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Nasif Chowdhury *

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AI and IoT in Apparel Quality Assurance: A Study on Innovation and Efficiency in Bangladesh's Ready-Made Garments Industry

Nasif Chowdhury

Assistant Professor, Department of Textile Engineering, Anwer Khan Modern University, Dhaka, Bangladesh; nafistextile@gmail.com

Abstract: The Ready-Made Garments (RMG) industry in Bangladesh stands as the backbone of the national economy due to its strong GDP contribution and its workforce of more than 4 million workers. Competitiveness abroad of Bangladesh's RMG sector faces threats from quality control inconsistencies and supply chain inefficiencies, and high defect rates. The investigation shows how Artificial Intelligence (AI) and Internet of Things (IoT) can revolutionize quality assurance (QA) administration in Bangladesh's Ready-Made Garments (RMG) sector. Through AI-based analytics and IoT real-time network systems, manufacturers can boost operational efficiencies and reduce production errors, and foster environmental sustainability. This article uses literature review methods together with case studies and analysis of existing implementations to show strategic recommendations and opportunities, along with challenges for implementing these technologies in Bangladesh's RMG industry.

Keywords: AI and IoT; quality assurance; RMG industry; Bangladesh

1. Introduction

The RMG industry in Bangladesh stands as the world's second biggest apparel exporter since it reached $42.6 billion in 2021-2022 exports. The RMG sector dominates the Bangladesh economy through its female workforce of 4.4 million, while bringing in more than 80 percent of the nation's export earnings. Despite its position as Bangladesh's second-largest export sector, the industry fights ongoing barriers such as poor product quality and delayed production times, and inefficient supply chain operation. Labor-intensive production methods combined with outdated quality control methods substantially increase these industry problems.

Supplied by Industrial Revolution 4.0 technology, particularly AI and IoT, organizations now possess solutions to their operational problems. These technologies bring predictive analytics and automated defect detection and process optimization abilities to manufacturing while enabling real-time monitoring between connected production lines. This research examines how Bangladesh's RMG industry can revamp its quality assurance through the combination of AI and IoT technology to achieve innovative outcomes while maximising efficiency and sustainability. The research aims to answer:

The RMG industry can benefit from AI and IoT to improve its quality assurance operations.

The Ready-Made Garment sector in Bangladesh ranks as the world's second-biggest apparel exporter, serving brands like H&M, Zara, and Walmart. Although the clothes industry makes money, it still deals with ongoing problems in product testing quality, delivery speed, and following buyer standards. Human-based quality control methods take too long to perform and often produce mistakes because employees make manual errors on mass production lines.

Next-generation technology, such as Artificial Intelligence and the Internet of Things, is changing how things are done. AI camera systems identify fabric defects better than people do, and internet-connected sensors track machinery behavior plus environmental factors, plus production

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flow. This research examines how RMG companies in Bangladesh can use new technology to strengthen product quality checks and make better use of production time.

1.1. Research Objectives

The Ready-Made Garment (RMG) industry supports Bangladesh's economic development by bringing in 84% of all export revenue. Quality requirements and worldwide demand remain hard to balance in the present scenario. Our research studies how AI and IoT technology work with apparel quality control systems to improve performance and innovation within RMG production in Bangladesh. Research examines how AI systems check products for errors, combined with IoT observation and predictive models, to boost production quality, improve efficiency, and meet international quality regulations. Using AI and IoT technology enables Bangladesh to outperform its global competitors in the apparel market.

1.2. Research Question:

- What challenges stop Bangladesh from implementing these technologies?
- The success-oriented implementation needs what kinds of strategies?

2. Literature Review

2.1. AI in Apparel Quality Assurance

Artificial Intelligence technology has found three key applications in apparel manufacturing: material grading, defect identification, and predictive maintenance solutions. AI systems, including computer vision, work better than human inspectors through fabric examination, which leads to more accurate results and better quality consistency. High-resolution cameras feed images to algorithms that automatically identify tears and stains and stitching mistakes at the moment they occur. Research indicates AI achieves a 30% boost in quality control efficiency while decreasing manufacturing garment defects by 20%.

AI creates superior forecasting capabilities that enable better inventory control while preventing excessive manufacturing and wasting resources. Through their analysis of past data and market patterns, machine learning models assist manufacturers in matching their production levels properly. Fast fashion rules production timelines in Bangladesh, so the country benefits from AI applications that optimize production workflow because they help preserve competitive standing.

Machine learning and computer vision technologies have transformed how AI finds textile defects. AI systems detect fabric defects more accurately at a 95% success rate than human inspectors (Zhang et al., 2021). The use of deep learning network types such as Convolutional Neural Networks (CNNs) lets high-resolution cameras analyze images to detect defects at speeds beyond manual inspection.

2.2. IoT in Apparel Manufacturing

The Internet of Things enables real-time data collection by interconnected devices to provide a smooth production process monitoring. Manufacturers use IoT-enabled sensors in the RMG sector to obtain information about their machinery, along with environmental measurements and production data. IoT devices that track sewing machine vibrations serve to predict maintenance requirements, which shortens machine downtime by approximately 25%.

Supply chain transparency finds support from IoT implementations. The combination of Radio-Frequency Identification (RFID) tags and IoT platforms enables manufacturers to track all materials from supplier to product completion for quality standards compliance and product traceability. The combination of IoT systems would help reduce Bangladesh's extended lead times from 80-90 days to meet required buyer response times of 35-40 days.

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The Internet of Things helps measure sewing machine data and fabric production in real-time with environmental sensors. The combination of IoT technology and Predictive Maintenance allows production facilities to see when machines will break down before it happens (Lee et al. 2020). The use of RFID tags and smart wearables tracks product information precisely to meet all sustainability regulations.

2.3. Industry 4.0 in Bangladesh's RMG Sector

Bangladesh's National Industry 4.0 Policy (2020) from the government recognizes AI systems and the Internet of Things as primary technologies to transform industry production. Implementation of new technologies in the RMG sector remains slow despite the existing obstacles related to spending costs and scarcity of technical professionals and workers who hesitate to accept technological advancements. Research conducted in 2025 reveals the Industry 4.0 maturity score sits at 1.91 out of 5 points, thus reflecting limited adoption within the industry.

Early adoption success stories can be found in the case of Skylark Soft Limited alongside other companies. Through their AQAI system, which integrates Artificial Intelligence with Internet of Things architecture, they enhanced factory quality control and product tracing in Bangladeshi manufacturing sites. New technological solutions demonstrate how the garment manufacturing industry can undergo digital transformation through technology adoption.

The development of new technology has not spread widely in Bangladesh's clothing industry because of three main barriers. The AI and IoT equipment requires significant initial monetary investment. Small factories find it hard to find enough employees with technical knowledge for technology adoption. Many operators in the industry remain opposed to shifting away from traditional ways of working.

3. Methodology

A combination of literature review with case studies and qualitative industry report analysis makes up the methodology of this study. The research used academic journals and industry publications, together with web resources that featured studies on AI and IoT applications in apparel manufacturing production. A review of practical impacts involved the analysis of Bangladeshi firms using AI and IoT technology. The study uses analysis of statistical data provided by the Bangladesh Garment Manufacturers and Exporters Association (BGMEA) and Export Promotion Bureau to better understand the industry's performance.

4. Findings

4.1. AI and IoT Systems Implementations for Quality Control Functions

4.1.1. Automated Defect Detection

The RMG industry of Bangladesh experiences a transformation of its quality assurance practices through AI-powered computer vision systems. High-resolution cameras work together with machine learning algorithms to check fabrics as well as garments throughout their manufacturing process. The real-time defect detection capability of Skylark Soft's AQAI tool helps companies reduce manual inspection needs and achieve better accuracy levels. Research indicates that factories using AI technology achieved a 15-20% decrease in their product defects through automated quality assurance systems in 2024.

4.2. Real-Time Production Monitoring

IoT-enabled devices track production lines continuously to ensure that operations meet all quality requirements. The performance indicators from sewing machines and cutting equipment are tracked through sensors installed in the equipment. Managers can detect bottlenecks and fix

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problems through centralized dashboards that receive this data. Production efficiency at Apparel Solutions Bangladesh improved by 10% since their implementation of IoT systems.

4.3. Predictive Maintenance

Networking of AI with IoT allows companies to identify upcoming machinery breakdowns before they materialize. IIoT sensors check equipment status, then AI programs examine collected data to project when maintenance will become necessary. Predictive maintenance reduces factories' exposure to daily costs running into thousands of dollars from unexpected equipment breakdowns. The Bangladeshi factory applying IoT-based predictive maintenance systems reduced maintenance expenses by 20% according to its case study findings.

4.4. Supply Chain Optimization

Real-time product and material tracking capabilities enable IoT technology to improve supply chain visibility. Manufacturers can optimize inventory management and shorten lead times through predictive analytics, which AI provides together with this process. Blockchain-connected IoT systems enable Bangladeshi exporters to offer their buyers exact data about their manufacturing processes and material origin for better trust and compliance.

4.5. The integration of Artificial Intelligence with the Internet of Things in Quality Assurance offers the Following Advantages

4.5.1. Improved Efficiency

Artificial Intelligence, along with the Internet of Things, operates quality assurance functions through automation for time savings and reduced human work. Automated systems operate at thousands of garment inspections per hour, while human inspectors can only conduct inspections at a rate of a few hundred per hour. Fast fashion demand requirements and shorter lead times heavily rely on this operational efficiency.

4.5.2. Enhanced Quality Control

The precise defect detection capabilities of AI allow products to achieve the widely used AQL 2.5 quality standard that is standard in Bangladesh. Real-time monitoring through IoT detects quality issues in real-time, thus resulting in reduced rework costs.

4.5.3. Cost Reduction

AI technologies, together with IoT systems, help manufacturers reduce stresses on their production costs by eliminating failures and streamlining operations. Implementation of lean methodologies with IoT technology in factories led to a 10-15% decrease in defect-related costs during a 2020 research study. Predictive maintenance reduces maintenance and repair expenses while increasing the overall equipment life duration.

4.5.4. Sustainability

AI combined with the Internet of Things creates sustainable manufacturing through its ability to decrease waste output and reduce energy usage. Green factories with IoT capabilities in Bangladesh obtained their certification from the U.S. Green Building Council through sensor usage that led to 20-30% better resource management. The ability of AI to forecast demand helps decrease manufacturing waste because it supports global sustainability initiatives.

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4.6. Challenges to Adoption

4.6.1. High Initial Costs

The deployment of AI and IoT systems demands investment in hardware infrastructure alongside programs and the development of skilled workforce capabilities. Small and medium-sized factories face high-cost barriers to adopting these technologies that hinder their overall implementation.

4.6.2. Lack of Skilled Workforce

The manufacturing sector of ready-made garments in Bangladesh currently has an insufficient number of workers who are qualified in AI and IoT technologies. Research conducted in 2021 established that Industry 4.0 adoption requires worker upskilling to be successful. Unemployed factories find it impossible to achieve maximum technology benefits because of insufficient training.

4.6.3. Data Privacy and Cybersecurity

IoT devices produce substantial amounts that create privacy and security risks for users. The deficient level of cybersecurity infrastructure across Bangladesh makes organizations vulnerable to data breaches, which inhibits the user adoption of new technologies.

4.6.4. Resistance to Change

Organizations and cultures within these institutions face major obstacles to accepting new technology approaches. Management in factories prefers original methods because they are comfortable with traditional approaches while maintaining concerns about workforce reduction.

4.7. Case Studies

4.7.1. Skylark Soft Limited: AQAI Implementation

The AQAI tool developed by Skylark Soft uses AI and IoT technology to boost quality assurance systems within Bangladeshi RMG factories. Real-time production tracking occurs through the combination of computer vision defect detection with IoT technology. Manufacturers using AQAI technology faced up to 15% lower product defects in addition to 12% higher manufacturing productivity. Bangladesh has used Artificial Intelligence and Internet of Things Technology to build smart factories in Dhaka EPZ. One of the top garment manufacturers installed AI inspection tools to reduce product flaws by 40% while following EU requirements more effectively. The Pacific denim factory successfully implemented IoT water and energy monitors to save 25% in waste production without impacting product quality, which ensures sustainable apparel production.

4.7.2. Apparel Solutions Bangladesh

The company implemented IoT-enabled machinery monitoring together with AI-based quality control systems at Apparel Solutions Bangladesh. The company succeeded in shortening lead times by 10% and raised customer happiness with product quality consistency.

5. Recommendations

5.1. Government Support

Factories embracing AI and IoT technologies need expanded government financial support through subsidies and tax incentives following the guidelines set by the National Industry 4.0 Policy. Through public-private partnerships, the transfer of technology becomes easier, together with infrastructure development.

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5.2. Workforce Training

Technical education investments, together with workforce upskilling, present essential requirements. Manufacturers should partner with universities and international tech companies to teach AI and IoT skills to their RMG workforce.

5.3. Phased Implementation

High-impact areas, including quality control, need to be the starting point for factory AI and IoT implementation via incremental deployment through pilot projects. This deployment method simultaneously decreases financial challenges while enabling workers to adapt to new systems step-by-step.

5.4. Cybersecurity Investments

Organizational security frameworks must be built with strength to protect Internet of Things data. BGMEA, together with other industry associations, should take the lead in forming standards about data security.

6. Conclusions

AI and IoT systems represent a massive opportunity to modernize quality assurance procedures in Bangladesh's RMG industry. These technologies boost operational efficiency and minimize prices and maintain sustainability through automated inspection systems that combine real-time process tracking and predictive equipment maintenance features. The necessary strategic interventions need to solve the problems of high costs and skill gaps alongside challenges in change management. By partnering with the government and implementing workforce development programs, and stage-by-stage adoption, Bangladesh's RMG manufacturing sector should use IoT and AI while staying competitive globally to reach its $100 billion export goal during the 2030 timeframe.

Integrating Artificial Intelligence and Internet of Things technology leads to new ways of testing products in Bangladesh's ready-made garment sector. Companies increasing their use of these technologies will improve how they work while decreasing mistakes and achieving international quality requirements successfully. To maintain its smart apparel manufacturing leadership, Bangladesh needs to invest strategically while training its workforce.

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