Green Transformation and Environmental Sustainability in Bangladesh's Readymade Garment Industry: Evidence from Narayanganj and Mymensingh

Md Shahabuddin[1*], Most Jesmin Ara[2], Mst. Nupur Aktar[4], Banani Biswas[2], Faizah Sadik Tapti[3], Kazi Afnan Maha Sneha[3], Sumia Akter Mim[3], Tanisha Tabassum khan[5]

[1] Faculty of Science, University of Lisbon, Portugal

[2]Nowlamari Fazil Madrasha (Degree College), Chuadanga, Bangladesh (Bangladesh)

[3]Department of Genetic Engineering and Biotechnology, East West University, Dhaka, Bangladesh

[4]Department of Political Science, Dhaka Central University, Bangladesh (Bangladesh)

[5]Department of Genetic Engineering and Biotechnology, East West University, Dhaka, Bangladesh

[*]Corresponding Author

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ABSTRACT

Bangladesh's ready-made garment (RMG) industry is a major contributor to employment, exports and economic development, but its production processes place substantial pressure on water, energy and other environmental resources. This study examines the scope for environmental sustainability through green industrial practices in the RMG sector, using evidence from Narayanganj and Mymensingh and complementary industry-level data. The analysis combines a 58-factory industry dataset, field-based case studies of Bay Creation Limited and Envoy Textiles Limited, key-informant interviews, focus group discussions, field observation and secondary literature. The assessment focuses on building and structural integrity, production systems, water use and wastewater management, energy use, workplace conditions and alignment with Leadership in Energy and Environmental Design (LEED) parameters. The industry-level results show heavy dependence on groundwater, which supplied 82% of reported factory water sources, while municipal water accounted for 14%, rainwater 3% and surface water 1%.

Energy use was dominated by natural gas at 77%, followed by grid electricity at 19% and diesel at 4%. The case studies indicate substantial improvements after green conversion: Bay Creation Limited reported reductions of 40% in water use, 30.7% in energy use, 45% in vehicle use associated with carbon footprint and 39% in waste, while Envoy Textiles Limited reported corresponding reductions of 40%, 33.7%, 35% and 40%. The study also identifies major investment requirements for water efficiency, energy efficiency, sustainable sites and indoor environmental quality. Overall, green transformation can improve resource efficiency, environmental performance and workplace conditions, but financing, metering, technical capacity and stronger policy support remain important constraints. The study recommends accessible green finance, systematic water and energy monitoring, renewable energy adoption, improved wastewater treatment and coordinated technical support for RMG factories.

Keywords: Green industry; RMG sector; environmental sustainability; resource efficiency; Bangladesh

INTRODUCTION

The ready-made garment (RMG) industry is central to Bangladesh's economic development and international export performance. Its expansion has generated employment and contributed to poverty

reduction and improved living conditions, but the sector has also created significant environmental pressures through intensive use of water, energy and materials, wastewater generation, emissions and waste. The original thesis underlying this article argues that the long-term competitiveness of the sector increasingly depends on reducing resource intensity and meeting environmental and social expectations in global apparel value chains. This perspective is consistent with the broader sustainability literature, which treats environmental, social and economic performance as interconnected dimensions of long-term viability (Carter & Rogers, 2008).

Green industry approaches seek to reduce environmental impacts while maintaining productive capacity. UNIDO's green-industry framework emphasizes environmentally responsible investment, resource efficiency, cleaner production and technological improvement. Research on industrial green transformation also suggests that green transformation can reduce pollution, although outcomes depend on technological, institutional and regulatory conditions (Hou et al., 2018). Evidence from China further indicates that green industrial development can reduce pollution and improve resource efficiency while remaining closely connected to economic development (Chen et al., 2017).

In Bangladesh, the transition toward greener RMG production is particularly relevant because factories operate within a resource-intensive manufacturing system and face increasing demands for environmental compliance. The thesis identified water management, energy efficiency, wastewater treatment, workplace conditions, certification and investment as interconnected areas requiring attention. The present article condenses those findings into an empirical assessment of environmental sustainability and green transformation in the RMG sector.

Research Objectives

The study pursued three objectives: (1) to assess the environmental and operational condition of RMG factories against green-industry principles and relevant national and international standards; (2) to identify major investment areas required for green transformation; and (3) to examine reported changes in environmental conditions and resource efficiency associated with green production practices.

Study Area

The field case studies were located in Narayanganj and Mymensingh, two important RMG-producing areas in Bangladesh. Bay Creation Limited was examined in Rupganj, Narayanganj, while Envoy Textiles Limited was examined in Bhaluka, Mymensingh. The thesis also used industry-level data covering factories in Dhaka, Narayanganj and Chattogram, with the Dhaka-region dataset including Dhaka, Narsingdi, Gazipur and Mymensingh.

METHODS

The research followed a mixed qualitative and quantitative case-study design. The evidence base comprised an industry-level dataset covering 58 RMG factories, two detailed factory case studies, primary field evidence, and secondary/association materials. The primary case-study component used structured interviews, key-informant interviews, focus group discussions, field observation and photographs collected in October 2018. The industry-level dataset was compiled from Bangladesh Knitwear Manufacturers and Exporters Association (BKMEA) materials and related secondary sources. The source materials identify factories across Dhaka, Narayanganj and Chattogram, with the Dhaka-region dataset including Dhaka, Narsingdi, Gazipur and Mymensingh.

Judgment sampling was used for the two detailed case studies under budget and time constraints. Bay Creation Limited in Rupganj, Narayanganj, and Envoy Textiles Limited in Bhaluka, Mymensingh, were selected because both had undergone conversion from conventional to green operations, allowing reported before-and-after comparisons. The two case studies therefore provide illustrative evidence of changes associated with green conversion rather than a probability-based estimate for the RMG sector.

Table 1 summarizes the research components and sample coverage. The source materials provide the reported factory counts and fieldwork activities, but do not retain a complete probability-sampling frame, factory-level selection protocol, or consistent denominator documentation for every percentage reported in the original thesis. Accordingly, the present article treats the 58-factory evidence as a descriptive dataset rather than a statistically representative sample of all Bangladeshi RMG factories.

The assessment framework covered five broad domains: building and structural integrity; production techniques; water use and wastewater management; energy use; and work environment and workplace safety. The study also compared factory conditions with LEED-oriented parameters covering sustainable sites, water efficiency, energy and atmosphere, materials and resources, indoor environmental quality, innovation and regional priority. The LEED-oriented assessment should not be interpreted as evidence of formal LEED certification unless certification is independently documented.

For the case studies, reported before-and-after indicators were compared to describe changes associated with green conversion. The investment-mapping component estimated indicative requirements for sustainable sites, water efficiency, energy efficiency and indoor environmental quality. These estimates were derived from the thesis dataset and reported source materials and were treated as scenario-based investment requirements rather than universal costs.

The analysis is primarily descriptive. Percentages, resource-use patterns, operational characteristics, certification conditions and reported before-and-after changes were compared across factory categories and case studies. No causal econometric model or counterfactual comparison was used, and no statistical significance tests were conducted in the source analysis. The results therefore describe observed patterns and reported changes rather than identifying causal effects of green conversion.

Table 1. Research design and sample coverage

Component	Respondents / units	Sample
Individual interviews	Factory representatives	6
Key-informant interviews	Sector and technical specialists	4
Focus group discussion	Top- and mid-level factory management	2
Case studies	RMG factories	2
Industry dataset	Factories covered in comparative analysis	58

Source: Adapted from the author's thesis dataset and reported source materials.

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For the case studies, before-and-after indicators were compared to assess changes associated with green conversion. The investment mapping component estimated the costs associated with sustainable sites, water efficiency, energy efficiency and indoor environmental quality. These estimates were treated as indicative investment requirements rather than universal benchmarks because the thesis explicitly notes that costs vary by factory size, technology and market conditions.

The analysis is primarily descriptive. Percentages, resource-use patterns, operational characteristics, certification conditions and reported before-and-after changes were compared across factory categories and case studies. No causal econometric design was used; therefore, the observed improvements in the two case studies should be interpreted as reported changes associated with green conversion rather than as experimentally identified causal effects.

RESULTS

Water use and Wastewater Management

Water dependence is one of the clearest environmental sustainability challenges identified in the study. Groundwater accounted for 82% of reported raw-water sources in the industry dataset, followed by municipal water at 14%, rainwater at 3% and surface water at 1%. The reported total groundwater use was 28,166.795 m³/day. The concentration of industrial water demand on groundwater creates risks for resource depletion and reinforces the importance of water tracking, reuse and alternative sources.

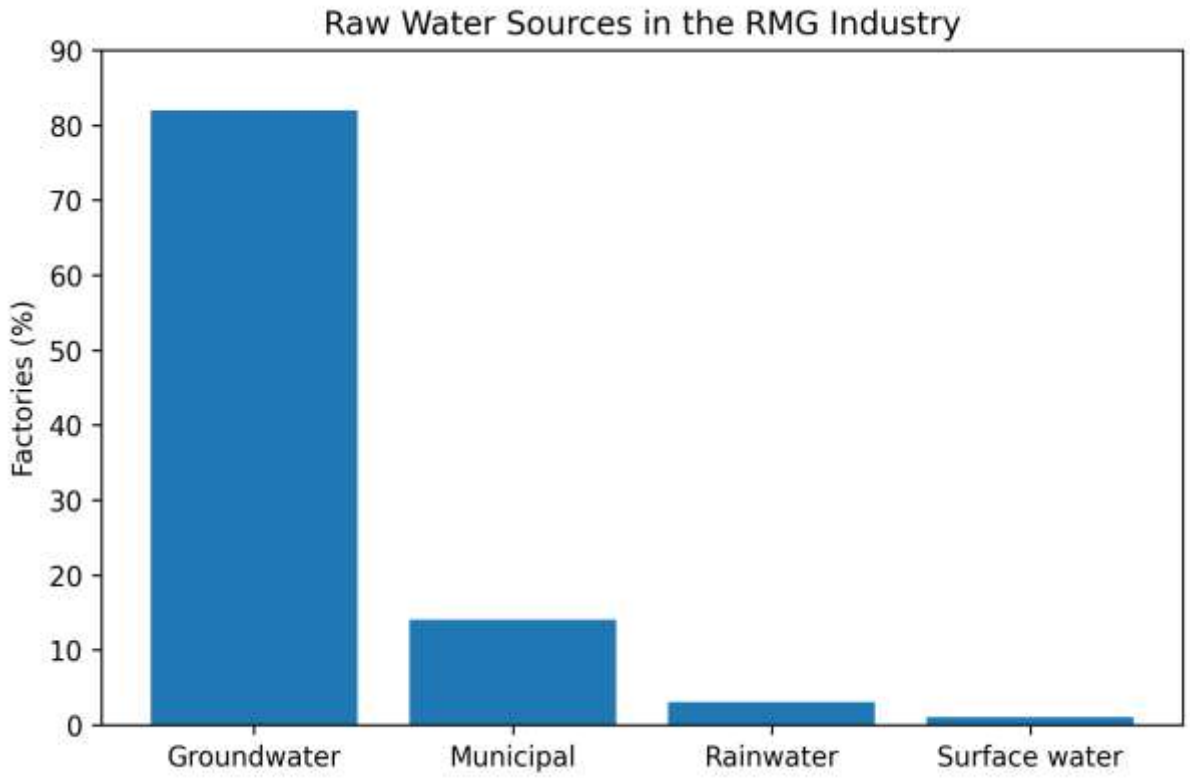


Figure 1. Distribution of reported raw-water sources in the RMG industry. Source: Author's reconstruction from the thesis data.

Water monitoring was uneven. In the Dhaka region, 17 of 31 factories were reported to have water tracking systems; in Narayanganj, 11 of 17 factories had such systems; and in Chattogram, 7 of 10 factories had tracking systems. These counts are reported as documented in the thesis dataset. Because the underlying factory-level records were not retained in a public repository, the article does not independently reconstruct the sampling denominators beyond the reported counts.

Wastewater treatment performance was also examined. The reported ETP results showed that treated effluent generally met several Department of Environment parameters in the dataset, although the thesis identifies weaknesses in water-quality monitoring, treatment infrastructure and process-level measurement. The findings support stronger ETP assessment, water-flow metering and reuse of treated water where technically appropriate.

Energy Use and Efficiency

The industry-level energy profile was strongly dependent on natural gas. Approximately 77% of reported energy use came from natural gas, while grid electricity and diesel accounted for 19% and 4%, respectively. Heavy machinery was a major energy load: generators accounted for 34% of energy consumption, air compressors 29%, boilers 13%, dyeing machinery 6%, sewing machines 5%, and other equipment 13%.

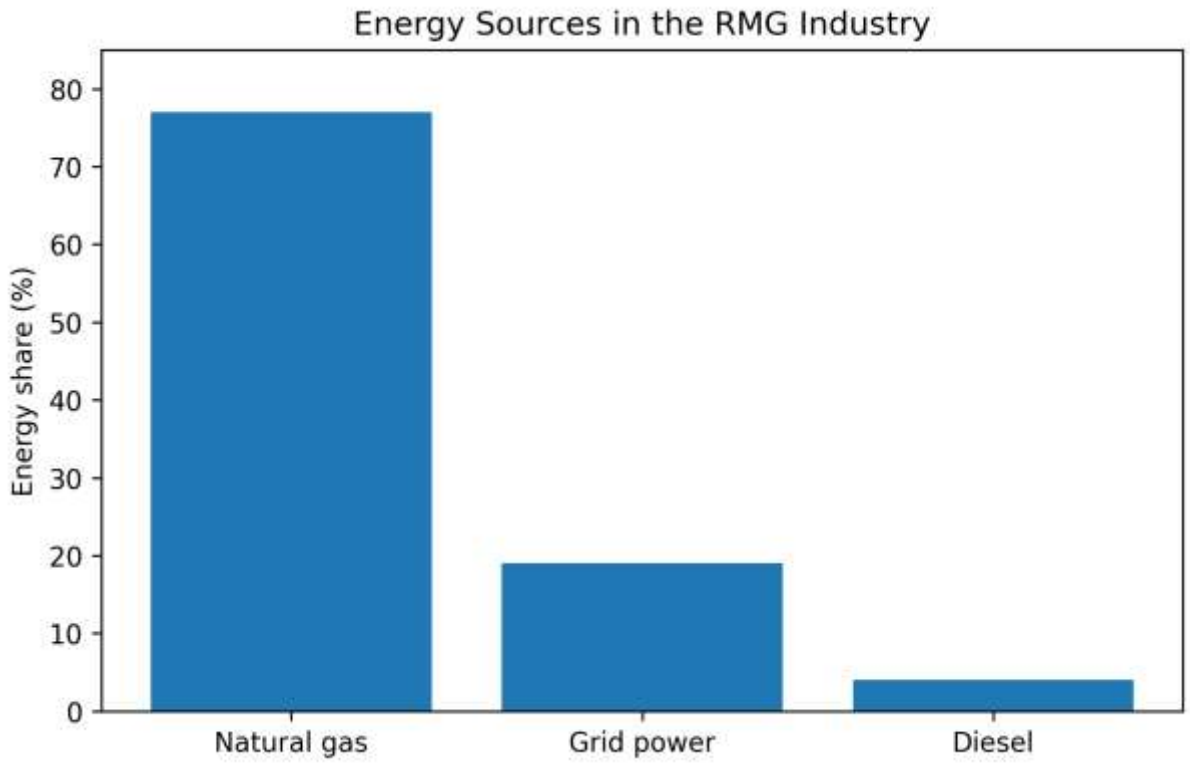


Figure 2. Reported energy-source composition in the RMG industry. Source: Author's reconstruction from the thesis data.

Table 2. Selected energy-management practices by factory size

Energy-management indicator	Large	Medium	Small
Equipment maintenance	100.0%	100.0%	100.0%
Calibration of equipment	63.6%	58.8%	42.1%
Preventive maintenance	95.5%	52.9%	52.6%
Energy awareness programmes	50.0%	23.5%	10.5%
Energy audit plan and team	18.2%	0.0%	5.3%
Commitment to renewable-energy expansion	22.7%	0.0%	15.8%
Commitment to GHG reduction	27.3%	17.6%	10.5%

Source: Adapted from the author's thesis dataset and reported source materials.

The results indicate a substantial management gap between routine equipment maintenance and higher-order energy-management practices. While equipment maintenance was reported at 100% across factory sizes, only 8.6% of factories in the broader assessment had conducted an energy audit, according to the thesis narrative. The study also found limited use of advanced sub-metering, energy-saving plans, renewable-energy commitments and greenhouse-gas reduction programmes, particularly among small and medium factories.

The percentages in Tables 2 and 3 are reported as percentages of the factory categories in the underlying thesis dataset. Because the archived source materials do not provide a complete machine-readable denominator and item-level dataset for every indicator, these percentages are presented descriptively and are not used for inferential comparisons.

Work Environment and Workplace Safety

Environmental management and workplace conditions varied substantially by factory size. ISO 14001 certification was reported for 55.0% of large factories, 41.7% of medium factories and 11.1% of small factories. Written environmental policies were more common, reported for 95.0%, 90.0% and 88.9% of

large, medium and small factories, respectively. Fire-safety measures were comparatively strong: 100% of the factories reported fire extinguishers, while 94.5% reported fire alarms and 98.2% reported hose pipes.

Table 3. Selected environmental-management and workplace indicators

Indicator	Large	Medium	Small
ISO 14001 certification	55.0%	41.7%	11.1%
Written environmental policy	95.0%	90.0%	88.9%
Environmental risk-management plan	65.0%	66.7%	33.3%
Fresh-air requirement met in sewing	90.5%	88.2%	100.0%
All solid waste segregated	95.5%	64.7%	78.9%

Source: Adapted from the author's thesis dataset and reported source materials.

The evidence indicates that formal policy adoption was more widespread than systematic environmental measurement. The study also identified gaps in air-quality monitoring, especially for carbon dioxide and particulate matter, and limited metering in smaller factories. These gaps are relevant because green transformation requires not only capital investment but also operational monitoring and technical capacity.

Case-study evidence on green conversion

The two factory case studies provide a direct comparison between reported pre-conversion and post-conversion conditions. Bay Creation Limited in Narayanganj reported a 40% reduction in water use, a 30.7% reduction in energy consumption, a 45% reduction in vehicle use associated with carbon footprint, and a 39% reduction in waste after green conversion. Envoy Textiles Limited in Mymensingh reported reductions of 40% in water use, 33.7% in energy use, 35% in vehicle use and 40% in waste. Both case studies reported the use of ETP/STP/WTP and reuse or recycling practices after conversion.

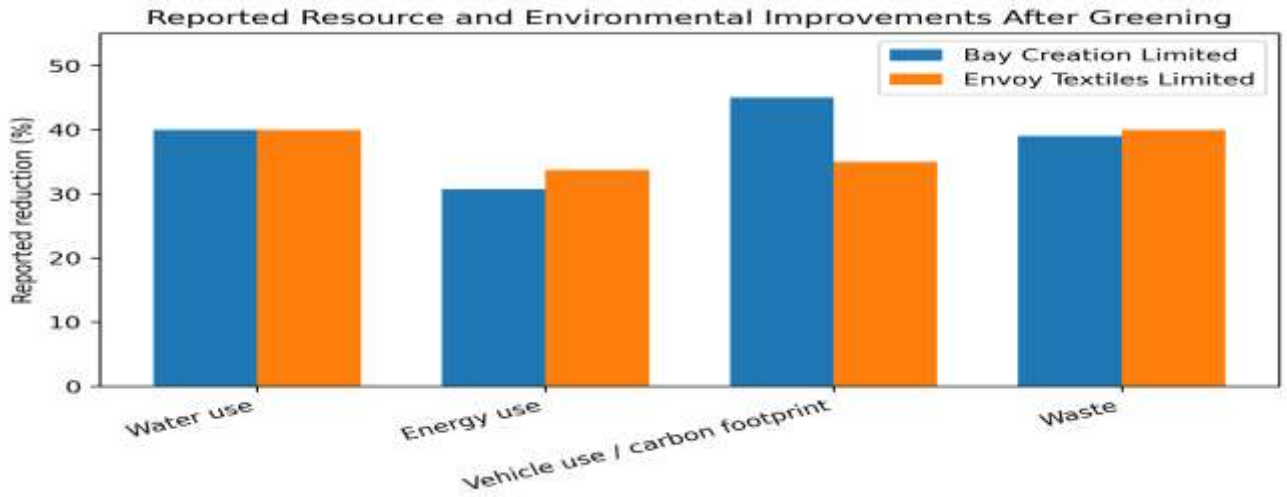


Figure 3. Reported reductions after green conversion in the two case studies. Source: Author's reconstruction from the thesis case-study tables.

Table 4. Reported environmental improvements following green conversion

Indicator	Bay Creation Limited	Envoy Textiles Limited
Water use reduction	40%	40%
Energy-use reduction	30.7%	33.7%
Vehicle-use / carbon-footprint reduction	45%	35%
Waste reduction	39%	40%
Post-conversion treatment/reuse	ETP/STP/WTP and reuse/3R	ETP/STP/WTP and reuse/3R
Indoor temperature after conversion	26°C	26°C

Source: Adapted from the author's thesis dataset and reported source materials.

The case studies also reported workplace benefits, including improved thermal comfort through cooling systems and stronger acceptance from international buyers. These observations are consistent with the broader literature that links environmental performance with organizational competitiveness and stakeholder expectations, although the present study does not independently quantify buyer price premiums or productivity gains.

LEED-oriented certification and investment requirements

The thesis assessed RMG factories against LEED-oriented parameters rather than documenting formal LEED certification outcomes. The assessment framework covered location and transportation, sustainable sites, water efficiency, energy and atmosphere, materials and resources, indoor environmental quality, innovation and regional priority, with 110 possible points in the version used in the thesis. The thesis notes that mandatory prerequisites were not uniformly satisfied and that smaller factories were generally further from the assessment thresholds.

Table 5. Estimated investment requirements for green transformation

Investment area	Estimated total investment (BDT)
Sustainable sites	93,151,845.59
Water efficiency	1,065,996,000.00
Energy efficiency	496,931,000,000.00
Indoor environmental quality	52,406,677.50
Total reported estimate	498,142,554,523

Source: Adapted from the author's thesis dataset and reported source materials.

Energy efficiency represented by far the largest estimated investment category, with BDT 496.931 billion of the reported BDT 498.143 billion total, or approximately 99.76% of the aggregate estimate. This concentration means that the overall investment figure is highly sensitive to the assumptions used for renewable-energy and high-efficiency-equipment costs. The estimate should therefore be interpreted as an indicative scenario based on the thesis calculations, not as a validated sector-wide capital requirement. The source materials do not retain a full technology-by-technology cost schedule or sensitivity range; these should be provided as supplementary documentation if the underlying calculations are available.

DISCUSSION

The findings indicate that environmental sustainability in Bangladesh's RMG sector is not a single-technology problem. It is a systems problem involving resource dependence, monitoring, technology, management capacity, finance and external standards. The strong dependence on groundwater demonstrates the need to move beyond end-of-pipe treatment toward water-use reduction, process efficiency, metering and reuse. Likewise, the dominance of natural gas and heavy machinery in energy consumption suggests that energy audits, sub-metering, efficient motors, compressors, boilers, cooling systems and renewable-energy integration are central to the sector's transition.

The study's findings are consistent with the concept of green industrial transformation as a process that combines technological change with institutional and regulatory conditions. Hou et al. (2018) found that green transformation can reduce pollution but that regulatory conditions shape its effectiveness. In Bangladesh, the thesis similarly identifies policy implementation, financing and technical capacity as constraints. The relatively strong prevalence of written environmental policies compared with energy audits and advanced metering suggests that formal compliance alone may not be sufficient to deliver resource efficiency.

The case studies demonstrate the potential magnitude of operational improvements. However, because the two factories were not selected through a probability design and the before-and-after comparisons were not accompanied by a counterfactual, the reported reductions should not be interpreted as causal estimates applicable to the entire RMG industry. They are best understood as evidence of the practical potential of green conversion under specific factory conditions.

Factory size is another important dimension. Large factories are better positioned to finance certification and capital-intensive technologies, while small and medium factories face stronger constraints. This pattern suggests that green-industry policy should not rely exclusively on voluntary certification. Targeted finance, technical assistance, pooled services such as centralized effluent treatment where feasible, and accessible domestic engineering expertise could reduce the fixed costs of transformation.

The study also has implications for sustainable supply-chain management. Environmental performance increasingly affects relationships between manufacturers, buyers and other stakeholders (Roy et al., 2026). Carter and Rogers (2008) emphasize the integration of environmental, social and economic dimensions in sustainable supply chains. For Bangladesh's RMG sector, investments in water efficiency, cleaner energy, workplace safety and environmental monitoring can therefore be viewed not only as environmental expenditures but also as measures supporting long-term supply-chain resilience and competitiveness.

Taken together, the evidence suggests an interaction among factory size, finance, regulation and export-market requirements. Larger factories appear better positioned to finance certification and capital-intensive technologies, while smaller and medium factories face stronger fixed-cost and technical constraints. At the same time, environmental policies, buyer expectations and international market requirements can create incentives for investment, but these incentives are unlikely to translate into operational improvements without accessible finance, measurement systems and technical capacity. The study therefore treats green transformation as an institutional and investment process rather than a certification exercise alone.

CONCLUSION AND RECOMMENDATIONS

This study finds that green transformation has meaningful potential to improve environmental performance in Bangladesh's RMG sector, while the available evidence remains primarily descriptive. The most important pressures identified are dependence on groundwater, high energy consumption, limited advanced metering, uneven environmental-management capacity and substantial financing requirements. The two case studies show sizeable reported reductions in water, energy, waste and vehicle use following green conversion, but these changes cannot be interpreted as causal estimates without a counterfactual. At the same time, the industry-level evidence shows that smaller factories remain less prepared for certification and advanced environmental management.

Based on the evidence, six priority actions are recommended. First, Bangladesh should strengthen accessible green finance, including more transparent and affordable financing mechanisms for RMG factories seeking environmental upgrades. Second, factories should install systematic water and energy metering and establish routine resource-efficiency audits. Third, groundwater dependence should be reduced through water reuse, rainwater harvesting and, where feasible, alternative surface-water sources that meet regulatory and treatment requirements. Fourth, factories should strengthen ETP operation and monitoring and explore centralized treatment solutions where individual facilities face space or cost constraints. Fifth, energy-efficiency measures should prioritize high-load equipment such as generators, compressors, boilers and cooling systems, alongside renewable-energy deployment where technically and financially feasible. Sixth, government, industry associations and educational institutions should develop domestic technical capacity in environmental engineering, energy management, water management and green-building technologies.

The study is limited by its judgment-based case selection, reliance on descriptive analysis, use of an industry

dataset compiled from secondary/association sources, incomplete documentation of the original sampling frame and denominators for some indicators, and lack of a counterfactual for the two before-and-after case studies. The source materials also do not provide a complete reproducible record of the original instruments,

factory-level observations or detailed cost assumptions underlying the investment estimates. Consequently, the findings should be interpreted as descriptive evidence and illustrative case-study evidence rather than representative or causal estimates for the entire RMG sector. Future research should use a documented probability sample or clearly defined census frame, standardized factory-level environmental indicators, longitudinal measurements, transparent cost assumptions with sensitivity analysis and, where possible, quasi-experimental designs to estimate the causal effects of green investments on resource efficiency, environmental quality, productivity and competitiveness.

Ethical Considerations

Ethical approval and informed consent: The original thesis reports questionnaire surveys, key-informant interviews, focus group discussions and field observation, but the source document available for this article does not document a formal institutional ethics approval number or exemption. The authors should provide the applicable approval/exemption information and confirm the informed-consent procedure before submission. No unsupported institutional approval claim is made in this manuscript.

Conflict of interest: The authors declare that they have no known competing financial or non-financial interests that could have influenced the research or its interpretation.

Data Availability

Data availability: The underlying thesis data are not identified in the source document as a publicly accessible dataset. The article therefore does not provide a public data link. Subject to applicable permissions, anonymized data and supporting materials may be made available by the corresponding author upon reasonable request. Where materials cannot be shared because of participant confidentiality, institutional restrictions or source-data ownership, the corresponding author will provide the applicable access rationale.

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