

An Appraisal of the Potential Impact of Artificial Intelligence (AI) on Nigeria's Local Tie-Dye (Adire) Industry

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Abstract

Despite the reported positive impact of AI on manufacturing and production businesses, the adoption of AI in Africa and Nigeria manufacturing sector remains low. While the impacts of AI are laudable, the textile manufacturing sector in Nigeria has not embraced fully the growing application in AI in their production systems. The local tie-dye (Adire) industry in Nigeria is a vital component of its cultural heritage, it showcases the nation's rich creative textile tradition while also a vital economic player for the Nigerian cottage industry. This industry faces significant challenges, including inconsistencies in production quality, limited design innovations, international competitiveness, and inefficiencies in manufacturing and distribution. This paper comprehensively analyses the application of artificial intelligence (AI) in revolutionising the Nigerian local tie-dye industry by improving design processes, quality control, supply chain management, design cataloging and global market competitiveness. This article employs case studies and contemporary AI technologies in the textile sector in order to create a framework for incorporating AI into the Adire industry, Aiming to maintain its cultural relevance while promoting economic growth. It can be concluded that the application of Artificial Intelligence in the Nigerian tie-dye industry presents a unique opportunity to enhance productivity, foster innovation, and expand market reach while preserving cultural heritage.

Keywords: Nigeria, AI, Adire, Tie-dye, Textile, Economy, Industry.

1. Introduction

1.1 Background

The Tie-dye industry in Nigeria also known as Adire represents a significant part of the cottage and textile sector of the Nigeria economy. Over the years, the production of local tie-dye has become a major part of the country's cultural identity. This industry is centuries old with roots dating as far back as the 11th century. The famous dye pits in Kano was established around 1498 and remains iconic of local Nigeria traditional dyeing practices. However, in Southwest Nigeria the Yoruba people developed Adire around the 19th century. Adire is a traditional textile art form that involves dyeing fabrics using resist-dyeing techniques to create intricate patterns. Despite its cultural and economic significance, the industry remains largely artisan, characterized by manual processes that limit scalability and innovation. The industry's challenges among many others, includes; inconsistent product quality and limited access to international markets due to poor quality standards. These highlight the need for technological interventions that can modernize production without compromising cultural values.

1.2 The Role of Artificial Intelligence in Textiles

The Advent of Artificial Intelligence AI has greatly impacted the manufacturing industry, it is now the driving force behind innovations and dictates the direction all aspects of manufacturing. According to Plathottam et al. (2023), AI and machine learning can significantly enhance manufacturing by enabling predictive maintenance, real-time process monitoring, and quality assurance. These capabilities lead to reduced downtime, improved product consistency, and greater operational efficiency. When deployed in manufacturing systems, AI ensures product consistency and improved quality. Similarly Balcerzak et al. (2025) opined that artificial intelligence creates intelligent manufacturing systems that can forecast failures, adapt in real time, and optimise operations. This capability of AI has led to a reduction in downtime, leading to increased profitability. In general, AI allows for faster decision-making and product customization in manufacturing, resulting in quicker innovations, more profits and wider acceptability of products. Gao and Feng (2023), in their research on AI adoption in Chinese A-firms, reported that after a 1% increase in penetration of AI, the productivity factor increased by 25%. Similarly, Zhong et al. (2023) analysed Chinese A-share firms and concluded that AI adoption significantly increased total factor productivity, particularly in high-tech and producer services, with stronger effects in state-owned large manufacturing enterprises. These recent reports show consistent gains in the adsorption of AI in manufacturing as well as improved profitability due to efficiency, quality and innovation.

Due to the obvious advantages of artificial intelligence (AI), it has become increasingly influential in the textile and fashion industries, offering solutions for design automation, quality control, and supply chain optimisation. AI technologies such as machine learning, computer vision, and predictive analytics can address the inefficiencies of traditional textile production methods (Wang et al., 2020).

Despite the reported positive impacts of AI on manufacturing and production businesses, the adoption of AI in Africa and Nigeria manufacturing sector remains low. While the impacts of AI are laudable, the textile manufacturing sector in Nigeria has not embraced fully the growing application in AI in their production systems, consequently, the tie-dye sector in Nigeria is already witnessing an influx of foreign-made tie-dye cheap imitations, which are basically machine-printed tie-dye patterns. These fabrics, from close observation, are comparatively below the traditional Adire version of tie-dyed fabrics in terms of artistic appeal and quality. However, these fabrics have been received widely in the Nigerian market due to the fact that international marketers have flooded the market with these cheap trendy imitations of the Nigerian local Adire patterns. This paper investigates how AI applications can be adapted to enhance the Nigerian tie-dye industry, particularly focusing on the potential for AI to preserve the cultural essence of Adire while improving its marketability and production efficiency.

2. Current Challenges in the Nigerian Tie-Dye Industry

2.1 Inefficient Quality Control

African products have so far experienced low patronage in the international market. Key reasons for this include inconsistent quality control, non-compliance with international regulations (ISO, ASTM) on a consistent basis, and absence of quality certifications have led to products from Nigeria being rejected consistently on the global stage. The inability of the Nigeria Textile sector to break into the international market have resulted in poor revenue due to international customers unwillingness to pay good price for not ascertained quality products, job loses and decline the Adire sector (Ubi & Mohammed, 2025)

The artisanal nature of Adire production, where most stages of production, like folding, tying, stitching and application of resists, are done by

hand on a small scale that only employs a few people, makes it difficult to follow international quality standards. This consequently leads to variations in colour consistency, pattern precision, and fabric quality, making it difficult to meet standardised quality requirements, particularly for international markets.

2.2 Inadequate Design Innovation

Traditional tie-dye methods rely heavily on manual, age-old processes, which limit innovation, which is the ability to experiment with new patterns and colours. Traditionally, most local Adire manufacturers rely on a small range of motifs and patterns. This has made their work less creative in a market that is changing and open to a blend of tradition with modern trending styles and patterns. The inability of the Nigerian Adire sector to innovate in terms of design and technology restricts the industry's ability to break into new markets and demographics to meet consumer preferences and global fashion trends despite an increasing global demand for modern design interpretations of Adire that retain cultural appeal while appealing to contemporary markets. (Zelda & Adiji., 2023).

2.3 Limitation in the Supply Chain

The supply chain for Adire production is often fragmented, with challenges in sourcing raw materials, managing inventory, and distributing finished products. These inefficiencies contribute to higher production costs and delays, further limiting the industry's competitiveness. Despite a government ban on the activities of smugglers, It is widely reported that about 85% of locally consumed textiles are imported. Also, inadequate machinery, lack technological know-how is also a cause of inefficient supply (Zelda & Adiji., 2023).

2.4 Restricted Global Market Penetration

Practitioner of Adire are usually oblivious of what appeals to the different target market worldwide. They lack the network and platform to showcase their craft and designs. Despite the

cultural and aesthetic value, Adire has a limited presence in the global market. The industry's lack of standardized quality control, branding, and integration with international fashion trends makes it difficult to attract and retain global customers.

3. Potential AI Applications in the Tie-Dye Industry

3.1 AI-Driven Design Innovation

AI can significantly enhance design processes in the tie-dye industry by enabling more efficient and creative pattern development. Machine learning algorithms can analyze vast amounts of data from global fashion trends and consumer preferences to suggest new designs that combines traditional and contemporary elements. Additionally, AI-powered design tools can allow artisans to experiment with different color combinations and patterns in a virtual environment before applying them to the fabric, reducing material waste and enhancing creativity.

3.2 Quality Control Using Computer Vision

AI could be deployed to improve and control quality in textile dyeing. This can be achieved by real time colour matching technology by AI powered camera system to monitor shade, colour and consistency across batches of production against standardized colour profiles chosen by customers or companies to limit variations. This system allows for detection of defects and irregularities such as uneven dye uptake, patch dyeing, spots, and colour variation with great speed and efficiency than human inspectors. Computer vision systems, powered by AI, can be integrated into the tie-dye production process to monitor and ensure consistency in dye application and pattern accuracy. These systems can detect defects such as uneven dyeing or incorrect pattern placement in real-time, allowing for immediate in-process corrective actions. Machine learning are also capable of implementing adjustment like temperature, processing time, addition of more dye and dye

assistants within desired tolerance. This technology can help maintain high quality across large batches of products, thereby meeting both local and international quality standards (Raisul et. al.,2024).

3.3 Supply Chain Optimization

AI-driven analytics can optimize various aspects of the tie-dye supply chain, from raw material procurement to final product distribution. Predictive analytics can forecast demand based on historical sales data and market trends, helping manufacturers manage inventory more effectively (Agrawal & Gans, 2022).

AI has also been deployed to manage inventory by determining optimal reorder points, management of safety, and tracking of raw material usage thereby minimizing wastage delays. Supplier selection can also be fast tracked by AI via analysis of suppliers performance, pricing, financial stability and delivery time-lines thereby helping companies reduce supplier related bottlenecks and risks. Furthermore, AI can streamline logistics by optimizing routes, scheduling of production runs and delivery routes, thereby reducing transportation costs, improving overall operational efficiency and conserving energy.

3.4 Market Analysis and Trend Prediction

The adoption of AI can be a game-changer for the tie dye fabric businesses in Africa by guiding both market strategies and creative directions. Through trend forecasting and analysis, AI can surf through social media applications such as Facebook, Instagram, Twitter, Fashion Blogs and Pinterest to indentify trending patterns, colours, designs, colour schemes that are gaining popularity. AI tool could also be of great use in target market analysis by segmenting potential customers into different categories such as age, price range, location, and lifelsyle. It can also give insight into a potential competitor's product and customer reviews. AI gives an edge as inventory and demand planning can be easily

achieved by analysing trends and forecasts to determine peak periods.

AI tools can also analyze global market trends and consumer behavior to provide insights that inform product development and marketing strategies. By understanding what designs, colors, and styles are currently popular, Adire producers can tailor their designs to meet international demand, thereby increasing their market share (Haleem et al., 2022).

4. Case Studies and Practical Implementations

4.1 Global Examples of AI in Textile Production

AI technologies have been deployed to various aspect of production in the textile industry worldwide. Several examples from the global textile industry demonstrate the successful integration of AI. For instance, the Indian textile industry has leveraged AI for automated pattern recognition and quality control, resulting in significant improvements in production efficiency and product quality (Das et al., 2021). Similarly, in China, AI-driven quality control systems have been implemented in silk production to detect defects with high precision, reducing waste and ensuring product consistency (Sikka et al., 2024).

Specific examples where AI has been incorporated to textile production include:

- i. Quality Control: where AI powered camera and sensors have been deployed to detect defect in fabrics in real time spotting defects like patch dyeing, poor shade much faster than manual human methods.
- ii. Process Optimization: these are machines where machine algorithm are deployed to detect and control production parameters such as temperature, pressure, and speed. This has resulted in reduction in raw material waste, downtime , energy savings and consistent product quality.
- iii. Demand Forecasting : these AI collects data, social media signals, and fashion blogs to predict colours and patterns or material type

that are likely to be in high demand in the market.

- iv. Automated Dye Formation: here these AI tools assist in formulating dye recipes by analysing historical data and colour properties thereby allowing companies to match colours more accurately while reducing waste due to trials.
- v. Sustainable Operations: here, the deployed AI helps to track energy usage, raw materials sourcing, water consumption, and wastes. Optimizing their processes for better sustainability.

4.2 AI Experimental Projects in Nigeria

In Nigeria, many experimental projects are exploring the application of AI in traditional crafts, including Adire. For example, a collaborative project between local artisans and tech startups in Lagos has introduced AI-powered design tools that allow for greater creativity and faster prototyping. These tools have the potential of helping artisans produce innovative designs that appeal to both local and international markets (Eze & Adebayo, 2023; NITDA, 2024).

A number of pilot projects are further looking into incorporating AI in textile and other related industry production systems. Some of these are highlighted below:

- i. Automated textile-printing dryer (TETFAIR pilot): utilizing automation and IoT platforms to manage drying and curing process for cottage scale textile producers.
- ii. AI & VR for Cultural textile revitalization: to preserve cultural heritage via technology and act as a platform where cultural textiles can be easily accessed from all over the world.
- iii. Broader 4IR pilots in agriculture and Textile adjacent sectors: looks into natural raw materials like cotton traceability and smart processing of textile raw materials.

While these pilot projects are laudable, the textile sector in Nigeria has not embraced fully the growing application in AI in their

production systems (Eze & Adebayo, 2023; NITDA, 2024).

5. Benefits of AI Adoption in the Tie-Dye Industry

5.1 Economic Empowerment

The adoption of AI can lead to increased productivity and profitability in the tie-dye industry. By improving efficiency and reducing waste, AI can help artisans and entrepreneurs achieve higher margins, contributing to economic empowerment in Nigeria (Haleem et al., 2022).

5.2 Cultural Preservation through Innovation

The incorporation AI into cultural textile production practices has great potential of preserving the rich cultural heritage of a country like Nigeria. AI can be deployed for digital preservation of traditional patterns, where AI can scan, catalog and recreate traditional motifs and patterns from fabrics thereby preserving their details. Machine learning can identify, group and compare motifs across different ethnic groups or historical periods. This forms a rich platform which can serve as a database of design for designers, researchers and cultural institutions.

AI offers a means of preserving the cultural heritage of Adire while enabling innovation. By incorporating AI in design and production, the industry can evolve to meet modern demands without losing its cultural significance (Ogunleye, 2021).

5.3 Environmental Sustainability

AI has the potential to help the Nigeria textile sector become more sustainable by waste reduction, conservation of resources, optimizing energy usage, and extending the life-cycle of materials while retaining product quality. For example, AI-driven dyeing techniques can minimize the environmental impact by using less water and chemicals, aligning the industry with global sustainability standards. If deployed AI has the potential to; reduce waste and water consumption, improve energy efficiency and

emission reduction, impact on sustainable material sourcing and traceability, and demand forecasting to reduce over production.

6. Challenges and Considerations

6.1 Cost of Implementation

The initial cost of adopting AI technologies can be a significant barrier for small-scale artisans in the tie-dye industry. However, potential solutions include government subsidies, partnerships with tech companies, and collective investment by artisan cooperatives (Eze & Adebayo, 2023). Also, collaborating with local Tech Hubs and Institutions like NITDA's digital Innovation Hub or Co-creation Hub for technical expertise. To offset the initial cost implication, firms can consider subscribing to cloud based AI-as-a service solutions such as Amazon Web Services (AWS), Microsoft, or Google Cloud which enables companies to pay for services based on usage. (Eze & Adebayo, 2023; NITDA, 2024)

6.2 Skill Development and Training

Skill development and training are key to unlocking the full potentials of AI for African manufacturing firms. Due to the fact that many firms lack the technical expertise to implement or manage AI technologies, providing training on data literacy and coding to algorithm design and maintenance is key is closing the gap between Africa and the rest of the world.

To effectively implement AI, there is a need for skill development and training programs that equip artisans with the knowledge to use AI tools. This will require collaboration between educational institutions, industry stakeholders, and the government to ensure that the workforce is prepared for the technological transition (Eze & Adebayo, 2023).

6.3 Ethical and Cultural Considerations

The integration of AI into a traditional craft raises ethical and cultural concerns, such as the potential loss of artisanal skills and the commodification of cultural heritage. It is essential to approach AI adoption in a way that

respects and preserves the cultural integrity of Adire while embracing the benefits of technological advancement. Some ethical considerations to be considered for successful implementation of AI include; balancing this innovation with fairness and human dignity, safeguarding data and intellectual property, and respecting and preserving cultural heritage (Ogunleye, 2024).

7. Conclusion

The textile sector which is one of the largest employers of labour worldwide has the potential to serve as a catalyst for Nigeria and African industrial reemergence. This can only happen if AI is Adopted to cover the many years of technological gap that currently exists between Africa and the rest of the world. The application of Artificial Intelligence in the Nigerian tie-dye industry presents a unique opportunity to enhance productivity, foster innovation, and expand market reach while preserving cultural heritage. By addressing current challenges and leveraging AI's potential, the industry can achieve sustainable growth and global recognition. Collaboration among stakeholders, including government agencies, industry players, and technology providers, is crucial for the successful integration of AI into the tie-dye industry.

References

- Abubakar, M., and Adeyemi, T. (2024). Artificial intelligence adoption in Nigerian universities: Opportunities and disparities. *Nigerian Journal of Educational Technology*, 12(2), 45–59.
- Agrawal, A., and Gans, J. S. (2022). "Predictive analytics in supply chain management: Applications in the textile industry." *Journal of Supply Chain Management*, 47(4), 365-382.
- Balcerzak, A.P., Valaskova, K., and Nagy, M. (2025). Artificial intelligence in Financial Decision Making: Enhancing Portfolio management and risk assessment. *Equilibrium. Quarterly Journal of Economics and*

Economic Policy, 20(3), 863-875.
<https://doi.org/10.24136/eq.3884>

Das, S., Sharma, V., & Ray, P. (2019). "AI applications in the Indian textile industry." *Textile Technology Review*, 14(1), 27-35.

Das, S., Sundaramurthy, S., Aiswarya, M. and Jayaram, S. (2021), —Deep learning convolutional neural network for defect identification and classification in woven fabric, *Indian Journal of Artificial Intelligence and Neural Networking (Networking)*, Vol. 1 No. 2. Eze, C. (2023). "Financing the adoption of AI in traditional industries: The Nigerian perspective." *African Journal of Economics and Finance*, 18(2), 98-112.

Eze, C., & Adebayo, F. (2023). Faculty attitudes and governance challenges in AI integration in Nigerian universities. *Nigerian Educational Review*, 15(1), 58–74.

Gao, X and Feng, H. (2023). AI-Driven Productivity Gains: Artificial Intelligence and Firm Productivity, *Sustainability*, MDPI, vol. 15(11), pages 1-21, June.

Haleem, A., Javaid, M., Qadri, M.A., Singh, R.P., and Suman, R. (2022) Artificial intelligence (AI) applications for marketing: A literature-based study, *International Journal of Intelligent Networks*, Volume 3, 2022, Pages 119-132, ISSN 26666030, <https://doi.org/10.1016/j.ijin.2022.08.00>.

Market Penetration Techniques for Small Businesses in Nigeria: A Case Study Approach. (2025). *Journal of the Management Sciences*, 61(8), 228-247. <https://journals.unizik.edu.ng/jfms/article/view/5955>

National Bureau of Statistics & Smedan. (2017). National MSME Survey 2017. <https://www.nigerianstat.gov.ng/elibrary/read/966>

NITDA. (2024). National Artificial Intelligence Strategy. <https://ncair.nitda.gov.ng>

Ogunleye, I. (2024). Artificial-Intelligence-for-Economic-Development-in-Nigeria.

<https://www.scribd.com/document/802023004/Artificial-Intelligence-for-Economic->

[Development-in-Nigeria-Ifejesu-Ogunleye#page=3](https://www.scribd.com/document/802023004/Artificial-Intelligence-for-Economic-Development-in-Nigeria-Ifejesu-Ogunleye#page=3)

Pan, Y., Zhang, C.C., Lee, C.C., and Lv, S. (2024). Environmental performance evaluation of electric enterprises during a power crisis: Evidence from DEA methods and AI prediction algorithms. *Energy Economics*, 130 (2024), Article 107285

Plathottam, S. J., Rzonca, A., Lakhnori, R. and Iloje, C. O. (2023) *J. Adv. Manuf. Process.* 2023, 5(3), e10159.

<https://doi.org/10.1002/amp.2.10159>

Raisul, I., and Hossain, Z, Z., Eshmam, R., Kabir, M., Satoshi, N., and Jungpil, S. (2024). Deep Learning and Computer Vision Techniques for Enhanced Quality Control in Manufacturing Processes. *IEEE Access*. PP. 1-1. 10.1109/ACCESS.2024.3453664.

Sikka, M.P., Sarkar, A. and Garg, S. (2024), "Artificial intelligence (AI) in textile industry operational modernization", *Research Journal of Textile and Apparel*, Vol. 28 No. 1, pp. 67-83. <https://doi.org/10.1108/RJTA04-2021-0046>.

Ubi, F. L. and Mohammed, U.D. (2025) Challenges Of Nigeria Textile Industry And Economic Recovery Policies. (2025). *Abuja Journal of Business and Management*, 3(2). <https://doi.org/10.7118/fb1jv453>

Wang, S., Wang, F., Zhu, Z., Wang, J., Tran, T. and Du, Z. (2024). Artificial intelligence in education: A systematic literature review, *Expert Systems with Applications*, Volume 252, Part A, 2024, 124167, ISSN 0957-4174, <https://doi.org/10.1016/j.eswa.2024.124167>.

Zelda, N and Adiji, B. (2023). The Evolution of Contemporary Indigenous Textile Practice in South West Nigeria. 2023, *East African Journal of Interdisciplinary Studies* 6(1):100-106 DOI:10.37284/eajis.6.1.1145

Zhong, W., Liu, Y., Dong, K., and Ni, G. (2024). Assessing the synergistic effects of artificial intelligence on pollutant and carbon emission mitigation in China. *Energy Economics*, 138 (2024), Article 107829