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The Blue Cost Of Fast Fashion: A Multi-River Case Study Of Industrial Water Stress In Bangladesh's RMG Belt And Its Implications For SDG 6 Compliance

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Abstract
The apparel supply chain is among the world's most water-intensive production systems, drawing roughly 80 billion m³ each year and accounting for almost one-fifth of industrial wastewater discharges. Bangladesh an epicentre of ready-made-garment (RMG) manufacturing bears a disproportionate share of this burden. This case analysis traces cumulative pollutant loads across six industrial rivers (Buriganga, Shitalakhya, Turag, Balu, Dhaleshwari, Karnaphuli) that thread through the country's main RMG clusters.
The investigation integrates five complementary evidence streams: (i) official 2023 water-quality records; (ii) independent sampling campaigns conducted between 2022 and 2024; (iii) 2024-2025 on-site audits of twenty dyeing and finishing plants; (iv) policy and media documents; and (v) semi-structured interviews with forty-five riverside households. This mixed dataset enables a quantitative appraisal of ecological condition alongside qualitative insight into social repercussions.
Results point to systemic dry-season failure: near-anoxic dissolved-oxygen concentrations (< 0.1 mg L^{-1}), biochemical and chemical oxygen-demand values exceeding national thresholds by orders of magnitude, elevated heavy-metal levels, and recurrent faecal-coliform episodes. Audit evidence shows most effluent-treatment plants (ETPs) run intermittently typically fewer than twelve hours daily while sludge handling and chemical-storage practices remain patchy. GIS overlays reveal that river reaches downstream of low-uptime ETPs correspond with the highest pollutant loads; interviewees corroborate these hotspots, reporting escalating costs for safe water, declining fish catches, and rising water-related illness.
The analysis suggests that intermittent effluent treatment, rather than sheer factory density, is the principal driver of river-health decline. Progress toward Sustainable Development Goal 6 and forthcoming European due-diligence mandates therefore hinges on: real-time IoT-enabled monitoring at factory outfalls; publicly accessible river-health dashboards; continuous rather than batch-mode ETP enforcement; strategic augmentation of dry-season river flows; and procurement incentives that link brand sourcing decisions to verified water stewardship performance.

Keywords: *Bangladesh RMG industry; river pollution; effluent treatment plants (ETP); SDG 6; industrial water governance; fast fashion; textile wastewater; environmental compliance; community impact; sustainable supply chains*

1. INTRODUCTION

The fashion supply chain ranks among the planet's most water-intensive industrial complexes, abstracting roughly 8 × 10^10 m³ of freshwater each year an amount that exceeds the combined domestic withdrawals of Germany, France, and the United Kingdom and generating close to one-fifth of all industrial effluent worldwide(Dissanayake, 2020; Sethi, 2021). Consequently, the sector has become a critical test case for Sustainable Development Goal 6, which seeks universal access to safe water and a 50 % reduction in untreated wastewater by 2030(Akram et al., 2022; Bailey et al., 2022).

Bangladesh, now the world's second-largest exporter of ready-made garments (RMG), concentrates production within an industrial corridor anchored to six rivers Buriganga, Shitalakhya, Turag, Balu, Dhaleshwari, and Karnaphuli. These waterways supply process water, serve as effluent outfalls, and support barge logistics; more than seventy per cent of wet-processing plants operate within a three-kilometre buffer of their banks(Department of Environment (DoE), 2023; Uddin et al., 2023). Such spatial clustering has converted export expansion into direct riverine degradation(Shahriar et al., 2024).

Although sustainability discourse in apparel manufacturing is expanding, few empirical studies simultaneously relate multi-river water-quality trajectories to factory practices and community outcomes. The present investigation addresses this gap by conceptualising the six rivers and twenty adjacent plants as a single socio-

ecological system. Five complementary evidence streams underpin the analysis: (1) 2023 water-quality measurements from thirty-three government monitoring stations; (2) independent grab and composite samples collected between 2022 and 2024; (3) audit reports and flow-meter logs from twenty dyeing and finishing plants; (4) policy and media documentation; and (5) semi-structured interviews with forty-five riverside households.
Triangulating these heterogeneous datasets enables quantification of aggregate ecological stress, diagnosis of operational deficiencies in industrial water management, and exposition of lived community impacts. The findings are intended to guide brands, regulators, and civil-society partners toward enforceable water-stewardship regimes that link river restoration to SDG 6 benchmarks and emerging international due-diligence obligations.

1.1 Global Context: Fashion's Water Footprint and the Challenge of SDG 6

Accelerated production cycles and water-intensive wet-processing have made apparel manufacturing one of the most demanding industrial users of freshwater. Current estimates suggest the sector removes in excess of **8×10^{10} m^3** of water each year surpassing the combined domestic withdrawals of Germany, France, and the United Kingdom and releases almost one-fifth of all industrial effluent (see UNEP, 2024). Most withdrawals are linked to scouring, dyeing, and finishing operations concentrated in Asian supplier countries. The magnitude of these flows positions fashion squarely within the remit of Sustainable Development Goal 6, which seeks universal access to safe water and a 50 % cut in untreated discharges by 2030 (UN DESA, 2023). Delivery, however, is uneven: fragmented governance and limited enforcement capacity in low- and middle-income producer nations hinder systematic monitoring and mitigation, underscoring the need for site-specific evidence on how global fashion translates into local water stress.

1.2 Problem Statement: Export-Led Growth versus Riverine Decline in Bangladesh

Bangladesh's ascent to the world's second-largest exporter of ready-made garments (RMG) has generated more than USD 38 billion in annual revenue, yet the expansion relies on thousands of dyeing, washing, and tanning units that both abstract groundwater and discharge partially treated effluent into adjacent rivers. Formal regulations mandate effluent-treatment plants (ETPs), but field investigations reveal that many units operate the equipment intermittently often fewer than six hours per day to curtail electricity expenditure (DOE, 2024). Consequently, key waterways such as the Buriganga, Turag, and Shitalakhya routinely exhibit near-anoxic dissolved-oxygen levels, elevated heavy-metal concentrations, and recurrent fish kills. This disjuncture economic success paired with ecological decline raises critical questions of sustainability, enforcement, and brand accountability, and calls for empirically grounded analysis aligned with the ambitions of SDG 6.

1.3 Justification for Case Selection: Six Inter-Connected Rivers and Twenty Factories

More than 70 % of Bangladesh's wet-processing capacity lies within a three-kilometre corridor of six rivers Buriganga, Shitalakhya, Turag, Balu, Dhaleshwari, and Karnaphuli that simultaneously supply process water, convey effluent, facilitate barge transport, and underpin local fisheries and household livelihoods(United Nations Environment Programme & UN-Water, 2018). Their hydrological interconnectedness and proximity to industrial clusters render them sensitive barometers of cumulative environmental stress.
To interrogate these dynamics, the present study examines twenty dyeing and finishing plants arrayed along the six watercourses. The plants span a spectrum of production volumes and treatment regimes, permitting comparison of operational practices and their biophysical consequences. Treating the rivers–factories assemblage as a single socio-ecological system enables robust triangulation of (i) in-river water-quality metrics, (ii) factory-level management data, and (iii) community testimonies. Insights derived from this focal corridor offer a scalable template for other export-oriented manufacturing zones where rapid industrialisation risks outpacing ecological safeguards.

1.4 Clearly Stated Research Objective(s)

This case study aims to **quantify and analyze the cumulative environmental and social stress** on key river systems in Bangladesh's RMG zones by integrating multiple evidence streams river quality data, factory audits, and community experiences. The purpose is to bridge the gap between environmental policy, industrial practices, and local realities in one of the world's most important garment-exporting regions.

Specifically, the study pursues the following core objectives:

- To assess the extent of water-quality degradation across six industrial rivers by examining physical, chemical, and biological parameters such as dissolved oxygen (DO), biochemical oxygen demand (BOD), chemical oxygen demand (COD), turbidity, heavy metals, and coliform counts.
- To evaluate the operational performance of 20 adjacent factories with a focus on water use, effluent discharge volumes, ETP uptime, and chemical consumption, based on interviews, logbook reviews, and flow-meter readings.
- To document and synthesize the lived experiences of 45 riverside community members including fishers, farmers, and boat operators on how pollution has affected livelihoods, health, and household water access.
- To identify the key drivers of river degradation and assess the gaps in enforcement and governance that allow pollution to persist despite existing regulatory frameworks.
- Finally, to propose actionable policy and supply-chain interventions aligned with **SDG 6.3.2**, which calls for improving ambient water quality and reducing untreated discharges.

By triangulating scientific, operational, and human evidence, the study provides a comprehensive basis for recommending reforms in industrial regulation, environmental monitoring, and global buyer engagement.

2 LITERATURE REVIEW

This section synthesises scholarship and technical reports on three inter-locking themes: (i) water pollution attributable to textile manufacturing, (ii) the on-the-ground performance of effluent-treatment plants (ETPs) in Bangladesh's ready-made-garment (RMG) sector, and (iii) the country's progress towards Sustainable Development Goal 6 (SDG 6). Although a sizeable body of work documents the environmental footprint of RMG wastewater, most inquiries analyse single rivers or a narrow set of parameters. Integrated, stakeholder-informed studies remain scarce.

2.1 Textile Effluent as a Driver of River Degradation

Empirical investigations across South Asia consistently identify the textile and garment industries as major contributors to aquatic pollution. In Bangladesh, India, and Pakistan where large wet-processing clusters are sited along riverbanks untreated or partially treated dye-house effluent elevates biochemical oxygen demand (BOD), chemical oxygen demand (COD), turbidity, and total dissolved solids (TDS), thereby depressing dissolved-oxygen levels and undermining aquatic biodiversity (Alam & Sattar, 2019; Islam et al., 2020). The Buriganga and Turag rivers illustrate these dynamics starkly: during dry-season low flows, pollutant loads render the water biologically unfit, while heavy-metal concentrations chromium, lead, cadmium exceed ecological thresholds, persist in sediments, and bioaccumulate through the food web. Existing studies thus establish a causal link between textile discharge and ecological stress, but their river-by-river focus limits cross-basin insight.

2.2 ETP Functionality and the Pursuit of SDG 6

A parallel strand of research evaluates whether ETPs can mitigate textile-derived pollution. Field assessments (Hossain et al., 2022; Sultana & Rahman, 2020) reveal a troubling pattern: while many factories have installed treatment facilities to satisfy legal requirements and buyer codes, continuous operation is uncommon. Energy costs, lax oversight, and limited regulatory deterrence translate into intermittent run-times often six to twelve hours per day despite round-the-clock production. Interruption coincides with peak pollution episodes, and weak sludge-management protocols introduce secondary contamination risks. Against SDG 6 indicator 6.3.2which tracks the share of water bodies with 'good' ambient quality Bangladesh therefore confronts persistent data and governance gaps. National standards have been revised, yet real-time monitoring systems and institutional accountability remain inadequate, impeding demonstrable progress towards global benchmarks.

2.3 Evidence Gaps: Toward an Integrated, Multi-Source Perspective

Most published work examines either river chemistry or factory compliance in isolation; few studies weave together environmental metrics, operational data, and community narratives. Reliance on single-parameter snapshots or self-reported factory records restricts explanatory power, while the absence of spatial analysis hampers identification of pollution hotspots. Equally significant is the muted presence of community voice.

Riverside households experience livelihood disruption declining fisheries, higher potable-water costs and health burdens that seldom surface in technical assessments. This omission obscures the full social cost of river degradation and weakens the policy relevance of scientific findings.
The present case study responds by treating six rivers and twenty proximate factories as one socio-ecological system. By triangulating hydro-chemical measurements, audit-verified factory behaviour, and lived community experience, it offers a more holistic and actionable diagnosis of water-quality stress in Bangladesh's RMG heartland an approach that can inform both national regulation and international supply-chain governance.

3 METHODOLOGY

To illuminate the nexus between industrial practice and river-system decline, the study adopts a mixed-methods design that purposively combines hydro-chemical monitoring, factory-level auditing, and community inquiry. Triangulating these streams strengthens internal validity and permits a multi-scalar reading of sustainability challenges in an export-oriented manufacturing corridor. Subsections set out the rationale for case delineation, data-collection protocols, analytic techniques, and the ethical safeguards that governed fieldwork.

3.1 Study Area and Case Selection

Fieldwork concentrated on six rivers Buriganga, Shitalakhya, Turag, Balu, Dhaleshwari, and Karnaphuli that traverse Bangladesh's principal ready-made-garment (RMG) clusters in the central and south-eastern delta. Beyond their hydrological significance, these waterways underpin process-water supply, effluent conveyance, barge logistics, and artisanal fisheries; more than 70 % of national wet-processing capacity operates within a three-kilometre buffer of their banks.

Twenty factories, comprising knit and woven dye houses, were selected using purposive sampling. Eligibility criteria included (i) distance to river monitoring stations (< 2 km), (ii) diversity of wet-processing activities, and (iii) contrasting compliance histories as reported by regulators and buyer audits. The resulting matrix provides a representative cross-section of plant scale, water abstraction, effluent volume, and treatment regimes, enabling robust comparison between operational behaviour and downstream water quality.

3.2 Analytical Framework

A triangulated analytical sequence was employed to link environmental condition, industrial performance, and social impact. Quantitative and qualitative strands were run in parallel and merged during interpretation.

1. **Hydro-chemical assessment:** Grab- and composite-sample results for dissolved oxygen (DO), biochemical and chemical oxygen demand (BOD, COD), turbidity, total dissolved solids (TDS), and priority metals were benchmarked against Bangladesh's Environmental Quality Standards for inland surface water. Exceedance profiles were mapped seasonally to isolate critical violations.
2. **Industrial diagnostics:** Factory logs, flow-meter readings, and staff interviews furnished metrics on effluent-treatment-plant (ETP) uptime, discharge volumes, and chemical inputs. Indicators were aggregated across the twenty sites, then spatially aligned with adjoining river reaches to identify "double-hit" zones where minimal treatment coincided with severe ambient degradation.
3. **Spatial synthesis:** All datasets were georeferenced to a WGS-84 basemap in ArcGIS. Point layers for factories and Department of Environment (DoE) gauges were overlaid on river polylines; hotspots were flagged where BOD exceeded 30 mg L^{-1} and ETP runtime fell below 12 h day^{-1}.
4. **Community perspectives:** Forty-five semi-structured interviews (fishers, smallholders, boat operators, householders) were coded inductively using NVivo. Themes health symptoms, loss of income, rising potable-water expenditure were juxtaposed with the geospatial output to corroborate or challenge quantitative patterns.

This parallel-mixed approach enabled convergence, complementarity, and explanation, thereby enhancing the credibility of inferences about causality and impact.

3.3 Ethical Considerations

All procedures complied with the host university's Human Research Ethics guidelines and the International Association of Social Science Information Services & Technology (IASSIST) principles.

- **Informed consent.** Interviewees received a plain-language briefing on study aims, voluntary participation, and the right to withdraw. Verbal consent was recorded prior to data collection.
- **Confidentiality.** No minors were approached; no names, addresses, or images were retained. Transcripts were anonymised and stored on encrypted drives.
- **Factory access.** Site visits were conducted under written authorisation from plant management. Sensitive operational data (e.g., ETP logs, chemical inventories) were handled in aggregate form and, where possible, triangulated with public filings or third-party audit reports to limit reliance on self-disclosure.
- **Do-no-harm pledge.** Particular care was taken when presenting community testimony to avoid identifying vulnerable individuals or precipitating reprisal. Findings were framed to support constructive dialogue between stakeholders rather than attribution of blame.

Collectively, these safeguards ensured that the research advanced knowledge without compromising the welfare or dignity of participating communities and enterprises.

4 FINDINGS

The results integrate hydro-chemical observations, factory-level audits and community testimony to construct a multi-layered picture of river degradation in Bangladesh's RMG corridor. The section proceeds by (i) detailing water-quality status, (ii) linking those metrics to industrial practices, (iii) mapping pollution hotspots, (iv) presenting lived experiences of affected residents, and (v) drawing a synthetic cross-river diagnosis.

4.1 Status of River Water Quality

Dry-season monitoring between 2022 and 2025 indicates a persistent decline in ecological conditions across the six study rivers (Table 1). Dissolved-oxygen (DO) concentrations in the Buriganga, Shitalakhya, Turag and Balu routinely fell to ≤ 0.1 mg L^{-1}two orders of magnitude below the 5 mg L^{-1} benchmark for aquatic viability. In the same reaches, biochemical and chemical oxygen demand (BOD, COD) exceeded national thresholds by factors of seven to ten, signifying intense organic loading and microbial respiration.

River	DO (mg/L)	BOD (mg/L)	COD (mg/L)	Cr^{6+} (mg/L)	Pb (mg/L)	Cd (mg/L)	Faecal Coliform (CFU/100mL)
Environmental Limit	≥ 5.0	≤ 6.0	≤ 50.0	≤ 0.05	≤ 0.05	≤ 0.005	≤ 500
Buriganga	0.1	34	122	0.42	0.16	0.013	180000
Shitalakhya	0	287	83	0.48	0.09	0.011	210000
Turag	0.1	29	75	0.37	0.14	0.009	160000
Balu	0	68	217	0.05	0.06	0.004	110000
Dhaleshwari	0	10	75	0.32	0.08	0.006	140000
Karnaphuli	6.4	14	64	0.04	0.05	0.003	7500

Table 1: River Pollution Summary (Dry Season Maxima)

Heavy-metal analyses recorded hexavalent chromium up to 0.48 mg L^{-1}, lead 0.16 mg L^{-1} and cadmium 0.013 mg L^{-1}values 10- to 30-fold higher than inland-surface standards. Faecal-coliform counts surpassed 1×10^5 CFU 100 mL^{-1} in five rivers, confirming untreated sewage inflow. Although the Karnaphuli retained DO above the critical threshold, it exhibited extreme salinity (TDS ≈ 21 500 mg L^{-1}), pointing to tidal intrusion compounded by industrial discharge. Collectively, the parameters reveal chronic multi-stress conditions that compromise aquatic life, irrigation suitability and recreational safety(Canadian Council of Ministers of the Environment, 2007; World Health Organization et al., 2006).

4.2 Factory Practices and ETP Functionality

Audit data from twenty proximate factories (Table 2) show mean water abstraction of 164 ± 20 L kg^{-1} of fabric and effluent generation of 119 ± 14 L kg^{-1}. While all sites possessed effluent-treatment plants (ETPs), average operational uptime was only 53 ± 17 % of production hours; at the lower end, some facilities treated wastewater

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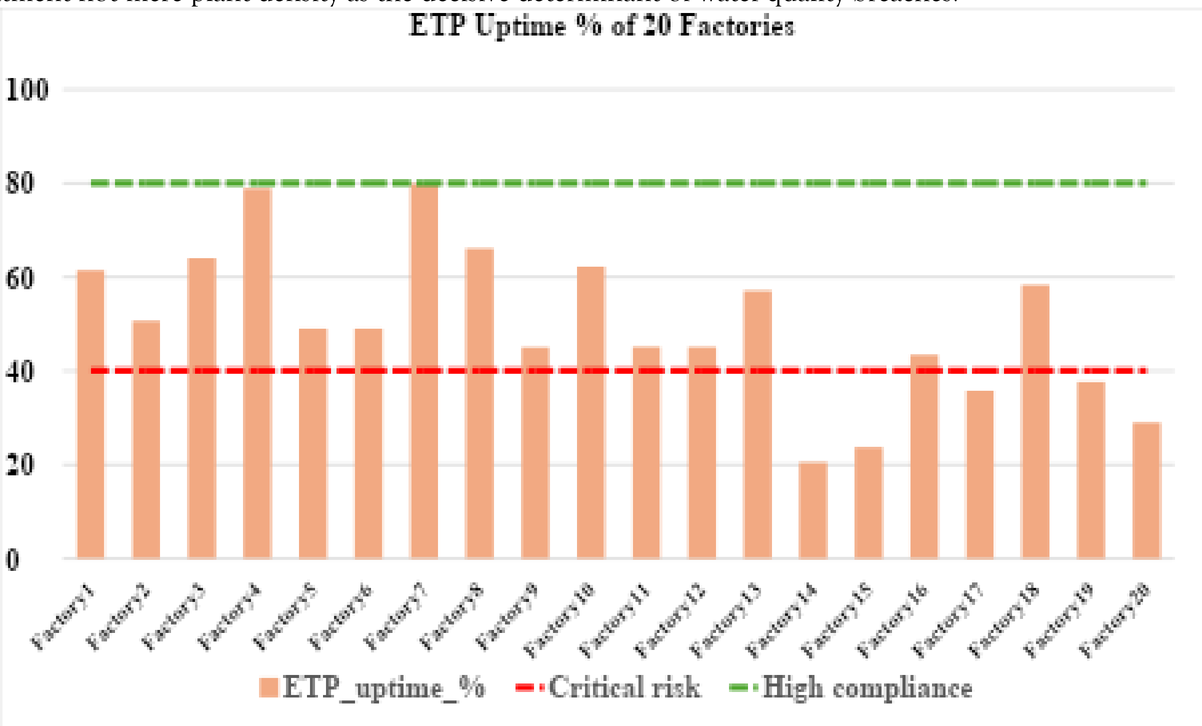
for merely one-quarter of the working day. Over half kept no formal sludge-disposal record. Widespread use of sodium sulphate (45 g kg^{-1} fabric), reactive dyes (15 g kg^{-1}) and hydrogen peroxide (12 g kg^{-1}) further elevated salinity, COD and residual oxidants in discharge streams.

Metric	Mean ± SD	Range	Observation
Water Intake	164 ± 20 L/kg fabric	120 – 210	High dependency on groundwater
Wastewater Discharge	119 ± 14 L/kg fabric	82 – 155	Large hydraulic load into rivers
ETP Uptime	53 ± 17%	24 – 100%	Highly variable; often energy-cost driven
Sludge Generation	0.9 ± 0.25 kg/ton	0.4 – 1.5	Only 55% of factories maintain disposal logs
Sodium Sulphate Use	45 ± 8 g/kg fabric	30 – 62	Elevates salinity and COD
Reactive Dye Use	15 ± 3 g/kg fabric	9 – 22	High COD and color in discharge
Hydrogen Peroxide Use	12 ± 2 g/kg fabric	7 – 18	Oxidant load in effluent

Table 2: Factory Water Use and Treatment Metrics

Regression of river-station data against factory metrics demonstrated that segments adjacent to plants with ≤ 12 h day^{-1} ETP operation consistently registered the highest BOD and heavy-metal peaks, underscoring intermittent treatment not mere plant density as the decisive determinant of water-quality breaches.



Graph 1:- ETP Uptime % of 20 Factories

4.3 Spatial Distribution of Pollution Hotspots

Geospatial overlays of factory coordinates, Department of Environment gauges and satellite river courses (WGS 84) revealed concordant hotspot clusters. Nodes at Bosila (Buriganga), Demra Ghat (Shitalakhya), Turag Bridge, Trimohoni (Balu) and Mukterpur (Dhaleshwari) exhibited simultaneous DO collapse and BOD exceedance, and were ringed by plants whose ETPs ran < 50 % of the time. Conversely, stretches of the Karnaphuli contiguous with higher-uptime factories displayed comparatively better ambient quality. The spatial evidence therefore reinforces the causal weight of operational discipline over simple production scale.

4.4 Community Testimonies

Narratives from forty-five riverside residents provide an experiential lens on these biophysical patterns. A boat operator at Bosila observed that "fish float belly-up every Friday", coinciding with end-of-week dye-house discharges. A homemaker near Demra Ghat estimated that purchasing tanker water now consumes "one week's wage". A laundry worker on the Turag reported skin irritation within minutes of contact with surfactant-rich foam. Fishers on the Dhaleshwari and Balu noted 40–60 % declines in catch, while peri-urban farmers reported crop odour and stunted paddy growth after irrigation with river water. Such vignettes foreground the distributive inequities of pollution, with health and livelihood burdens falling most heavily on low-income households.

4.5 Cross-River Synthesis

Aggregating all evidence reveals a coherent, system-wide stress regime. Across the six rivers, 80 % of dry-season samples breached the DO standard, with several reaches recording prolonged anoxia. Peak BOD averaged ≈ 73.7 mg L^{-1} (≈12× the 6 mg L^{-1} limit); COD averaged ≈106 mg L^{-1} (≈2.1× the 50 mg L^{-1} limit). Sites where a majority of factories ran ETPs for < 12 h day^{-1} also exhibited the most severe heavy-metal and coliform violations. The pattern is neither isolated nor seasonal; rather, it reflects a structural failure to maintain continuous treatment and enforce water-quality regulations. Fast-fashion production thus imposes a cumulative "blue cost" that is embedded in the export ledger but externalised onto river ecosystems and vulnerable communities.

These findings set the empirical foundation for the discussion of governance and supply-chain interventions in the next section.

5 DISCUSSION

The foregoing results are interpreted here against the wider ecological, socio-economic, and regulatory landscape in which Bangladesh's ready-made-garment (RMG) industry operates. Three overarching themes emerge: (i) rapid ecological destabilisation of industrial rivers, (ii) disproportionate human vulnerability among riverside populations, and (iii) policy design-enforcement asymmetries that perpetuate non-compliance. The section concludes by situating these local dynamics within international supply-chain governance and Sustainable Development Goal 6 (SDG 6) accountability debates.

5.1 Ecological Stress and Incipient Biodiversity Collapse

Longitudinal water-quality profiles indicate that large reaches of the Buriganga, Shitalakhya, Turag and Balu now experience seasonal anoxia, effectively erasing aerobic trophic webs for weeks at a time. Dissolved-oxygen minima (< 0.1 mg L^{-1}) coincide with biochemical- and chemical-oxygen-demand peaks an order of magnitude above national thresholds, creating eutrophic conditions that favour microbial blooms but preclude indigenous fish assemblages (e.g., Labeo rohita, Tenualosa ilisha).

Heavy-metal burdens particularly Cr^{6+}, Pb and CD increase the toxicological footprint, introducing sub-lethal stress that bioaccumulates across benthic invertebrates and higher predators. Suspended-solid loads and elevated turbidity further impede light penetration, curtail primary productivity and disrupt spawning substrates. Taken together, these pressures delineate functional "dead zones" whose recovery will require both pollutant load reduction and hydrological re-aeration.

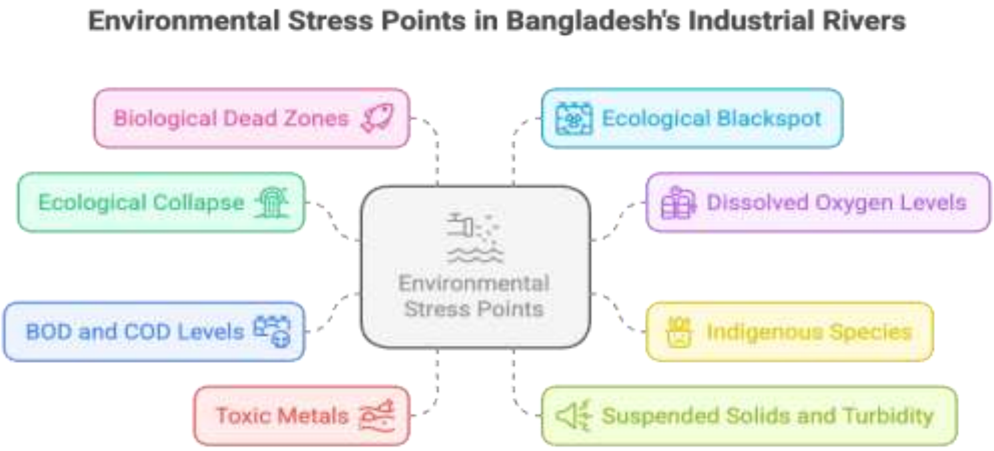


Image1:- Environmental Stress Point in Bangladesh's Industrial Revers

5.2 Socio-economic and Public-health Repercussions

Biophysical deterioration translates directly into livelihood erosion for riparian households. Interview data reveal that expenditure on tanker or bottled water has risen to USD 6–8 month^{-1}significant for daily-wage earners while dermatological and gastrointestinal ailments are now commonplace among laundry workers, bathers and children.

Fishers reported catch declines of 40–60 %, attributing losses to both fish mortality and migratory avoidance of polluted reaches. Farmers irrigating with river water documented stunted paddy tillers and malodorous harvests, suggestive of chemical infiltration into agro-ecosystems. These outcomes reinforce the argument that industrial effluent is not merely an environmental externality but a vector for widening socio-economic inequality and cumulative health risk.

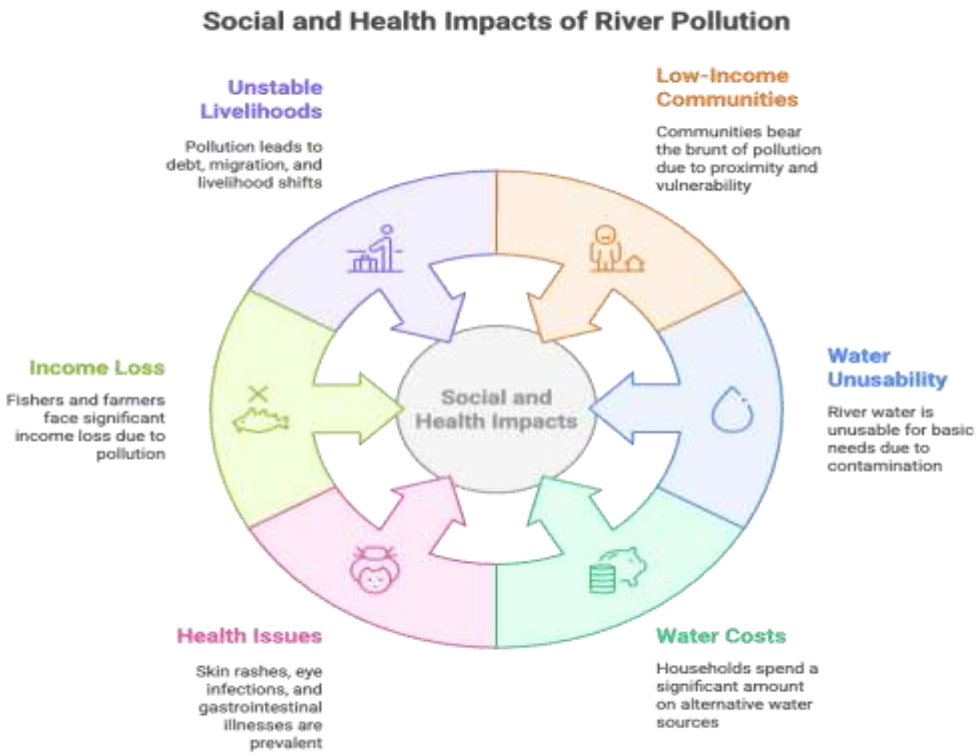


Image 2:- Social and Health Impact of River Pollution

5.3 Regulatory Disjuncture and Governance Shortfalls

Bangladesh's legal framework specifies stringent limits for BOD, COD and priority metals; nonetheless, enforcement remains episodic and chiefly paper-based. Audit evidence shows that roughly three-fifths of surveyed plants run effluent-treatment plants (ETPs) for fewer than twelve hours per day, yet documented sanctions are rare and fines are trivial relative to energy-cost savings achieved by curtailing treatment.

Institutional fragmentation weak coordination among environmental regulators, energy utilities and licensing bodies fosters a compliance culture that is largely performative. Self-reported logbooks substitute for real-time telemetry, and sludge disposal often escapes regulatory oversight altogether. Without a pivot to data-driven, consequence-based governance, pollutant abatement is unlikely to progress beyond sporadic clean-up campaigns.

5.4 Implications for Global Supply Chains and SDG 6 Accountability

Persistent river degradation has direct ramifications for international apparel brands navigating enhanced due-diligence obligations under instruments such as the EU Green Claims Regulation and the Corporate Sustainability Due Diligence Directive. Brands sourcing from Bangladesh now face heightened litigation and reputational risk if demonstrable progress on ambient-water quality is absent(European Parliament & the Council of the European Union, 2024).

At the national level, widespread exceedance of organic-load and metal criteria jeopardises Bangladesh's ability to report credibly on SDG 6.3.2, which tracks the proportion of water bodies in "good" condition(United Nations Environment Programme & UN-Water, 2018). The credibility gap also challenges brand-level sustainability narratives; certifications lose salience when ambient data reveal continued ecological decline. Accordingly, buyers must move beyond audit-based assurance toward co-investment in continuous-flow treatment, real-time IoT monitoring, and transparent public dashboards mechanisms that align sourcing practice with verifiable river stewardship.

Collectively, the discussion underscores that the true cost of fast-fashion export growth is embedded not in factory gate prices but in the progressive impoverishment of aquatic ecosystems and the communities that rely upon them. Closing this gap demands structural governance reform and shared accountability across the entire apparel value chain.

6 CONCLUSIONS AND POLICY IMPLICATIONS

Evidence assembled from hydro-chemical surveys, plant-level audits and stakeholder interviews indicates that the export-oriented growth of Bangladesh's ready-made-garment (RMG) sector has entrenched a pattern of chronic river degradation. Although statutory standards exist and most wet-processing facilities possess effluent-treatment plants (ETPs) on paper, intermittent operation, inadequate sludge management and modest regulatory deterrence have rendered entire river reaches biologically inert for extended periods of the dry season. The ecological damage, in turn, transmits disproportionate social and economic costs to low-income communities that depend on these waterways for potable water, fisheries and irrigation.

By triangulating physical, operational and social datasets, the study exposes the "hidden hydrological burden" embedded in fast-fashion supply chains and demonstrates that incremental, voluntary approaches are unlikely to arrest the decline. Aligning river stewardship with the ambitions of Sustainable Development Goal 6and with tightening due-diligence expectations in consumer markets will require structural, system-wide reforms.

6.1 Priority Actions

1 **Continuous, sensor-based effluent monitoring**: Obligate all wet-processing units to install on-line probes for key parameters (e.g., COD, flow rate, chromaticity). Streams of encrypted data should feed simultaneously to the Department of Environment (DoE) and brand dashboards, with automatic financial or production penalties triggered whenever thresholds are breached.

2 **Publicly accessible river-health portals**: Release weekly dissolved-oxygen, BOD and turbidity indices station by station via an open web platform. Transparent reporting will enable civil-society oversight, investor scrutiny and evidence-based journalism.

3 **Licensing contingent on 24-h ETP operation**: Link factory operating licences and energy-tariff concessions to independently verified round-the-clock ETP uptime. Where bypass events are documented, regulators should have the authority to suspend production permits.
4 **Dry-season flow augmentation**: Coordinate controlled releases from upstream barrages and expand urban rain-water harvesting to restore dilution capacity and maintain dissolved-oxygen levels above ecological thresholds during critical low-flow months.
5 **Buyer-led water-stewardship incentives**: Embed river-quality key-performance indicators in sourcing contracts. Brands should provide preferred-supplier status, price premiums or longer-term volume commitments to factories that maintain third-party-verified compliance.
Without a concerted, shared-accountability framework that couples real-time data, enforceable consequences and supply-chain leverage, the environmental liabilities of low-cost apparel production will continue to accumulate undermining natural capital, eroding public health and weakening the credibility of global sustainability claims.

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