

## Bachelor-Thesis Business Engineering | Innovation

# Optimization of Capsule Production for Plant Cultivation - Evaluating Sustainable Material Alternatives, Process Scalability, and Life Cycle Impacts

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## Purpose

This bachelor thesis tackles the sustainability challenge of single-use plastic capsules used in sterile plant cultivation. With production volumes projected to increase significantly, the continued use of pristine fossil-based plastics raises ecological, regulatory, and reputational concerns. The aim is to identify alternative materials that reduce environmental impact while preserving the technical functionality and economic feasibility required for scalable production.

To achieve this, a structured selection framework was developed that integrates life cycle assessment data, expert knowledge, and industry-specific constraints. The framework supports decision-making on sustainable material integration by balancing ecological indicators, cost drivers, process compatibility, and scalability. The result is a strategic foundation that enables CAPSERO to transition toward a more resilient and future-ready material system.

## Applied Skills



Expert Interviews



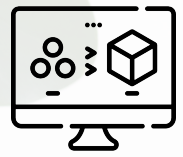
Material Sustainability evaluation



Scalability Modeling



Innovation & Transition planning



Uncertainty Simulations

A mix of qualitative and quantitative methods was applied. Expert interviews defined practical requirements and constraints. A material sustainability framework was developed using life cycle data on environmental and economic impacts. Scalability modeling explored cost and emissions across production volumes. Uncertainty was addressed through simulations and threshold models. The insights were consolidated into a phased innovation roadmap tailored to CAPSERO's strategy.

## Results

Recycled polypropylene and thermoplastic elastomers emerged as viable short-term options. They offer strong ecological benefits and fit seamlessly into existing processes, enabling quick implementation with minimal adjustments.

In the medium term, reusable systems can outperform single-use designs, provided return rates and cleaning protocols are in place. Bio-based and biodegradable materials show long-term promise but are currently limited by water use, infrastructure gaps, and cost.