Advancing the circular economy for e-commerce packaging waste in India by closed loop models

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Introduction

Solid waste management has always been a critical challenge for most of the countries and acts as a barricade for development. With continuous technological advancements and increasing user demands the global e-commerce sector is expanding rapidly. In 2021, India had 150 million online shoppers, placing it third behind China and the US and by 2026, that number is predicted to rise by 133% (IBEF, 2022). Packaging materials are one of the largest contributors that accelerate the waste generation in urban areas (Worrell and Sluisveld, 2013), and due to lack of efficient waste management processes most of the solid waste is ended up in landfills. Problems associated with waste in e-commerce are especially driven by overpackaging, the low recycling rate of packaging materials, and customers' low motivation to recycle (Pinos et al., 2022) which makes the integration of sustainable practices a key challenge. The concept of sustainable and reusable packaging is still new and less explored, especially in India.

The objective of this study is to develop a closed-loop logistic approach for e-commerce deliveries that focuses on the implementation of sustainable and reusable packaging made from recycled PET. This approach involves defining an integrated and exhaustive system for e-commerce logistics, and compares the CO_2 emissions (kg CO_2 eq.) from all life stages (raw materials, manufacturing, disposal, and transportation) of conventional cardboard packaging and reusable packaging by performing Life Cycle Assessment. The study addresses the needs of e-commerce firms (product safety, flexibility, durability) along with the consumers (frustration-free packaging, incentives) and shows a pathway for significant reduction in CO_2 emissions and overall solid waste generation. The findings of this study could serve as a foundation for a more circular packaging strategy for Indian e-commerce sector contributing to sustainable solid waste management, and eventually many parts of the world.

Methodology

1) *Defining integrated e-commerce logistics systems* – Inputs for these systems (Fig.1) are based upon (i) Literature review on existing waste management practices and the mix of Indian packaging waste, (ii) Spatial analysis of Indian cities to determine distances needed to transport goods, (iii) Information provided on journey of an e-commerce package by Amazon (Amazon, 2023) and (iv) Primary surveys and secondary data from literature to understand user behaviour.

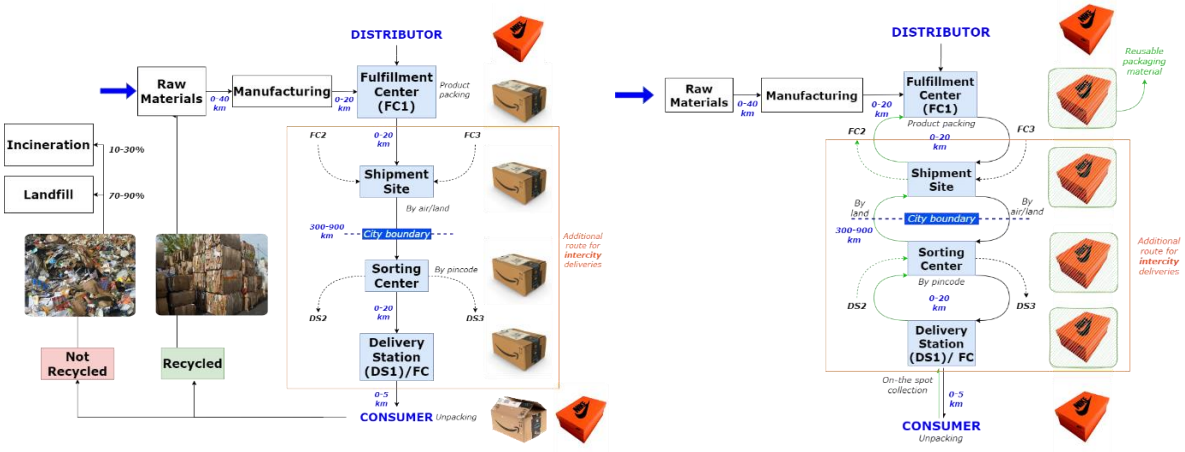

Fig 1. Integrated intercity and intracity e-commerce logistics systems for cardboard (L) and reusable packaging (R)

2) *Estimation of CO_2 emissions from cardboard and reusable packaging* – The CO_2 emissions were estimated in open LCA software with evoinvent database using 2016 ReCiPe Midpoint (H) methodology. For cardboard packaging, CO_2 emissions (kg CO_2 eq./kg) were estimated for all cardboard recycling rates depending on the type of city. The study involves a size standard cardboard box each of ~200 grams for e-commerce delivery which was replaced by a reusable packaging. Each reusable packaging is assumed to be made from rPET fabric, recycled polystyrene foam for cushioning, a zipper and an innovative flexible folding mechanism for space optimization,

shown in Fig 2. Calculations are based upon an on-the-spot return mechanism such that each reusable package has the potential to replace multiple cardboard boxes by making circular loops to enhance overall sustainability, with successful global models like LimeLoop in the US which is designed for 200+ cycles (LimeLoop, 2023)

Results

Life Cycle Assessment shows that in Indian cities with 80% cardboard recycling, a cardboard package of ~200g results in total CO_2 emissions (all life stages) of 0.174 and 0.132 kg CO_2 eq. for intercity and intracity delivery systems, respectively. Fig. 3 depicts total CO_2 emissions per delivery of cardboard packaging corresponding to different recycling rates. One proposed reusable packaging (made from virgin materials) on the other hand results in total CO_2 emission of 0.738 and 0.785 kg CO_2 eq. for intercity and intracity delivery systems respectively, which further is reduced more by 44.3% by using rPET as a raw material. This is higher than that of one cardboard packaging but due to higher durability the emissions are significantly reduced by 67.5%, 92.5% and 95.6% for 10, 50 and 100 successful cycles respectively for cities with 80% of cardboard recycling and intracity delivery system. Fig 3 shows comparison of total CO_2 emissions, both for intercity and intracity.

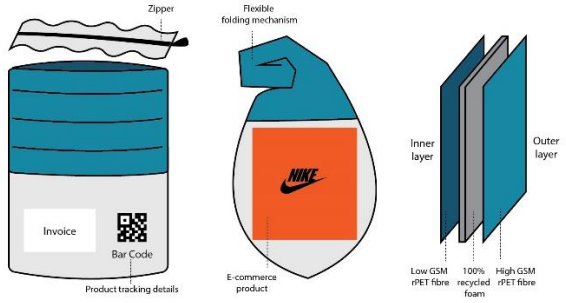

Fig 2. rPET based reusable e-commerce packaging.

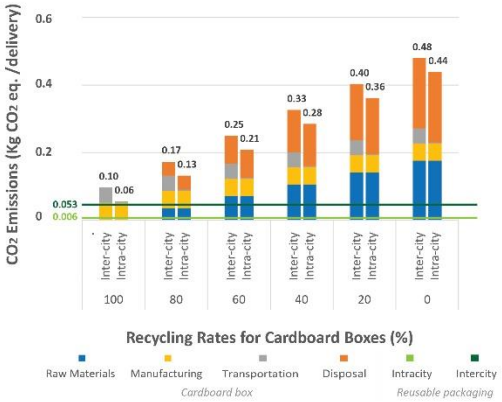

Fig 3. Comparison of CO_2 emissions from cardboard boxes and reusable packaging (100 cycles) for e-commerce application in India with varying cardboard recycling rates.

Conclusion and Suggestions

A significant reduction in CO_2 emissions (more than 95%) is possible in Indian e-commerce sector by the implementation of on-the-spot closed-loop logistic approach, which can also potentially decrease the generation of solid waste associated with e-commerce. This can open new doors for recycling PET bottles and could serve as an EPR opportunity for e-commerce companies. Governments could play a crucial role in the implementation by providing separate funds to boost circular economy and waste management in India. To scale rapidly, e-commerce companies can incentivize users who are willing to take part in it with subscription or deposit-based models.

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