

Integrated E-Commerce Platform

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Abstract:

The rapid expansion of eCommerce has reshaped consumer behavior but has also intensified environmental concerns such as excessive packaging, increased carbon emissions, and resource overuse. To address these challenges, this project introduces an integrated eCommerce platform that emphasizes sustainability through environmental scoring. Leveraging data-driven algorithms, the platform evaluates key metrics including product life cycle analysis, carbon footprint, and recognized eco-certifications to generate an environmental score for each item. These scores are seamlessly integrated into the shopping experience, enabling consumers to make informed, eco-conscious purchasing decisions. The backend, powered by Flask, handles product metadata processing and sustainability evaluation, while a React and TailwindCSS-based frontend presents products with interactive score indicators and eco-impact summaries. Retailers are incentivized to adopt greener practices through increased visibility of high-scoring products. Power BI integration supports in-depth analysis of product trends, sustainability metrics, and consumer behavior. A RESTful API ensures real-time synchronization between components, maintaining smooth and efficient data flow. By merging eCommerce with sustainability intelligence, this platform fosters environmentally responsible consumption while preserving user convenience and commercial viability.

Keywords — E-sustainability, Environmental impact assessment, Carbon footprint scoring, Green consumer behaviour, Sustainable online shopping, Eco-friendly product ratings, Data driven sustainability.

I. INTRODUCTION

The rapid expansion of eCommerce has revolutionized consumer shopping habits, offering convenience and accessibility on a global scale. However, this digital transformation has also led to significant environmental concerns, including increased carbon emissions, excessive packaging waste, and resource depletion. These issues are becoming more pronounced as online shopping continues to grow, underscoring the urgent need for more sustainable solutions within digital commerce ecosystems. Studies by Thompson and Lee [1] have shown that environmental impacts such as carbon

footprint, raw material sourcing, and end-of-life recyclability can be effectively assessed through Life Cycle Assessment (LCA) methodologies.

To address these sustainability challenges, this project proposes an "Integrated eCommerce Platform with Environmental Scoring" designed to embed eco-awareness directly into the consumer shopping experience. Inspired by the research of Kim and Zhao [2], which emphasized the influence of sustainability information on consumer decision-making, this platform evaluates the environmental impact of each product and assigns an environmental score based on multiple criteria. These include

carbon emissions during production and transport, the sustainability of materials used, and adherence to eco-certifications. In addition to empowering consumers, the platform promotes sustainable retail practices by highlighting greener alternatives and offering incentive mechanisms to environmentally responsible vendors. As supported by Nguyen and Patel [3], transparent and easy-to-understand environmental labels can drive market-wide shifts in behavior by making sustainability a competitive advantage.

The backend architecture of the system uses data analytics to compute environmental scores from product metadata, while the frontend—developed using React and TailwindCSS—displays these insights through user-friendly interfaces. Inspired by Garcia and Ahmed [4], who advocate for intuitive design in sustainability-focused systems, this platform integrates visual indicators and comparative tools that simplify the understanding of complex environmental data.

By aligning consumer behavior with environmental accountability, this platform aims to foster a more sustainable digital marketplace. Its data-driven, user-centric approach not only educates consumers but also encourages systemic change across the supply chain. The following sections detail the system's architecture, environmental scoring model, user experience design, and the metrics used to evaluate its effectiveness in promoting green consumer practices.

II. OBJECTIVE

The rapid growth of eCommerce has brought significant changes to consumer behavior and global trade, offering convenience and market expansion opportunities. However, this growth has also introduced substantial environmental challenges, including increased carbon emissions from logistics, excessive packaging waste, and unsustainable resource consumption. As environmental awareness rises among consumers and regulatory bodies, there

is a pressing need for digital commerce platforms to incorporate sustainability into the online shopping experience. This research proposes the development of an Integrated eCommerce Platform with Environmental Scoring, designed to empower users with eco-impact insights and encourage sustainable choices.

The primary objective of this study is to build a robust eCommerce platform that integrates environmental assessment tools, transparent scoring mechanisms, and interactive visualizations to support environmentally responsible consumption. The system is structured around the following key objectives:

1. Environmental Impact Assessment and Scoring Model:

Design a multi-factor environmental scoring algorithm that evaluates the sustainability of products based on life cycle assessment (LCA) methodologies. Factors include carbon footprint during manufacturing and transportation, material origin (renewable vs. non-renewable), energy usage, recyclability, and adherence to environmental certifications (e.g., FSC, Energy Star, GOTS). The algorithm will assign a normalized environmental score to each product, reflecting its overall eco-impact.

2. Dynamic Product Metadata Collection and Processing:

Create a backend system capable of ingesting and analyzing product metadata provided by vendors or sourced from third-party sustainability databases. The system will parse and validate information such as product category, raw material composition, packaging type, and shipping distance to ensure accurate environmental assessments.

3. Eco-Conscious User Interface and Shopping Experience:

Develop a modern, responsive frontend using React and TailwindCSS that integrates environmental scores into the product listing and

detail pages. Visual indicators such as badges, color-coded ratings, and side-by-side sustainability comparisons will help consumers easily identify and choose greener alternatives without disrupting their browsing experience.

4. Retailer Engagement and Sustainable Practice Incentivization:

Encourage retailers to provide detailed product data and adopt sustainable practices by offering visibility benefits within the platform. Products with high environmental scores will be promoted in featured sections and search results, motivating sellers to improve their sustainability metrics.

5. RESTful API for Seamless Data Exchange and Real-Time Updates:

Implement a RESTful API architecture to ensure smooth communication between the scoring engine, product databases, frontend interfaces, and analytics tools. This API will enable real-time updates to product scores, support API-based vendor onboarding, and maintain data integrity across components.

By achieving these objectives, the system bridges the gap between digital commerce and environmental stewardship, delivering a shopping experience that aligns economic activity with ecological responsibility. It equips consumers to make informed decisions and motivates businesses to adopt sustainable practices—fostering a greener, more transparent, and ethically aligned marketplace.

III. MODULE AND ALOGRITHM

The Integrated eCommerce Platform with Environmental Scores is designed to revolutionize online shopping by embedding sustainability into every functional layer. From browsing and ordering to analytics and customer engagement, the platform promotes environmentally conscious behavior while maintaining high performance, user-friendliness, and security.

A. Modules:

1. User Interface (UI) Module:

The User Interface Module provides a dynamic and responsive environment for customers to interact with products and access sustainability information. Users can browse items with filter options for eco-friendly features such as recyclability, low carbon footprint, and sustainable sourcing. The interface is also equipped with a personalization engine that tailors recommendations based on the user's previous purchases and stated eco-preferences, promoting informed and conscious shopping decisions.

2. Centralized Inventory Management System:

This module manages real-time stock updates while embedding environmental data within product inventories. Built using MongoDB for scalability and efficiency, the system ensures product availability is synchronized across all platforms. In addition to traditional inventory tracking, it monitors sustainability metrics such as percentage of recycled materials used, product origin, and packaging type. Products with high environmental impact are flagged for visibility and reporting. This eco-inventory approach not only supports operational efficiency

but also reinforces the platform's commitment to transparency and sustainability in supply chain management.

3. Order Management Module:

The Order Management Module streamlines the entire order lifecycle, from placement to delivery, while integrating eco-friendly shipping options and sustainability impact tracking. It automatically updates inventory levels and order statuses and provides real-time tracking for both customers and administrators. A key feature is the ability to offer carbon-neutral shipping methods and minimal packaging choices during checkout. Customers are presented with the estimated carbon emissions for each shipping option, encouraging greener delivery decisions. After purchase, the system generates a sustainability impact summary for each order, showcasing the carbon footprint and environmental savings associated with the products chosen.

4. Payment Gateway Integration Module:

The Payment Gateway Module ensures seamless and secure transactions, while also introducing options for environmental contributions. It supports multiple payment methods including credit cards, PayPal, Stripe, and international gateways, with encryption and fraud protection in place. During checkout, customers are encouraged to round up their purchase total to support environmental causes or choose eco-friendly incentives such as discounts on green shipping. This module enhances the ethical aspect of purchasing by making it easy for users to contribute to sustainability goals while finalizing their orders.

5. Admin Dashboard Module:

The Admin Dashboard Module acts as the control center for system operations and sustainability oversight. It provides administrators with real-time analytics on product performance, user engagement, sales trends, and stock levels. Sustainability metrics are also prominently displayed, allowing admins to monitor the platform's overall carbon footprint, the impact of green product lines, and user interaction with eco-conscious features. The module includes tools to manage product listings, update environmental scores, and generate performance reports. This empowers decision-makers to optimize both business strategy and environmental impact.

6. Customer Management Module:

The Customer Management Module focuses on enhancing user engagement and promoting sustainable shopping habits. Customers can manage their profiles, review their order history, and track personal sustainability statistics such as carbon offset, plastic saved, or water conserved. The platform rewards eco-conscious behavior with badges and loyalty points that can be redeemed for discounts or special offers. Additionally, it collects feedback on product quality and sustainability features, creating a feedback loop that informs continuous platform and product improvements.

This module helps nurture a community of informed, responsible shoppers.

7. Advanced Analytics Module:

The Advanced Analytics Module provides deep insights into business operations and environmental trends. It tracks key metrics such as revenue growth, customer retention, product popularity, and green purchase penetration. The module uses these insights to identify correlations between product sustainability and consumer behavior, helping the business refine its sustainability strategy. Tools like Chart.js or Power BI are used to create interactive dashboards that visualize sales trends and environmental data. The analytics module also supports A/B testing to evaluate the effectiveness of green labels and sustainability scores in influencing purchasing decisions.

8. Backend Security Module (Node.js & Express.js):

Security is critical in maintaining trust and data integrity. This module ensures all backend operations are protected through token-based authentication (JWT). It uses `express-rate-limit` to guard against brute-force attacks and `sanitize-html` to prevent injection vulnerabilities. Integration with OAuth2 enables secure third-party access, such as login via Google or Facebook. These features ensure that the platform remains secure for both users and administrators while protecting sensitive transaction and sustainability data.

9. Database Module (MongoDB):

The Database Module serves as the centralized storage hub for all platform data, including product details, user information, transactions, and sustainability metrics. Using MongoDB's flexible schema design, the system efficiently stores complex data structures like environmental scores and historical order impacts. The database is optimized for real-time querying and scalability, ensuring quick response times for product searches, analytics queries, and user interactions.

10. Testing and Evaluation Module:

To ensure stability, performance, and the effectiveness of environmental features, the Testing and Evaluation Module conducts continuous validation across system components. Performance tests simulate high-traffic scenarios to assess the platform's responsiveness under load, particularly for API endpoints and database calls. Sustainability scoring models are evaluated using A/B testing to compare user behaviour with and without green indicators. This module also benchmarks the platform's sustainability metrics against industry standards to ensure environmental accuracy and integrity. Regular testing ensures the platform remains reliable, impactful, and user-focused.

B. Algorithm:

Core algorithmic processes focus on environmental scoring, real-time inventory synchronization, customer personalization, and impact visualization.

1. Environmental Scoring Algorithm:

This algorithm calculates a composite environmental score for each product by evaluating multiple impact factors such as carbon footprint during manufacturing, energy consumption in logistics, material recyclability, and sustainability certifications. Data is sourced from supplier reports, lifecycle analysis databases, and third-party environmental APIs. Each factor is assigned a weight based on its ecological significance, and the weighted average is used to generate a unified environmental score on a 0–100 scale.

2. Inventory Synchronization Algorithm:

The Inventory Synchronization Algorithm ensures that product stock levels are consistent and up-to-date across all user interfaces — including the website, mobile app, and admin dashboard. Built using event-driven updates and MongoDB change streams, the algorithm listens for stock changes due to new orders, returns, or restocking activities. Once a change is detected, the inventory database is

updated in real-time, and synchronization events are triggered to reflect the new quantities across front-end modules. The algorithm also includes a sustainability tracker that logs each product's environmental data (such as eco-material composition or packaging details), ensuring that this information remains visible to users even as stock levels fluctuate. This dual-layered synchronization helps maintain inventory integrity while reinforcing transparency in product sustainability.

3. Personalized Recommendation Algorithm:

The Personalized Recommendation Algorithm enhances the customer experience by suggesting eco-conscious products tailored to individual user preferences and past behaviors. Using a combination of collaborative filtering and content-based filtering, the algorithm analyzes historical purchases, product views, and user-selected sustainability filters. Environmental impact metrics are incorporated into the scoring logic to boost visibility for low-impact, eco-certified items.

4. Payment Processing and Green Incentive Algorithm:

The Payment Processing Algorithm integrates with third-party gateways like Stripe and PayPal while embedding eco-friendly incentives into the checkout flow. Once the order total is calculated, the algorithm prompts users with options to round up their payments for environmental donations or apply discounts for choosing green delivery methods. The system also includes logic to match donations during campaigns and display real-time counters. All transactions are secured through encrypted tokenization and validated with JWT-based authentication. This fusion of secure processing and sustainable incentives drives ethical consumer behaviour at the payment stage.

5. Backend Security and Data Validation Algorithm:

The Security Algorithm governs API interactions, data validation, and threat protection across the platform's backend infrastructure. Developed with

Node.js and Express.js, it uses JSON Web Tokens (JWT) for user authentication and implements `express-validator` to check incoming requests for malicious inputs. The `sanitize-html` package further ensures that no script injection or XSS attacks are executed through form inputs. Brute-force attacks are mitigated using `express-rate-limit`, which restricts failed login attempts. These layers of security ensure data integrity and compliance while safeguarding customer, transaction, and environmental data stored in MongoDB.

The Integrated eCommerce Platform with Environmental Scores combines intelligent algorithms and system logic to deliver a seamless, secure, and sustainability-driven shopping experience. These algorithms work in harmony to support both operational efficiency and environmental awareness across all user touchpoints

By combining these intelligent algorithms, the Integrated eCommerce Platform delivers not just a robust online marketplace, but a purpose-driven shopping ecosystem that empowers users, promotes eco-conscious behavior, and supports businesses in meeting their sustainability goals.

IV. METHODOLOGY

1. Data Acquisition and Processing:

The system begins by collecting and storing product details (materials, certifications, suppliers), customer behavior (purchase history, preferences), and sustainability data (carbon footprint, recyclability). Admins upload product data manually via an intuitive web interface or through JSON imports. MongoDB stores all records in structured collections, while the Express backend ensures validation and normalization of environmental metrics (e.g., CO₂ equivalents). This clean, standardized data is served to the front end using REST APIs for seamless rendering in product listings.

2. Environmental Feature Engineering:

Using backend logic in Node.js, the platform processes raw environmental data into enhanced features such as Eco Score, Eco Rank, and Shipping Impact Level. Products with verified green certifications are automatically tagged with dynamic HTML/CSS badges like “Plastic-Free” or “Carbon Neutral.” These engineered attributes are shown on product cards and details pages, and also power the eco-aware recommendation engine that helps users discover sustainable alternatives.

3. Order Processing and Eco-Impact Evaluation:

Upon checkout, the system evaluates the order’s total environmental impact by summing individual product scores and calculating shipping emissions using real-time logistics data. Customers are presented with an Eco Impact Summary, showing metrics such as carbon emissions saved, recycled material usage, and packaging type. The system offers eco-conscious shipping options like carbon-neutral delivery and paper-based packaging. These selections influence both the final order impact report and user reward points, reinforcing sustainable shopping behaviour. Backend processes also update inventory levels and reflect stock movement in real time.

4. Notification and Feedback System:

The system supports automated, event-driven notifications that enhance user engagement and promote environmental action. Customers receive emails confirming eco-friendly actions (e.g., choosing green shipping or earning a sustainability badge). Additionally, a feedback module collects user opinions on the platform’s sustainability features, using responses to refine environmental scoring algorithms and recommendation logic.

5. Data Visualization via Admin and User

Dashboards:

Processed data and environmental analytics are visualized using Chart.js within both customer-facing and admin dashboards. Customers can view

personalized reports showing their cumulative eco-impact, including metrics like CO₂ saved and eco-badges earned. Admins access real-time dashboards displaying sales performance, inventory trends, and environmental metrics, such as average product sustainability score and the percentage of green orders. These visualizations help stakeholders make informed decisions, adjust product offerings, and promote high-performing sustainable goods.

V. EXISTING SYSTEM

1. Traditional eCommerce Platforms:

Conventional eCommerce platforms primarily focus on pricing, availability, and delivery logistics, offering limited or no insights into a product's environmental impact. These platforms emphasize customer convenience and product variety but neglect sustainability aspects such as carbon footprint, material origin, and recyclability. As a result, customers are unable to make environmentally informed purchasing decisions.

2. Sustainability Labels and Manual Research:

In the absence of integrated sustainability features, eco-conscious customers must rely on third-party labels or conduct independent research to understand a product's environmental credentials. This lack of standardized sustainability information leads to low consumer awareness and engagement with green products.

3. Generic Product Recommendations:

Existing platforms typically employ recommendation engines based on popularity, purchase patterns, or user ratings. These engines do not consider environmental metrics, thereby failing to promote sustainable alternatives. As a result, high-impact, non-eco-friendly products may be promoted over greener options, limiting the platform's contribution to environmentally responsible consumption.

4. Lack of Environmental Impact Tracking:

Most eCommerce platforms do not track or display the environmental impact of a user's shopping behavior. Customers are unaware of the carbon emissions generated by their purchases, the sustainability of the materials used, or the waste associated with packaging. This lack of visibility results in missed opportunities for behavioral change and engagement with low-impact choices.

5. No Real-Time Impact Evaluation or Visualization:

Traditional systems lack a real-time mechanism to compute and visualize environmental impact during the shopping experience. Even platforms that claim to support sustainability often do not show live impact scores or comparisons across products, preventing users from making side-by-side evaluations of greener alternatives.

6. Challenges in Existing Systems:

Traditional e-commerce platforms are primarily designed around convenience, price, and variety, offering little to no visibility into a product's environmental impact. Most systems lack built-in mechanisms to display sustainability metrics such as carbon footprint, water usage, or material recyclability. As a result, eco-conscious consumers are forced to rely on third-party certifications or conduct manual research to assess product sustainability—an approach that is often inconsistent, incomplete, or unavailable. This fragmented information landscape limits transparency and prevents users from making informed, environmentally responsible choices.

VI. PROPOSED SYSTEM

The proposed system is designed to promote sustainable shopping by integrating environmental scores into a user-friendly e-commerce platform. Unlike traditional online stores, this system provides real-time environmental impact data for each product, helping users make eco-conscious purchasing decisions. The platform is developed using HTML, CSS, and JavaScript for the front-end, while the backend is powered by Node.js, Express,

and MongoDB for fast and scalable data management.

products with lower environmental impact, enhancing responsible shopping behavior.

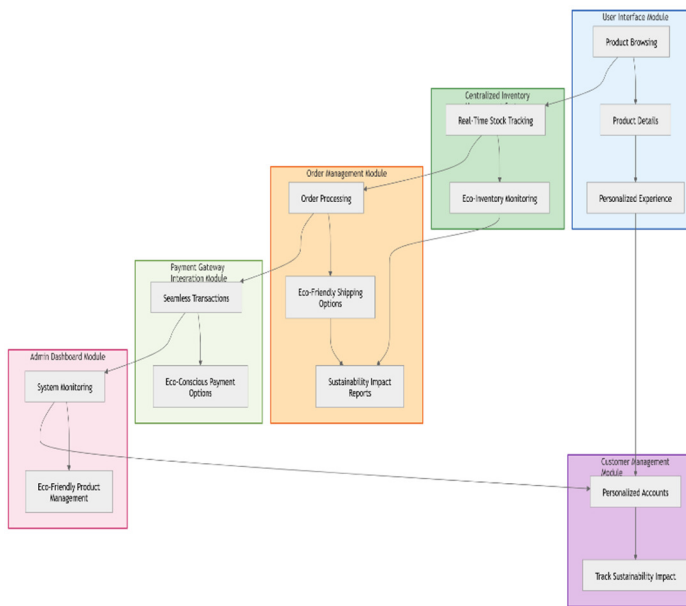


Fig. 1: Architecture diagram of Integrated E-commerce Platform

1. Real-Time Product and Environmental Data Management:

The platform allows admin users to upload and manage product details—such as name, category, price, and description—alongside environmental impact metrics including carbon footprint, water usage, and recyclability index. This data is stored in MongoDB and served dynamically via Express APIs. Users can instantly view environmental scores on the product details page, offering transparency and driving sustainable choices.

2. Environmental scoring Algorithm:

An internal scoring system normalizes and aggregates multiple environmental metrics to compute a product’s Eco Score, ranging from A (Excellent) to E (Poor). The score is calculated using a weighted average of carbon emissions, water consumption, and material sustainability. This scoring model allows users to quickly identify

3. Interactive Product Filtering and Sorting:

Users can filter products based on eco-scores, categories, and price range. Additionally, sorting options like “Lowest Environmental Impact” or “Eco Score: High to Low” enable shoppers to prioritize greener alternatives. This filtering system is implemented via front-end JavaScript and dynamically fetches data from the backend to provide a seamless and responsive user experience.

4. Integrated Shopping Cart and Checkout:

The platform features a fully functional shopping cart and checkout system. Users can add products, adjust quantities, and view total environmental impact summaries of their selected items before purchase. The backend calculates cumulative eco-metrics for the entire cart, providing insight into the environmental footprint of each order. Order details are saved in MongoDB and accessible via a user dashboard.

5. Dashboard with Sustainability Analytics:

The admin dashboard—built with charting libraries like Chart.js—offers insights into product categories with the highest and lowest environmental impact, user preferences for eco-friendly products, and sales vs. sustainability trends. Bar and pie charts visualize key sustainability KPIs, helping platform owners track impact and make informed inventory decisions. MongoDB’s aggregation pipeline is used to generate backend data for these analytics in real time.

6. Responsive Front-End and User Experience:

The front-end is built with responsive HTML and CSS, ensuring mobile-friendly design and intuitive navigation. Eco-score badges are color-coded for clarity, and product pages include tooltips explaining the environmental metrics. The UI is designed for

accessibility, encouraging all users to engage with sustainability-focused e-commerce.

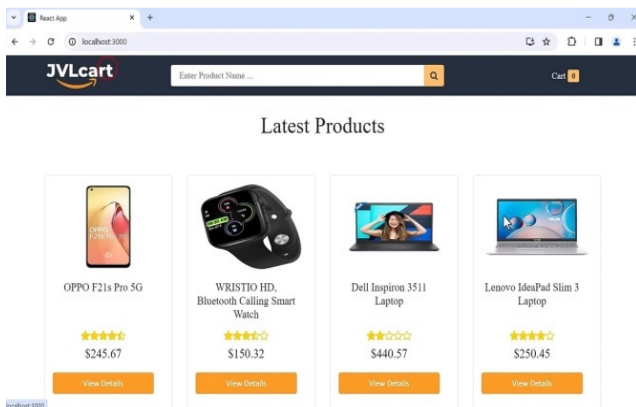
VI. OUTPUT

The Integrated eCommerce Platform provides impactful outputs designed to promote sustainable shopping behavior by offering real-time environmental scoring, personalized recommendations, and eco-insightful visualizations. These outputs help customers and administrators make environmentally informed decisions throughout the shopping journey.

1. Product Browsing and Detail View:

Users can explore a wide range of products through a clean and responsive product catalog. Each product is displayed as a card containing:

- Product image, name, and price
- Quick highlights (e.g., available certifications or material origin)



Clicking View Details navigates to a detailed product page, where users can learn more about manufacturing origin, packaging type, and product certifications.

2. Product Composition and Packaging Insights:

Each product detail page includes structured information such as:

- Material breakdown (e.g., cotton, recycled plastic)

- Packaging type (paper-based, plastic-free, etc.)

- Shipping method and delivery range

Relevant data is stored in MongoDB and retrieved dynamically through Express APIs, then rendered on the front end using HTML/CSS components and small JavaScript widgets for interactivity.

3. Checkout Experience and Impact Summary:

During checkout, the platform displays a concise summary of each product’s origin, packaging, and delivery method. If the user selects optional eco-conscious delivery choices (e.g., paper packaging or carbon-neutral shipping), these are reflected in a brief impact overview, presented using Chart.js graphs. The impact summary provides users with awareness of their order composition without disrupting the shopping flow.

3. Notifications and Engagement:

The system automatically sends confirmation emails after purchases, summarizing order contents and any eco-friendly selections made. These emails are generated using Node Mailer, helping build transparency and trust. Customers are also invited to provide feedback on the sustainability features, collected through a short form integrated into the dashboard.

Fig. 2: Output of Eco-Friendly Purchases

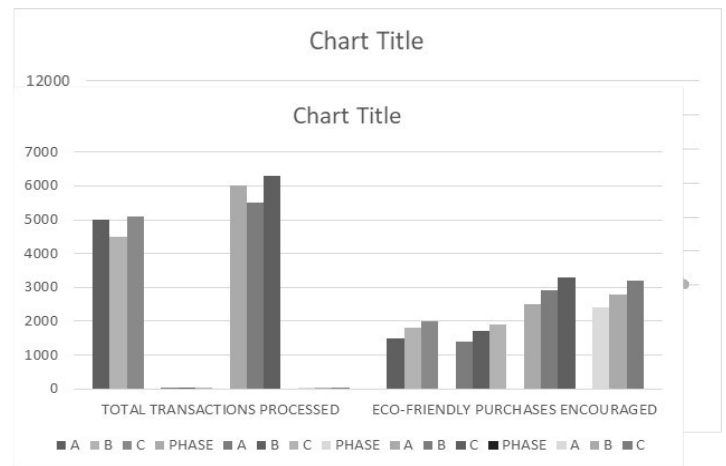


Fig. 3: Output of Increase in Eco-Scoring

4. Dashboards for Customers and Admins:

The platform includes two types of dashboards:

- Customer Dashboard: Shows purchase history, shipping preferences, and optional impact summaries (e.g., total eco-packaging used).
- Admin Dashboard: Displays sales trends, inventory status, and aggregated insights on product types, user preferences, and delivery method selections.

All dashboards are powered by MongoDB aggregation pipelines and visualized using Chart.js components styled with HTML and CSS. They provide a unified view of user behavior and operational performance, supporting informed decision-making and continuous improvement.

VII. CONCLUSIONS

The Integrated eCommerce Platform with Environmental Sustainability Scores provides an innovative and effective approach to promoting sustainable shopping. By incorporating real-time sustainability metrics, advanced data analytics, and an intuitive user interface, the system empowers consumers to make informed, eco-conscious purchasing decisions.

1. Encouraging Sustainable Consumer Behavior:

The platform successfully influences purchasing habits by providing real-time environmental scores for products, enabling users to assess sustainability factors such as carbon footprint, recyclability, and eco-certifications. Studies indicate that immediate feedback on these metrics leads to significantly improved sustainable shopping choices compared to conventional eCommerce experiences.

2. Enhanced Decision-Making Through Environmental Data:

By evaluating products based on comprehensive sustainability criteria—including material sourcing, production emissions, and shipping impact—the system offers a holistic view of a product's environmental footprint. This structured approach

encourages consumers to consider a wider array of eco-friendly alternatives, promoting greener consumption habits.

3. Real-Time Performance and Scalability:

The backend infrastructure, built using Node.js, Express.js, and MongoDB, ensures high-speed processing of environmental scores even under peak user traffic, providing critical insights into consumer behavior, product trends, and sustainability score effectiveness.

4. Interactive and User-Friendly Interface:

The platform features an intuitive design that seamlessly integrates sustainability insights into product pages, checkout summaries, and recommendation systems. Users can easily navigate the platform to find eco-friendly alternatives, compare sustainability ratings, and make ethically responsible purchasing decisions without disrupting their shopping experience.

4. Contribution to Environmental Sustainability:

By steering consumers toward sustainable products, the system actively reduces environmental impact at a large scale. The data-driven approach provides businesses with valuable insights into consumer sustainability preferences, encouraging eco-friendly product development and responsible business practices.

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