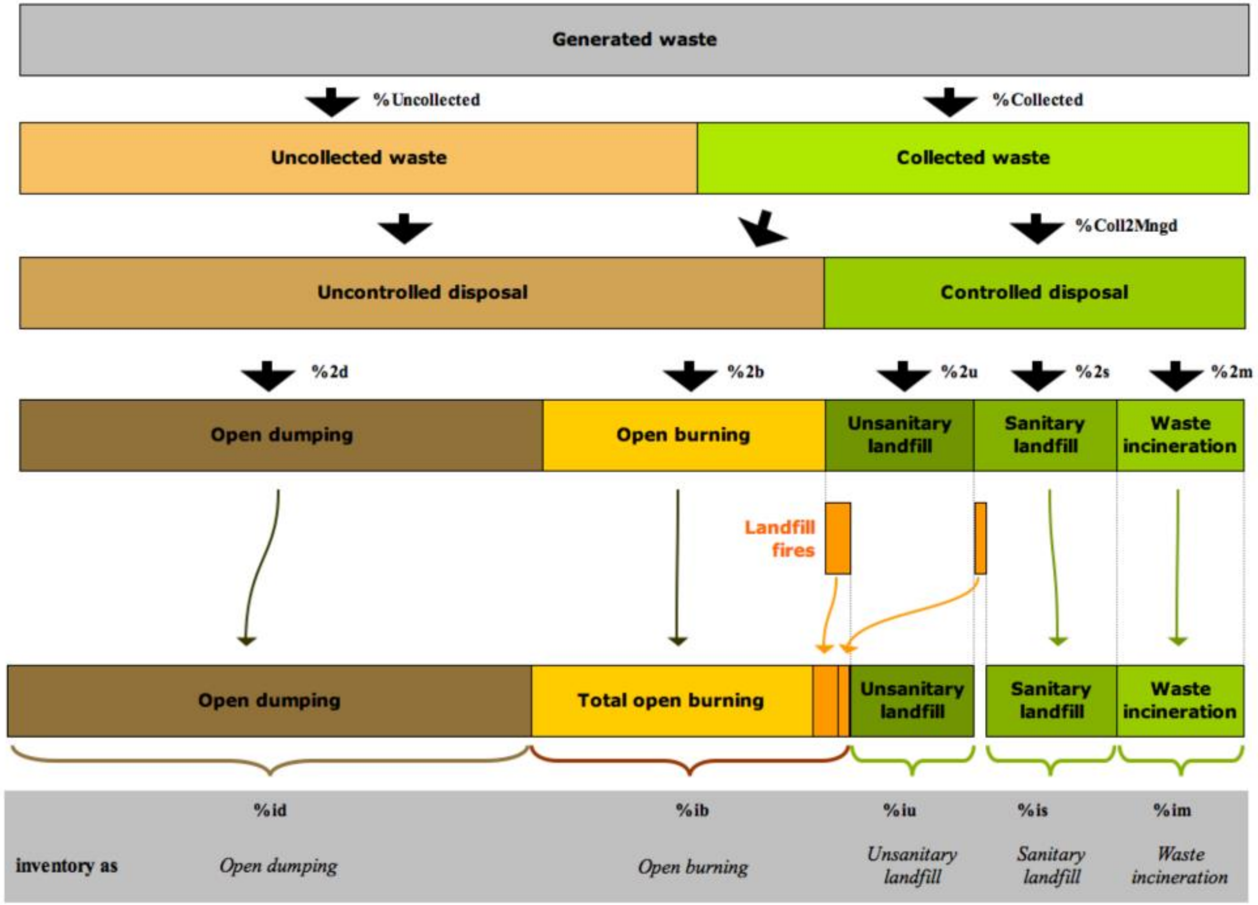
End-of-life waste management

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.