

ARTIFICIAL INTELLIGENCE (AI) INTEGRATION IN THE GARMENT INDUSTRY: NAVIGATE THE CHANGES AND ASSESS THE IMPACT OF THE FUTURE - A CASE STUDY BASED ON THE BANGLADESH GARMENTS SECTOR

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ABSTRACT

This work offers a novel method for recognizing emotions in real time with wearable technology and deep learning algorithms. Utilizing a range of wearable sensors, such as ECG and EEG, the system continuously records physiological data that represent emotional states. Using long short-term memory networks for temporal analysis and convolutional neural networks for feature extraction, the system employs a hybrid deep learning architecture. When compared to conventional single-sensor systems, our approach improves the accuracy of emotion classification. Because of its real-time processing power, the system can be used for a variety of applications, including human-computer interfaces, adaptive entertainment systems, and mental health monitoring. Initial assessments demonstrate its resilience and adaptability in a range of application contexts. Compared to single-modality approaches, the multi-modal approach better represents the complexity of human emotions. Additionally, the study tackles issues such as data unreliability, the study also tackles issues including noise, customized models, and inconsistent data. The system's effectiveness in real-time applications is demonstrated by experimental findings, suggesting applications in healthcare, entertainment, and human-computer interaction.

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1. INTRODUCTION

Artificial intelligence (AI) is a Digital world changer. It can enhance productivity through automation, Machine learning, and precision (Soori et al., 2023). But to automate tasks through an intelligent system that can reduce time, costs and the need for labor also has the potential to diminish jobs. This is the case in the garments sector in Bangladesh.

As commentators have put it: Changes to the garment industry's business model are threatening the livelihoods

of millions of people in low and middle-income countries and how these economies adapt will have far-reaching implications. In particular, female and male workers who are at the bottom of the production process and are often engaged in repetitive tasks, are at the greatest risk of losing their jobs in this sector. Bangladesh is the world's exporter of garments (after China) (Hoque et al., 2022). The garment sector in Bangladesh employs 2.5 million female workers in around 4000 factories across in country (Uddin, 2018) and generates 80% of total exports in Bangladesh, contributing approximately 16% to the

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GDP. (Uddin, 2018) As a result, any technology disruption in this sector will have a long-term impact, not only on the sector's production processes and outputs but also on the workforce of employees in the sector (Ambrogio et al., 2022). This report explores the impact of AI on the Garments sector in Bangladesh from an impact and development perspective.

2. BACKGROUND OF THE STUDY

The Garment Industries is play significant impact on Bangladesh economic, contributing vital role its GDP and employment (Islam, 2021). Day by day increasing global competition and the demand for higher efficiency and sustainability. The integrating of AI provided promising away for innovation and growth.

2.1 Objective of the study

2.1.1 Broad Objective: The broad objective of this research is to investigate AI integration impacts in the garments industry in Bangladesh.

2.1.2 Specific objectives:

- To analysis the current situation of AI integration in Bangladesh garment sectors.
- To identify the opportunity and challenges presented by AI.
- To assess the impact of AI on productivity, quality and employee.
- To forecast future trends and implication of AI adaptation
- To provide strategic recommendation for the garments industries.

3. LITERATURE REVIEW

Workers in the Garments sector are mostly involved in the labor-intensive tasks of product development, such as marking and spreading fabric, cutting, sewing, ironing, finishing, tagging, and packaging. A study done by the Manusher Jonno Foundation on garment workers in Dhaka and Gazipur found that 72.7% do not have any signed contact with their employers.

Garment factories in Bangladesh are also known for their unsafe working environments (Kabir et al., 2022). The collapse of buildings, factory fires, and other incidents in the sector claimed at least 1,512 workers' lives between 2005 and 2013, while 1,691 workers were killed between 1990 and 2013. (Mobarok, 2014). Technology adoption is directly related to factory size.

According to a study by the Centre for Policy Dialogue, the use of advanced technologies in the RMG sector is prevalent in 47% of large-scale RMG enterprises, compared to 25% of mediumscale RMG enterprises. (Saadat, 2019). AI and automation technologies are also slowly being adopted by RMG factories, not only because of AI's time-, cost- and resourcesaving properties but also because of its game-changing nature in the RMG business model, as many garment factory

owners have said. For example, as a representative of the RMG sector explained: AI's powerful vision and image recognition system can easily help in identifying and grading textile fabric (Sikka et al., 2024).

AI can enable accurate performance during cutting, spreading, and sewing. CAD and patternmaking, production planning and control, shop floor control systems – all these can be performed at a much higher level of productivity and accuracy with AI technology. (Uddin, 2018).

3.1 Statement of the AI impact problem:

This study identified the RMG sector as one of the most affected sectors due to AI and automation. The Centre for Policy Dialogue shows that the automation of manufacturing reduced the participation ratio of female Workers in the garment sector to 60.8% in 2016 from 64% in 2015. The study also shows that the factory owners think female workers are not able to handle modern machinery properly (Bello et al., 2021; The Daily Star. 2018).

Bangladesh still does not have any formal policy on AI implementation in the Garments sector. Recently, the government's Information and Communications Technology (ICT) (Akter et al., 2024). Interestingly, the strategy does not touch upon the issue of job losses and how and when the existing workforce who may lose their jobs due to the implementation of AI would be compensated or redeployed through training or skills development (George, 2024). While it may make some jobs redundant, may also bring in new types of jobs that did not exist before which nevertheless may require new skill sets.

The question is obviously to understand whether new jobs will match the rate of worker lay-offs and whether or not the country can keep pace with the skills gaps and training required to acquire new skills. (Uddin, 2018). Recent research into the sector found that RMG factories provide few training and development opportunities for their workers outside of the immediate demands of their jobs. Only 5% of respondents confirmed that they have training facilities for their employees.

Training for supervisors is nevertheless common (70%). Akter and Alam (2016). Skill training institutes for garment workers are rare and, as a result, workers in many cases feel frustrated: 86% of worker respondents reported that there are no training institutes available for developing their knowledge and capability. So what would be the future for them and their family?

4. METHODOLOGY

4.1 Research design

The research, here is intended to investigate the AI integration impact in the garments industry of Bangladesh. The research methodology applied for this study is discussed in the following text.

This study will be apply mixed methods approach, combining quantitative data analysis, with qualitative

insights from industries experts. Data source include industries reports, company case studies and interview with key stockholders in the Bangladesh garments sectors.

4.2 Data Collection Method

There are two types of data collection method are: Primary data and Secondary data. This study is based on only secondary data.

4.2.1 Primary data: Primary data is a type of data that is collected by researchers directly from main sources through interviews, surveys, experiments, etc. Primary data are usually collected from the source—where the data originally originates from and are regarded as the best kind of data in research.

Face to face interview, managers, engineers, employee and workers from leading garments factories.

4.2.2 Secondary data: Secondary data is the data that has already been collected through primary sources and made readily available for researchers to use for their own research.

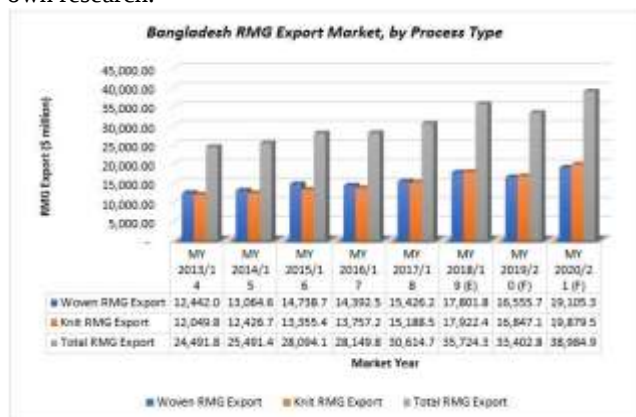


Figure 1. Bangladesh RMG Export Market

Source: BGMEA (2023)

It is a type of data that has already been collected in the past.

- Data collected from the online, reports, newspaper, journals, articles, publications and unpublished articles, journals etc.
- Bangladesh Garment Manufacturers and Exporters Association (BGMEA, 2023) (Figure 1).

5. FINDINGS AND DISCUSSIONS

5.1 Current state of AI integration

5.1.1 Production Process: The initial stage of pattern making is crucial. But AI algorithms analyze extensive data including body measurement, design requirements and fabric properties to create accurate properties. AI's powerful vision and image recognition system can easily help in identifying and grading textile fibers of the most important element of design "color", AI can enable an accurate prediction of dye recipe, process control during dyeing, automated dispensing of dyes and even in final color evaluation. When it comes to garment

manufacturing, AI can enable accurate performance during cutting, spreading and sewing. CAD and patternmaking, production planning and control, shop floor control systems—all these can be performed at a much higher level of productivity and accuracy with AI technology.

5.1.2 Supply Chain Management: The Garment industries of Bangladesh increase supply chain management process by AI. AI can evaluate demand forecasting by analyzing vast amounts of data. To allow for more accurate customer needs and market demands. It helps inventory management, ensuring optimal stock levels, and reduces wastage.

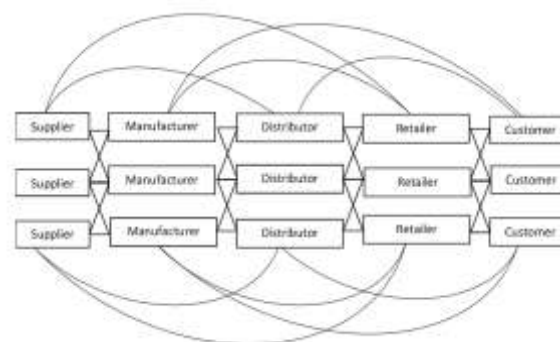


Figure 2. Supply Chain Management of RMG Sector

AI integration systems enhance streamline production planning by efficiency allocating resources and scheduling production tasks. It identify mistakes and maintain quality control by monitoring Supplier Manufacturer Distributor Retailer Customer Figure 2. Production process moreover, Artificial Intelligence (AI) operates supplier management by evaluating supplier productivity and managing the procurement process. AI integration provide logistics supports transportation and delivery schedules, reducing costs and improving delivery times.

AI integrate supply chain management in Bangladesh garments sector increases efficiency, reduces costs, and improves responsiveness to market demands.

5.2 Challenges

High Initial Investment: After Pandemic, Bangladesh has faced local and global challenges. Here inclusive some point.

5.2.1 Inflation Rate: The global inflation rate was the highest in 2022 with a rate of more than 9%. Starting from necessary commodities to utilities, everything experienced a price hike during the period.

5.2.2 Change in brands behavior: Due to the potential threat of a global recession, brands and buyers began taking cautionary steps. Many of our factories have disclosed that they do not have enough orders from February onwards to run the factories at full capacity.

5.2.3 Increased production cost: Throughout 2022, we faced a difficult situation with record-high cargo rates and container shortages. Many brands favored

nearshoring countries to ensure the fastest delivery. In accordance with the global trend, production costs increased significantly in our sector as well. Diesel and other utility prices had been increased to balance with the current world trend, which put significant pressure on the manufacturers.

5.3 Local Challenges

5.3.1 Utility price increase: Utility bills, i.e. gas, water and electricity cover a big portion of the costs in RMG factories. Plunged by the dire effects of Covid-19, factories were already struggling to retain competitiveness in the global market.



Figure 3. Main pillars of Industry 4.0

Amidst that, the price of gas, electricity and fuel has increased. Due to the geopolitical situation, production cost has already significantly increased in the last few years. And this new price hike will challenge the sustainability of the industry. Main pillars of Industry 4.0 are presented on figure 3.

5.3.2 Overdependence on markets and products: Even though the industry has been operating for almost 40 years, our markets and products have been heavily congested towards a few products and markets. T-shirts, trousers and knit items are our strengths, however the current world demand is for non-cotton and manmade fibre-based products.

Our market is also heavily concentrated towards the EU and a select few traditional markets. In order to grab more market share and utilize the untapped opportunities, we have to explore more in the coming days.

5.3.3 Backward linkage: As mentioned in the previous point, our backward linkage is very weak at this moment; this poses a serious problem after Bangladesh's LDC graduation.

After LDC graduation, we will have to follow the double transformation rules of origin. We will also have to produce our own fabric before making the clothes. Due to this, joint venture or FDI is a must in this sector, so that along with financial and technical know-how, the necessary skills can be learned by our industry.

5.4 Skills Gap

According the, Bangladesh Institute of Development Studies (BIDS) has found. The readymade garments

sector has a 60 percent skills gap among employee especially machine operators

The study was conducted in early 2021 among 476 workers and their employers in around 119 small, medium, and large factories in Chattogram (50), Dhaka (43), Gazipur (9), and Narayanganj (17). It focused on three aspects – skill shortage, skill mismatch, and skill gap.

5.5 Social economic impact

The relationship between inequality and technological unemployment despite widespread concerns about technology leading to significant job losses, the World Economic Forum asserts that artificial intelligence (AI) and robotics have the potential to generate more employment opportunities than they displace. If individuals are terminated from their jobs, it becomes the responsibility of the government to provide other sectors for their employment. Table 1 presents growth of the number of factories and employees after every 10 year.

Table 1. Growth of the number of factories and employees after every 10 year.

Year	No. of garment factories	Employment (million workers)
1987–88	685	0.31
1997–98	2726	1.50
2007–08	4743	2.80
2017–18	4560	4.00

Source: BGMEA (2018)

If new work opportunities arise, it is essential to develop a corresponding pool of skilled individuals. The presence of a significant number of low-skilled workers plays a crucial role in driving economic growth across multiple manufacturing industries. If individuals become unemployed as a result of automation, it is imperative for the government to establish alternative provisions for their sustenance. Free or subsidized large-scale population training should be made available.

5.6 Opportunities

5.6.1 Increased Efficiency and Productivity

Bangladesh, productivity percentage was very loose and flexible. Labor cost was low, and CM standard was high, for which companies did not focus on workers' productivity and skill level. Now while the scenario is different from other parts of the world, Bangladesh still needs to catch up to make rapid progress with the massive development of the global apparel market. Skilled labor is becoming more critical as manufacturing operations demand better and improved performance. From the manufacturer's point of view, profitability is meager, and many also suffer from cash flow problems. The investment that factories had to make in building and fire safety created an additional strain for some companies. However, several manufacturers are making changes in their infrastructure, improving workers' skills, etc.

Dhaka Chamber of Commerce and Industry (DCCI) released the latest data statistics citing Asian Productivity Organization (APO) Database 2018. It says that hourly

labor productivity is calculated as the GDP produced per hour at constant prices. Contribution to GDP of Bangladesh is presented on the figure 4.

Hourly garment labor productivity in Bangladesh is still low, except for Cambodia in average output. Bangladesh is the second lowest in terms of labor productivity per hour, which according to the data, is worth \$3.4. Hourly productivity levels in China, the largest apparel exporter, are calculated at \$11.1

Based on hours worked, labor productivity in Sri Lanka was recorded at \$15.9, followed by Indonesia at \$12.3 and the Philippines at \$8.7. Other major apparel exporters, India, Vietnam, and Myanmar, also have higher labor productivity at \$7.5, \$4.7, and \$4. Respectively 1. Bangladesh lags behind all seven garment-producing competing countries except Cambodia and has a 77 percent gap with China. The government claims that the country's overall labor productivity increased by 3.8% between 1995 and 2016, thanks to the efforts of the National Productivity Organization (NPO).

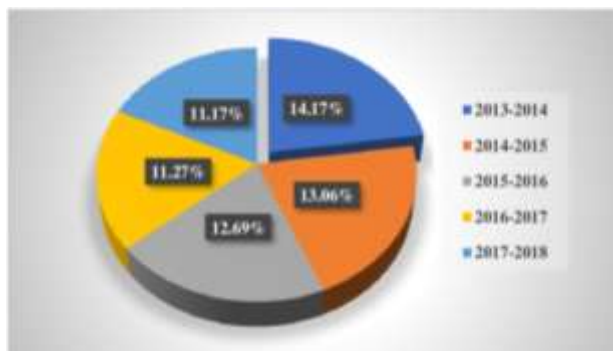


Figure 4. Contribution to GDP of Bangladesh

The government also set a target to increase productivity in working hours by an average of 5.6% per year between 2021 and 2030. The efficiency of most garment factories could be much higher than the average 40% - 45% in Bangladesh compared to global benchmarks.

75-85% with necessary efforts undertaken by National Productivity Organization (NPO). The government also set a target to increase productivity in working hours by an average of 5.6% per year between 2021 and 2030. The efficiency of most garment factories could be much higher than the average 40% - 45% in Bangladesh compared to global benchmarks.

75-85% with necessary efforts undertaken by National Productivity Organization (NPO). The government also set a target to increase productivity in working hours by an average of 5.6% per year between 2021 and 2030. The efficiency of most garment factories could be much higher than the average 40% - 45% in Bangladesh compared to global benchmarks. 75-85% of the various reasons and problems behind the low productivity of Bangladesh's RMG industry can be identified from multiple sources and studies. In general, company authorities or management and infrastructure employees can be identified as key stakeholders to influence the

productivity level of any garment industry in our country. The causes and problems of low productivity can be stated under these stakeholder.

5.7 Enhanced Quality and Customization

Continuous improvement in Bangladesh's garment industry can bring numerous benefits. Lean manufacturing principles emphasize waste elimination, streamlining processes, and optimizing efficiency. By embracing these principles, garment factories can reduce lead times, improve productivity, enhance quality, and lower production costs. This enables them to deliver products faster, respond to market demands effectively, and remain competitive in the global market.

Implementing lean manufacturing processes fosters a culture of constant innovation and employee engagement. It encourages all levels of the organization, from management to frontline workers, to actively identify opportunities for improvement. As a result, the company's overall growth will be boosted. In order to achieve a more streamlined and efficient workflow, it is important to evaluate processes regularly, identify bottlenecks, and take corrective action. Number of garment factories is presented on figure 5.

Moreover, continuous improvement in the garments industry aligns with sustainability goals. Lean manufacturing promotes resource optimization, reducing waste in materials, energy, and time. By adopting eco-friendly practices, such as reducing energy consumption and utilizing recycled materials, garment factories can contribute to a more sustainable and environmentally conscious industry.

Furthermore, continuous improvement drives customer satisfaction. Lean manufacturing processes focus on meeting customer demands efficiently and delivering high-quality products. By consistently refining processes, addressing customer feedback, and adapting to changing market trends, the garments industry can maintain customer loyalty, enhance brand reputation, and increase market share.

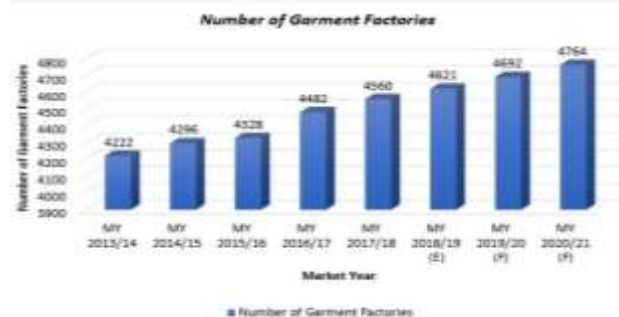


Figure 5. Number of garment factories

Source: - BGMEA. (2023)

Continuous improvement, supported by lean manufacturing processes, is vital for Bangladesh's garment industry. It drives efficiency, enhances quality, reduces waste, promotes sustainability, and ultimately leads to customer satisfaction. By embracing a culture of continuous improvement, garment factories can stay

ahead in a highly competitive global market. This will contribute to the industry's growth and the overall economic development of the country.

5.8 Sustainable Practices

The global apparel landscape is undergoing a significant shift towards sustainability. The EU's "Strategy for Sustainable and Circular Textiles" demands increased use of recycled fibers and ecofriendly manufacturing practices. This presents challenges and opportunities for Bangladesh, the world's second-largest apparel manufacturer.

However, Bangladesh boasts two significant advantages in this new reality: nearly half of its pre-consumer textile waste is pure cotton, the most readily recyclable fiber and its dominance in knitwear production, as knit fabrics are ideal for recycling.

With this strong foundation, investing in fibre recycling technology not only addresses environmental concerns but also enhances Bangladesh's reputation globally, attracting environmentally conscious brands and investment.

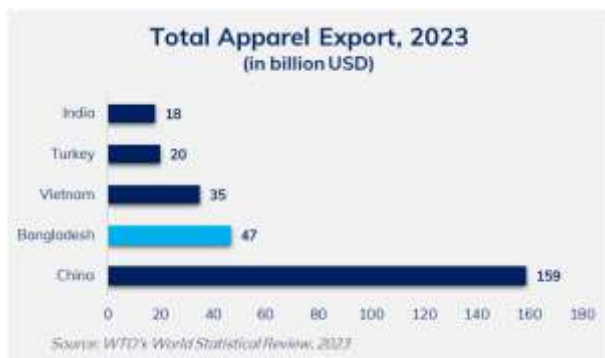


Figure 6. Total apparel export in Billion USD

Bangladesh is also shifting towards sustainable practices due to new environmental regulations, growing consumer demand for eco-friendly products, and an understanding that sustainability is essential for long-term success.

Bangladesh's commitment to sustainability is evident in its growing number of LEED-certified green factories. With 214 LEED certifications, including 80 Platinum and 120 Gold, Bangladesh is a global leader in sustainable manufacturing, attracting further investments and solidifying Bangladesh's competitive edge. Total apparel export in Billion USD is presented on figure 6.

Beyond certifications, factories are reducing their environmental footprint via water-efficient dyeing systems and energy-saving machinery, addressing textile waste by recycling fabric scraps for new products, etc.

Use of recycled materials like polyester and cotton is gaining traction and the Brand BGMEA is actively promoting sustainable sourcing via agreements with international brands. Progressive manufacturers are investing in recycling plants and sustainable production facilities. For e.g., HaMeem Group's recycled yarn plant, Pacific Jeans's waste management facility.

6. FUTURE IMPLICATIONS

Bangladesh's readymade garment (RMG) sector has been a vital economic pillar, boosting GDP, creating jobs, and generating income from exports. The RMG industry will inevitably include artificial intelligence (AI) as technology develops. AI has the enormous potential to transform many facets of the industry, including supply chain management, communication and negotiation procedures, and manufacturing efficiency. AI in Production and Supply Chain Management: RMG manufacturers can optimize their production processes by utilizing AI-powered technologies like predictive analytics and machine learning algorithms. Artificial intelligence (AI) can more correctly estimate demand by evaluating real-time and historical data, which improves inventory management and decreases waste. Furthermore, production line efficiency can be improved by AI-driven automation, leading to higher productivity. In supply chain management, AI can improve transparency and traceability by enabling real-time monitoring of raw material sourcing, production progress, and shipping logistics. This enhanced visibility helps in identifying potential bottlenecks and mitigating risks, ensuring timely delivery of orders to clients.

As AI continues to evolve, its impact on the RMG industry in Bangladesh is expected to grow exponentially. From enhancing operational efficiency and supply chain resilience to facilitating smoother communication and negotiation processes, AI technologies hold the potential to drive innovation and competitiveness in the sector. However, it's essential for stakeholders to embrace AI responsibly, ensuring that its deployment aligns with ethical standards and prioritizes the well-being of workers and communities.

One real-world example of AI adoption in Bangladesh's RMG industry is the use of AI-powered quality control systems. Traditionally, quality control in garment manufacturing involves manual inspection by workers to identify defects such as stitching errors, fabric flaws, and color discrepancies. However, this process can be time-consuming and subjective, leading to inconsistencies in product quality.

To address these challenges, some garment factories in Bangladesh have started implementing AI-based quality control solutions. These systems utilize computer vision technology and machine learning algorithms to automatically inspect garments for defects with greater speed and accuracy than human inspectors. By analyzing images of garments captured by high-resolution cameras, AI algorithms can detect even subtle defects and anomalies in stitching, fabric texture, and color.

One such example is the partnership between Aamra Technologies Limited, a leading IT solutions provider in Bangladesh, and several RMG factories. Aamra Technologies has developed an AI powered quality control system called "Aamra Vision" specifically tailored for the garment industry. The system uses advanced image processing techniques and deep learning

algorithms to identify defects in garments during the production process.

7. STRATEGIC RECOMMENDATIONS

7.1 Investment in Training and Education

The readymade garment (RMG) sector is one of the economic lifelines of the country, but a bottleneck hampers the efficiency and productivity of the industry significantly. It is a hard fact that the industry has been suffering from a lack of skilled workforce. Enterprise-based training (EBT) is a must for development of the RMG and textile sector. It is a process of teaching or learning particular skills, knowledge or attitude on the premises of the enterprise and at the company level.

7.2 Collaboration with Tech Companies

Technology adaptation and digitization will support the industry in capacity building, product diversification, improving predictability, efficiency, decision making, accuracy and cost optimization - not just in sourcing, but throughout the business process.

7.3 Policy Support

Policy support is necessary to stimulate industry growth and sustainability, particularly streamlining business procedures, including swift unloading of imported machinery and raw materials.

7.4 Focus on Sustainability

Leveraging AI in the ready-made garment (RMG) sector can significantly enhance sustainable practices and reduce environmental impact, aligning with global sustainability goals. By utilizing predictive analytics, AI helps forecast demand accurately, minimizing overproduction and waste. Furthermore, AI-driven tools optimize material usage, ensuring efficient fabric cutting and reducing leftover waste.

7.5 Stakeholder Engagement

Engaging stakeholders effectively is crucial for managing the transition to sustainable practices in the ready-made garment (RMG) sector. This involves fostering open communication with all parties, including workers, suppliers, and consumers, to ensure that their

perspectives and concerns are considered. By actively involving workers in the process, organizations can address their needs and mitigate potential negative impacts, such as job displacement or changes in working conditions.

8. CONCLUSION

As the world embraces technological advancement Bangladesh apparel industry stands at a crucial crossroads. By viewing digital technology particularly AI. As an opportunity rather than a threat, we can transform the RMG sector into a hub of innovation and skill. Moving beyond the stigmas of low paid low skilled work is essential for our progress, we must focus on elevating our workforce through targeted skill development and retraining initiatives.

The promise of AI in enhancing productivity, customization, and sustainability offers a pathway o greater value for both customers and workers. However to harness this potential responsibly, we must adopt a balanced strategy that prioritizes ethical guidelines, data privacy and technical preparedness. Collaboration among the government, industry associations, and businesses is vital for creating ecosystem that supports innovation while respecting human artistry.

By collectively implementing these strategies, Bangladesh can not only thrive in the competitive global market but also ensure the social and environmental sustainability of its RMG sector. This approach will secure a prosperous future for the industry and its workforce, ultimately benefiting the nation as a whole.

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