Eco-Returns

Sustainable Reverse Logistics Management System

A Synopsis

for

Project Work-1

BACHELOR OF TECHNOLOGY in COMPUTER SCIENCE & ENGINEERING

BY

Anushka Paharia

EN22CS301183

Under the Guidance of

Prof. Mohammad Mazhar

Department of Computer Science & Engineering
Faculty of Engineering
MEDICAPS UNIVERSITY, INDORE- 453331

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Introduction

The exponential rise of e-commerce has created a parallel surge in product returns, estimated to be worth $816 billion in 2022 in the U.S. alone [1]. Traditional return processes are financially costly and environmentally damaging, with many items ultimately ending up in landfills, contributing to carbon emissions and wasted resources [2]. Studies show that nearly 80% of returned goods are discarded rather than resold or recycled [3].

This project proposes a Software-as-a-Service (SaaS) platform to help small-scale online businesses manage reverse logistics more effectively and sustainably. By integrating automation, analytics, and sustainability-driven disposition options such as refurbishment, donation, and recycling, the system will reduce waste-to-landfill and support circular economy practices.

Literature Review

Reverse logistics has been recognized as a key driver in sustainable supply chain management [4]. It enables the flow of products from the point of consumption back to the origin for reuse, repair, or safe disposal. However, in most developing economies, reverse logistics remains fragmented, informal, and poorly documented [5].

Recent industry reports highlight that returns in the U.S. alone generated **9.5 billion pounds of landfill waste and 24 million metric tons of CO_2 emissions** [2]. Academic studies confirm that urban waste management systems in many regions are already overwhelmed, and innovative digital solutions are required to support sustainable practices [6]. Consumer awareness of the environmental impact of returns also remains low [7].

This literature establishes both the **environmental urgency** and **technological gap** that motivate this project.

Problem Definition

E-commerce returns have become a significant environmental and economic challenge. Studies indicate that a large share of returned goods are not resold but end up in landfills, contributing to waste accumulation and unnecessary carbon emissions. While large retailers often invest in reverse logistics systems, small and medium-sized businesses lack access to affordable platforms that combine operational efficiency with sustainability. In addition, both businesses and consumers often have limited visibility into the environmental footprint of returns, which reduces awareness and action toward sustainable practices.

The major problems addressed in this project are:

- **High landfill contributions** from returned goods due to the absence of structured reverse logistics workflows.
- **Limited access for small businesses** to affordable returns management platforms with sustainability-driven features.
- **Low visibility and tracking** of ecological impacts, such as CO_2 emissions, landfill diversion, and packaging waste.
- **Consumer unawareness** regarding the environmental consequences of frequent returns and lack of tools to make greener choices.

Objectives

The main objective of this project is to design and implement a **sustainability-driven SaaS platform for reverse logistics**, tailored to the needs of small-scale online businesses. The system aims to combine operational efficiency with measurable environmental benefits.

The specific objectives are:

- **Develop a modular SaaS platform** that enables businesses to manage product returns through a customer self-service portal and business dashboard.
- **Integrate sustainability-focused features**, including returnless refunds, recycling/donation workflows, and automated computation of CO_2 savings, landfill diversion, and packaging waste avoided.
- **Design optimization algorithms** to recommend the most eco-efficient disposition (resell, refurbish, donate, recycle) based on cost and environmental trade-offs.
- **Incorporate fraud detection mechanisms**, starting with heuristics and extending to basic machine learning models for identifying suspicious return behaviors.
- **Build an analytics and simulation module** to compare baseline (traditional) vs optimized return processes, using synthetic data and Monte Carlo simulations to quantify reductions in landfill waste and emissions.
- **Evaluate the system's impact** by measuring cost recovery and sustainability outcomes, demonstrating its role in promoting circular economy practices for small businesses.

Methodology

This project adopts a design–build–evaluate methodology. The system will be implemented as a modular SaaS platform, combining software engineering with sustainability analytics and optimization.

System Architecture

The system is designed as a cloud-based platform with:

- **Frontend:** React.js interface for customers (returns portal) and businesses (analytics dashboard).
- **Backend:** Node.js/Express with MongoDB for transactions and data persistence.
- **Analytics Engine:** Computes return metrics, landfill diversion, and CO_2 emissions.
- **Integration Layer:** APIs for Shopify/WooCommerce and CSV import with validation and enrichment.

Functional Modules

The platform goes beyond a simple returns manager by incorporating computation-heavy modules:

- **Customer Portal:** Initiates returns, generates labels, tracks status, and shows sustainability impact.
- **Workflow & Optimization Engine:** Routes items to resell, refurbish, donate, recycle, or returnless refund using rules; extended with linear programming to minimize cost and carbon footprint.
- **Sustainability Metrics Engine:** Calculates CO_2 saved, packaging waste avoided, and landfill diversion rates.
- **Fraud Detection:** Starts with heuristics (repeat returns, mismatches) and extends to ML (logistic regression / decision trees).
- **Analytics & Simulation:** Compares baseline vs optimized scenarios, e.g., "70% landfill vs 30% landfill," using Monte Carlo simulations.

Evaluation

The system will be validated on both technical and sustainability grounds:

- **Technical Testing:** Synthetic datasets used to measure system scalability, accuracy, and response times.
- **Sustainability Impact:** Compare landfill diversion, CO_2 reduction, and cost recovery between traditional and optimized methods.

- **Pilot Study:** Small business users will test the platform, providing feedback on usability and ecological awareness.

References

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