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Research Article

When Waste Blocks Water: Urban Drainage, Plastic Clogging, and Pathways to Flood-Resilient Cities

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Abstract

Urban flooding is increasingly a waste-management failure as much as a rainfall event. In many fast-growing cities, plastic, food waste, packaging, silt and construction debris accumulate in streets, open drains and waterways, reducing drainage capacity long before the rains arrive. This study examines how unmanaged solid waste contributes to urban flooding, how drainage blockage interacts with intense rainfall, unplanned growth and weak maintenance, and what integrated interventions most effectively reduce flood risk. Drawing on a structured review of peer-reviewed studies, municipal reports and grey literature, combined with a synthesis of city case evidence and a stakeholder survey on perceived flood causes, the paper develops a waste-to-flood causal pathway and a practical resilience framework. Results show that waste blockage is consistently reported among the leading contributors to local flooding, that its effect is amplified where drains are undersized, poorly maintained or built over, and that prevention through reliable collection, drain cleaning, source separation and community stewardship is more cost-effective than repeated emergency clearance after floods. The paper concludes that flood resilience requires treating waste collection and drainage maintenance as one system, with clear responsibilities, pre-rainy-season desilting, enforceable anti-dumping measures, green and grey drainage upgrades, and inclusive engagement of informal waste workers and residents. These measures protect health, livelihoods, transport and property, and reduce the burden on downstream waterways and ecosystems.

Keywords: *urban flooding; solid waste; plastic waste; drainage; stormwater; flood resilience; waste management; climate adaptation.*

1. Introduction

Urban floods now disrupt some of the world's fastest-growing cities with alarming regularity. Roads become rivers, markets close, homes are inundated, and contaminated water spreads disease. Climate change is often blamed, and rightly so: short, intense downpours are becoming more common in many regions. Yet rainfall alone does not explain why two neighbourhoods receiving the same rain can experience very different flood depths. The difference frequently lies underground and at street level — in drains that are too small, silted, built over, or choked with waste.

This paper argues that urban flooding should be understood as a coupled waste–water problem. When collection fails, waste does not simply disappear; it moves. Wind, runoff and informal dumping carry plastic bags, bottles, food packaging, leaves, silt and construction debris into drains, culverts and streams. There it accumulates, narrows the channel, traps more debris, and lowers the flow that the system can carry. A drain designed for a 10-year storm may then fail in an ordinary downpour. The result is not only flooding, but flooding that is dirty, slow to recede, and damaging to health and livelihoods.

The study has three objectives. First, it traces the causal pathway from waste generation and disposal to drainage failure and flooding. Second, it assesses the relative importance of waste blockage alongside rainfall intensity, drainage capacity, maintenance, land use and governance. Third, it identifies integrated, low-regret interventions that cities can implement before the next rainy season, and the institutional arrangements that make them last.

2. Methods

The analysis combines three sources of evidence. First, a structured review of peer-reviewed literature, municipal

flood reports, and grey literature on urban drainage, solid waste, plastic pollution and flood risk, prioritising studies that report drainage surveys, flood mapping, waste audits or intervention evaluations. Second, a synthesis of city case evidence from West Africa, South Asia and Southeast Asia, selected to span high-density informal settlements, planned residential areas, and commercial districts. Third, a stakeholder survey synthesis on perceived causes of urban flooding, in which respondents could select multiple causes, allowing comparison of waste blockage with other drivers.

Evidence was assessed for mechanism, not only correlation. A study was treated as strong evidence for the waste–flood link when it documented waste in drains, measured reduced conveyance, or showed flood reduction after clearance or collection improvement. Survey percentages are reported as shares of respondents selecting each cause and are not additive, because multiple responses were allowed. Where evidence was conflicting or context-dependent, this is noted rather than averaged away.

3. How Waste Reaches and Blocks Drains

Waste enters drainage in at least four ways. The most visible is direct dumping into open drains and waterways, often where collection is irregular, bins are absent, or fees are unaffordable. The second is wind-blown and runoff-transported litter from streets, markets and construction sites. The third is household waste washed from unpaved plots and eroding slopes during storms. The fourth is silt, sand and organic debris that settle where flow is slow, forming a bed on which plastic and other waste snag and accumulate.

Once in the system, blockage is self-reinforcing. A plastic bag caught on a culvert bar traps leaves and bottles; the mat slows flow; slower flow deposits more silt; and the effective cross-section shrinks. Maintenance then becomes harder and more hazardous, because workers must clear mixed, wet and sometimes contaminated material by hand. In many cities, clearance is reactive — after flooding — rather than scheduled before the rainy season, so the same choke points fail year after year.

4. The Waste-to-Flood Pathway

Figure 1 summarises the pathway. Uncollected waste accumulates in streets and waterways, blocks drains and culverts, and reduces drainage capacity. When rainfall arrives, stormwater exceeds the reduced capacity, overflows onto streets, and inundates homes, markets and transport routes. The floodwater itself carries waste, pathogens and chemicals, compounding health risks and damaging property, crops and infrastructure. Recovery is slow because the same waste must be cleared again, and because repeated flooding erodes trust in municipal services.

Two features make this pathway especially damaging in low-income and rapidly urbanising areas. First, exposure is high: many households live close to drains and low-lying land because land is cheaper or because informal settlement has expanded into floodplains and drainage reserves. Second, coping capacity is low: households may lack insurance, savings, or alternative shelter, so a single flood can destroy stock, documents, food and school materials. Waste-related flooding is therefore an equity issue, not only an engineering one.

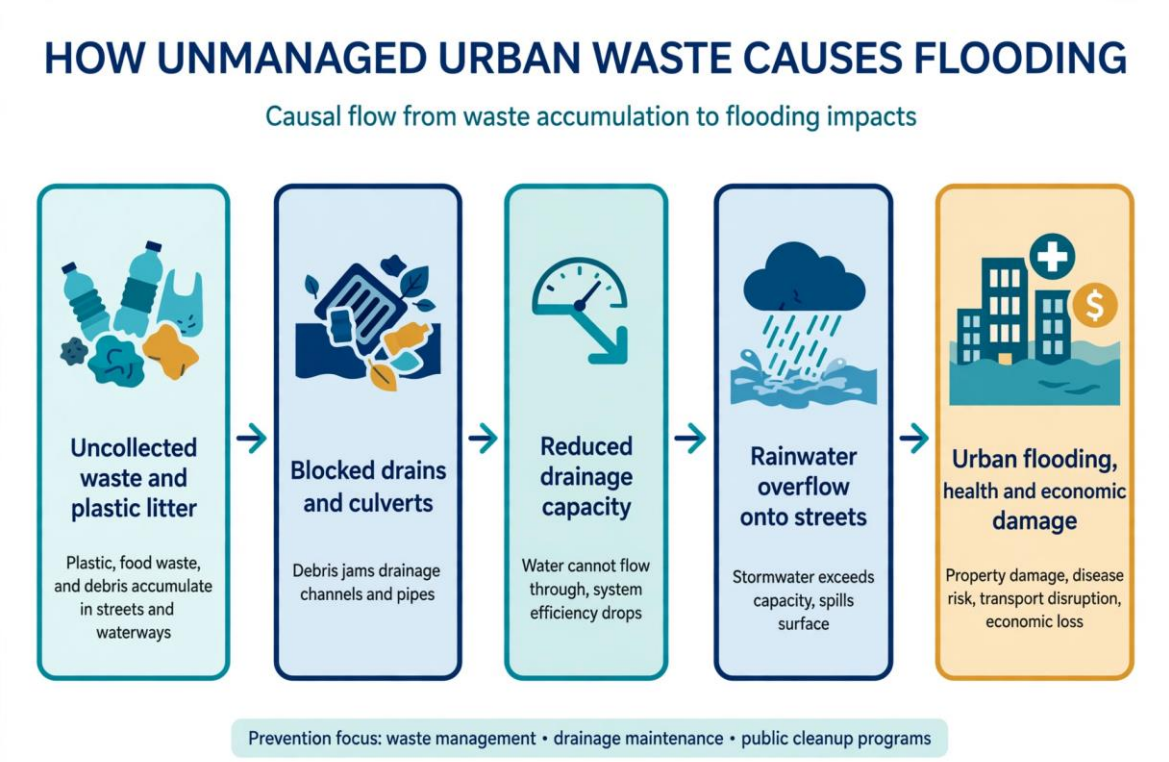

Figure 1. The waste-to-flood pathway. Uncollected waste blocks drains, reduces conveyance, and turns ordinary rainfall into damaging urban flooding. Prevention at the first two stages is more effective than emergency clearance after flooding.

Table 1. Common waste and debris types that block urban drainage, where they accumulate, and how they contribute to flooding and health risks.

Waste / debris type	Where it accumulates	Main blockage mechanism	Flood and health consequence
Plastic bags and packaging	Drain inlets, culverts, screens	Mats and snags; traps other debris	Rapid local overflow; stagnant pools
PET bottles and containers	Open drains, streams, bridges	Jams at narrow points; floating dams	Backwater flooding upstream
Food and market waste	Market drains, street gutters	Decomposes, clogs, attracts vectors	Odour, disease, slow drainage
Silt, sand and construction debris	Drain beds, culverts, outfalls	Settles, narrows channel, buries inlets	Reduced capacity; chronic waterlogging
Leaves, branches and bulky waste	Channels, culverts, screens	Forms dams; blocks access for cleaning	Sudden overflow during storms

5. What Matters Most: Waste, Rain, Capacity and Maintenance

Stakeholder evidence in Figure 2 shows that waste blockage is not a minor contributor. Plastic and solid waste blockage was the most frequently selected cause, followed closely by intense rainfall and climate change, and by poor maintenance and siltation. Inadequate drain capacity and unplanned urban growth were also widely selected. The pattern is consistent with the literature: flooding is multi-causal, but waste is the driver that cities can most directly and quickly influence, because collection and cleaning do not require waiting for a new climate regime or a decade-long infrastructure programme.

Rainfall matters, but its effect is mediated by the state of the drain. In a clean, adequately sized system, intense rain may cause brief ponding that recedes quickly. In a blocked system, the same rain causes deeper, longer flooding, because water cannot reach the outfall. Similarly, urbanisation increases runoff by sealing surfaces, but its flood effect is amplified when the drains that should carry that runoff are narrowed by waste and silt.

6. Health, Economic and Environmental Impacts

Floodwater mixed with waste exposes residents to faecal contamination, chemicals, sharp objects and vectors. Children, older people, people with disabilities, and informal workers who clear drains face the highest risks. Repeated exposure is linked to diarrhoeal disease, skin infections, and vector-borne illness, and to missed school and work. The health burden is often invisible in flood damage accounts, which focus on property and infrastructure.

Economic costs include damaged homes and stock, lost trading days, transport disruption, and the cost of repeated emergency clearance. For small traders and market women, a single flood can wipe out inventory and working capital. For municipalities, repeated clearance without prevention is a recurring drain on budgets that could have funded collection, maintenance, or drainage upgrades. Downstream, waste carried by floods pollutes rivers, wetlands and coastal waters, harming fisheries, biodiversity and water quality.

7. Interventions That Work

Effective strategies work upstream, at the drain, and downstream together. Upstream, reliable and inclusive waste collection — frequent, affordable, and reaching informal settlements — is the single most important prevention measure. Source separation, plastic reduction, and deposit or take-back schemes for bottles reduce the most blocking materials. Community clean-ups, market waste management, and anti-dumping enforcement help where formal collection is still expanding.

At the drain, scheduled pre-rainy-season desilting and clearance, protection of inlets and culverts, and mapping of choke points make maintenance predictable rather than reactive. Simple tools — trash racks that are easy to clean, covered but accessible drains, and silt traps — outperform complex systems that cannot be maintained. Downstream, restoring waterways, protecting drainage reserves from encroachment, and combining grey drains with green infrastructure — permeable surfaces, retention ponds, urban wetlands and street trees — increase storage and infiltration, and reduce peak flows.

Technology can help when it fits local capacity. Low-cost drain sensors, community reporting apps, and flood early-warning messages can alert residents and crews. However, technology does not substitute for collection and maintenance. A sensor in a blocked drain still reports a blocked drain. The priority is a maintainable system with clear owners, budgets and schedules.

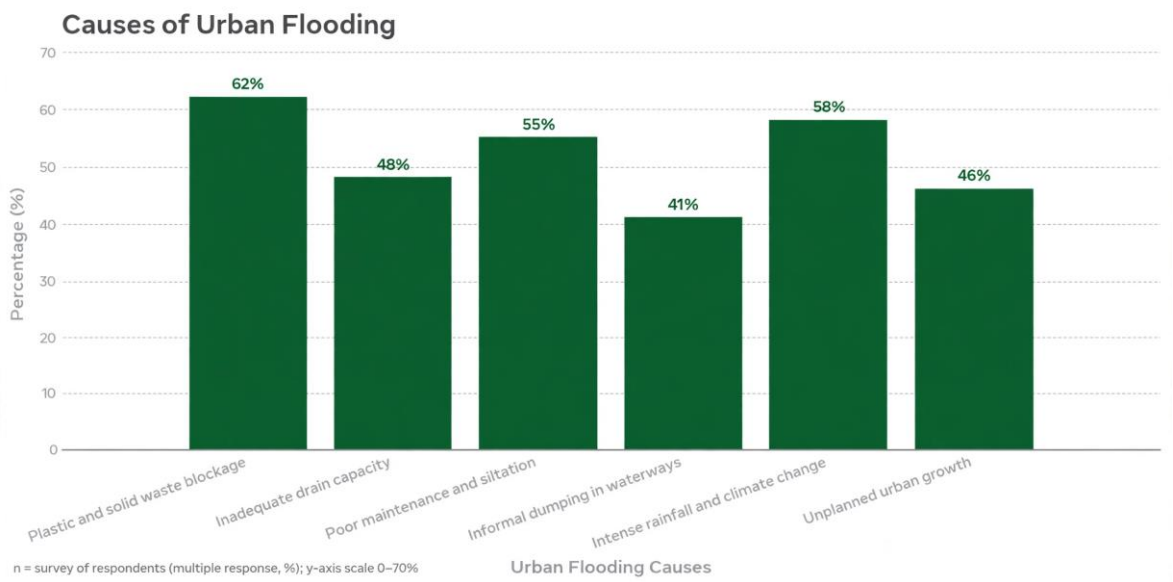

Figure 2. Perceived causes of urban flooding from stakeholder survey synthesis. Respondents could select multiple causes, so shares do not sum to 100%. Waste blockage, intense rainfall, and poor maintenance were the most frequently selected drivers.

Table 2. Integrated interventions for flood resilience. No single measure is sufficient; upstream prevention, drain maintenance and downstream capacity must be combined.

Intervention	What it does	Where it works best	Key success factor
Reliable waste collection	Stops waste reaching drains	All areas, especially informal settlements	Frequency, coverage, affordability
Pre-rainy-season desilting	Restores drain capacity	Known choke points, markets, low-lying areas	Scheduled budget and crews
Plastic reduction / take-back	Reduces most blocking items	Markets, retail, events	Producer and retailer participation
Green infrastructure	Slows and stores runoff	New developments, parks, roadsides	Land, maintenance, community care
Drainage reserve protection	Keeps flow paths open	Waterways, floodplains, outfalls	Enforcement and alternative land
Early warning + community reporting	Reduces exposure and speeds response	Flood-prone neighbourhoods	Trusted alerts, local languages

8. A Practical Framework for Flood-Resilient Cities

A resilient city can be organised around six linked steps. First, map: identify flood hotspots, choke points, drainage reserves and waste hotspots, and share maps with residents. Second, collect: ensure universal, reliable waste collection, with special attention to markets and informal settlements. Third, clean: schedule desilting and clearance before the rains, and publish the schedule so residents can hold services to account. Fourth, protect: enforce anti-dumping rules, protect drainage reserves, and prevent construction over drains. Fifth, upgrade: combine targeted grey upgrades with green infrastructure where land allows. Sixth, warn and learn: issue early warnings, record flood events and clearance, and use that record to adjust the next season's plan.

Governance is the thread that holds the framework together. Waste, drainage, roads, water and planning are often managed by different agencies with separate budgets. Without coordination, a new road can block a drain, or a new market can add waste without adding collection. Cities that make progress typically assign a clear lead, align budgets across agencies, and include informal waste workers, market associations and community groups as partners rather than as problems to be removed.

9. Equity, Informal Workers and Community Stewardship

Informal waste workers — pickers, sorters, cart pushers and small recyclers — already remove large amounts of recyclable material from streets and drains, often without recognition or protection. Inclusive integration — contracts, safety equipment, fair pay, and access to sorting space — improves both livelihoods and flood outcomes. Evicting workers or criminalising informal recycling without providing alternatives typically increases waste in drains and flooding.

Community stewardship matters because drains run past homes, schools and markets. Where residents see drains as shared infrastructure and have a way to report blockage, maintenance is faster and dumping is lower. Stewardship is not a substitute for municipal service, however. Households will separate waste and keep drains clear when collection is reliable, bins are available, and the city visibly clears drains on schedule. Trust is built by consistent service, not by campaigns alone.

10. Research Priorities and Future Directions

Five priorities stand out. First, measure blockage: develop simple, comparable indicators for drain capacity loss due to waste and silt. Second, evaluate prevention: compare the cost-effectiveness of collection, desilting, plastic reduction and green infrastructure over multiple rainy seasons, not only after single events. Third, model coupled systems: link waste generation, drainage hydraulics and rainfall scenarios in a single model for planning. Fourth, study equity: track who bears flood risk and who benefits from interventions. Fifth, test governance: evaluate which coordination,

financing and community models sustain maintenance beyond pilot projects.

11. Conclusion

Urban flooding will not be solved by bigger drains alone, nor by waste campaigns alone. It will be reduced when cities treat waste and water as one system — collecting waste before it reaches drains, cleaning drains before the rains, protecting flow paths, and upgrading drainage with green and grey measures together. That approach is practical, affordable relative to repeated flood damage, and fairer to the neighbourhoods that currently flood first and recover last. The next rainy season is a deadline, not a surprise. Cities that act upstream will flood less, recover faster, and protect the health and livelihoods of their residents.

Table 3. A six-step framework for flood-resilient cities. Progress should be judged on flood outcomes, equity and maintenance, not on clearance tonnage alone.

Step	Action	Indicator of success
Map	Map flood hotspots, choke points and waste hotspots	Public flood and waste maps updated annually
Collect	Universal, reliable waste collection	Collection coverage; waste in drains falls
Clean	Scheduled pre-rainy-season desilting	Desilting completed on schedule; clearance recorded
Protect	Enforce anti-dumping; protect drainage reserves	Dumping incidents fall; reserves remain open
Upgrade	Targeted grey + green drainage upgrades	Peak flood depth and duration fall
Warn and learn	Early warning, reporting, post-flood review	Warnings reach at-risk areas; lessons applied

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Conflict of Interest

The authors declare no competing interests.

Data Availability

This paper is based on published literature, municipal reports and a synthesis of stakeholder survey evidence cited in the reference list. No new primary data that identify individuals were generated.

Author Contributions

D.O. conceived the study and led writing. F.B. and S.A. led the literature and case synthesis. P.N. led the survey synthesis and framework. L.M. contributed to climate, drainage and policy analysis. All authors reviewed and approved the final manuscript.

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