Harnessing Artificial Intelligence in Textile Production for Entrepreneurial Development

By

Vite Juliet Chinasa (PhD)
Department of Fine and Applied Art,
Ignatius Ajuru University of Education, Port Harcourt, Rivers State.
Email: **julietvite32@gmail.com**

Abstract

Artificial Intelligence (AI) is rapidly and profoundly transforming the textile and garment industry across its entire value chain, including design, manufacturing, supply chain management, and consumer engagement. This review systematically examines how AI-enabled tools (which include generative design and Computer-Aided Design (CAD), robotics, predictive analytics, and intelligent e-commerce) can increase efficiency, personalisation, and sustainability in textile production. We conducted a scoping literature review (2015 to 2024 English-language sources) using Scopus, Google Scholar, IEEE Xplore and industry reports using keywords including "AI in textiles," "smart manufacturing," and "textile entrepreneurship." A thematic analysis resulted in five areas, including: (1) design and pattern creation, (2) smart manufacturing, including drone and robotic delivery and quality assurance, (3) supply chain workability, (4) customisation and consumer experience, and (5) sustainability and eliminating waste. Across these themes, AI allows for new business models, including on-demand and microfactory production, and supports small entrepreneurs and artisans through digital and, increasingly, low-cost tools. For example, AI-based demand forecasting has helped fashion brands reduce excess inventory by 50%. The Giri today platform facilitates the connection of African artisans with global shoppers. However, the integration of AI in emerging markets is not without significant challenges, including limited digital infrastructure, pervasive skills gaps, cultural resistance to

technological adoption, and inadequate or nascent policy support. This paper discusses emerging opportunities, including affordable AI applications tailored to microenterprises and the crucial incorporation of AI literacy into vocational training programs. It highlights pertinent research gaps, including the gendered impacts of AI adoption and the imperative to include the informal sector. The paper concludes by advocating robust interdisciplinary collaboration to ensure that AI deployment aligns with the Sustainable Development Goals and fosters inclusive economic growth within the global textile sector.

Keywords: Artificial Intelligence (AI), Textile Production, Smart Manufacturing, Fashion Design

Introduction

The textile industry is at a crossroads with the rapid development of Artificial Intelligence (AI) and various digital technologies. AI is being applied to every stage of textile production: from design and conceptualisation, where generative models and machine-learning-assisted CAD are becoming essential (Ejinkeonye-Christian, 2025; Kumar et al., 2024), to manufacturing, where automation and real-time quality control are the norm (Kistamah, 2024). It extends to supply chain management, where logistics and forecasting are optimised (Bravo & Iturralde, 2024), and to retail through e-commerce personalisation (Ejinkeonye-Christian, 2025). This review explores the expanding role of AI in textile entrepreneurship—a field that encompasses fibre production, garment making and clothing design—how intelligent tools can drive innovation, create new business models and competitiveness. AI can process and analyse large data, automate repetitive tasks and extract meaningful insights, which has revolutionised processes such as fabric inspection, defect detection and demand forecasting (Kumar et al., 2024; Kistamah, 2024). As Bravo and Iturralde (2024) said AI is everywhere in business management helping in informed decision making, task automation and process optimization which is very relevant to textile industry. AI also supports sustainability by minimising waste, optimising resource usage and enabling the circular economy (Kumar et al., 2024; Lodhi et al., 2024). Meanwhile, AI-driven platforms and analytics are

democratising global market access for Small and Medium-sized Enterprises (SMEs) as seen in digital marketplaces that connect artisans to diaspora consumers (Ashiru, 2025), a trend also noted by Abrar et al. (2016) in e-marketing for specialised textile products. The growth of AI software market especially in machine learning is a testament to its importance as algorithms get smarter and computing power increases (Kistamah, 2024).

Scope and objectives: This article provides an extensive review of the scholarly and industry literature (2015–2024) related to AI in textiles through an entrepreneurial lens. It intends to (a) summarize broad applications of AI within the textiles industry into discrete thematic topics; (b) critically examine the implications of new potential business models, enhanced market accessibility/market empowerment for SMEs, about implications for developing countries; (c) review and examine industry's multiplicity of challenges regarding AI implementation (technical, skills-based, cultural, and policy) faced in emerging markets; and (d) identify possible future opportunities and areas of urgent research. Our interest is not in empirical experimentation but in a creative synthesis of the knowledge to create a knowledge map relevant to a variety of audiences, including entrepreneurs, educators, policymakers, and researchers who wish to leverage AI for sustainable and inclusive textiles entrepreneurship.

2. Review Methodology

The review utilized a scoping/narrative approach, allowing the review to scope out not only the reach of AI in the textile industry, but also the look into the depth which is relevant and important for understanding the potential impact of AI in textiles. Systematic searching of academic databases (Scopus, IEEE Xplore, Google Scholar) and industry sources (such as trade journals, reputable media and reports from organizations such as Ohmatex) was undertaken using a combination of search terms including, “AI in textiles”, “textile entrepreneurship”, “smart manufacturing”, “predictive maintenance”, “AI supply chain”, “sustainable fashion AI”, “textile coloration AI”, and “AI in fashion retail”. To be included in the review, material had to be in English, published between 2015-2024, focus explicitly on some AI or machine learning applications in a textile or garment (particular) context. There were some exclusions for example, material that was not from textiles, non-textile related consumer applications unless it functionally demonstrated and provided connectedness to textile production, and for articles which did

not have substantive analytical detail. After deduplication and screening of titles and abstracts of approximately 1200 records using systematic inclusion criteria, full texts of around 200 records were reviewed. Ultimately, around 51 core records (academic articles, industry case studies and legitimate news coverage) were curated for detailed analytical review and synthesis.

3. Thematic Synthesis of AI Applications

3.1 Design and Pattern Generation

AI design tools are changing the world of textile pattern creation and fashion design in ways we never thought possible. Generative design methods such as Generative Adversarial Networks (GANs) and neural style transfer can generate new textile patterns or motifs by learning from large-scale image datasets (Edwards, 2024). This is significant, as Wu and Li (2024) have shown that GANs can generate creative and practical knitted textile designs that resemble real textiles. Edwards (2024) proposes AI pipelines that combine historical lace patterns with deep learning to generate new designs that honour cultural heritage while optimising for aesthetics and mechanics. This is what Kistamah (2024) means by AI in pattern recognition. In applied research, Chen and Tong (2025) developed a deep-learning enhanced CAD system for clothing graphics, using Convolutional Neural Networks (CNNs) to achieve what they called "seamless integration" and significantly improve design efficiency and output quality over traditional methods (Chen & Tong, 2024). This is what Jung and Suh (2023) mean by AI for customising textile designs inspired by traditional Korean motifs. And AI based fashion design systems are being developed to mimic the work process of human designers to generate and modify designs while maintaining brand identity (Choi et al., 2023).

Beyond pattern creation, AI is supporting trend forecasting and demand-driven design. By analysing vast datasets from social media, fashion show images and real-time sales data, advanced AI tools (e.g. Heuritech, WGSN AI) can predict emerging colours, styles and fabric preferences with increasing accuracy (Ejinkeonye-Christian, 2025). This allows designers and small brands to align their collections more closely with actual market trends and reduce guesswork and overproduction. As Ejinkeonye-Christian (2025) says, these AI analyses enable entrepreneurs to "create

collections that match customer demand" and cut waste. AI-assisted sketch-to-product software also accelerates the prototyping stage by converting rough designer drawings into technical patterns. The perspective of Değirmenci (2024) is worth noting here, that AI should be a tool to support human creativity not replace it, which is key to maintaining the artistic integrity of fashion.

3.2 Smart Manufacturing

Modern textile factories are using AI enabled automation to get a big boost in productivity and quality as part of the industry 4.0 journey. Robotics and computer vision is at the heart of this. For example, cutting operations now use vision guided robots where high speed cameras track fabric positions to automate spread and cut sequences and minimize material waste (Asamaka Industries Ltd, 2025). This is part of a bigger trend where AI driven digital twins are enabling smart manufacturing and advanced robotics (Huang et al., 2023). In sewing and assembly which have been difficult to automate due to fabric flexibility, innovations like the Sewbo system are showing progress by using soluble polymers to temporarily stiffen cloth so robotic arms can stitch pieces with precision (Asamaka Industries Ltd, 2025). Such breakthroughs show how AI especially advanced vision systems combined with new material handling can assemble and stitch fabric pieces with minimal human intervention (Asamaka Industries Ltd, 2025). Kistamah (2024) also highlights AI's role in process optimization in garment manufacture and textile coloration and finishing.AI also brings a paradigm shift in quality control (QC). High-definition cameras combined with advanced machine learning algorithms can inspect fabric for multiple defects – holes, stains, pattern errors – at speeds and accuracy far beyond human capabilities (Asamaka Industries Ltd, 2025; CPC Central Committee Bi-Monthly, 2024).

This automated QC is crucial as noted by Bhargava (2018) who highlights AI's utility in fibre grading and fabric defect detection. For example, the Chinese startup Zhijing Technology developed miniature robots that operate directly on looms, using AI powered visual recognition to detect weaving flaws in real time, enabling "non-stop" inspection and instant defect alarms (CPC Central Committee Bi-Monthly, 2024). This has resulted in remarkable efficiency gains; one Sichuan textile firm reported that these AI robots produced 250,000 meters of fabric per day at 95%

machine efficiency, a big jump from previous rates (CPC Central Committee Bi-Monthly, 2024). The system streamlined operations, improved product consistency and reduced sampling time from days to hours (CPC Central Committee Bi-Monthly, 2024). Moreover, IoT based and cloud assisted AI driven monitoring platforms are being developed for real time anomaly detection and risk classification in manufacturing (Caiazzo et al., 2024) and specialized systems like ZigBee based loom monitoring enhance data collection and fault alarming (Dong & Jia, 2009). Predictive maintenance is another big area of AI in smart manufacturing. Sensors monitoring equipment parameters such as vibration and temperature feed data into machine learning models that predict equipment failures before they occur. A case study at India's Jay Shree Textile Mill showed that IoT sensors and AI analytics increased overall equipment reliability by 19%, as measured by Mean Time Between Failures (MTBF) (Yadav & Tiwari, 2024). This proactive approach enabled the mill to shift from reactive repairs to planned servicing, reducing downtime and costs (Yadav & Tiwari, 2024). Early work by Tu and Yeung (1997) also explored AI approaches for integrated maintenance management systems in textile companies, indicating a long-standing interest in this area.

3.3 Supply Chain Optimisation

AI is simplifying and transforming textile supply chains through better demand forecasting, logistics management and inventory optimisation. Traditional forecasting methods struggle to account for the volatile, rapidly changing trends in the fashion industry. AI models can incorporate multiple real-time data sources – historical sales, social media sentiment, weather patterns, macroeconomic indicators – to generate more accurate demand signals and reduce the costly problems of overstock and stockouts (Saha, 2025). This is critical, as an IDC report (via SAP, in the article) states that AI in supply chain planning is "enabling businesses to predict demand, optimise logistics and drive sustainability". For example, some fashion retailers have reduced excess inventory by up to 30% using AI-powered forecasting tools (Saha, 2025). In India, predictive analytics is being used to address overstocking issues; brands are using AI to reduce excess stock by 30-50% and markdowns by 20-40%, thereby improving profitability (Saha, 2025). These efficiency gains also lead to huge sustainability benefits – reduced waste, water consumption and carbon emissions of unsold goods (Saha, 2025). The importance of this forecasting

is further highlighted by research on specific materials, such as Jain's (2024) work on AI for demand forecasting of weaving materials, and by earlier models, such as those by Sébastien and Pierre (2005), which incorporated uncertainty and cost in forecasting for the apparel industry.

Beyond forecasting, AI plays a key role in managing risk and supply chain resilience. Algorithms can analyse vast amounts of data – shipping information, port congestion levels, supplier reliability metrics – to proactively flag potential disruptions (The Textile Think Tank, 2025). One textile company, using AI-based risk assessment, anticipated raw material shortages and avoided millions in potential production losses (The Textile Think Tank, 2025). This aligns with Rezaei et al. (2024), who found that data analytics capability has a positive impact on supply chain resilience and, consequently, on competitive advantage in the textile industry. AI also helps optimise logistics routing and inventory allocation; machine learning identifies optimal transport routes and reorder points to reduce lead times. As an industry blog puts it, "integrating AI is essential to be competitive, resilient and sustainable" in today's complex global supply chains (The Textile Think Tank, 2025). Thomassey and Zeng (2021) illustrate this by developing a digital platform for demand-driven fashion supply chains that uses multi-criteria decision-making for supplier selection and genetic algorithms for order scheduling.

Supply chain transparency and compliance are also greatly enhanced by AI. Brands are using AI tools to track emissions across their supply networks and ensure ethical sourcing. For example, by integrating emissions data from multiple suppliers, a major apparel brand met new regulatory requirements and reduced its carbon footprint by 15% (The Textile Think Tank, 2025). This aligns with the research by Hazen et al. (2016), who advocate the use of Big Data and Predictive Analytics (BDPA) to improve supply chain sustainability beyond financial metrics, encompassing environmental and social outcomes. Inventory optimisation is another key benefit, with companies employing AI-driven inventory management systems—often cloud-based dashboards—to align stock levels with real-time demand, thereby improving cash flow and reducing waste (Saha, 2025). The development of Decision Support Systems (DSS) for supply chain performance measurement, as proposed by Charkha and

Jaju (2020), further facilitates the identification and analysis of key performance indicators.

3.4 Customisation and Consumer Experience

AI is transforming the consumer side of the textile industry through personalisation and new digital platforms. In e-commerce, AI-powered recommendation engines analyse individual browsing habits, purchase history, and inferred preferences to suggest products tailored to each customer (Ejinkeonye-Christian, 2025). On platforms such as ASOS and Jumia, AI personalisation clearly increases sales by surfacing relevant products, thereby increasing conversion rates. This is where AI tools directly impact customer experience in online fashion retail (Pillariserny & Mishra, 2022). Virtual try-on and AI-powered size-fitting tools enhance online shopping; AI can overlay digital garments on user images or recommend sizes based on body measurements or visual analysis, thereby reducing return rates (Mirrorsize, 2025). Industry reports indicate that AI-powered fitting solutions can reduce fashion e-commerce return rates by up to 60%, resulting in more satisfied customers and higher profit margins (Mirrorsize, 2025). The concept of "i-Fashion," which integrates digital services and mass customisation through 3D body measurement technologies and virtual avatars, is another example of this trend towards personalised shopping (Park, 2012).

On-demand manufacturing and mass customisation are becoming viable business models largely driven by AI-powered design and production technologies. Small entrepreneurs can now offer custom-made garments using AI pattern generators and digital printing, thereby producing unique items for each order. For example, made-to-measure services use AI body scanners and algorithmic pattern creation to produce tailored garments for individual customers, offering greater value than generic off-the-rack clothing. As Vioreanu (2024) notes, on-demand manufacturing, in which garments are produced only after an order is placed, directly addresses the problem of overproduction (30% of garments go unsold) and enables deep personalisation. Virtual fashion shows and digital avatars, as discussed by Anuar and Jumrah (2024) and Renaningtyas (2023), both cited in Kumar et al. (2024), constitute another form of consumer engagement and product presentation that transcends physical limitations and enhances accessibility and creativity.

Digital Platforms and Market Access: Beyond production, AI-powered marketplaces and fintech solutions are expanding access to global markets for small textile businesses and artisans. Platforms such as Nigeria's GiriToday exemplify this trend by connecting African artisans directly to global buyers through a full e-commerce site and mobile application that also handles payment processing and shipping logistics (Ashiru, 2025). AI and digital trust systems play a significant role in securing these transactions, for instance, by verifying product authenticity before listing (Ashiru, 2025). Similar digital hubs are emerging across Asia, using AI-driven advertising and matching algorithms to help micro-enterprises tap into diaspora markets. This is especially relevant for niche products such as organic textiles, where e-marketing can build customer confidence and connect consumers with these specialised products (Abrar et al., 2016). AI marketing tools, such as targeted advertising and intelligent chatbots, enable even a rural tailor or a small boutique to compete effectively online, learn customer preferences, and offer responsive, personalised service. These e-commerce enablers, often built on affordable cloud services, are pivotal in expanding entrepreneurship beyond local markets, thereby fostering a more inclusive global textile economy.

3.5 Sustainability and Waste Reduction

Sustainability is a key driver of AI adoption in the textile industry. AI offers multiple solutions to reduce waste at different stages: in the design phase by predicting trends to avoid unpopular styles that lead to deadstock; during production by optimising cutting layouts to minimise fabric off-cuts; and in post-consumer stages by automating the complex task of sorting textile waste for recycling. The overstock and fashion waste crisis has prompted the development of innovative AI-driven solutions. For example, the African startup FARO uses predictive analytics to channel unsold luxury garments into emerging markets, preventing their incineration or landfills (FARO, 2025). FARO's AI system analyses past sales data, forecasts demand, and intelligently tags products, then allocates this stock to the right stores or markets to boost sell-through rates and reduce waste (FARO, 2025). The same AI engine powers personalised marketing campaigns that match overstock items to likely buyers, thereby reducing inventory waste (FARO, 2025). This is complemented by AI tools that predict fabric waste during production, enabling better resource management (Atik et al., 2022).

AI is also key to the circular economy in textiles. In recycling, machine vision and spectroscopy are being used to classify fabrics for reuse or reprocessing. A notable example is the AI-powered garment-sorting system developed by the Hong Kong Research Institute of Textiles (HKRITA), which analyses visible and hyperspectral images of used clothing to automatically identify material type, fabric blend, and construction (H & M Foundation, 2024). This has an accuracy of approximately 96%, outperforming human sorters and enabling large-scale automated recycling. Industry partners expect this to reduce demand for virgin fibres and divert millions of garments from landfills each year (H&M Foundation, 2024). Spyridis et al. (2024) also describe an autonomous AI-enabled industrial sorting pipeline to improve textile recycling efficiency and scalability. AI can also support decision-making in the outsourcing of circular-economy strategies for fashion waste management, thereby making these strategies practical and contributing to cleaner production (Oliveira Silva & Morais, 2022).

In dyeing and finishing processes, which are resource-heavy, AI optimises water and chemical usage. Deep learning models can predict the optimal dye recipe, reducing trial-and-error and resource consumption (Kistamah, 2024). Energy-intensive processes can be made more efficient by AI, which can schedule machinery and power use to balance load and reduce the carbon footprint. Data analytics, as noted by Mridha et al. (2024), is essential for predicting the performance of eco-friendly textiles and improving industry practices. AI-enabled production using sustainable materials further enhances material efficiency and enables the creation of recyclable products (Lodhi et al., 2024). Collectively, AI's role in promoting resource efficiency and enabling innovative recycling solutions is pivotal in aligning textile production with pressing environmental goals and fostering a more sustainable industry (Kumar et al., 2024; Saha, 2025).

4. Implications for Entrepreneurial Development

The AI-driven transformations delineated above carry profound and multifaceted implications for entrepreneurs and small businesses operating within the textile sector:

• **New business models:** AI is a significant enabler of new business models such as on-demand manufacturing and microfactories. The made-

to-order production system is being adopted by startups and artisanal businesses, in which clothing is produced upon order payment, with no upfront inventory costs and minimal waste (Vioreanu, 2024). Enabling these new business models are digital platforms that support effective demand-driven fashion supply chains, including supplier selection and order scheduling (Thomassey & Zeng, 2021). For example, Italian "maker fashion" businesses offer highly customizable clothing that is printed or woven only when the customer makes their selection. Microfactories are innovative, adaptable, small, and modular production units that use robotics, automation, and AI to enable local production with agility in every new production run, require very little capital to start, and can switch production lines rapidly (Hussain, 2024). These facilities have the advantage of meeting consumer demand for customisation without requiring extensive inventories. As Hussain (2024) states, AI-powered microfactories can "quickly change operations to accommodate a variety of styles and sizes". Just as significant, they equip firms to respond quickly to market opportunities.

• **Empowerment of small-scale entrepreneurs:** AI tools have gradually lowered entry and operational hurdles for startups and craft businesses day by day. The ecosystem of cloud-based AI services has grown so much, and you can acquire sophisticated capabilities for micro-entrepreneurship that were previously only available to corporations. With lower and no-cost mobile apps and free open-source models (like TensorFlow, AutoML), a local designer can explore as many designs as their heart desires using an AI-driven pattern generator in minutes, or leverage cloud-based analytics to analyse local trend demand with greater precision than before. An established manufacturing region (Hub) may now have access to AI-powered fabric-cutting tools and digital sewing machines through leasing or as-a-service plans. The machinery also makes it easier for small workshops in a hub setting to operate without building a full technical team in-house, as the machines enable greater precision and throughput. The newfound availability and value of AI have also led to AI-based microloan platforms and recognition of alternative credit-scoring opportunities (using non-traditional data), helping small textile businesses secure funding necessary for growth and the adoption of new technologies, made even easier by the advent and development of AI. Early examples of

how AI was used to aid SME's are internal control and risk assessment for textile firms (Corchado et al., 2004).

• **Global market access via digital platforms:** Digital marketplaces, including both national and global vendors such as Etsy and larger e-commerce vendors, combined with AI, are facilitating unprecedented opportunities for artisans and other small textile producers to sell globally. Ashiru (2025) provides a compelling example of African textile entrepreneurs accessing e-commerce marketplace platforms that offer a Shopify-like dashboard embedded with payment gateways and logistics solutions, sometimes featuring AI-driven vetting systems. This disintermediation allows buyers of niche products to bypass intermediaries and access sellers directly in international markets, including diaspora communities seeking authentic goods that reflect rich cultures. Similar platforms are emerging in Asia and Latin America, leveraging AI tools to connect niche textile producers (e.g., handloom fabrics, organic textiles, traditional crafts) with global buyers. E-marketing, particularly for specialised products such as organic textiles, also helps entrepreneurs cultivate awareness and customer trust (Abrar et al., 2016). There are also social media AI marketing tools now available to smaller fashion labels targeting overseas customers with low budgets and limited experience. All of these marketplace developments are crucial for enabling creative, craft-based entrepreneurs to grow their small businesses when market demands frequently exceed local or national lineups.

• *Examples/case studies:* Both African and Asian SMEs are exemplifying these transformative trends. In Africa, FARO (South Africa) is a sustainable fashion technology startup that deploys an AI solution to convert global overstock into opportunities for local consumers, thereby reducing waste while creating value (FARO, 2025). In Asia, already large retailers like reliance retail and myntra in India appear to be using AI forecasting at scale to manage and reduce inventory across millions of SKUs (FARO, 2025, note: original text attributes to FARO, 2025, but it seems the author is referring to general industry knowledge or other sources on these large retailers), and a medium-sized Chinese weaving firm has increased their daily output to 250,000 meters with 95% efficiency after implementing AI-powered inspection robots (CPC Central Committee Bi-Monthly, 2024). This demonstrates here, as one example from China, AI can positively

impact operational excellence (e.g. dashboards, etc). Globally, SMEs are increasingly creating sophisticated e-shops, with AI-driven recommendation engines and monitoring dashboards from platforms such as Shopify (and its ecosystem of AI applications) and Google's suite of AI-powered commerce tools (including their work on AI obsolescence in B2B). These diverse examples show that AI is a technology for operational efficiency and personalisation, but more importantly, it is an essential enabler for new start-ups and new business models in the textile industry.

5. Challenges in Emerging Markets

Despite the transformative potential, the deployment of AI in textile entrepreneurship within emerging economies faces a series of significant and often interconnected hurdles:

• **Technological barriers:** A significant hurdle is the frequent inadequacy, or misalignment, in digital infrastructure. Contributing factors may include availability of reliable high-speed internet connections, constant access to on-demand cloud computing services, comparatively cheap savings on the newest hardware, including sensors, high-resolution cameras, and processing units, particularly if you are in a rural or peri-urban setting (Loubby, 2025). Without a sufficiently robust digital backbone, the success of AI and Internet of Things (IoT) cloud-based solutions may be unattainable. In addition to a digital backbone, data and data quality are important; AI models, especially machine learning techniques, require large amounts of relevant and high-quality data to train and perform effectively. In many cases, the data that would work in some Emerging Market contexts is missing, incomplete, or the quality is poor quality (Kumar et al., 2024). Cross-border interoperability - e.g., between local SME suppliers and the global digital marketplace - can also be a concern due to incompatible systems, standards or data types.

• **Skills and knowledge gaps:** A significant lack of AI-related skillsets, as well as a lack of wider digital literacy, can be seen in many emerging economies. In many cases, owners, managers, and workers are not trained in data science, machine learning, or even elementary IT skills (Loubby, 2025). This skills gap is an important limitation. In a World Bank report, the authors highlight that in vocational training programs across sub-Saharan Africa, they observe AI and advanced digital skills seldom

incorporated as a vertical component in the programs for modern manufacturing (Ecofin Agency, 2025). The lack of the requisite skills and capabilities makes it hard for textile entrepreneurs to effectively adopt, adapt, integrate and sustain complex AI tools. Therefore, while design-led and community-driven efforts such as "AI Saturdays" or intra-country trains in partnership with international training institutions have begun to appear, the supply of AI-competent people is still far behind demand (Loubby, 2025). This point was raised in a number of ways in this specific context, but also in regard to a longstanding access to human creativity and skills-based development in cultures with AI adoption (Ahmmed, 2023).

• **Cultural resistance and trust issues:** In traditional textile communities, which often have long-established artisanal practices, there can be significant skepticism or resistance towards automation and AI. Artisans and factory workers may harbor fears that AI will "steal jobs," devalue craftsmanship, or undermine generations of accumulated tacit knowledge. There can also be a general reluctance to prioritize data-driven decision-making over long-standing, experience-based techniques. Overcoming this cultural inertia requires sensitive change management strategies, clear demonstrations of AI as a tool that augments rather than replaces human creativity and oversight, and inclusive implementation processes. Additionally, small businesses may exhibit distrust towards external AI vendors, harbor concerns about data privacy (e.g., safeguarding proprietary designs or sensitive business information), or fear vendor lock-in (Noor et al., 2021).

• **Policy and regulatory concerns:** Numerous emerging markets still do not possess a comprehensive national AI strategy or specific policies for Industry 4.0 adoption within certain key sectors such as textiles. The absence of specific subsidies, tax reliefs or financial support programs for SMEs, to incentivise modernisation with new technologies, may be noteworthy. Weak intellectual property (IP) frameworks or inadequate enforcement or challenges to investment in AI driven design innovations. A lack of data protection laws, or inadequate or inconsistent regulation on data protection and cybersecurity also complicates issues, and create risks and uncertainties for SMEs in relation to cloud service-based AI or cross-border data flows. There is also the ethical considerations of AI, such as bias embedded within algorithms or what is referred to as 'de-skilling'

through widespread automation, which requires a robust policy framework for legislation (Kumar et al., 2024). Finally, the upfront cost and ongoing operational costs of many AI solutions are prohibitive for SMEs to adopt (thinking particularly of SMEs, which have few opportunities to obtain affordable funding). Reports indicate that "cost prohibitive" AI system configuration is significant in preventing the uptake of AI from African SMEs (Loubby, 2025). Other reports by Akram et al. (2022) highlight wider challenges specific to the digitalised technologies that are required by SMEs for Fashion Industry 4.0. This indicates that, for many emerging economies, the relevant supporting infrastructure, education, regulation and financial accessibility, alongside an enabling environment for SMEs to develop is only at a nascent stage.

6. Opportunities and Future Directions

Despite the array of challenges, several emerging trends and opportunities offer considerable promise for advancing AI in textile entrepreneurship, particularly in developing regions:

• **Low-cost AI tools for microenterprises:** The AI field is witnessing increasing democratization. Open-source machine learning libraries (such as TensorFlow, PyTorch, etc.), access to pre-trained machine learning models (to perform standard tasks such as image recognition and natural language processing), and growing numbers of AI-as-a-Service (AIaaS) platforms provided by large cloud providers (for example Google Cloud AI, IBM Watson, etc.) are making high-quality AI capabilities more available, more accessible, and less expensive. AI functionality is available through a voice assistant or phone app, without necessitating the same level of expense for on-premise hardware. For example, mobile applications are available now that will do fabric recognition, colour matching, or even basic pattern making with on-device machine learning. Kistamah (2024) argues that the AI software market will experience expanded growth from increasingly sophisticated ML algorithms, which will continue to lower costs and improve tools. Governments, NGOs, and industry associations can all foster the establishment of AI hubs or shared facilities centres in order for entrepreneurs to have access to tools, training, and expertise. There is a burgeoning opportunity for local tech startups to develop domain-specific, low-cost AI applications tailored to the unique needs of textile microenterprises, such as an app that scans traditional

fabric patterns to suggest production plans or links artisans with ethical material suppliers.

• **Tech–local artisan partnerships:** Collaborative partnerships between technology producers (from global firms to local start-ups) and traditional craft communities are an exciting new model for innovation. The H&M Foundation's (2024) partnership with HKRITA to pursue AI garment sorting is an example of how industry funding can leverage AI research that has meaningful sustainability implications. Likewise, universities and innovation districts can engage artisan communities to co-develop AI tools that honour and enhance localised knowledge, whether through digitising traditional pattern libraries for generative design systems, or crafting AI tools to consider the extinction of craft techniques. Hackathons, maker spaces, and design sprints can be effective environments to bring together engineers, data scientists, and textile designers to spur collaboration (Jung & Suh, 2024 illustrate the potential of using generative AI within design education). Such synergistic practice will lend support to ensuring AI solutions are culturally relevant, respond to real-world engagement, and integrate heritage with innovation.

• **Policy and education:** Recommendations from international bodies like the World Bank and insights from academic research underscore the critical need to integrate AI and digital skills into vocational training and higher education curricula (Ecofin Agency, 2025). Textile vocational schools and fashion institutes can incorporate dedicated AI modules covering data literacy, digital design tools, AI ethics, and the basics of machine learning. National and regional policies should actively foster the creation of "AI+Textile" research and development centers, provide training grants for SMEs, and offer incentives for technology adoption, as suggested by Chatbri et al. (2019) for the Tunisian textile industry. Programs aimed at upskilling and reskilling garment workers in digital tools are also essential to smooth the technological transition and mitigate job displacement. International development agencies and philanthropic foundations could play a role by sponsoring AI labs and innovation challenges focused on solving specific problems within the textile sectors of emerging economies.

• **Future research gaps:** Some areas need more research. The gendered impact of AI in the textile industry is under-researched: how does AI affect female textile entrepreneurs, artisans and factory workers who make up the majority of the workforce? Does it perpetuate existing gender biases in business and employment or can it open up new opportunities? Another gap is understanding AI's role and impact in the huge informal textile sector (e.g. home-based tailors, small scale dyers). Research should explore how AI tools can be made accessible to these often-marginalised informal entrepreneurs via mobile platforms. Cross cutting issues such as data ethics in AI (especially worker data and design IP), AI design inclusivity and long-term socio-economic impact of AI deployment need rigorous interdisciplinary research. For example, studies could look at AI's role in improving fair trade certification, worker welfare monitoring or developing more robust models for predicting fabric properties and hand feel with a focus on sustainability (Tu et al., 2024). The move towards real time fashion systems (RTFS) using AI for sustainable and innovative supply chains is another area to explore (Lee, Y.K., 2024). The frequency of words like "sustainability" and "industry 4.0" in bibliometric analysis (Bravo & Iturralde, 2024) indicates the importance of research in these connected areas.

7. Conclusion

Artificial Intelligence in textile production is a game changer for entrepreneurship, a new era of innovation and efficiency for the industry. By automating mundane tasks, optimizing complex design processes and supply chains and enabling highly personalized customer engagement AI is creating new business models like on demand production and custom manufacturing. Small scale textile entrepreneurs will benefit the most by using AI to scale up their operations, access global markets through digital platforms and implement sustainable practices by reducing waste and optimizing resources. The applications are many from AI in textile coloration and finishing to advanced recycling systems and the emerging field of virtual fashion.

But to realize this huge potential especially in emerging economies requires a concerted effort to address the persistent challenges of technology access, digital infrastructure, targeted skills training and policy frameworks. The challenges of data quality, ethical considerations and

integration with traditional systems must also be managed proactively. We urge policymakers, educators and industry leaders to foster interdisciplinary collaboration: textile technologists, computer scientists, social scientists and business strategists must work together to co-design and implement AI solutions that uplift artisans, empower SMEs and promote equitable growth. A key imperative is to align AI deployment with the Sustainable Development Goals – for instance by using AI to empower women entrepreneurs in the textile value chain or to ensure environmentally responsible and circular production methods. In short harnessing AI in the textile sector is not just a technical upgrade but a socio-economic transformation. With a commitment to inclusive innovation, ethical considerations and global collective effort AI can help the textile industry weave a future of shared prosperity, creativity and sustainability.

References

Abrar, M., Safeer, A. A., Baig, S. A., & Ghafoor, A. (2016). E-Marketing and Its Implementation on Developing Social Perceptions of Customers through Effective Marketing Mix of Organic Textile Products. *American Journal of Industrial and Business Management, 6*(12), 1194-1211. https://doi.org/10.4236/ajibm.2016.612110

Ahmmed, M. E. (2023). Artificial intelligence (AI) in garment design: Opportunities and challenges in the ready-made garments (RMG) sector of Bangladesh. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.4575301

Akram, S. V., Malik, P. K., Singh, R., Gehlot, A., Juyal, A., Ghafoor, K. Z., & Shrestha, S. (2022). Implementation of Digitalized Technologies for Fashion Industry 4.0: Opportunities and Challenges. *Scientific Programming, 2022*, Article 7523246. https://doi.org/10.1155/2022/7523246

Anuar, M. F., & Jumrah, M. H. (2024). Digital fashion show: Metaverse unveiling designer expression through digital runways. In *International Conference on Business Studies and Education (ICBE)*. Retrieved 3 June 2025, from https://www.icbe.my/wp-content/uploads/2024/04/34-1.pdf

Asamaka Industries Ltd. (n.d.). Investigating the Application of Robotics in Textile and Garment Manufacturing. A3 Association for Advancing Automation. Retrieved 3 June 2025, from https://www.automate.org/robotics/news/-69

Ashiru, G. (2025, February 25). GiriToday Connects African Artisans with Global Buyers, Redefining E-Commerce. Tech In Africa. https://www.techinafrica.com/giritoday-connects-african-artisans-with-global-buyers-redefining-e-commerce/

Atik, C., Kut, A., Birant, D., & Birol, S. (2022). Prediction of Cloth Waste Using Machine Learning Methods in the Textile Industry. In *The 9th International Conference on Electrical and Electronics Engineering, ICEEE 2022* (pp. 165-169). IEEE. https://doi.org/10.1109/ICEEE55327.2022.9772517

Bhargava, G. (2019). *Artificial Intelligence and Its Implementation in the Textile Industry*. Indian Institute of Information Technology Bhopal. *Review of International Geographical Education, RIGEO*, 8 (3), 614-625

Bravo, M. V. C., & Iturralde, W. M. P. (2024). Artificial Intelligence in the Management of Textile Companies: A Contextual Analysis. *Open Journal of Business and Management, 12*(2), 945-960. https://doi.org/10.4236/ojbm.2024.122050

Caiazzo, B., Murino, T., Petrillo, A., Piccirillo, G., Santini, S., & Piccirillo, G. (2024). An IoT-based and cloud-assisted AI-driven monitoring platform for smart manufacturing: design architecture and experimental validation. *Sensors, 24*(1), 507. https://doi.org/10.3390/s24010507

Charkha, P. G., & Jaju, S. B. (2020). Decision Support System for Supply Chain Performance Measurement: Case of Textile Industry. In S. Patnaik (Ed.), *New Paradigm of Industry 4.0. Studies in Big Data* (Vol. 64, pp. 99-131). Springer. https://doi.org/10.1007/978-3-030-25778-1_5

Chatbri, H., Jemmali, S., & Harinachi, S. (2019). Empowering the Tunisian textile industry with artificial intelligence. [*Note: Full publication details needed. Retrieved 3 June 2025, from https://www.researchgate.net/publication/339079880_Empowering_the_Tunisian_textile_industry_with_artificial_intelligence*

Chen, L., & Tong, Z. (2024). Optimization of clothing pattern design combining deep learning and CAD. Computer-Aided Design and Applications, 237–252. https://doi.org/10.14733/cadaps.2025.s1.237-252

Choi, W., Jang, S., Kim, H. Y., Lee, Y., Lee, S.-g., Lee, H., & Park, S. (2023). Developing an AI-based automated fashion design system:

Reflecting the work process of fashion designers. *Fashion and Textiles, 11*(1), 1-18. https://doi.org/10.1186/s40691-023-00353-y

Corchado, J. M., Borrajo, M. L., Pellicer, M. A., & Yáñez, J. C. (2004). Neuro-Symbolic System for Business Internal Control. In P. Perner (Ed.), *Advances in Data Mining. ICDM 2004. Lecture Notes in Computer Science* (Vol. 3275, pp. 1-10). Springer. https://doi.org/10.1007/978-3-540-30185-1_1

CPC Central Committee Bi-Monthly (2024). China's manufacturing sector revs up with AI-empowered innovation. Retrieved 3 June 2025, from https://subsites.chinadaily.com.cn/Qiushi/2024-05/29/c_991215.htm

Değirmenci, Z. (2024). Artificial intelligence in textile design: A mini review. *Journal of Textile Engineering & Fashion Technology, 10*(3).

Dong, F., & Jia, X. (2009). Distributed Loom Running Monitoring System Based on Zigbee Technology. In *The 2009 International Conference on Computational Intelligence and Natural Computing* (pp. 326-329). IEEE. https://doi.org/10.1109/CINC.2009.85

Ecofin Agency. (2025). World Bank Urges Overhaul of Vocational Training Systems in SSA. Ecofin Agency. Retrieved 3 June 2025, from https://www.ecofinagency.com/news-services/0206-47104-world-bank-urges-overhaul-of-vocational-training-systems-in-ssa

Edwards, G. (2024, December 12). Generative AI Meets Textile Engineering: Blending Tradition and Innovation. Café Mila. https://cafemila.co.uk/generative-ai-meets-textile-engineering-blending-tradition-and-innovation/

Ejinkeonye-Christian, P. (2025, March 2). How AI is Changing Fashion And What It Means For Entrpreneurs. Modern Ghana. https://www.modernghana.com/news/1383129/how-ai-is-changing-fashion-and-what-it-means-for.html

FARO. (2025, April 23). AI-powered start-up, FARO, turns global textile overstock crisis into luxury fashion movement. Ai Impact. https://ai-impact.co.za/ai-powered-start-up-faro-turns-global-textile-overstock-crisis-into-luxury-fashion-movement/

H & M Foundation (2024). AI-powered Smart Garment Sorting System automating textile recycling – H&M Foundation. Retrieved 3 June 2025, from https://hmfoundation.com/project/ai-powered-smart-garment-sorting-system-automating-textile-recycling/

Hazen, B. T., Skipper, J. B., Ezell, J. D., & Boone, C. A. (2016). Big data and predictive analytics for supply chain sustainability: A theory-driven research agenda. *Computers & Industrial Engineering, 98*, 592-598. https://doi.org/10.1016/j.cie.2016.06.014

Huang, Z., Shen, Y., Li, J., Fey, M., & Brecher, C. (2023). A Survey on AI-Driven Digital Twins in Industry 4.0: Smart Manufacturing and Advanced Robotics. *Sensors, 23*(19), 8673. https://doi.org/10.3390/s23198673

Hussain, T. (2024, April 23). Garment Microfactories: Is it the Future of Garment Manufacturing? The Textile Think Tank. https://thetextilethinktank.org/garment-microfactories-is-it-the-future-of-garment-manufacturing/

Jain, P. (2024). Demand Forecasting in Textile Industry for Weaving Materials Using AI. *International Journal of Scientific Research & Engineering Trends, 10*(3), 2395-566X.

Jung, D., & Suh, S. (2024). Enhancing Soft Skills through Generative AI in Sustainable Fashion Textile Design Education. *Sustainability, 16*(4), 2304. https://doi.org/10.3390/su16042304

Jung, D., & Suh, S.-F. (2023). Development of Customized Textile Design Using AI Technology: A Case of Korean Traditional Pattern Design. *Journal of the Korean Society of Clothing and Textiles, 47*(6), 1137-1156. https://doi.org/10.5850/JKSCT.2023.47.6.1137

Kistamah, N. (2024). The Applications of Artificial Intelligence in the Textile Industry. In T. P. Fowdur, S. Rosunee, R. T. F. Ah King, P. Jeetah, & M. Gooroochurn (Eds.), *Artificial Intelligence, Engineering Systems and Sustainable Development* (pp. 257-269). Emerald Publishing Limited. https://doi.org/10.1108/978-1-83753-540-820241020

Kumar, D. T. S., Muthuvelammai, S., & Jayachandran, N. (2024). AI in textiles: A review of emerging trends and applications. International Journal for Research in Applied Science and Engineering Technology, 12(9), 1663–1678. https://doi.org/10.22214/ijraset.2024.64404

Kumar, T. S., Muthuvelammai, S., & Jayachandran, N. (2024). AI in Textiles: A Review of Emerging Trends and Applications. *International Journal for Research in Applied Science & Engineering Technology (IJRASET), 12*(6), 1019-1029. https://doi.org/10.22214/ijraset.2024.64404

Lee, Y. K. (2024). Transformation of the Innovative and Sustainable Supply Chain with Upcoming Real-Time Fashion Systems. *Sustainability, 16*(19), 12043. https://doi.org/10.3390/su161912043

Lodhi, S. K., Gill, A. Y., & Hussain, H. K. (2024). Green Innovations: Artificial Intelligence and Sustainable Materials in Production. *Journal Multidisiplin Ilmu, 3*(4), 492-507. [*Note: Check if this journal has a more specific name or publisher details if available.*]

Loubby. (2024, November 19). Artificial Intelligence in Africa: Opportunities and Challenges. Loubby. https://www.loubby.ai/artificial-intelligence-in-africa-opportunities-and-challenges/

Mirrorsize (2025). How AI is Slashing Fashion Ecommerce Returns by 60%: The Secret to Happier Shoppers and Higher Profits. Retrieved 3 June 2025, from https://www.mirrorsize.com/blogs/reduce-e-commerce-returns-in-fashion-industry-with-ai

Mridha, Y., Pathan, S. H., Amin, M. R., Tania, I., & Ouboucetta, R. (2024). Sustainable fashion analytics: Predicting the future of eco-friendly textile. *Global Mainstream Journal of Business, Economics, Development & Project Management, 3*(3), 13-26. [*Note: Confirm publisher or any associated DOI if available.*]

Noor, A., Saeed, M. A., Ullah, T., Uddin, Z., & Ullah Khan, R. M. W. (2021). A review of artificial intelligence applications in apparel industry. *The Journal of The Textile Institute, 112*(11), 1781-1792. https://doi.org/10.1080/00405000.2020.1833099

Oliveira Silva, W. D., & Morais, D. C. (2022). Impacts and Insights of Circular Business Models' Outsourcing Decisions on Textile and Fashion Waste Management: A Multi-Criteria Decision Model for Sorting Circular Strategies. *Journal of Cleaner Production, 370*, Article 133551. https://doi.org/10.1016/j.jclepro.2022.133551

Park, C. K. (2012). Digital Convergence in IT and Fashion: i-Fashion. In *3rd International Conference on 3D Body Scanning Technologies* (pp. 1-10). Hometrica Consulting - Dr. Nicola D'Apuzzo.

Pillariserny, R., & Mishra, P. (2022). A Review of AI (Artificial Intelligence) Tools and Customer Experience in Online Fashion

Retail. *International Journal of E-Business Research, 18*(2), 1-16. https://doi.org/10.4018/IJEBR.307738

Renaningtyas, L. (2023). The digital fashion: Concept of realness, design process and consumer experience with clothing tailored by AI. In *The 17th International Conference on Creative Design, Business and Society (ICCDBS)*.

Rezaei, G., Hosseini, S. M. H., & Sana, S. S. (2024). Exploring the Relationship between Data Analytics Capability and Competitive Advantage: The Mediating Roles of Supply Chain Resilience and Organization Flexibility. *Sustainability, 16*(7), 3900. https://doi.org/10.3390/su16073900

Sébastien, T., & Pierre, D. (2005). Implementation of the Newsboy Method for the Sales Forecasting of the Apparel Industry. In *The 2005 3rd International Industrial Simulation Conference, ISC 2005* (p. 21).

Spyridis, Y., Argyriou, V., Sarigiannidis, A., & Radoglou, P. (2024). *Autonomous AI-enabled industrial sorting pipeline for advanced textile recycling*. arXiv preprint arXiv:2405.10696v1. https://doi.org/10.48550/arXiv.2405.10696

The Textile Think Tank (2025). The Future of AI in Textile Supply Chain. The Textile Think Tank. https://thetextilethinktank.org/the-future-of-ai-in-textile-supply-chain/

Thomassey, S., & Zeng, X. (2021). FBD_Bmodel Digital Platform: A Web-Based Application for Demand Driven Fashion Supply Chain. In A. Dolgui, A. Bernard, D. Lemoine, G. von Cieminski, & D. Romero (Eds.), *Advances in Production Management Systems. Artificial Intelligence for Sustainable and Resilient Production Systems. APMS 2021. IFIP Advances in Information and Communication Technology* (Vol. 630, pp. 21-30). Springer. https://doi.org/10.1007/978-3-030-85874-2_3

Tu, Y., & Yeung, E. H. H. (1997). Integrated Maintenance Management System in a Textile Company. *International Journal of Advanced Manufacturing Technology, 13*(7), 453-462. https://doi.org/10.1007/BF01179041

Tu, Y.-f., Kwan, M.-y., & Yick, K.-l. (2024). *A Systematic Review of AI-Driven Prediction of Fabric Properties and Handfeel*. arXiv preprint arXiv:2409.1549v1.

Vioreanu, D. (2024, May 14). How Does On-demand Clothing Manufacturing Work for Fashion Brands? 3DLOOK.

https://3dlook.ai/content-hub/on-demand-clothing-manufacturing/

Wu, X., & Li, L. (2024). An application of generative AI for knitted textile design in fashion. *The Design Journal, 27*(2), 270-290. https://doi.org/10.1080/14606925.2023.2296173

Yadav, P., & Tiwari, V. (2024, March 12). Textile Industry Case Study for AI Driven Predictive Maintenance. AI Software & IoT Sensors for Predictive Maintenance. https://www.sensegrow.com/blog/customer-stories/textile-industry-case-study-for-ai-driven-predictive-maintenance