Journal of General Management Research Vol. 11, Issue 1, July 2024, pp. 33-45

**JOURNAL OF
GENERAL MANAGEMENT RESEARCH**

THE FAST FASHION INDUSTRY: GROWTH, CHALLENGES, AND SUSTAINABILITY CONCERNS UNDER THE NEW ERA OF AI

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Abstract

Despite its economic growth, the fast fashion industry has become a major cause of environmental deterioration because of waste, overproduction, and unfair business practices. This study investigates how combining artificial intelligence (AI) and predictive analytics can revolutionise the apparel industry's pursuit of sustainability. The study explores how predictive tools help fashion brands to precisely predict consumer demand, optimise inventory, and decrease unsold stock by utilising a wealth of literature, case studies, and industry data. The promise and paradoxes of adopting AI are demonstrated by real-world examples from Shein, ASOS, and H&M. Although these technologies increase productivity and decrease waste, they may also speed up consumption or mask more serious sustainability problems. The study points out important deficiencies in longterm impact analyses, scalability for SMEs, and ethical oversight. It comes to the conclusion that although predictive analytics presents a strong case for more environmentally friendly fashion, real change necessitates open accountability, equitable access to technology, and implementation that is socially conscious.

Keywords:
Fast fashion industry, Sustainability, environment, consumer demand,(SMEs).

1. *Introduction:*

In The fashion industry has joined the ranks of one of the fastest-developing industries in emerging markets, with a projected worth of up to $1.8 trillion globally. Such phenomenal growth has been driven by a turn in consumer trends, digitization, and the emergence of fast fashion (Guide & Cardona, 2025). This phenomenal growth of the industry has come with critical issues, ranging from inefficient supply chains to the growing pressure to fully adopt sustainable practices. The most serious of these environmental issues is annual waste: Currently, about 92 million tons of textile waste is produced each year and is expected to reach 134 million tons by 2030 (Igini, 2023). Much of this waste is due to overproduction, in which clothes are sent to the landfills without ever being used. It is also due to the fast pace of the trend cycles that shorten the life cycle of fashion products and create extremely high demand for new merchandise at an unsustainable speed. Among fast fashion brands, this problem has an acute contribution of giving rise to the environment by making great quantities of affordable clothes and throwing them away almost as soon as they are purchased. As sustainability increasingly becomes an issue for consumers and policymakers alike, the need has never been greater for the fashion industry to rethink its production and consumption models. According to the European Environmental Agency (2024), textile production is one of the top five most environmentally damaging sectors, causing not only high water consumption and CO_2 emissions but also significant microplastic pollution.

The goal of this paper is to review the possible harness of fashion forecasting analytics to address these obstructions. Predictive analytics, driven by AI, big data, and machine learning, empower fashion brands to forecast consumer demand with higher accuracy. Hence, these technologies will lead to a data-based approach toward optimizing production as well as waste reduction by analyzing consumer trends, purchase behaviors, and demand patterns. Fashion industry trends that are emerging are a result of the ever-growing demand for such innovations. H&M's move to begin AI-powered modeling ignited debates regarding the technology's place in retail (Bain, 2025). Similarly, AI adoption by Shein and Asos introduces a paradox of hope and sophistication into fashion retail (Rajvanshi, 2024). The study will illustrate how predictive technologies can be used to augment brand innovations in product lifecycles, material sourcing, and inventory management. The question is whether as a result these innovations will contribute to advancing sustainability objectives or will exacerbate the existing overproduction cycle.

2. *Literature Review*

2.1 *Sustainability Issues in Fashion and Overproduction*

In 1990, this industry started growing in order to create more rejection towards nature. The European Environmental Agency in 2024 mentions the fashion industry as one among the five industries least envied by nature. If overproduction is a huge market contributor to the issue, then production puts in its consideration too. Poor forecasting of demand, very short fashion cycles, and customers' pressure to have something new all the time create a systemic waste. It is said by Igini (2023) that over 30% of garments made every year are never sold. Hence, these items are disposed of into landfills, causing wastage, excessive carbon emissions, and water wastage in that respect of the production cycle. In addition, fast fashion always sells for lower prices is sustained by this unsustainable linear sort of production and consumption. Consumers benefit from its cheap prices and trendy accessibility at the expense of ecosystems and marginalized labor markets.

2.2 *Predictive Analytics and AI in Fashion Retail*

The fast fashion sector- and the fashion industry as a whole- have begun to put their existing business model under strain; hence, A.I. and predictive analytics have emerged as potential solutions. Predictive Analytics simply means understanding future consumer behaviour by distilling past and real-time data. This knowledge would assist in adjusting production, design, and inventory levels to avoid overproduction. Extensive studies on AI adoption in the fashion industry between 2010 and 2022 were documented by Silva in 2023. The results testify to a phenomenal growth trend in the adoption of AI-enabled tools for trend foresight, sales optimization, and user engagement. ML models utilize datasets from e-commerce websites and combine them with weather datasets and social media, engaging in insight generation of current consumer trends. According to the research done by Okeleke et al. (2024), AI-enabled forecasting Tools could predict with 80-90% accuracy on seasonal demand and style preference. Such an accuracy level becomes

ISSN 2348-2869 Print
ISSN 2348-5434 Online

paramount to waste mitigation. Granular foresight gives an agile stockist who can immediately service his product to meet actual demand rather than guess.

2.3 *Case Studies and Industry Applications*

Some fashion brands have started to integrate AI into their operations for the betterment of sustainability. An example of this is Refabric, a startup under the LVMH incubator program, which is using instant digital sampling technologies to limit overproduction during the design phase. Wasting less in this way helps facilitate the speed of conceptualization to collection and minimizes the need for physical samples. But with that, challenges arrive in the application of AI in fashion. According to an article published in Time magazine (Rajvanshi 2024), with respect to rapid adjustments to consumer demand and listing hundreds of products on its platform, Shein is said to use AI-supported algorithms. Whereas this might prevent wastage in inventory through demand prediction, it may also cause overproduction and encourage overconsumption if not controlled responsibly. Critics argue that, if fastened without a stringent set of ethical and environmental standards, the solution set powered by AI will create more sustainability issues for fashion. (Rajvanshi 2024) (Silva 2023)

2.4 *Identified Research Gaps*

Gaps in our research respond to the various ways in which predictive analytics and AI can be utilized to enhance sustainability:

- ***Long-term Impact Assessment:*** Long-term research assessing the long-term impacts of their interventions on preventing overproduction and waste in the fashion industry should be conducted using AI technologies.
- ***Ethics and the Environment:*** There is a need for further studies on how AI technology's ethical implications and environmental effects occur within its use within the fashion sector (Bain, 2025) and ensure that utilizing these tools would not inadvertently boost overproduction.
- ***Integration with Regular Practice:*** Minimum evidence exists documenting the ways of incorporating the paradigm of predictive analysis within the mainstream fashion design and manufacturing processes.
- ***Scalability and Accessibility:*** There are not many publications on applications being scalable for small and medium-sized enterprises (SMEs) in the fashion industry, resulting in a greater need for creating accessible, simplified, and affordable technologies.

Thus, if predictive analytics and AI are applied to tackle overproduction and waste, opportunities would arise to help more strongly integrate sustainability in fashion. Focusing on these observed gaps will be critical to developing applied, ethical, and sustainable solutions for the fashion world in the future.

3. *Understanding Fast Fashion and Its Implications*

3.1 *The Fast Fashion Business Model*

Fast fashion is quick design, quick manufacture, and quick distribution of fashion goods made to suit the trends from catwalk or celebrity apparel-oriented influences. Companies like Zara, H&M, and Uniqlo have pioneered this format by creating collections that are fast and cheap. For fast fashion business models, new styles take two to six weeks to appear on shop shelves. To put it all in perspective, a traditional fashion calendar takes much longer, about 2 to 2.5 times longer. The model is totally reliant on long supply chains located around the globe and cheap labor. The business model works successfully since it generates horrendous amounts of cash in sales- the model generates billions in profits- whereas technically it fools us all at the cost of the environment due to the immense amount of overproduction that leads to mass waste of products, not even taking into account the textile and resource depletion worldwide.

3.2 *Environmental and Social Impacts*

The environmental costs that fast fashion incurs are enormously varied and hidden in the supply chains. This part of the business for global fashion is also among the largest consumers of water, since garment production processes, especially dyeing and finishing,

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consume billions of litres of freshwater every year (United Nations Environmental Programme, 2018). An example according to Ro (2020) reports that approximately 10,000 litres of water during a pair of jeans' life span are used. Many brands, to combat this impact they have on the environment have found ways to ensure reduced usage of water, one of them being Uniqlo. (Hardcastle & Kemp, 2024) The fast fashion industry is responsible for about 10% of the world's carbon emissions, higher than the total of international aviation and shipping emissions combined (UNEP, 2023). Low-cost production technique and use of synthetic polyester, additionally, still release microplastics into oceans and bodies of water with every wash, facilitating long-term contamination problem that includes marine life and human well-being in the food chain. Socially, fast fashion has been condemned for the perpetuation of the current exploitative labor system. Gunawan et al.(2023) The garment workers of the majority of developing countries suffer under humane working conditions with little supervision, deplorable compensation, and few safeguards from labor legislation. Besides all these systemic problems that already had been exposed in the infamous Rana Plaza disaster of 2013 in Bangladesh (Gunawan et al., 2023), most brands persist with the practice of subcontracting their contract manufacturing to suppliers who never cared about good labor practices. Cosmopolitanism and fast turnarounds often mean flagrant violations of labor and children's rights and forced overtime. Such double environmental and social externalities provide a strong testimony of the absolute necessity for a revolutionary reshaping of fashion that harmonizes cheapness and access with ecological stewardship and human dignity.

3.3 *Sustainability Initiatives by Leading Brands*

Over the years, brand fast-fashion has turned its attention towards implementing sustainability campaigns. The Conscious Collection by H&M comes from garments that are either recycled or sustainably sourced (H&M Group). Zara promises that by 2025, it will have completely converted to 100% sustainable fabrics (Conlon, 2019). Uniqlo has introduced various initiatives in its recycling process, claiming that the designs it produces have longevity in mind (Hardcastle & Kemp, 2024). On the other hand, many critics say that such initiatives are only for show and behind-the-scenes sunlight manipulations. There is almost zero visibility on the production volumes, carbon emissions, and progress around sustainability-related goals. (United Nations).

4.*AI Advancements in Fashion Forecasting*

4.1 *Integration of Big Data and AI*

The fashion industry can now access new applications through AI human technology that goes beyond recommendation engines and chatbots. The development of trendy forecasts as well as demand forecasting activities has made big data their central focus. Customer preferences result from the algorithm which analyzes various complex interconnected factors between search trends and sales analytics while including social media expressions and meteorological conditions. New data entries enable the system to implement Machine Learning technology that detects pattern changes in its forecasting procedures. The fashion trends are extracted from social media sites through NLP analysis which finds new trends by tracking popular blog mentions and using TikTok and Instagram hashtags that can affect mainstream retail consumption. The tactical connection between brands and social media provides market understanding needed to develop products which meet future customer requirements.

5. *Case Studies- Reducing Overproduction Through AI*

5.1 *Shein's Real-Time Analytics Model*

Shein's technology-driven strategy is a quintessential illustration of the ways in which AI can disrupt inventory and manufacturing management in the fast-fashion space. (Santa Rosa Lana & Afonso Brardo Duarte, 2025) Part of the bedrock of their strategy is a micro-batch manufacturing system that is powered by real-time customer feedback. Items are released in tiny batches and rigorously overseen through algorithmic analysis of user interaction, search patterns, and sales. If the product has a fairly good acceptance, it is replenished in a prompt way; otherwise, it is discontinued altogether. This demand-based reaction minimizes risks associated with overproduction bulk, significantly reducing waste in inventory, while sell-through rate is enhanced (Santa Rosa Lana & Afonso Brardo Duarte, 2025). In addition, Shein's in-house AI technology is programmed to analyze enormous sets of data such as

ISSN 2348-2869 Print
ISSN 2348-5434 Online

browsing history, click-through rates, and local trends to facilitate hyper-localized forecasting. This enables Shein to align supply with a granular, geographically localized demand. While the brand continues to come under fire for opaque labor practices (Gunawan et al., 2023) and environmental effects, its application of AI to prevent overproduction represents a significant departure from traditional fast fashion models that prioritize scale over accuracy.

5.1.1 A Case Study of Shein - The Pinnacle of AI-Fast Fashion and Its Sustainability Imbroglio

SHEIN is a China-based ultra-fast-evolving fashion brand that stands for quick, tech-infused consumerism. From 2008 to date, the brand has managed to disrupt the fashion scene with an unmatched combination of AI-turned prediction of emerging trends, a solid supply chain, and, of course, active social media marketing. Today, Shein is ranked as one of the world's biggest digitalfirst fashion retailers, boasting an annual revenue of over $30 billion (as of 2023), outstripping most other traditional brands in growth and reach.

5.1.2 AI and Trend Prediction at Scale

Artificial Intelligence is one of the highlighted strategies in Shein whereby this company tends to keep a tab on what the consumer wants and makes an attempt to predict future demands. Real-time data pertaining customers are composed from search engines, Instagram and TikTok, competitor brands' websites, and their application activity. The data are then processed using an AI-ML model that identifies the microtrends at early stages of becoming trends. However, while most traditional fashion brands use incessant cycles of designs throughout the seasons, Shein actually introduces hundreds of designs each day. Thousands of SKUs are produced each day by designers; AI grades what snips ends up producing on a small scale. If a product is successful, the company will scale production within days. This model is popularly called trial and error.

The system of inventory that is computerized shrinks the incidence of overproduction to a minimum absolute extent while maximizing consideration for customer needs. But it also speeds the consumption cycle and inspires a culture of disposability in clothing, making people regard clothing as something temporal.

5.1.3 Shein's Supply Chain and Labor Controversies

Local reports, such as Channel 4 and the Public Eye, exposed shocking information regarding the factory conditions in China where most of Shein's employees work:

- Most of the employees work beyond 75 hours a week, which is not within China's limits.
- In some cases, there are neither contracts nor forms of protection for the workers.
- Places have no ventilation, no fire exits or basic safety provision.
- Despite the tremendous profits that Shein makes from worldwide sales, salaries remain very low.

Furthermore, it has been shown that Shein passes through a dispersed chain of suppliers, which are difficult to hold accountable for the same ethical standards. The subcontracting and lack of transparency allow everything to be hidden under the carpet. The issue of forced labor is also raised by the country's Muslim community, especially the Uyghurs from Xinjiang. Though Shein has denied the allegations, the non-traceability of its supply chain raises eyebrows among global watchdogs. Forced labor concerns have also been raised, particularly against the Uyghur Muslim community from the Xinjiang region. Although Shein denied direct involvement, the lack of traceability along its supply chain has raised red flags with global watchdogs.

5.1.4 Environmental Costs: Fast and Disposable

Shein manufactures as many as 10,000 new garments every day, most of them made from plastic, mainly polyester, which has been deemed a fossil fuel. This adds to the ever-increasing carbon footprint for the brand while adding to microplastic pollution. While the ordinary fast fashion industry sells seasonal stuff, Shein put itself into a business model system of perpetual demand, one of the leading contributors to textile waste. As reported by Greenpeace and Earth.org, on average, Shein clothes have a very short lifespan, with items being worn only a few times before they go to the landfill. Less than 1% of production is recycled, to be honest. They have tried to promote a resale and recycling program in 2023,

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ISSN 2348-5434 Online

but critics allege these measures are just greenwashing with little actual impact.

5.1.5 Global Regulatory and Legal Scrutiny

The patterns of Shein's business have been started to be viewed under the regulatory lens-off late with the US Congress as well as European Union. Criticism has mounted in the US against the custom loopholes which have allowed the company to avoid tariffs and inspections under the de minimis import rule, whereby goods under $800 are exempt from inspections. This loophole has allowed Shein to saturate the US market with cheap goods and at the same time shield the company from complying with labor and environmental requirements. In 2023, a bipartisan group of US lawmakers requested probes into Shein's alleged use of forced labor and environmental abuse. Similarly, one can see the EU pushing for stricter Digital Product Passports and ESG disclosures, which would force businesses like Shein to open up on their supply chains, labor practices, and sustainability metrics.

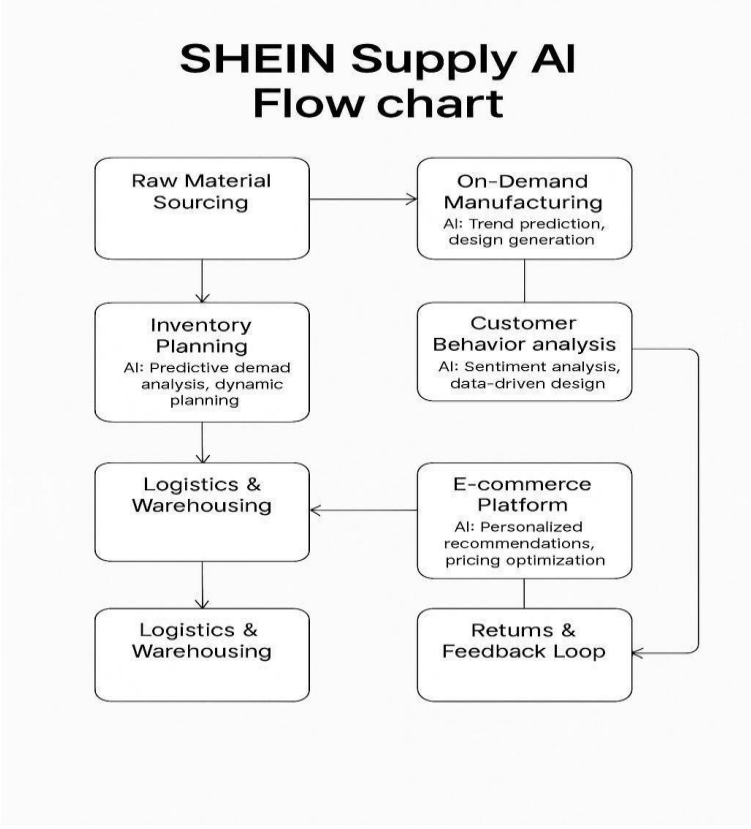

Figure 1: SHEIN AI-integrated supply chain model. Source: Created by the author.

5.2 *ASOS and Predictive Inventory*

ASOS employs advanced machine learning algorithms to analyse vast datasets encompassing customer purchase history, browsing patterns, and real-time feedback. These tools help forecast the popularity of various product attributes such as size, fit, style, and colour—allowing ASOS to make data-informed decisions on inventory management (Silva, 2023). By aligning supply with consumer preferences, the brand significantly reduces excess inventory, reducing the likelihood of unsold products, markdowns, and the associated waste. In addition, ASOS integrates AI into its logistics operations to streamline packaging and distribution. The system suggests optimal packaging sizes based on order combinations, which minimises the use of packing materials and reduces shipment volume. Furthermore, AI-driven route optimisation ensures energy-efficient delivery paths, helping the company lower its carbon footprint in the last-mile delivery phase. These innovations underscore ASOS's commitment to using technology to enhance customer experience and support environmentally responsible operations. ASOS has rapidly evolved into a data-first retailer by using predictive analytics and artificial intelligence (AI) across all its operations to further enhance sustainable operations. ASOS does business in over 200 markets and has millions of active customers -26 million as of October 2023 (ASOSplc, 2023), all of which complicates things for the company to maximize inventory management and reduce waste while working toward meeting its environmental and ethical commitments. In turn, the company has machine learning algorithms and sophisticated analytical templates entirely integrated throughout the value chain- from design through delivery forecast fashion trends and building a more agile and eco-business.

5.2.1 AI-Powered Demand Forecasting and Inventory Management

ASOS compiles billions of customer behaviours, returns, weather, product searches, and social trends data points to precisely calculate demand and apply predictive demand algorithms to identify what would be a bestseller and adjust production accordingly. As ASOS's Tech Blog (2023) states, the firm set up a "demand forecast optimisation engine" in its fulfillment centers, which cuts down understock instances by 21% and overstocking by 35%. A good

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ISSN 2348-5434 Online

case in point was last summer's season 2022, where ASOS anticipated a surprise spike in demand for resort wear shortly after the relaxation of COVID-19 travel bans, using AI. Rather than the conventional 12-week lead time, AI-driven demand signals now allow designers and suppliers to so within less than 4 weeks- cutting waste by 18% and improving on-time delivery by 24% (ASOS Sustainability Insights, 2023).

5.2.2 Decreasing returns with Predictive Sizing and Fit Tools

Returns have turned into a severe sustainability issue in e-commerce fashion. ASOS mentioned that nearly 25% of all orders are returned, primarily due to size. In the battle to conquer returns, ASOS has used AI-driven size products like Fit Assistant, employing machine learning and customer data to inform best-fit recommendations based on previous or other buys, age, weight, and body type. In a pilot conducted by ASOS in early 2023 across Germany and the UK, the conclusion was that the device resulted in a decrease in sizing-related returns by 11.2%. This decrease then leads to hugely lower emissions in reverse logistics and approximately 260 tons of CO_2 in six months (ASOS, 2023 ESG Report).

5.2.3 Virtual Sampling and Eco-Design with Data-Driven Insights

ASOS has explored virtual sampling and 3D modeling for minimizing the utilization of physical prototypes, which primarily contribute to textile wastage. Designers utilize CLO 3D agnostic AIcreated trend data for visualizing and iterating on products prior to entering into final production. In 2023, ASOS released a capsule collection that was completely prototyped virtually. The firm achieved more than 12,000 liters of water and 1.8 tons of material waste savings from the sample stage alone (Fashion Innovation Alliance, 2023). Earthy predictive analysis framework directed ASOS to sustainable material performance in terms of styling and markets. Organic cotton jeans were expected to catch on in France and Germany; therefore, ASOS finished the final meta-communication planning and logistics with production. Accordingly, the increase in eco-friendly jeans in both markets was set to be 19% by 2023. Supplier mapping and due-diligence compliance help in employing Natural Language Processing (NLP) and anomaly detection models to analyze reports from supplier submission, social media signals, and labor compliance audits executed by ASOS to ensure transparency in supply chains. The company then uses AI in monitoring compliance through the Open Apparel Registry for more than 1200 supplier factories around the world. In 2022, a 'Supplier Scorecard System' was been established by ASOS, which would evaluate environmental and ethical scores of factories based on predictive indicators such as energy indicators, water-use trends, and history of violations. As such, higher risk factories are subjected to excessive scrutiny and audits. This resulted in an obtained value of 12% incremental annual improvement (Ethical Trading Initiative, 2023).

A whole level of innovation has been introduced in terms of sustainable packaging and logistics AI. Machine learning is also used in effectively overcoming warehousing and logistics matters within ASOS, optimizing for maximum packing size for every delivery so that wastage is minimized every time. In 2023, the company launched the Right Pack, which is AI-enabled as a further way of ensuring order quantities match even further packing sizes, leading to size reductions of unnecessary boxes by 22% and packing material by 31%. Last-mile networks opened their arms to routes delivered from predictive routing networks that considered traffic, weather, and delivery density in determining minimal carbon routes. According to the ASOS Climate Strategy Report (2023), this function results in a 9 percent emissions reduction coming from delivery, equivalent to taking about 1,500 delivery vans off the roads.

5.2.4 Conclusion

Predictive analytics have offered ASOS measurable improvements in both business performance and environmental impact. ASOS's use of predictive AI tools to enhance demand forecast accuracy, increase return efficiencies, digitize product development, and monitor ethical sourcing means it is well on its way to changing fast fashion into responsible fashion. However, unresolved issues remain, including developing fit algorithms across all shapes and sizes, enabling transparency for third-party logistics, and balancing innovations and consumer privacy. But the larger view is evident: data-centric sustainability is not a buzzword but the beginning of a paradigm shift. The movement towards net-zero emissions by 2030 and using 100% recycled or sustainable materials by

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2025 is entwined with investment in predictive technologies at ASOS.

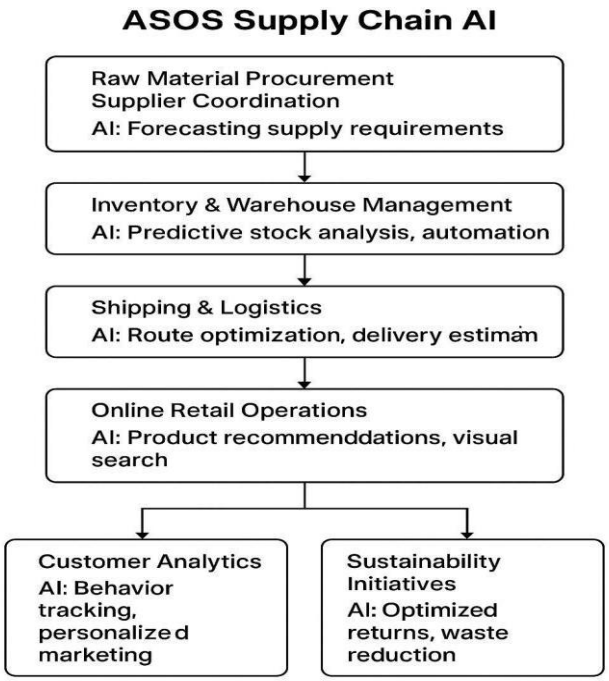

Figure 2: ASOS AI-integrated supply chain model. Source: Created by the author.

5.3 *H&M*

H&M has made immense progress in using AI to enhance its decision-making processes across the supply chain. The company employs a team of over 200 data scientists, analysts, and engineers who analyse data from various sources, including store receipts, returns, loyalty card data, blog posts, and search engines. This data-driven approach allows the brand to predict trends with high accuracy, helping H&M stay ahead of the curve in an industry that thrives on rapidly changing styles. For example, by analysing data from 5 billion visits to its stores and websites annually, H&M's AI algorithms can forecast fashion trends three to eight months in advance, allowing the company to plan its inventory and pricing strategies better. This predictive capability supports profitability and plays a crucial role in reducing overproduction, thus minimising waste. Moreover, in a pilot project at a store in Stockholm's Östermalm neighbourhood, AI-driven insights led to a 40% reduction in stock-keeping units (SKUs) (Alaimo, 2018), which helped streamline operations and improve sales performance. Though specific sales figures were not disclosed, this outcome demonstrates the potential of AI to enhance operational efficiency. H&M has also integrated AI tools for visual trend analysis and virtual modelling, significantly reducing the need for physical samples in the design phase, thus minimising the environmental toll of traditional prototyping.

Looking towards the future, H&M is focused on sustainability goals that align with its AI-driven efforts. The company aims to use 100% recycled or sustainable materials in its products by 2030 (H&M Group, n.d.), and AI plays a pivotal role in assessing the environmental impact of raw materials. By leveraging advanced machine learning algorithms and scalable data infrastructure in partnership with Google Cloud, H&M is improving inventory accuracy and supporting its commitment to sustainability. These efforts underscore a more profound shift toward a datadriven, sustainability-conscious retail model that seeks to transform fast fashion from a wasteheavy system into a more agile and responsible industry. H&M is taking artificial intelligence a step further. All improved supply chains have become associated with decision-making at H&M. The strongest treasure for about two hundred of H&M's data scientists, analysts, and engineers underwrites all forms of in-store return receipts- from loyalty card information to blog-entry data and gifted search engine data- to analyze it all. This led to the style-like forecasting of impending trends so that H&M remains ahead of this superchanging mega-trend environment. For example, the algorithms built with AI will analyze data from 5 billion visits to the stores and websites and be able to predict fashion trends five to eight months ahead to enhance inventory and pricing decisions. It is, on the other hand, predicting revenues and eliminating excessive production and, therefore, waste. Another pilot that this store had in Östermalm in Stockholm indicated that insights from AI increased sales by about 40 percent (Alaimo, 2018), thus considerably improving operations and sales performance. While it may be obscure in specific sales numbers, there is much to suggest that AI may well work to enhance operational efficiencies. Whereas H&M is not using AI in visual trend analysis and virtual modeling combined with some physical sampling during the design phase, this is ultimately an effort to reduce the environmental footprint associated with traditional prototypes. Long term, H&M's sustainability directives will be part of its AI initiatives heading into 2030, to get 100 percent

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of its products either fully recyclable or sustainably graded (H&M Group, n.d.). AI is the most crucial step in monitoring the environmental impact of raw materials. Right now, H&M is scaling for data infrastructure and advanced machine learning algorithms along with Google Cloud under the method of footprinting the environmental impacts of raw materials. These are the first steps along a deeper, broader change to a data-first and sustainability-driven retail model that will change fast fashion from a waste-driven model into an agile and responsible industry.

5.3.1 Inventories and the Forecast of Requirements

H&M foresees a bright future in real-time replenishment stocks. The data feeding into H&M's AI systems feeds from local events, weather forecasts, social media opinions, and previous purchase behavior rather than prescriptive schedules or historical data. Such predictive analytics thus allowed H&M to launch a machine-learning-assisted system for piloting stores in Europe since 2022, recommending automatic restocking, abandonment, or markdowns of items. Predictive analytics, according to Retail Dive (2023), has so far achieved reductions in overstocking to the tune of more than 28% and increased stock turnover by 17% in the first year of application. To put into practice the funding of geospatial analytics as enhancing sustainability in sourcing and supply chain decisions, H&M will utilize some bucks. Jointly with Google Cloud and WWF, H&M has begun finding some sustainability assessments for cotton, viscose, and even wool in selected geographical areas worldwide by integrating Environmental Impact Data. Because of this program, H&M has been able to take approximately out 35% of its cotton sourcing from high-stress water zones into sustainable regions. This aids in water projected savings to be over 10 million liters per year (H&M Sustainability Report 2023).

5.3.2 Optimizing Returns, Prototypes, and Sampling

In H&M's online shopping platform, these AI-offered size and style recommendation tools reduce the opportunity for mismatched purchases. H&M's "Perfect Fit Predictor" was rolled out in 2023 and received a launch in 80% of its e-commerce markets around the globe, using body scan measurements and previous return analyses to achieve an 11% drop in returns (McKinsey, 2024). Traditionally, brands would have prototyped the product several times physically and then approved it to go into real production. The AI-enabled virtual modeling software is set to save the designers in H&M time creating their garments physically, doing this in a very realistic way by simulating draping, movement, and material behavior. Such a trial was done in 2023 for Conscious Choice Collection, which consumed about 70% fewer physical samples, saving approximately 45,000 liters of water and preventing 2.4 tons of textile waste from being produced over 12 SKUs (Sustain Your Style Journal 2023).

5.3.3 Circular Product Life and Smart Tagging

The launch just recently in the H&M facility in Sweden was a smart tagging with blockchain technology in 2023, by Worn Again Technologies. Such tagging allows for the tracking of the garment throughout its entire lifecycle. Scanning will deliver care information on the garment and slots for recycling. Over 10,000 items were processed in the six-month pilot, with 87% success in diversion from landfill (H&M Foundation, 2023).

5.3.4 Data-Informed Ethical Sourcing and Local Success Stories

Ethical sourcing by H&M was in place before the time of feasible use of predictive analytics. Anomaly detection finds its place on global supplier networks through natural language processing and warns against risk related to any node in the system. Based on the 2023 Fashion Transparency Index, H&M ranks fourth out of five global leaders when it comes to reporting ethical information and hence by proving an increasingly data-driven compliance systems approach. Other such cited case studies are the Tiruppur in India, where AI-powered forecasting enabled the reduction of waste during production by 22%. Another shift supported by AI-powered forecasting was a two-week reduction of delivery time towards an efficient, sustainable value chain.

5.3.5 Personalized Marketing and Sustainable Shopping Behavior

Now, AI personalizes messages and deals. Wardrobe integration solutions belong to this group. The markets where AI would dress wardrobes boost

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basket value by 12% based on H&M (H&M Internal Marketing Analytics Report, 2023). Above all, these suggest a kind of support for sustainable shopping or suggesting fewer but necessary items based on current wardrobe information.

Summary and Conclusion

Viewing this through its prism, H&M asserts that this analytics forecast has become nigh unto the revolution of sustainability or flexibility in the world of customer-centricity. H&M forms a case of data as the new cloth of fashion by predicting needs with accuracy and cutting back inventories of leftover items in ethical sourcing or product recycling. With all materials sustainably sourced or recycled in their 2030 target and H&M climate positive by 2040, all this would not have been achievable without having AI and machine learning integrated at all nodes of the value chain. Unbeknownst to them, however, are data privacy concerns and algorithmic ethical regulation alongside a digital divide within their supplier universe! Either way, positive possibilities are plentiful. H&M has proved to the world that predictive analytics is not only a technological advantage in the future; it believes it is becoming a norm in establishing an industry of fashion prioritizing responsibility as much as profit.

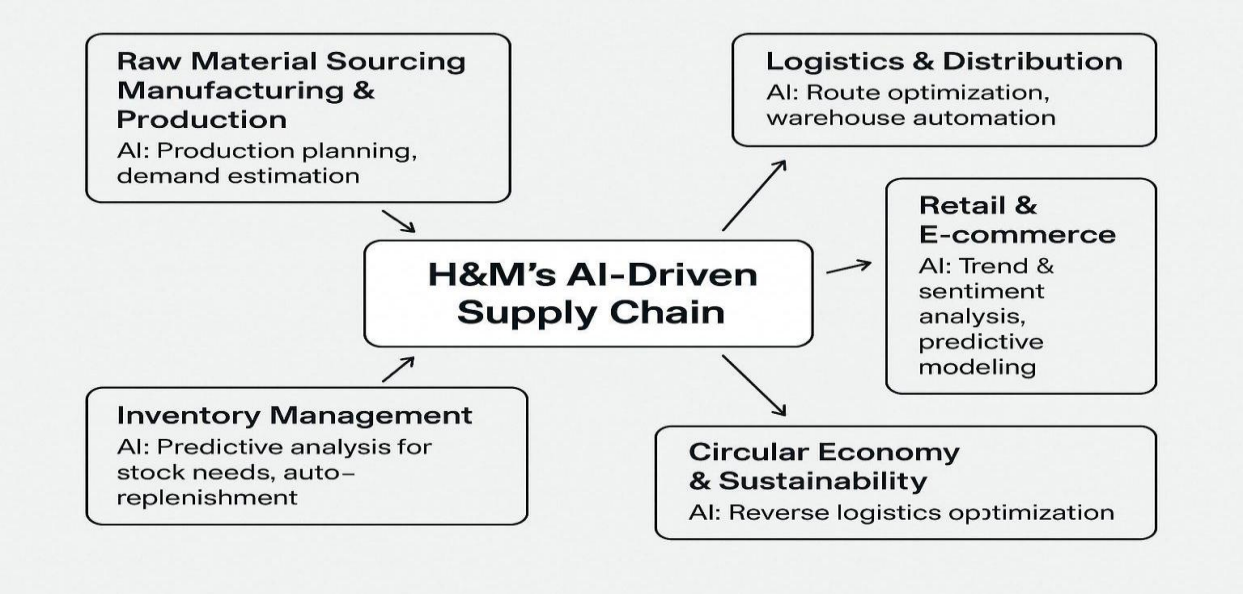

Figure 3: H&M AI-integrated supply chain model. Source: Created by the author.

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Company	AI Usage	Sustainability Efforts	Challenges
H&M	**Inventory Management:** Utilizes AI to analyse sales data and predict fashion trends, optimising stock levels to meet customer demand. **Customer Service:** Employs AI to analyse customer inquiries and feedback, enhancing product recommendations and support.	**Waste Reduction:** AI-driven inventory management aims to minimise overproduction. **Sustainable Lines:** Introduced eco-friendly clothing lines like "Conscious."	**Overproduction:** Despite AI efforts, the fast fashion model may still lead to excess production. **Transparency:** There is a need for clear metrics to assess AI's impact on sustainability.
Shein	Trend Analysis: Implements AI to adapt to customer demand rapidly, listing many items on its platform. **Design Optimization:** Uses AI to streamline design processes and increase efficiency.	**Inventory Control:** AI helps reduce inventory waste by predicting demand more accurately.	**Environmental Impact**: Faces criticism for ecological damage and labour rights violations. **Overproduction**: AI-driven rapid production may lead to overconsumption and increased waste.
ASOS	**Personalised Recommendations:** Uses AI to suggest products based on customer behaviour. **Inventory Forecasting:** Employs AI to predict demand and manage stock levels. **Visual Search:** Allows customers to search for products using images.	**Waste Reduction**: AI-driven sizing tools help reduce return rates, minimising waste. **Packaging Initiatives**: Reduced mailing bag thickness, saving approximately 583 tonnes of plastic annually. **Sustainable Lines**: Offers products made from recycled or sustainable fibres.	**Greenwashing Concerns**: Faced scrutiny over sustainability claims. **Limited Scope**: Sustainable products represent a fraction of total offerings.

6. *Implications of AI for Sustainable Fashion*

6.1 *Operational Efficiency and Waste Reduction*

AI contributes immensely to the cause of sustainability by aligning production volumes with consumer demand, hence transforming the traditionally speculative and evasive nature of fashion manufacturing. By using real-time data analytics, machine learning models, and predictive algorithms, brands can forecast trends and purchasing behaviours more accurately. This shift from intuition-based planning to data-informed decision-making reduces the likelihood of overproduction, which historically contributed to large volumes of unsold inventory. Fewer unsold garments mean fewer resources are wasted. AI and trend reading can also help these fashion brands to align themselves with the upcoming trends before they become mainstream, ensuring reduced production costs, hence also contributing to the revenue of the brand. One issue that might be in the forefront of this all the integration and the trained staff to do this, and the initial trial and error with the predictions, as well as external competition from organisations that work in trend analytics and analysis. To overcome this, the brands will need to work in cohort with such organisations to ensure that the costs are reduced for them, the information that they are getting is accurate and accountability in all these steps are taken by the experts, and not the brand, whose main function is to put trending clothes on the hanger and ensure revenue.

6.2 *Ethical and Social Considerations*

Undeniably, a slew of ethical concerns arise vis-à-vis the socio-economic and political implications of AI

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ISSN 2348-5434 Online

technology in improving productivity and sustainability with efficient production and wastes. Of the most pressing issues is how the replacement of labor workers by AI would potentially result in huge losses for garment workers in low-income countries, where handwork, at the moment, greatly builds fashion supply chains. Millions of workers, most of whom are women and members of vulnerable populations, have their prime source of income disturbed by gazing at the efforts of AI-driven automation encroaching into traditional roles. The fast fashion industry, even the fashion industry in general, puts at stake the livelihood of vulnerable women and children, and the introduction of AI and new equipments will only incentivise the industry to let go of the people on whose back they have built their fortunes. (Gunawan et al., 2023 Middlemen in their context.) This will allow a transition that may even increase global disparities unless reskilling initiatives and inclusive technology access are put into place. Moreover, the unequal distribution of benefits may confine some regions and communities from embracing AI. Therefore, sustainability would endorse the environmental benefits brought by AI through decreased overproduction and lesser carbon footprints against possible social implications of loss of employment and technology exclusion. As in such, it should touch all dimensions-geographical and human-of the path toward innovation. (Okeleke et al., 2024).

6.3 *Greenwashing vs. Genuine Transformation*

Some fashion-focused groups have started expressing skepticism regarding whether AI technologies could be put to such use by the brands in question as to provide an illusion for innovation, while the deeper concerns for sustainability that exist within operational practices are simply brushed aside. (Igini, 2023) (Léa Gossein, 2024) AI may give greenwashing enterprises a free pass again, as many brands are already accused of greenwashing. Such blatant AI abuse will only draw attention to ad-hoc tools such as trend forecasting that do nothing but lead to increased production. (Silva, 2023)For any AI pathway chosen to be substantively supportive of sustainability, punitive measures should be considered. On this note, it is important to strengthen transparent metrics to determine what compliance with sustainability means, independent mechanisms of verification, and third-party auditing for the needed accountability by these brands. (United Nations, n.d.)Such accountability measures will sift performative actions from meaningful progress, ensuring that AI is applied to operational efficiency and as a means of real environmental and ethical change.

7. *Discussion and Conclusion*

AI-powered predictive analytics offers a promising pathway to reducing overproduction in the fast-fashion industry. Enhancing demand forecasting, streamlining inventory, and enabling agile production can shift the sector toward more sustainable practices. As seen in the cases above, integration of AI in the processes of fast fashion brands would be a step taken towards the much needed sustainability practices, whether the integration is in the ideation, supply chain ,or trend prediction, it has been proven to deliver results. However, true transformation requires more than data-driven tools. Ethical implementation, labour protections, and accountability mechanisms must accompany AI adoption. Without this accountability, these brands, or as a matter of fact any brand, will not be able to call themselves ethical. Integration must follow accountability, as without it, the real purpose for such integrations is not fulfilled. As consumers become more conscious and data tools more sophisticated, the fashion industry has an opportunity to reconcile profitability with responsibility. The industry has the opportunity to ensure that the impact they are leaving behind on the people is positive. The next decade will determine whether predictive analytics serves as a bandage or a blueprint for systemic change in fashion.

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ISSN 2348-2869 Print
ISSN 2348-5434 Online