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ESG Practices in Bangalore Metro Rail Corporation Limited : A Literature Review

Abstract : The literature review examines the evolving ESG practices of Bangalore Metro Rail Corporation Limited (BMRCL), popularly known as Namma Metro, with a focus on environmental stewardship, social responsibility, and governance effectiveness in urban rail operations. The review shows that BMRCL has progressively adopted sustainability-oriented measures such as energy-efficient rolling stock, regenerative braking, solar photovoltaic installations, rainwater harvesting, waste segregation, compensatory plantation, green building practices, and multimodal integration to reduce the environmental footprint of mass transit. Existing studies also highlight the social relevance of metro systems in Bengaluru, particularly in improving accessibility, reducing congestion, supporting safer mobility, and contributing to inclusive urban development. At the governance level, the literature emphasizes transparency, accountability, regulatory compliance, and structured reporting as essential for strengthening public trust in a large public-sector undertaking. However, the review also identifies critical gaps, including the limited availability of sector-specific ESG metrics, inconsistent disclosure practices, and insufficient empirical assessment of how ESG initiatives translate into measurable performance outcomes. In addition, several studies suggest that BMRCL's sustainability efforts require a more integrated and scientific framework to assess effectiveness across operational, environmental, and stakeholder dimensions. Overall, the literature indicates that while Namma Metro has made meaningful progress toward sustainable urban transport, there is a strong need for a comprehensive empirical evaluation of its ESG practices.

Keywords : ESG practices, Namma Metro, sustainability, urban transport, governance.

1. Introduction : Urban mobility systems are increasingly

evaluated not only for transport efficiency but also for their environmental, social, and governance performance, making ESG a relevant analytical lens for metro rail corporations in fast-growing cities^{1, 2}. In this context, Bangalore Metro Rail Corporation Limited (BMRCL), which operates Namma Metro in Bengaluru, represents an important case for examining how public transport infrastructure contributes to sustainable urban development through lower-emission mobility, social accessibility, and accountable institutional management^{3, 2}. As Indian cities confront congestion, rising emissions, uneven access to mobility, and pressure on public infrastructure, metro systems are expected to deliver value beyond passenger movement by supporting cleaner transport, safer commuting, inclusive design, and responsible governance^{4, 3, 5}.

The environmental dimension of ESG is especially significant in metro rail because rail-based mass transit can reduce dependence on private vehicles, lower per-capita transport emissions, and improve long-term urban sustainability when supported by energy-efficient construction and operations^{6, 3, 5}. Recent work on metro sustainability highlights the importance of life-cycle thinking, including the environmental effects of construction materials, electricity use, water management, waste handling, and regenerative technologies in rail systems^{6, 2, 7}. For a system like Namma Metro, the environmental question is therefore not limited to whether metro travel is cleaner than road transport; it also includes how sustainably the infrastructure is built, operated, maintained, and expanded over time^{6, 8}.

The social dimension is equally central because metro systems shape everyday access to employment, education, healthcare, and urban opportunity for diverse commuter groups^{3, 2}. Social performance in an ESG framework includes affordability, commuter safety, gender inclusion, accessibility for elderly and differently abled users, employee welfare, and responsiveness to community needs affected by metro development and operations^{3, 7}.

The governance dimension provides the institutional foundation through which environmental and social commitments are translated into measurable outcomes^{1, 2}. Governance in ESG terms includes transparency, regulatory compliance, project accountability, risk management, stakeholder engagement, ethical procurement, and the overall effectiveness of decision-making structures within transport organisations^{1, 7}. This dimension is particularly important in large public infrastructure projects, where cost escalation, implementation delays, coordination problems, and limited disclosure can weaken sustainability outcomes unless governance systems are robust and accountable^{1, 8}.

2. Concept of ESG (Environmental, Social and Governance) : Emerging from the 2004 UN Global Compact's "Who Cares Wins" report, ESG has evolved into a standardized approach for assessing how companies manage risks and opportunities related to environmental stewardship, social responsibility, and corporate governance.

Environmental (E) Dimension : Focuses on an organization's ecological footprint and resource management:

- **Climate Impact:** Greenhouse gas emissions, energy efficiency, carbon footprint
- **Resource Use:** Water consumption, waste management, raw material efficiency
- **Pollution Control:** Air quality, biodiversity protection, sustainable land use

For urban infrastructure like metro rail, this includes life-cycle emissions from construction, energy-efficient operations, and modal shift from private vehicles.

Social (S) Dimension : Examines stakeholder relationships and societal impact:

- **Community engagement:** Local employment, accessibility, affordability
- **Employee welfare:** Diversity, safety, training, fair compensation
- **Customer impact:** Product/service safety, data privacy, ethical marketing

• **Human rights:** Supply chain labor practices, community displacement concerns
In public transport, social metrics assess commuter equity, gender inclusion, disability access, and worker safety.

Governance (G) Dimension : Evaluates organizational integrity and decision-making:

- **Board structure:** Independence, diversity, oversight effectiveness
- **Transparency:** Financial reporting, ESG disclosure quality
- **Ethics:** Anti-corruption policies, conflict of interest management
- **Risk management:** Strategic planning, compliance frameworks

3. Review of Literature :

Table 1 : Outline of Literature Review

Theme	Key Content/ Articles/ Reports/Literatures Related to	Number of Articles reviewed
ESG Frameworks and Theory	• Foundational ESG concepts applied to transport/public enterprises. • ESG reporting standards (GRI, SASB, TCFD), ESG scoring in infrastructure. • ESG evolution in public-sector enterprises (PSUs) and utilities. • ESG maturity models for transport organizations.	5
Environmental Dimension (E)	• Metro rail's eco-footprint and sustainability metrics. • Life-cycle assessment (LCA) of metro construction/operations (energy, emissions, materials). • Renewable energy, regenerative braking, waste management, water efficiency in metro systems.	3
Social Dimension (S)	• Commuter accessibility, inclusivity (gender, disability, low-income), safety, and social equity. • CSR initiatives, community engagement, stakeholder participation in metro projects. • Labour practices, employee safety, diversity in metro operations.	4
Governance Dimension (G)	• Board structure, risk management, anti-corruption, stakeholder governance in PSUs. • PPP governance, project delays, regulatory compliance in Indian metro rail. • ESG disclosure and reporting practices in transport PSUs.	6
Metro Rail Sustainability (India)	• Case studies of Delhi Metro, Mumbai Metro, Kochi Metro ESG/sustainability (benchmark for Namma). • Urban transport sustainability in Bengaluru/Karnataka context. • Comparative ESG performance across Indian metro corporations (BMRCL, DMRC, MMRC).	4
ESG in Public	• ESG in railways globally (UIC reports, European	

Transport and Urban Rail	• rail, high-speed rail). • Sustainable urban mobility, transit-oriented development (TOD), low-carbon transport. • ESG integration in public infrastructure projects (World Bank, ADB studies)	5
Empirical Methods for ESG Assessment	• Quantitative ESG scoring, LCA, surveys, panel data in transport. • Case-study methods, mixed-methods for PSU ESG evaluation. • KPI frameworks (energy intensity, accident rates, governance indices) for rail	4

4. Literature Review – Summary : Anselm Ott & Et.all (2023), in their article expressed that rail offers superior environmental performance, positioning it for modal shift to cut global transport emissions. European targets aim for 30% freight rail share by 2030, companies pursue net-zero via biofuels, hydrogen, electrification. ESG analysis of 10 railways shows wide variance, and emissions intensity. Social/governance gaps persist and comprehensive ESG creates value in terms of revenue, costs and capital access.

Voice of Environment (2006), GRI, SASB, TCFD, and ISSB operate as complementary ESG reporting frameworks rather than rivals, each addressing unique disclosure needs and audiences in a maturing regulatory landscape. GRI focuses on impact materiality, detailing how organizations affect the economy, environment, and society through its Universal Standards (2021), serving broad stakeholders with over 10,000 global users and anchoring EU ESRS thematic standards.

Y.P. Tsang & Et.all (2023), identified a critical gap in ESG measurement: while listed companies leverage KLD/ASSET4 rating schemes for investor decisions, SMEs—particularly logistics service providers (LSPs)—lack structured data systems, hindering ESG capability development. High ESG scores signal sustainable business models, yet listed firms' reliance on SME LSPs creates sourcing challenges without systematic assessment tools.

Ma et al. (2026) highlight transportation's critical role in SDG achievement yet analyze generic ESG indicators that ignore sector-specific dynamics. Existing frameworks fail transport's unique needs: high capex, public accountability, labor-intensive operations. Employing mixed-methods (systematic literature review + case studies of 4 international railways), they develop Trans-ESG-SDG: a tailored 28-indicator system with explicit SDG mappings incorporating temporal phasing, systemic interdependencies, and implementation feasibility.

GRI-SASB Reports (2021), demonstrates complementary dual- reporting through case studies of CDL (Singapore), Diageo (UK), General Motors (GM, US), and Suncor Energy (Canada)—all long-term GRI users (2000-2011) who adopted SASB (2018-2019) for investor focus. GRI enables broad stakeholder disclosure via sustainability reports/websites; SASB delivers financial materiality (industry-specific metrics) for investors through integrated/annual reports.

Hyderabad Metro's carbon footprint study (2023) demonstrates metro rail's superior emissions efficiency, producing 97% less CO₂ than cars and 98% less than buses for a 30-km trip, positioning metro as India's greenest urban transport amid Hyderabad's deteriorating air quality and traffic congestion. Broader sustainability benefits include congestion relief cutting idling emissions and improving public health via reduced respiratory illnesses.

Feng Zhao Et.all (2024), address metro rail's DC traction busbar voltage instability during braking, where excess energy causes voltage spikes without absorption. The proposed dual-mode

power management strategy allocates regenerative energy based on station low-voltage load demand: Mode 1 (low demand) prioritizes grid feed-in; Mode 2 (high demand) supplies station auxiliaries, dynamically setting reference power via control algorithms.

Shreyas Waim Et.all (2025), stated that modern metro sector demands sustainable solutions to meet rising energy needs and reduce environmental impact. This project explores a hybrid renewable energy model by integrating solar photovoltaic panels and Vortex Bladeless wind turbines into Mumbai Metro infrastructure. This hybrid system aligns with key Sustainable Development Goals (SDGs), reduces grid dependency, lowers operational costs, and presents a scalable model for green urban transport.

Paulose N. Kuriakos (2023), stated that in cities, social and economic functions are bound together by the transportation system. Indian cities have varied densities, incomes, land-use patterns and trip distances. They are now experiencing rapid urbanization, thus amplifying the demand for efficient transportation systems.

Changing Transport (2024) examines Delhi Metro's women-only coaches and free bus rides (2019 policy: 80% low-income female uptake), achieving 25% peak-hour female ridership growth. Gender safety innovations (CCTV, panic buttons, Pink Hoysalas in Bengaluru) address harassment (35% women report avoidance). Social equity framework prioritizes marginalized access: transgender quotas, subsidized passes for BPL families, proving inclusivity drives sustainable ridership.

Ram kumar &J. Rani (2024) employs mixed-methods research to evaluate current safety practices during construction and operations. The study identifies critical gaps in PPE compliance, risk communication, emergency preparedness, and organizational culture influencing safety outcomes, particularly among younger workers who show higher awareness but need targeted interventions.

Dr. Neha Gupta (2022) stated that employee demographics significantly influence HR practices in India's metro rail service sector, where workforce diversity shapes strategic human resource policies amid rapid urbanization and operational expansion. This research employs independent sample t-tests to analyze how age, experience, and grade affects employee attitudes toward key HR functions like recruitment, training, performance management, and retention strategies.

Lakhan Veer Singh (2023) expressed that in modern commercial landscape, corporate governance has transitioned from a private-sector priority to a fundamental necessity for government organizations. Public Sector Undertakings (PSUs) in India, which operate using taxpayer funds, bear a unique social responsibility to maintain the trust of stakeholders ranging from employees and bankers to society.

Naman Kumar (2021) stated that corporate governance in Indian Public Sector Enterprises (PSEs) remains pivotal for ensuring transparency, accountability, and operational efficiency in entities driving national infrastructure development. However, PSEs confront entrenched challenges including bureaucratic dominance, political appointments, weak accountability mechanisms, and suboptimal management practices that undermine strategic autonomy and performance.

Mahesha N M (2017) expressed that Contemporary business dynamics compel Indian Public Sector Undertakings (PSUs) to prioritize corporate governance for stakeholder confidence (customers, employees, shareholders, taxpayers) amid rising transparency expectations. Operating on public funds, PSUs must uphold four governance pillars—transparency, full disclosure, independent monitoring, and fairness—yet face persistent implementation failures due to bureaucratic inertia and weak accountability.

Akhtar Mahamadhusen Hangad & et.all (2026), Metro rail systems are crucial for sustainable urban mobility, congestion relief, and environmental goals, yet persistent construction delays trigger massive cost overruns, resource wastage, and eroding public trust. This mixed-methods study—integrating literature review, expert interviews, and structured surveys—identifies primary delay factors through statistical ranking: land acquisition bottlenecks, design change orders, inadequate risk allocation, financial closure delays, and stakeholder coordination failures.

Santanu Baruah (2025), stated in their article that urban metro projects represent critical infrastructure for mass transit expansion, congestion mitigation, and sustainable city development, yet consistently suffer chronic delays causing cost escalations, public disruption, and eroded investor confidence. This research dissects root causes specific to Indian metro execution—land acquisition gridlock, design revisions, regulatory delays—and benchmarks Mumbai Metro Line 4 against global precedents.

Haoran Ma & et.all (2026), opined in their article that, transportation sector sustainability is critical for achieving SDGs emphasizing equity, economic stability, and environmental protection, yet generic ESG frameworks fail to address transport-specific challenges. Academic research prioritizes policy innovation, employee rights, stakeholder relationships, and ESG disclosure, while industry emphasizes pollution prevention, health/safety, and fair practices revealing theory-practice disconnects.

Pramod Kumar Jha Dr. Manoj Bhatia (2026), opined in their article that sustainability initiatives significantly enhance urban mobility performance across environmental, operational, and social dimensions, as validated by mixed-methods research involving 421 user surveys, SPSS quantitative analysis and secondary data triangulation.

Yash Aryan & et.all (2025), expressed in their article that, Mumbai's first underground metro delivers substantial emission reductions by displacing high-emission road vehicles, with avoided emissions. Mode shift analysis reveals greatest gains from two-wheelers, auto-rickshaws, and taxis due to their emission intensity, while buses and cars contribute moderately. Operational emissions remain significantly lower than road transport externalities.

Sourav Dhawale & et.all (2022), addressed that Delhi and Mumbai Metro expansions demonstrate substantial environmental benefits through comprehensive Environmental Impact Assessments (EIA) comparing 'with' and 'without' project scenarios across air quality, noise, vibration, water, and soil parameters. Baseline data collection revealed 35% reductions in CO and NO₂ levels around major traffic intersections due to modal diversion from private vehicles to mass transit, confirming traffic decongestion as primary impact driver.

Mr.Vikas Navanath Dhakane (2025), did global metro systems comparative analysis—spanning Pune, Delhi, Lucknow, Kolkata, Chennai, London, Singapore, Dubai, Seoul, Frankfurt, Hong Kong, and Zurich—evaluates operational efficiency, economic viability, environmental impact, social equity, and technological innovation using multi-criteria framework drawn from official reports and academic literature.

Mirosław Antonowicz (2025), opined that Eurasian long-distance rail freight faces intensifying environmental pressures that are reshaping strategies and stakeholder expectations, as analyzed through literature review of environmental protection targets, railway company programs, and detailed case studies along Asia-Europe-Asia corridors, enriched by unique data from the Organization for Co-operation between Railways.

Atasi Mohanty & Et. all (2025), expressed that India's mandatory BRSR framework (FY 2025–26, top 1000 listed companies) exhibits critical environmental disclosure gaps—lacking noise pollution, animal extinction, soil contamination, and deforestation metrics—despite uniform

application across diverse industrial sectors facing regulatory/market pressures over genuine ecological priorities.

Yuyao Ye & Et. all (2017) addressed that Urban spatial optimization for low-carbon mobility requires compact forms, mixed land uses, and appropriately scaled blocks integrated with Green Transportation System Oriented Development (GTOD)—an enhanced Transit-Oriented Development (TOD) model incorporating walking-city principles and non-motorized systems.

Darshini Mahadevia & Et. All (2023) expressed that India's urban transport interventions in Surat (5.9M industrial hub) and Udaipur (0.8M tourist city) largely generate trade-offs across SDG11 delivery roles—Inclusive Access (-1 both cities), Climate-Resilient Development (-1 both), and Context-Sensitive Planning (-1 Surat, +1 Udaipur)—as revealed by mixed-methods assessment amid South Asia's impending urbanization wave critical to New Urban Agenda, SDGs, and Paris Agreement success.

Y.P. Tsang & Et. All (2023) addressed that ESG performance measurement frameworks like KLD and ASSET, designed for listed companies' structured data, prove impractical for SMEs in logistics and supply chain management lacking standardized metrics, creating sourcing challenges for larger firms dependent on responsible SME partners.

Nicola Magaletti & et. all (2025) expressed that Global logistics performance (LPI) exhibits systematic correlations with ESG dimensions across 163 countries (2007-2023), as revealed by IV panel regressions (2SLS/G2SLS) and machine learning models (Random Forest, SVM, clustering variants). Environmental trade-offs emerge with higher LPI—elevated GHG emissions alongside cleaner air and resource efficiency; social benefits include improved education and reduced child labor but risk social imbalances; governance gains encompass enhanced voice, participation, science productivity, and rule of law.

Henry Onomakpo Onomakpo (2025) mentioned that integrated ESG analysis in global transport/logistics reveals aggregate ESG scores drive excess returns (panel regression), with dynamic market spillovers (VAR/Granger causality) and superior volatility resilience (GARCH—no leverage effect) for ESG leaders.

Ana Claudia Nioac de Salles & Peter Brantsch (2025) addressed that Life Cycle Assessment (LCA) enables precise, quantitative sustainability reporting by measuring resource consumption and environmental impacts across product lifecycles, helping organizations prioritize high-impact areas for performance improvement.

Arwan Prabowo & Yudo Anggoro (2024) expressed that Global competition demands ESG integration beyond productivity, with mixed-methods research (interviews, thematic analysis, AHP) identifying the Integrated Approach (24.1% weight) as optimal for balancing environmental, social, and governance priorities in corporate strategy.

5. Research Gap : Existing literature extensively documents metro rail's environmental benefits (emission reductions, modal shifts) across Delhi, Mumbai, Hyderabad, and global systems, alongside generic ESG frameworks (GRI, SASB, TCFD) and logistics/transport sector analyses revealing financial materiality, SME challenges, and governance deficits in Indian PSUs. However, no empirical study systematically evaluates ESG practices specifically in Bangalore Metro Rail Corporation Limited (Namma Metro), despite Bengaluru's acute urbanization pressures, construction delays, and unique Phase 3 expansion needs. Sector-specific frameworks like Trans-ESG-SDG exist but lack Namma Metro application, while Indian BRSR gaps (noise pollution, deforestation) remain unaddressed in metro contexts, creating a critical void in localized, integrated E-S-G performance assessment for sustainable urban mobility.

6. Research Objectives :

Table 2 : Objectives

O – 1	To study the concept and evolution of ESG practices in urban rail transport with special reference to Namma Metro.
O – 2	To identify the major environmental, social, and governance factors influencing the sustainability performance of Namma Metro.
O – 3	To study the influence of social initiatives such as passenger safety, inclusivity, accessibility, employee welfare, and community engagement on commuter satisfaction.

7. Variable Identification :**Table 3 : Study Variables**

	Independent Variables	Mediating Variables	Dependent Variables
Component Dimensions	- Environmental (E) - Social (S) - Governance (G)	- Operational Efficiency - Public Trust - Service Quality	- Organizational Sustainability - Corporate Reputation - Financial Performance - Stakeholder Satisfaction

8. Research Implications :

- **Theoretical Implications :** The study advances the academic understanding of ESG by validating a sector-specific framework that accounts for the unique constraints of public sector transit, such as high capital intensity, social obligation, and long project lifecycles.
- **Managerial Implications :** For BMRCL leadership, the research provides a performance-linked diagnostic tool to identify operational inefficiencies. By mapping ESG dimensions to mediating variables like public trust and service quality, managers can prioritize high-impact interventions—such as solar energy adoption or transparent procurement digital platforms—that directly improve stakeholder satisfaction and project timeline discipline.
- **Policy Implications :** The study informs the broader national discourse on BRSR implementation by highlighting the limitations of one-size-fits-all reporting frameworks for infrastructure entities. It provides a blueprint for regulatory bodies to integrate transport-specific indicators into official reporting guidelines.

9. Conclusion : This research addresses the critical need to professionalize and institutionalize Environmental, Social, and Governance (ESG) practices within the Bangalore Metro Rail Corporation Limited (Namma Metro). As India's urban transport sector transitions toward high-capacity, low-carbon infrastructure, the study highlights a significant gap: while metros are inherently sustainable, they lack a unified, sector-specific framework to report and optimize their ESG performance against modern mandates like the BRSR.

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