

Optimising AI in e-commerce for sustainable production and consumption

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Abstract

The paper aims to investigate how artificial intelligence (AI) can promote sustainable practices in the e-commerce industry, particularly with reference to Sustainable Development Goal 12 (SDG 12): Responsible Consumption and Production, and to investigate how AI applications in e-commerce can be leveraged to create opportunities and address challenges related to SDG 12. This paper adopts a conceptual approach, drawing on existing literature to develop insights into AI applications in e-commerce and their impact on sustainability. Additionally, it also examines how leading e-commerce firms utilize AI to enhance the sustainability of their products and practices, deriving from the data from industry reports, company publications, and newspaper articles. The study found that AI has a significant impact on the sustainable practices associated with e-commerce through multiple applications. A large amount of overproduction activities leading to waste have been combated by using AI inventory and demand prediction management. AI promotes and encourages customers to involve in sustainable and environment friendly alternatives. Personalized recommendation systems motivate consumers to choose sustainable options by highlighting eco-friendly products. AI contribute in lowering negative environmental impact through reducing carbon emissions by efficient supply chains and logistics. AI driven solutions not only revamp product life cycle management, make the customers aware about sustainability but also reduces product returns and waste. These advancements demonstrate how AI can contribute to achieving SDG 12 by fostering more sustainable and eco-friendly e-commerce industry.

Keywords: SDG 12, AI Applications, E-Commerce, Sustainability, Responsible Consumption and Production.

Introduction

The e-commerce industry has seen remarkable expansion in the last ten years, profoundly shaping the consumer behavior and business operations worldwide (Grewal et al., 2020). The main drivers of this substantial growth are wider internet availability, seamless shopping experience, and the proliferation of mobile commerce (Campbell & MacDonald, 2024). More recently, the revolution in the e-commerce has been fueled with the advent of AI. The AI has enabled personalized recommendations, robust payment systems, seamless integration of social media platforms (Hussien et al., 2021). It is poised for greater innovations in future with continued benefits for both businesses and consumers. (George, 2024)

E-commerce provides businesses with advantages such as increased market penetration, reduced overhead expenses, easy access to customer data for customized marketing campaigns (Raji et al., 2024). However, e-commerce's rapid growth also raises significant sustainability concerns, including increased carbon emissions, excessive packaging, data center energy consumption, and promotion of overconsumption. These challenges highlight the crucial role of e-commerce in adopting sustainable practices and ethical business models to reduce its negative environmental and societal impact. As a result, the initiatives like carbon-neutral shipping, reducing single-use plastics and promoting eco-friendly products are growing at a faster pace (Singha et al., 2023). Promoting sustainability involves offering eco-friendly products, sustainable supply chains, and effective packaging and recycling (James & Kurian, 2021).

The transparent reporting of sustainability performance strengthens the trust and loyalty of customers. The UN's 17 Sustainable Development Goals (SDGs), adopted in 2015, provide a global roadmap for a sustainable future, addressing poverty, climate change, and inequality. One of the goals, SDG 12, "Responsible Consumption and Production" is particularly relevant to e-commerce. Specifically, SDG 12, "Responsible Consumption and Production," is highly relevant to e-commerce, emphasizing circular economy models, emissions mitigation, sustainable production, and waste reduction. In this context, it is essential to leverage the potential of AI technologies for streamlining the supply chain, optimizing resource utilization, and even projecting customer behaviour to minimize overproduction. Moreover, AI can facilitate more sustainable consumption patterns by recommending eco-friendly products and helping consumers make informed purchasing decisions. This paper aims to explore AI applications in e-commerce and their potential to contribute to SDG 12. The key objectives of the study are-

1. To examine the role of artificial intelligence in the context of e-commerce to promote sustainable practices in line with Sustainable Development Goal 12, Responsible Consumption and Production.
2. To investigate how AI applications in e-commerce can be leveraged to create opportunities and address challenges related to SDG12.

This study contributes to sustainability literature by examining AI's adoption and impact in e-commerce for advancing SDG 12 in India, addressing a gap identified by (Perera et al., 2023). Through its exploration of the under researched area, the study

provides a more comprehensive understanding of role of artificial intelligence in e-commerce in promoting progress towards a more sustainable future.

The study will introduce the theoretical background of sustainable e-commerce and SDG 12, review literature on AI integration, describe AI applications for sustainable consumption, and present conclusions.

Literature Review

Sustainability emphasizes meeting present needs without compromising future generations (WCED, 1987). AI's surge in e-commerce has transformed business operations (Rahman & Dekkati, 2022); (Sharma, 2023). AI powered solutions in e-commerce are emerging as a powerful enabler of sustainable practices (Nasir et al., 2023); (Song et al., 2019); (Shehadeh, 2024)).(Zborowski et al., 2024) emphasized analyzing ICT use, including AI and big data, across markets to assess its impact on sustainability goals. AI in B2B e-commerce supports sustainable supply chains, which traditional systems struggle to meet (Qi et al., 2023). Also, the study by (Kulkarni et al., 2024) emphasized that MSMEs are also leveraging AI to enhance social sustainability and concluded that technological advancements can improve business sustainability. Furthermore, (Haryanti & Subriadi, 2021) found that early-stage e-commerce adoption can benefit from sustainability incentives, highlighting the need for further research in developing economies. The research based on Indonesia, provides insightful information that may be used to create environmentally conscious and user-friendly e-commerce platforms. (Arman & Mark-Herbert, 2021) emphasizes how re-commerce can contribute to sustainable development in e-commerce. E-commerce can empower businesses and foster inclusive growth through sustainable practices and international collaboration (Raj, 2023). Moreover, (Bachmann et al., 2022) identified the significant gap between developed and developing nations in their ability to leverage AI for achieving the SDGs. While AI improves logistics and consumption tracking (Kwilinski, 2024); increased energy consumption, packaging waste, planned obsolescence, frequent replacements and logistics related emissions are serious environment concerns, (Sætra, 2021). (Nasir et al., 2023) found a trend where economic goals get priority and social and environmental aspects are neglected. Additionally, the research findings of (Sætra, 2021) reveal that the potential negative impact of AI within the broader social and technological context could be substantial. Achieving SDGs requires cross-disciplinary collaboration, ethical frameworks, and knowledge-sharing among academia, business, and policymakers (Carpentier & Braun, 2020), (Nasir et al., 2023).

Applications of AI in e-commerce to promote sustainable consumption and production practices (SDG 12)

Just as the advancements in technology have resulted in e-commerce boom, technology might hold the key for a sustainable future for this sector. The environmental impact of e-commerce contradicts the goals stated in SDG 12, demanding innovative solutions to bridge this gap. AI can transform e-commerce by optimizing usage of resources, minimizing waste, fostering responsible consumer

behaviour (Raj, 2023), (Haryanti & Subriadi, 2021), (Gupta & Singh, 2024). This section elaborates the applications of AI in e-commerce to support SDG 12.

Inventory Management and Demand Forecasting

Inventory management systems with AI capabilities can accurately project demand, which reduces waste and overproduction. Machine learning algorithms can be applied to estimate product demand by analysing past sales data, seasonal tendencies, and external factors like economic indicators ensuring optimum inventory levels (Chuang, 2018). The algorithms continuously learn and adapt as they gather more data, and in turn should calibrate their predictions about replenishment levels over time (Bala, 2012). Companies like Amazon and Flipkart use AI to optimize inventory levels and manufacture products based on actual demand, reducing excess inventory. As these firms extend AI decision making into the physical territory, they increase their productivity, reinforce their competitive profit-making strength, and help realize SDG 12.

Personalised Recommendations for Sustainable Products

The AI-driven recommendation engines can study the pattern of consumer preferences to determine the sustainable products with minimal carbon footprint and green alternatives, and recommendation for these items can be made (Vidhya et al., 2023). AI chatbots can address consumer queries related to sustainability characteristics of the product and recommend eco alternatives. AI can personalize post-purchase information, offer product care advice or guide repair and disposal options, thereby prolonging the product lifespan and reducing waste (Rana et al., 2022). For instance, online website Etsy use AI to gauge consumer behavior in conjunction with product meta-data in order to suggest sustainable products. Shopify and Myntra use AI- powered apps and plugins to tag sustainable products. Tata CLiQ uses AI tagging technology to make it easier for shoppers to locate sustainable options across an array of categories, including home products, electronics, and fashion.

Optimizing Logistics and Supply Chains

AI technologies are redefining supply chain management and logistics by increasing operational efficiency (Reddy & Khanna, 2024) and reducing the negative environmental effects. AI is also beneficial in computing the most efficient travel patterns shipping consolidation, which lowers greenhouse gas emissions and the number of trips required (Qi et al., 2023). By using predictive analytics, AI can foresee maintenance requirements and equipment breakdowns, improving machinery and vehicles efficiency and minimizing emissions and delays. AI solutions help businesses make intelligent logistics decisions by modelling and forecasting their impact on the environment. These benefits will help to create a more sustainable future for supply chain management and logistics. AI-driven supply chain solutions by IBM help companies like Unilever optimize their logistics operations that results in reduced energy consumption and lower greenhouse gas emissions. ITC and Mahindra Group use AI to improve its logistics and transportation services, vehicle utilization, reduce empty miles, and lower fuel consumption. As a result, both emissions and operating expenses are reduced.

Reducing Returns and Associated Waste

By analysing data from past purchases, reviews, feedbacks, product specifications, AI can help customers make informed decisions, reducing the chances of returns due to unfulfilled expectations which builds trust and loyalty and thus results in fewer returns (Yang & Lin, 2022). Applications like augmented reality (AR) and virtual fitting rooms significantly improve the shopping experience. For instance, users can perceive how clothes will fit on their bodies in virtual fitting rooms, and even see furniture or home decor items in their own spaces using augmented reality applications. These AI-driven solutions significantly lower the chance of returns and mitigating these environmental effects (George, 2024). Companies like Zalando, ASOS and Myntra use AI and AR to offer virtual try-ons, helping customers make better purchasing decisions and thereby reducing return rates.

Enhancing Product Life Cycle Management

IoT devices collect data throughout the lifecycle of the product, from production to disposal, by continuously monitoring and analyzing data at each stage. Sensors embedded in products and manufacturing equipment's provide real-time data on usage, wear, and disposal. Big data analytics assists the discovery of trends and machine learning algorithms analyze the lifecycle stages of the product, suggest areas for improvement in design for recycling, and optimize supply chain processes. AI can ensure that recycled materials are effectively reintegrated into production processes, further minimizing environmental footprints. Firms across industries like Patagonia, Tata Chemicals, Godrej Appliances, ITC Limited, and Titan Company employ AI to analyze the lifecycle of its products, ensuring they are designed for durability and recyclability.

Consumer Education and Engagement

There is a need to significantly promote consumer education and engagement by providing detailed and customized information about environmental consequences of their purchases (Villa et al., 2023), (Raji et al., 2024). AI driven chatbots and virtual assistants are immersive tools that educate consumers about sustainability of the product. AI systems use Natural Language Processing (NLP) to understand and respond to customers queries regarding product components, manufacturing processes, and environmental effects and enhance customer engagement, thereby contributes to waste reduction, resource efficiency, and responsible consumption and encourages producers and consumers to endorse eco- friendly practices. The well-known Indian retailer of handcrafted goods, Fabindia, AI to draw attention to the ethical and environmental features of its products. Applications powered by AI is used by Ayurvedic skincare firm Forest Essentials offer instructive material about the social and environmental effects of utilizing Ayurvedic and sustainably sourced products, encouraging conscious consumption

Combating Food Waste

The focus of SDG 12 is securing sustainable patterns of consumption and production that requires a strong effort to combat food waste. AI-driven technologies present

creative ways to efficiently combat food waste, sustainable consumption in the entire value chain, from farmers to consumers (Marvin et al., 2022). AI tools help users remember about items that are about to expire and recommend their timely use or disposal thereby encouraging sustainable consumption habits (Onyeaka et al., 2023). BigBasket, an online grocery provider uses AI driven predictive analytics towards effective inventory management and seeing to it the risks of overstocking and also perishable goods management. Grofers uses artificial intelligence to enhance efficiency and optimize inventory control. Natures Basket, a high-end grocery store chain leverages intelligence technology to enhance inventory management and maintain the freshness of its products.

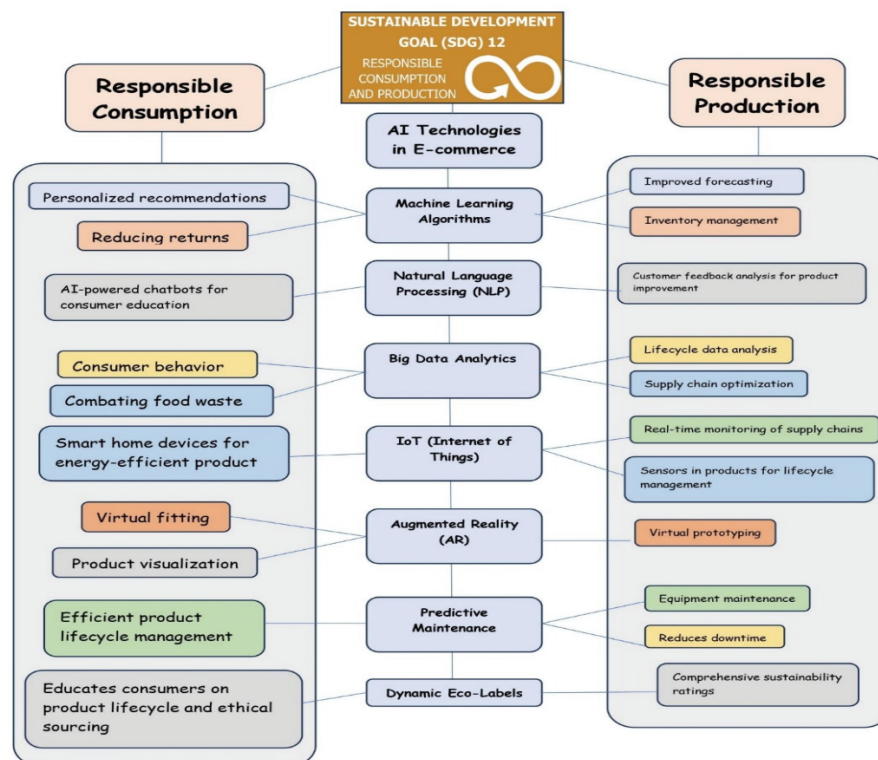


Figure 1: AI technologies in e-commerce (Source: Created by authors)

Optimising Energy Usage

AI has the ability to significantly improve the use of energy, at data centers—an aspect of e-commerce infrastructure (Awada et al., 2014). Artificial intelligence makes an important contribution to energy efficiency through its capability to anticipate and adjust patterns of energy use in data centers, warehouses, and retail spaces providing a noticeable net benefit to energy savings. Improvements in energy efficiency contributes to a net reduction in resource use and greenhouse gases for e-commerce organizations through reductions in TOTAL carbon footprints (van Wynsberghe, 2021). Reliance Jio and TCS, a significant telecommunications service provider and digital services, utilizes AI to reduce energy usage in its data centers.

Flipkart uses AI to predict peak hours so that the warehouse cooling equipment can efficiently maintain appropriate temperature with decreased energy consumption.

Conclusion

In the context of e-commerce, AI is becoming a key element in promoting sustainability aspects that corresponds directly with SDG 12 (Responsible Consumption and Production). SDG 12 promotes responsible production and consumption at all levels of the value chain. AI applications can help e-commerce companies to lower operating costs and environmental impact, optimize supply chain and inventory while being eco-friendly, increase customer satisfaction by providing personalized, green recommendations that improve reputation among environmentally conscious customers. The implementation of AI in the e-commerce sector can be advantageous for individual companies, but also aims at macroeconomic and environmental goals collectively. In summary, artificial intelligence (AI) offers e-commerce businesses an opportunity to accomplish SDG 12, contribute to a more sustainable future, and potentially open up economic opportunities for all. This research provides a road map for e-commerce companies and policy makers to utilize AI's potential, which will subsequently strengthen the global economy and advance sustainability.

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