From dumping to upcycling: Modeling the environmental and economic impact of coffee pulp uses

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1. INTRODUCTION AND OBJECTIVE

- Coffe by-products occur in large quantities and are mostly wasted.
- More than 10 mio tons of coffee pulp (globally) is wasted annually → environmental damage.
- Coffee pulp makes up approx. 43.2% of the total mass of the coffee cherry.
- Upcycling and value addition have potential for the environment and livelihoods

- **Objective: to assess the environmental and economic aspects of most common coffee pulp utilization scenarios, with a specific focus on smallholder coffee cultivation in Sri Lanka.**

2. USE SCENARIOS AND SYSTEM BOUNDARIES

A case study on coffee cherry in landfilling, compost, biogas & tea production in the context of smallholder arabica coffee farmers in Sri Lanka.

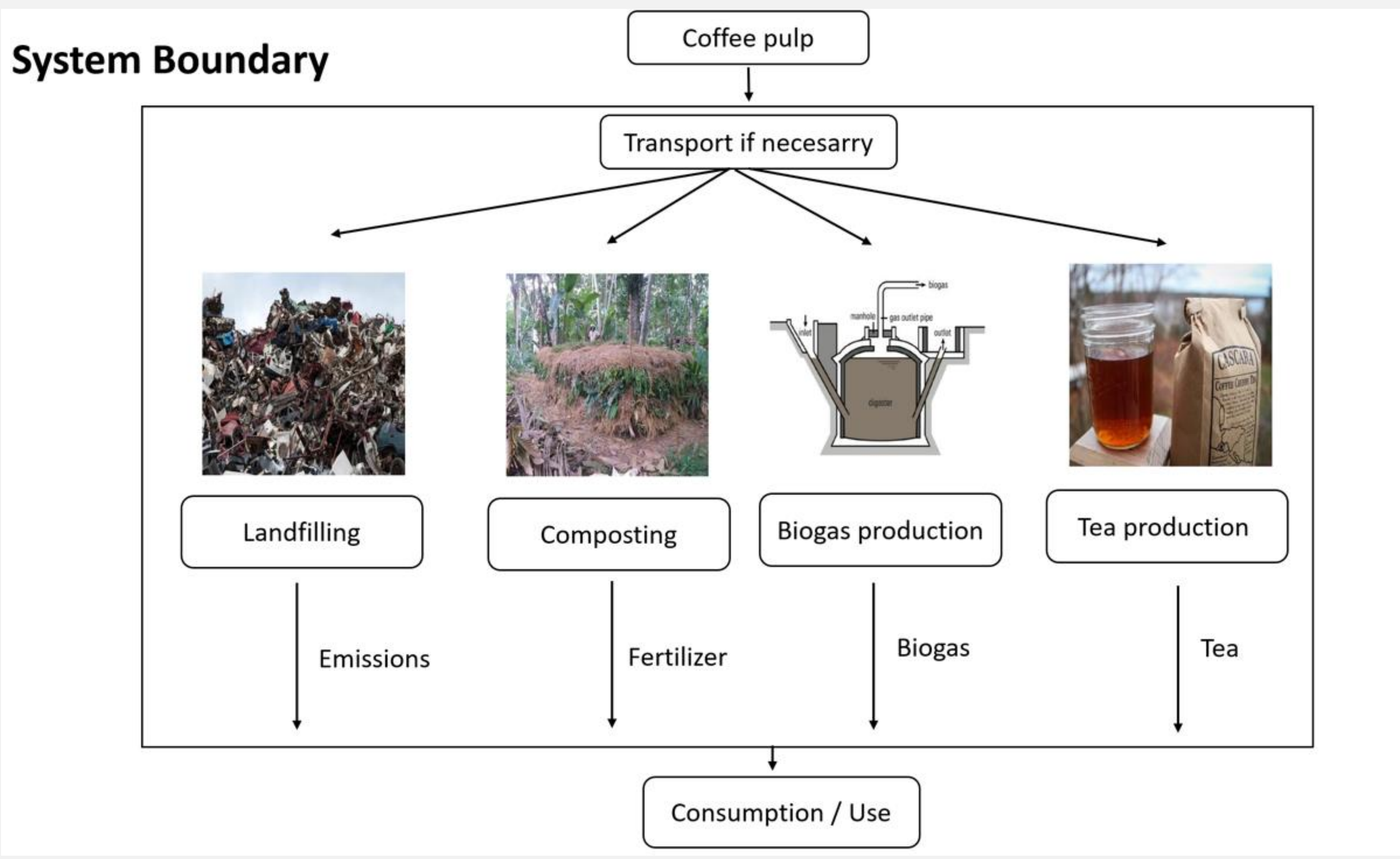


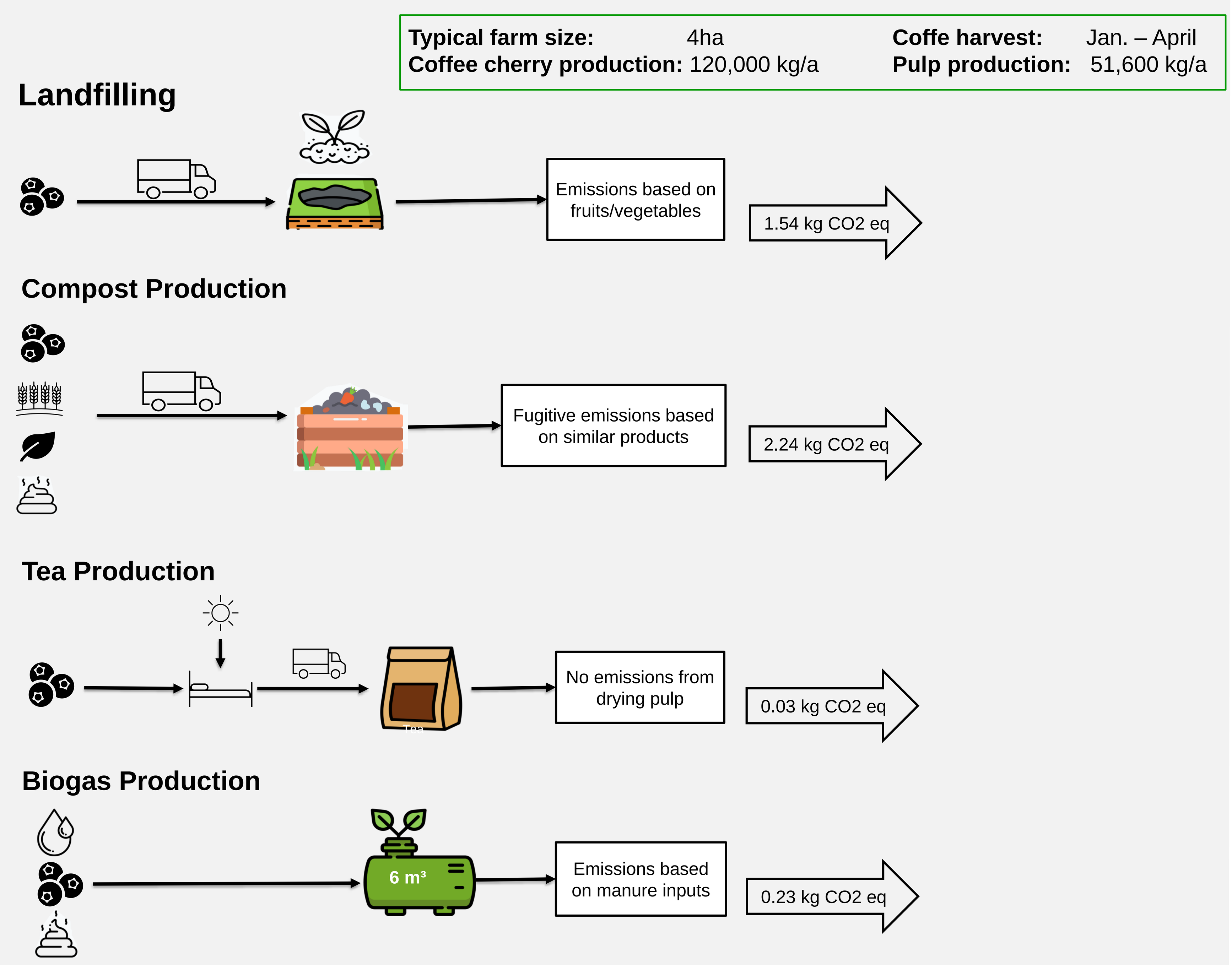
Figure 1: System boundary to analyse the different uses of coffee pulp

Functional unit: 1kg coffee pulp input
Screening Life Cycle Assessment, considering **only GHG emissions (CO_2eq)**
System boundary: Cradle to gate

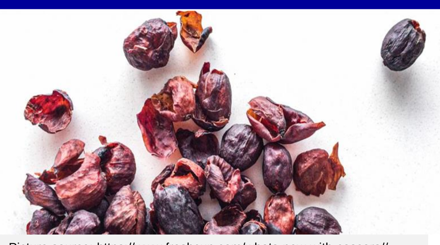
3. DATA SOURCES AND METHODOLOGY

- OpenLCA based on Ecoinvent database 3.8.
- Primary data from Sri Lanka was collected by Bandara (2023).
- Additionally, secondary data from relevant literature. In the case of biogas, an expert interview was conducted.

Scenarios and Assumptions:



4. LIFE CYCLE ASSESSMENT (LCA)



LCA + Sensitivity Analysis

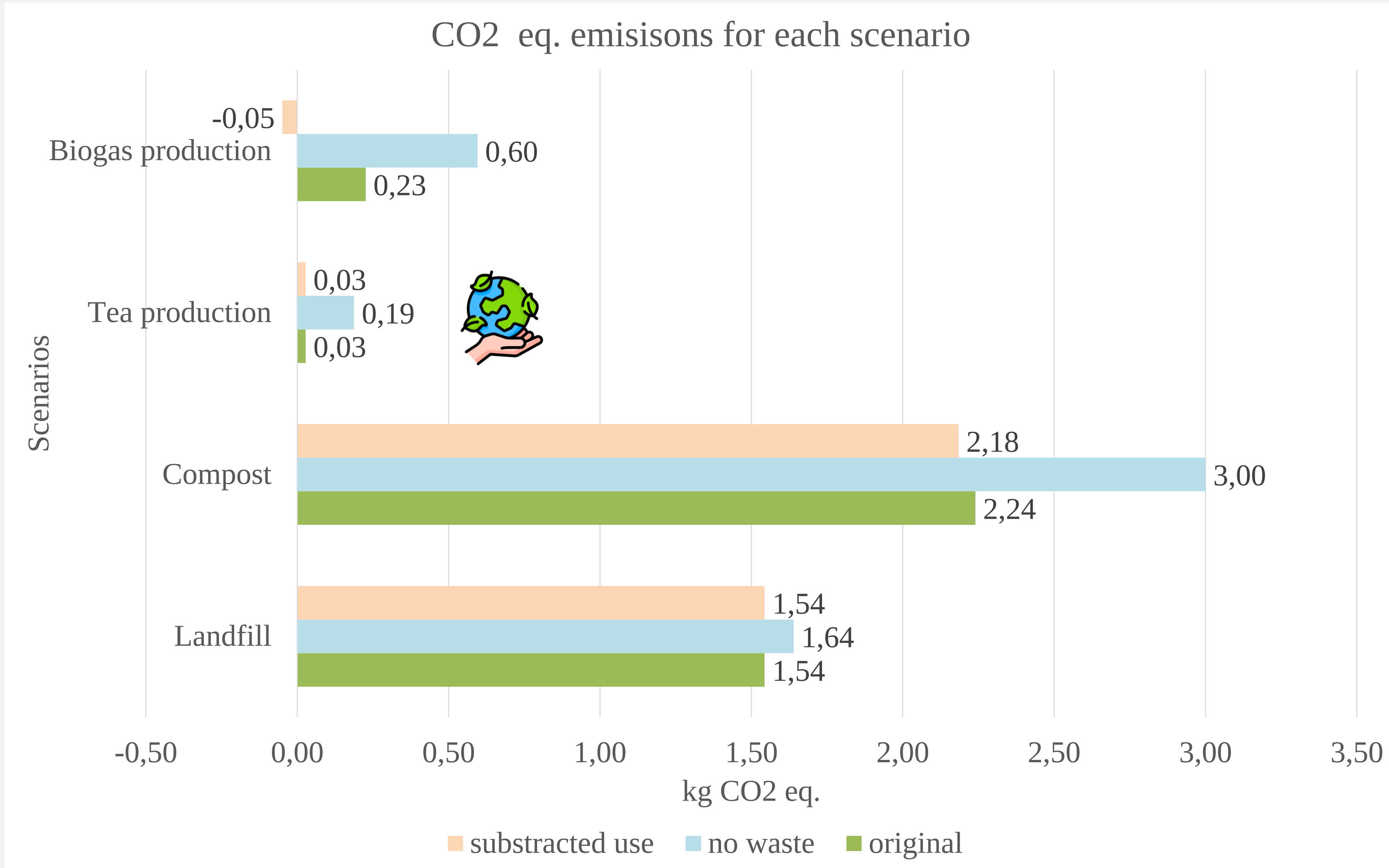


Figure 2: Results LCA

5. COST-BENEFIT ANALYSIS (CBA)

- Only approx. 8000 kg of pulp were considered for CBA.
- ≈ 15,5% of annual coffee pulp → realistic to process.
- Tea production is most economic scenario
- However, highly depends on retail prices and market access.
- In biogas, the revenue from methane is much less than from slurry output.

Table 2: Estimated value of coffee cherry

Value Chain	Breakeven price for 1 kg pulp (€)
Landfilling	-
Compost Production	0.146
Tea Production	0.144
Biogas Production	0.016

Table 1: Results CBA (20 years)

Indicators	Result
IRR	
Landfilling	-
Compost	-
Tea	587%
Biogas	67%
NPV	
Landfilling	-1,053 €
Compost	1,632 €
Tea	15,116 €
Biogas	3,831 €
BCR	
Landfilling	-
Compost	1.06
Tea	8.87
Biogas	7.28

6. DISCUSSION AND CONCLUSION

LCA
- Very unlikely that compost has more emissions than landfilling (Shih et al., 2021), (Seo et al., 2004).
- Might be mostly due to high number of additional inputs into the composting as practiced in Sri Lanka.

CBA
- Shadow Prices have not been included:

e.g. opportunity cost of fertilizer and heating supply or willingness to pay for use products.
- Benefits of new value chains are more than assigned benefits in direct CBA:

e.g. time saving, health benefits, fertilizer availability.
- Demand was excluded. A combination of different uses or collaborations in cooperatives could be further explored.

Conclusion:
- This study lays the **groundwork for future analyses and decision-making** aiming to enhance livelihoods, and ultimately realize sustainable agricultural practices.
- Particularly the **tea scenario seems promising,** market demand and thus prices will play an essential role for success.
- **Social and ecological benefits** are necessary to be monetized and integrated into the decision-making process.

Selected references:
1.Shih, M. F., Lin, C. Y., & Lay, C. H. (2021). Comparison of potential environmental impacts and waste-to-energy efficiency for kitchen waste treatment scenarios in central Taiwan. *Processes*, *9*(4).
2.Seo, S., Aramaki, T., Hwang, Y., & Hanaki, K. (2004). Environmental Impact of Solid Waste Treatment Methods in Korea. *Journal of Environmental Engineering*, *130*(1), 81–89.