



Urbanization and Plastic Pollution: A Review Based on Rajshahi Metropolitan Area, Bangladesh

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HOW TO CITE Islam, M. (2026). Urbanization and plastic pollution: A review based on Rajshahi Metropolitan Area, Bangladesh. <i>Development Compilation</i> , 19(1), 201–209. https://bips.bd/journal	ARTICLE HISTORY Received: 19 June 2026 Revised: 10 July 2026 Accepted: 13 July 2026 Available online: 20 July 2026
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Abstract

Plastic pollution is one of the most pressing environmental problems of the modern era. Rapid urbanization, increasing consumption of plastic products, and inadequate waste management have intensified this crisis in many developing countries, including Bangladesh. This paper examines how plastic pollution is affecting the Rajshahi Metropolitan Area—a city historically renowned for its clean, green environment. It explores the major sources of plastic waste, its impacts on the Padma River, urban drainage systems, soil quality, and public health. The study finds that unmanaged plastic waste poses a growing threat to environmental sustainability and urban livability in Rajshahi. It argues that effective waste management, stronger policy implementation, public awareness campaigns, and the promotion of environmentally friendly alternatives are indispensable for reducing plastic pollution and ensuring sustainable urban development.

Keywords: Plastic Pollution; Rajshahi; Urban Sustainability; Bangladesh; Waste Management

1. Introduction

Plastic pollution has emerged as a critical threat to the Rajshahi Metropolitan Area, progressively undermining its historical status as a "Green City." Rapid urban expansion and shifting consumer behaviors have resulted in the annual generation of approximately 15,927 tons of plastic waste within the metropolitan boundary, of which only an estimated 20% to 30% is formally recycled (Rajshahi City Corporation, 2024). This widening gap between waste generation and management capacity is disrupting the city's ecological balance and demanding urgent attention from researchers, policymakers, and civil society alike.

The environmental consequences of mismanaged plastic waste are wide-ranging. Plastic debris routinely blocks urban drainage channels, precipitating waterlogging and the infiltration of microplastics into the Padma River—a lifeline for both the local ecosystem and the population of northwestern Bangladesh. This contamination endangers aquatic biodiversity and creates long-term public health risks, as microplastics and their associated chemical additives have been detected in fish tissue, drinking water, and, alarmingly, in human blood and placentas (Leslie et al., 2022; WHO, 2022). The persistence of non-biodegradable plastics in the environment—sometimes for hundreds

to thousands of years—compounds these challenges, converting what are often perceived as short-term convenience items into multigenerational environmental liabilities (Barnes et al., 2009).

Despite Bangladesh's early and internationally recognized initiative in banning polythene shopping bags in 2002—the first country in the world to do so—enforcement gaps and the proliferation of single-use plastics have prevented meaningful reduction in plastic waste accumulation (Government of Bangladesh, 2002). Against this backdrop, the present paper reviews the intersecting dynamics of urbanization and plastic pollution in Rajshahi, drawing on available local, national, and international evidence. It analyzes the sources and types of plastic waste prevalent in the city, the multi-dimensional impacts of that waste, the existing legal and policy framework in Bangladesh, and practical pathways toward mitigation.

1.1. The Current State of Urbanization in Rajshahi

1.1.1 Urban Transformation and Growth

Rajshahi, the major urban center of northwestern Bangladesh, was historically characterized as a relatively small, quiet, and verdant administrative and residential city. Over the past three decades, however, accelerating urbanization has substantially transformed its character. Population growth, physical spatial expansion, proliferation of high-rise buildings, modern road infrastructure, and the diversification of commercial and industrial activities have collectively reshaped the metropolitan landscape (Bangladesh Bureau of Statistics [BBS], 2022). Approximately 87% of the city's land area is now classified as residential, with the remainder dedicated to commercial and administrative uses.

Infrastructure development has been rapid: educational institutions, IT parks, elevated roadways, riverfront beautification projects, and modern housing estates have fundamentally altered Rajshahi's urban morphology (Rajshahi City Corporation, 2020). This transformation carries both opportunities and risks, with modern amenities and economic dynamism coexisting with growing environmental pressures.

1.1.2 Urban Heat Island Effect

The expansion of built-up areas has contributed to the emergence of the Urban Heat Island (UHI) effect in Rajshahi. Research indicates that the average winter land surface temperature in the city increased by approximately 2.66°C between 1990 and 2023, driven by the replacement of vegetation, agricultural land, and open spaces with concrete buildings, paved roads, and commercial infrastructure (Islam, 2023). Areas including Shaheb Bazar, Laxmipur, Railgate, Upashahar, Talaimari, and Katakali have experienced particularly intense urbanization. The widespread adoption of heat-absorbing materials such as concrete and asphalt, combined with increasing vehicular density and commercial activity, intensifies thermal retention and raises ambient temperatures, with adverse effects on human comfort, energy consumption, and health.

1.1.3 Positive Dimensions of Urbanization

It is important to acknowledge that urbanization in Rajshahi has generated significant socioeconomic benefits. It has created new employment opportunities and improved living standards through investment in industrial, commercial, and information technology sectors, including the establishment of a Hi-Tech Park and the growth of service industries. Institutions such as the University of Rajshahi and RUET (Rajshahi University of Engineering and Technology) have enhanced educational access, while expanding healthcare infrastructure has improved medical service delivery (Rahman, 2012; Rajshahi City Corporation, 2022). Rajshahi's renowned silk industry and growing small and medium enterprises further contribute to economic vitality. Modern road networks, digital services, and upgraded urban infrastructure have improved connectivity and efficiency across the metropolitan area.

1.4 Environmental Impacts of Unplanned Urbanization

Alongside its benefits, unplanned urban growth in Rajshahi has produced a range of adverse environmental outcomes:

- **Increased temperatures:** Reduction of forested areas and open spaces, combined with heat-absorbing construction materials, has elevated urban temperatures by approximately 2–3°C above surrounding rural areas, intensifying heat-related health risks (Islam, 2023).
- **Encroachment of water bodies:** Illegal construction along canals and rivers obstructs natural drainage, increasing flood risk, disrupting hydrological cycles, and contributing to dry soils and reduced atmospheric moisture (Shafique, 2018).
- **Air and noise pollution:** Vehicular emissions and inadequate road infrastructure have elevated concentrations of PM_{2.5} and PM₁₀ above World Health Organization (WHO) standards in major thoroughfares and industrial zones, increasing respiratory disease burden (Department of Environment [DoE], 2021).
- **Loss of biodiversity:** Habitat destruction has led to the decline of local bird species, small mammals, and plant populations, disrupting ecological equilibrium and reducing urban livability (Sustainable Rajshahi Initiative, 2022).
- **Mental and social health impacts:** The reduction of parks, open spaces, and green areas increases stress and anxiety among urban residents. Research has consistently shown that insufficient access to green spaces negatively affects psychological wellbeing, particularly for children and the elderly.

2. Understanding Plastic and Plastic Pollution

2.1 What Is Plastic?

Plastic is an artificial or semi-artificial material composed primarily of polymers, produced from either virgin fossil-fuel-derived feedstocks or secondary recycled sources (Andrady & Neal, 2009). Plastics are valued for their lightweight properties, flexibility, durability, and moldability—characteristics that have driven their adoption across virtually every sector of modern society. Short-life plastics, including packaging materials, single-use bags, and bottles, account for approximately 35% of total global plastic production annually, while synthetic textiles (15%), household goods, automotive components, and agricultural inputs (such as greenhouse films and irrigation tape) constitute the remainder (Andrady & Neal, 2009).

Despite their utility, plastics are non-biodegradable and resist natural weathering processes. Rather than decomposing organically, plastics fragment under exposure to ultraviolet radiation, mechanical abrasion, and wave action into progressively smaller particles: macroplastics (>5 mm), microplastics (<5 mm), and nanoplastics (<1,000 nm). Many plastic formulations also contain chemical additives—such as phthalates and Bisphenol A (BPA)—that have been detected in human blood, lungs, and placentas, where they are associated with oxidative stress and endocrine disruption (Leslie et al., 2022).

2.2 What Is Plastic Pollution?

Plastic pollution refers to the accumulation of discarded plastic materials in the environment to levels that cause harm to ecosystems, wildlife, and human health. It represents a multi-dimensional global crisis driven by the structural imbalance between rapidly escalating plastic production and chronically inadequate waste management infrastructure (UNEP, 2021). Globally, an estimated 19–23 million tonnes of plastic enter aquatic ecosystems annually (UNEP, 2021). Plastics infiltrate oceans, Arctic environments, and agricultural soils, where they disrupt ecological functions including soil fertility and microbial activity (Tiwari & Sistla, 2024).

2.3 Durability and Persistence of Plastics

The environmental persistence of plastics is a function of polymer type and prevailing environmental conditions (UV exposure, temperature, oxygen, and mechanical abrasion). Estimated degradation timelines for common plastic products include (Barnes et al., 2009):

- Plastic bags (polyethylene): 100–500 years
- Plastic bottles (PET): 450–1,000 years
- Plastic straws (polypropylene): approximately 200 years
- Foam containers (polystyrene): 50–500 years
- Plastic cup lids: approximately 400 years

These figures are estimates; complete mineralization of plastics is rare. Instead, plastics fragment into microplastics and nanoplastics that persist indefinitely within ecosystems, bioaccumulating in food chains and entering human bodies through multiple pathways (Andrady, 2011).

2.4 Harmful Effects of Plastic on Human Health

Plastic pollution poses significant risks to human health, principally through the vector of microplastic contamination. Microplastics have been identified in rivers, oceans, drinking water, seafood, atmospheric dust, and human blood (Leslie et al., 2022). Aquatic organisms, including fish and shellfish, ingest these particles; when humans consume contaminated seafood or water, microplastics enter the body and can interact with toxic chemical additives—including Bisphenol A (BPA), phthalates, and persistent organic pollutants (POPs)—with documented health consequences:

- **Carcinogenicity:** Certain plastic-associated chemical additives and absorbed pollutants are classified as carcinogenic or potentially carcinogenic, raising cancer risk following chronic exposure (IARC, 2012).
- **Endocrine disruption:** BPA and phthalates are recognized endocrine-disrupting chemicals (EDCs) that interfere with hormonal regulation, reproductive function, and metabolic processes (Bergman et al., 2013).
- **Systemic organ damage:** Microplastic-associated toxins may induce oxidative stress, chronic inflammation, and damage to the nervous system, liver, and kidneys. Their presence in placental tissue raises particular concern for fetal development (WHO, 2022).

3. Plastic Pollution in Rajshahi: Current State and Causes

3.1 The Scale of the Problem

Although Rajshahi has long enjoyed recognition as a clean and green city, recent years of urban growth have substantially increased plastic waste generation. National research indicates that plastic waste in Bangladesh rose by approximately 27% over the five years preceding 2024, driven by rapid urbanization and rising consumption of packaged goods (Rajshahi City Corporation, 2024). At the local level, Rajshahi City Corporation reports that approximately 15,927 tons of plastic waste are generated annually within the metropolitan area, with daily production estimated at 35–40 tons. Of this daily output, only about 30% is formally recycled; the remainder accumulates in canals, along riverbanks, in open dumps, and within drainage infrastructure.

The dominant plastic waste streams in Rajshahi consist of polythene bags, polyethylene terephthalate (PET) water bottles, food packaging wrappers, straws, and single-use cups. During the monsoon season, the accumulation of these materials in drainage channels leads to blockages that cause urban waterlogging, infrastructure damage, and heightened flood risk.

3.2 Causes of Plastic Pollution

Plastic pollution in Rajshahi results from the interaction of structural, socioeconomic, and behavioral factors (UNEP, 2021; Jambeck et al., 2015; OECD, 2022):

- **Unplanned urbanization:** Poorly regulated urban development, including encroachment on natural drainage pathways, reduces the capacity of ecosystems to absorb and process waste, increasing plastic accumulation in waterways (Jambeck et al., 2015).
- **Population density and consumption:** High urban density drives demand for packaged goods and plastic-based products, elevating per capita waste generation (OECD, 2025).
- **Affordability and ubiquity of plastic:** Plastics are inexpensive and widely available, making them the preferred choice for packaging and everyday items in low- and middle-income contexts (Andrady & Neal, 2009).
- **Absence of scalable alternatives:** Affordable, biodegradable substitutes for plastic packaging remain limited or inaccessible in much of Bangladesh (UNEP, 2018).
- **Behavioral and awareness gaps:** Despite growing public knowledge of plastic pollution, systematic waste segregation and responsible disposal practices remain inconsistent (UNEP, 2021).
- **Weak waste management infrastructure:** Inadequate collection systems, limited recycling facilities, and governance deficiencies contribute substantially to plastic leakage into the environment (Jambeck et al., 2015).
- **Prevalence of single-use plastics:** Items designed for one-time use—bags, bottles, straws, and food containers—persist in the environment for centuries despite their transient utility (UNEP, 2018).
- **Low recycling rates:** Only a small fraction of plastic waste globally undergoes effective recycling; the majority is landfilled, incinerated, or released into natural environments (OECD, 2025).
- **Open disposal practices:** Littering and open dumping contaminate soils, surface water, and air, facilitating plastic entry into rivers and ultimately the ocean (UNEP, 2021).
- **Industrial plastic waste:** Improper handling of plastic waste by factories and manufacturing units adds to the cumulative burden of environmental contamination (OECD, 2025).

4. Impacts of Plastic Pollution in Rajshahi

The accumulation of plastic waste across Rajshahi produces interconnected environmental, public health, and socioeconomic impacts:

4.1 Soil and Environmental Degradation

Plastic waste deposited in streets, markets, and residential areas resists biodegradation, instead fragmenting and persisting in soils. Long-term accumulation reduces soil permeability, disrupts microbial communities, and can suppress agricultural productivity in peri-urban farming zones. Research from comparable South Asian contexts documents reductions in soil aeration and biological activity attributable to plastic contamination (Tiwari & Sistla, 2024; UNEP, 2021).

4.2 Urban Drainage Failure and Waterlogging

Plastic debris is a principal cause of drainage system failure in Rajshahi. Blocked storm drains and sewers impede stormwater flow during monsoon periods, producing extensive urban waterlogging, sanitation crises, and damage to road and utility infrastructure. These dynamics have been widely documented in rapidly urbanizing cities across South and Southeast Asia with similarly underdeveloped waste management systems (Jambeck et al., 2015).

4.3 Public Health Risks

The accumulation of plastic waste in open environments creates breeding habitats for disease vectors, notably mosquitoes and flies, thereby elevating risks of dengue fever, malaria, and diarrheal illnesses. Indirectly, microplastics enter human bodies through contaminated food and water, raising concerns

about endocrine disruption, chronic inflammation, and carcinogenic exposure with long-term consequences for population health (UNEP, 2021; WHO, 2022).

4.4 Degradation of the Padma River and Aquatic Ecosystems

Plastic waste discharged into the Padma River is a growing threat to water quality and aquatic biodiversity in the Rajshahi region. Microplastic contamination has been documented throughout major South Asian river systems, including the Ganges-Padma basin, where plastic particles are ingested by fish and other aquatic organisms, facilitating contaminant transfer through aquatic food webs (Lebreton et al., 2017). Accumulation of plastic debris along riverbanks and within river channels disrupts aquatic habitats, reduces ecological resilience, and threatens the long-term sustainability of local fisheries—with material consequences for communities whose livelihoods, food security, and domestic water supply depend on the Padma River.

4.5 Climate Change Contributions

When plastic waste is informally incinerated—a common disposal practice in the absence of formal collection—it releases carbon dioxide, dioxins, and furans. More broadly, plastics contribute to greenhouse gas emissions throughout their lifecycle, from fossil fuel extraction and processing to manufacturing and disposal (OECD, 2022; UNEP, 2018). This lifecycle carbon burden makes plastic pollution a direct contributor to the climate change drivers intensifying urban heat and flood risk in Rajshahi.

4.6 Aesthetic Degradation and Urban Livability

Rajshahi's reputation as a clean, green city is increasingly undermined by the indiscriminate dumping of plastic waste along roads, in public parks, and along the Padma riverbank. The resulting visual pollution diminishes the city's aesthetic appeal, reduces tourism potential, and degrades the quality of life for urban residents—reversing decades of investment in urban greening and beautification (UNEP, 2021).

5. Existing Legal Framework in Bangladesh

5.1 The Polythene Bag Ban (2002)

Bangladesh became the first country in the world to legally prohibit polythene shopping bags in 2002, through an amendment to the Bangladesh Environment Conservation Act, 1995 (Act No. 9 of 2002). The law prohibits the manufacture, import, marketing, sale, demonstration for sale, storage, distribution, commercial carriage, and use of polythene bags (Government of Bangladesh, 2002). Penalties under the original legislation include a minimum of six months' imprisonment or a fine of at least BDT 10,000 (or both) for producers and distributors, and a fine of BDT 500 for users. The Ministry of Environment, Forest and Climate Change and the Department of Environment (DoE) are mandated with enforcement. Between November 2024 and early 2025, 199 mobile court operations fined 514 businesses a total exceeding BDT 2.57 million and confiscated 50.56 tons of banned polythene bags, reflecting renewed enforcement commitment.

5.2 Solid Waste Management Rules (2021) and the Sustainable Plastic Management Action Plan

In response to intensifying plastic pollution—particularly from single-use plastics—Bangladesh enacted the Solid Waste Management Rules in 2021, establishing a comprehensive framework for sustainable plastic governance (Government of Bangladesh, 2021). The accompanying Sustainable Plastic Management Action Plan sets binding targets:

- Reduce single-use plastic consumption by 90% by 2026
- Increase plastic waste recycling to 50% by 2025 and 80% by 2030
- Reduce total plastic waste generation by 30% by 2030

Implementation measures include a ban on single-use plastics from October 2024, elimination of plastic water bottles from government offices, and coordination with the Ministry of Jute to ensure alternative supply. While the Solid Waste Management Rules (2021) provide a modern and

comprehensive legal architecture, effective implementation requires coordinated engagement between government agencies, the private sector, civil society, and individual citizens (Ministry of Environment, Forest and Climate Change, 2021).

6. Recommended Interventions and Local Initiatives

6.1 Strategic Recommendations

Reducing plastic pollution in Rajshahi requires a multi-level strategy integrating regulatory action, behavioral change, technological investment, and community mobilization:

- **Apply the 3R Principles (Reduce, Reuse, Recycle):** Systemic reduction of single-use plastic consumption, promotion of reusable materials, and strengthening of municipal recycling infrastructure are globally recognized as the most effective levers for minimizing plastic leakage into the environment (UNEP, 2021; OECD, 2022).
- **Strengthen Government–Industry–Civil Society Collaboration:** Effective plastic management requires rigorous enforcement of environmental legislation, adoption of Extended Producer Responsibility (EPR) frameworks obligating manufacturers to manage end-of-life plastic, and active citizen participation in waste segregation and responsible consumption (OECD, 2022).
- **Promote Environmentally Friendly Alternatives:** Incentivizing and subsidizing jute, cloth, paper, and glass products can substantially reduce reliance on fossil-fuel-derived plastics. Bangladesh possesses a comparative advantage in jute production that has yet to be fully leveraged as an alternative packaging material (UNEP, 2018).
- **Invest in Waste Collection and Recycling Infrastructure:** Expanding plastic waste collection points under Rajshahi City Corporation, introducing source segregation systems, and supporting the informal recycling sector through formalization and capacity building are critical operational priorities.
- **Scale Public Education and Awareness:** Sustained awareness campaigns delivered through schools, universities, mosques, markets, and mass media are essential for shifting behavioral norms around plastic use and disposal.

6.2 Government and Local Initiatives

Rajshahi City Corporation has taken positive steps in recent years, including intensified waste management operations, canal and drain clearance, and anti-plastic enforcement drives. National-level measures—including the ban on plastic water bottles in government offices, restrictions on single-use plastics in commercial spaces, and the national Plastic Management Action Plan (2021–2030)—signal growing institutional commitment (Ministry of Environment, Forest and Climate Change, 2021). However, the substantial gap between policy aspiration and on-the-ground reality underscores the need for accelerated implementation, sustained resourcing, and robust accountability mechanisms.

7. Conclusion

Rajshahi stands at a pivotal juncture. Its historical identity as a green and clean city is increasingly imperiled by the twin pressures of rapid unplanned urbanization and escalating plastic pollution. The evidence reviewed in this paper indicates that the city generates nearly 16,000 tons of plastic waste annually, of which the overwhelming majority is neither formally collected nor recycled. This waste burden is translating into tangible environmental harm—degraded water quality in the Padma River, compromised urban drainage systems, soil and biodiversity loss, intensified public health risks, and the progressive erosion of the city's urban livability.

At the same time, Bangladesh possesses a legal and policy architecture—anchored in the pioneering 2002 polythene ban and reinforced by the 2021 Solid Waste Management Rules—that, if effectively implemented, could form the basis of a meaningful national response. The Sustainable Plastic Management Action Plan's targets are ambitious and achievable, provided they are matched by political will, institutional capacity, and adequate resource allocation at all levels of government.

Addressing plastic pollution in Rajshahi requires a fundamental reorientation—from reactive waste management toward proactive plastic governance embedded in a broader framework of sustainable urban planning. This means moving beyond enforcement campaigns alone to systemic interventions: integrating plastic waste reduction into urban master planning; mandating Extended Producer Responsibility so that the costs of end-of-life plastic management are borne by producers rather than the public; investing in waste collection and recycling infrastructure, particularly in underserved peri-urban neighborhoods; and scaling up alternatives to single-use plastics by leveraging Bangladesh's natural advantage in jute production.

It is equally essential to recognize that technical and regulatory measures alone are insufficient. Durable behavioral change—across households, markets, educational institutions, and public spaces—is indispensable. Community engagement, especially involving youth and women's groups, can serve as a powerful multiplier of policy action. Educational institutions in Rajshahi, from primary schools to the University of Rajshahi itself, are uniquely positioned to anchor a culture of environmental responsibility in the next generation of urban citizens.

The global dimension of plastic pollution must also inform local responses. Bangladesh is one of 175 nations engaged in negotiating a legally binding international plastics treaty under UNEP auspices (UNEP, 2021). A robust global agreement, providing financial and technical support to developing countries, would significantly strengthen Rajshahi's and Bangladesh's capacity to address the structural drivers of plastic pollution—including inadequate waste management infrastructure and the proliferation of cheap single-use plastics.

Rajshahi's future as a livable, resilient, and sustainable city is not predetermined. The choices made in the coming decade—by city planners, policymakers, business leaders, educators, and individual citizens—will determine whether Rajshahi reclaims and sustains its green city identity, or whether unchecked plastic pollution erodes the environmental and social foundations on which that identity rests. The evidence and analysis presented in this paper argue unambiguously for the former: that planned, environmentally intelligent urbanization, anchored in robust plastic governance and supported by an informed and engaged citizenry, is not only necessary but achievable. For future generations of Rajshahi's residents, it is the only sustainable course.

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