Life Cycle Assessment (LCA) Report

Marine-Protein Bio-Based Leather (MPBL-1) on Organic Cotton Substrate

1. Executive Summary

This report presents a comprehensive Life Cycle Assessment (LCA) for a novel bio-based leather alternative, MPBL-1. The material leverages marine-derived proteins (collagen/gelatin) sourced from upstream seafood processing by-products and a 100% organic cotton textile backing. A key design constraint of this project is the **total exclusion of polyester** and synthetic petrochemical fibers, favoring a fully bio-based architecture.

2. Goal and Scope

The primary goal is to evaluate the environmental profile of MPBL-1 from **cradle-to-gate**. This includes the extraction of raw materials, processing of marine waste, textile manufacturing, and the material assembly of the bio-leather.

> **Functional Unit:** 1.0 m^2 of finished marine-protein bio-leather with a standard thickness of 1.2mm.

System Boundaries

- **Upstream:** Marine protein recovery (skimming/hydrolysis), organic cotton cultivation, and ginning.
- **Core:** Bio-polymer synthesis (polyol extraction from vegetable oils), protein cross-linking, and coating.
- **Downstream:** Excluded (Use-phase and End-of-life disposal).

3. Life Cycle Inventory (LCI)

The inventory data is modeled based on pilot-scale production for marine protein isolation and industry-average data for organic cotton textiles.

Input Category	Material / Resource	Amount (per m^2)
Raw Material	Marine Protein (Collagen Powder)	0.28 kg
Substrate	Organic Cotton Canvas (300 gsm)	0.42 kg
Binder/Coating	Bio-based PU (Castor Oil Derived)	0.35 kg
Energy	Electricity (Material Assembly)	4.80 MJ
Water	Process Water (Protein Hydrolysis)	12.50 L

4. Impact Assessment & KPIs

The analysis tracks five Key Performance Indicators (KPIs) to align with global environmental standards.

4.1 Global Warming Potential (GWP)

By substituting bovine leather with marine by-products and eliminating polyester, the GWP is drastically reduced. The biogenic carbon sequestered in the cotton and protein scaffold provides a negative carbon credit during the upstream phase.

$$GWP_{total} = \Sigma (E_{fossil} + E_{biogenic} + E_{LUC})$$

4.2 Water Consumption

This remains the primary "hotspot." Organic cotton requires higher irrigation than synthetic backings. Furthermore, the extraction of protein from fish skins requires multiple washing stages to remove salts and impurities.

4.3 Eutrophication Potential

Driven primarily by the cotton cultivation phase (organic fertilizer runoff) and the organic nitrogen load in the protein processing wastewater.

5. Comparison: MPBL-1 vs. Conventional Materials

MPBL-1 offers a unique profile compared to traditional bovine leather and synthetic "Vegan" leathers (PU/Polyester).

Metric	Bovine Leather	PU/Polyester Leather	MPBL-1 (Marine/Cotton)

Fossil Fuel Depletion	Moderate	High	**Low**
Carbon Footprint	High (Methane)	Moderate	**Low (Biogenic)**
Microplastic Risk	Low	High	**Zero**
Biodegradability	Variable	Low	**High**

6. Conclusion and Recommendations

The MPBL-1 material represents a significant advancement in circular economy textiles. By utilizing marine "upstreams" (waste from seafood) and a natural cotton base, the material achieves a low fossil-carbon footprint.

> **Key Strategy:** To further reduce impacts, the next iteration should explore *recycled* cotton to address the high water consumption and land use associated with virgin organic cotton.