EcoPack AI - Sustainable Packaging Recommendation System

1. Introduction

EcoPack AI is an AI-powered web application that recommends sustainable packaging materials based on product characteristics and user-defined priorities. The system integrates Machine Learning models, rule-based filtering, dynamic ranking, analytics dashboard, and sustainability report generation.

2. Problem Statement

Businesses struggle to select packaging materials that balance cost efficiency, material strength, and environmental impact. Manual decision-making often leads to higher emissions and unnecessary costs. EcoPack AI automates this decision using AI-driven ranking.

3. Objectives

• Predict packaging cost using Machine Learning
• Predict CO2 emissions using Machine Learning
• Rank materials dynamically based on user input
• Provide sustainability analytics
• Generate PDF and Excel reports

4. System Architecture

User Interface → Flask Backend API → PostgreSQL Database → Machine Learning Models → Dynamic Scoring Engine → Top 3 Recommendations → Analytics Dashboard & Reports

5. Technologies Used

Backend: Python, Flask, Pandas, PostgreSQL
Machine Learning: RandomForest, XGBoost, StandardScaler
Frontend: HTML, CSS, Bootstrap, JavaScript
Visualization: Plotly
Reporting: ReportLab, OpenPyXL

6. Machine Learning Models

Cost Prediction Model: RandomForest Regressor
CO2 Prediction Model: XGBoost Regressor
Input Features: Strength, Weight Capacity, Recyclability %, Biodegradability Score

7. Recommendation Logic

Step 1: Filter materials based on fragility and product category.
Step 2: Predict cost and CO2 using ML models.
Step 3: Calculate suitability score using dynamic weighted formula.
Step 4: Rank materials and return Top 3 recommendations.

8. Analytics Dashboard

Includes Ranking Chart, Cost Comparison, CO2 Comparison, CO2 Reduction Percentage, Cost Savings, and Material Usage Trends.

9. Conclusion

EcoPack AI provides an intelligent and sustainable packaging decision system that helps businesses reduce environmental impact while maintaining cost efficiency.