Research Square

Preprints are preliminary reports that have not undergone peer review.
They should not be considered conclusive, used to inform clinical practice,
or referenced by the media as validated information.

Blocked Drains and Rising Waters: Solid Waste Mismanagement as a Driver of Urban Flood Risk in Nigeria

Rasheed Opeyemi Olanrewaju

olanrewajurasheedopeyemi@gmail.com

Obafemi Awolowo University

Systematic Review

Keywords: solid waste management, urban flooding, drainage blockage, Nigeria, scoping review, SDGs, flood risk reduction

Posted Date: November 2nd, 2026

DOI: https://doi.org/10.21203/rs.3.rs-11514071/v1

License: This work is licensed under a Creative Commons Attribution 4.0 International License.
Read Full License

Additional Declarations: No competing interests reported.

Blocked Drains and Rising Waters: Solid Waste Mismanagement as a Driver of Urban Flood Risk in Nigeria

A Scoping Review

Author: Rasheed Opeyemi Olanrewaju (Corresponding author)

Email: olanrewajurasheedopeyemi@gmail.com

Abstract

Urban flooding is a recurrent natural disaster in Nigeria, displacing millions of people and causing major economic losses. This scoping review examines solid waste mismanagement as a driver of urban flood risk in Nigerian cities. The review followed the Arksey and O'Malley framework and was reported using the PRISMA-ScR checklist. A total of 100 studies were synthesised narratively, guided by the Pressure and Release (PAR) model. Findings show that only 20 to 30% of municipal solid waste is collected nationally. Uncollected waste, especially plastics and sachet water bags, blocks drainages at surfaces, inlets and channels. This reduces hydraulic capacity and amplifies flooding across Nigerian cities. Weak enforcement, fragmented governance and poor funding aggravates this problem. Consequences include property loss, livelihood disruption and outbreaks of cholera and typhoid. However, none of the reviewed study isolated waste as a measured hydraulic variable in flood models. The review concludes that drainage investment alone cannot reduce flood risk without waste governance reform. Hence, extended producer responsibility, wider collection coverage, routine desilting and coupled waste-hydraulic modelling are recommended. Without implementing all of these, Nigeria as a country will not be able to achieve SDGs 6, 11 and 13.

Keywords: *solid waste management; urban flooding; drainage blockage; Nigeria; scoping review; SDGs; flood risk reduction*

1. Introduction

1.1 Background

As captured in the global assessment report on disaster risk reduction, urban flooding is regarded as one of the most destructive recurrent hazards globally [1]. As tracked by United Nations Office for Disaster Risk Reduction (UNDRR), about 90% of disaster-related deaths occur in low- and middle-income countries, with flooding highlighted as the principal cause [2]. Moreover, about 3254 flood events were recorded globally between 2000 – 2019 [2]. Nigeria as a country, serves as a suitable site to explore vulnerability to flood in Africa. In Nigeria, year 2022 flood disaster alone led to displacement of 2,430,445 people, 662 deaths and about 3,174 with severe injury [3]. About $9.12 billion in economic damage was reported in the country for the 2022 - 2023 flood season [4]. The severity of this crisis still persists as 1, 158, 849 million Nigerians were affected across 31 out of 36 states in year 2024. In addition, 297 deaths were reported, 655,011 displacement, and 137,097 hectares of farmlands were damaged [5]. In 2025 season, the Mokwa dam release alone killed over 500 people in Niger State, with more than 3000 houses submerged, while 433,778 persons were affected nationwide [6].

Looking at this historical data, the project outlook for 2026 flood season was alarming. Thus, the advisory NFA-2026-262 was issued by the Nigeria Hydrological Services Agency (NIHSA), where 15 states were identified for high riverine flood risk in 2026. Overall, about 8,000 communities and 4,500 schools were named as exposed. In Ebonyi State alone, 2,574 communities, 1,064 schools, 422 healthcare facilities, and 1,882 hectares of farmland lay in the flood path [7]. Thus, the National Emergency Management Agency (NEMA) 2026 preparedness forum issued prioritisation of urban drainage management by the state government as part of the key preventive actions to mitigate the risk for the 2026 season [7]. On the backdrop of this escalating trajectory, it is essential to unravel the key drivers of Nigerian urban flooding, not only for an academic work, but crucial for sustainable environment and public safety.

Several institutional reports like the United Nations Environment Programme (UNEP) and the World Bank have established that dominant cause of Nigerian flooding is anthropogenic (human activity) failure [8, 9]. This includes failure around urban planning, drainage maintenance and solid waste management [8, 9]. Lagos being the most populous coastal city in Nigeria, is also the most susceptible city to urban flooding in Nigeria. In a study, it was reported that blocked drainage systems are directly attributable to 70% of flooding being reported in the state [10]. Another report from the World Bank's

2024 technical assessment confirmed that recurrent flooding events in Lagos, Nigeria are largely due to clogging of drains with solid waste [11]. Additional national study established that flooding in Nigeria is primarily human-induces, and it is indeed a barrier to attainment of United Nations (UN) 2030 Sustainable Development Goals in the country [12].

The mismanagement of solid waste is a major contributor to this flooding crisis. Nigeria is regarded as one of the largest waste producers in Africa, with yearly generation of 32 million tonnes of municipal solid waste [13]. Thus, the country generates around 90,000 tonnes daily [14]. Despite this massive amount of waste, both government and private waste authorities could only collect about 20 to 30% of this national total [15]. The remainders of the waste therefore accumulate along streets, major roads, open space, and critically, in urban drainage channels. Thereby, reducing the capacity of the hydraulic channels [16].

There appear concerted efforts from governments, as Lagos State spent N106.6 billion on dredging, rehabilitation and construction of drainage between 2025 and first quarter of 2026. However, there is still persistent of flood. This failure had earlier been attributed by both officials and environmental experts to clogging of drainage channels due to solid wastes, thus nullifying investment in the drainage construction [17]. This failure has been recorded in 2026 study of Ogunbode et al. [18], where they established that flooding in Nigeria is not just because there is absence of drainage, but because existing drainage systems are blocked by solid waste. Similarly, survey study by Atubi and Edewor [19] indicated how improper solid waste disposal in Nigeria has high impact on urban flooding in the country. Same thing was recorded by World Bank [20] in their assessment of flood risk in Nigeria, where it was established that flooding in the country is largely due to poor waste management and blocked drainage system.

The insight established in this background is integral to the engineering and governance problem this review addresses. Moreover, it is projected that annual waste generation in Nigeria will triple by 2050 [13]. Nigeria’s flood risk is also being worsened with lack of adequate waste infrastructure investment to match urbanisation in cities like Lagos [21]. Thus, with Nigeria's urban population at 55.8%, totalling 135 million people in 2026, and urbanisation continuing at 3.4% annually, these pressures are mounting, not declining [22]. Therefore, without systemic reform, the waste-flood crisis will intensify alongside population growth.

1.2 Research Problems

There is fragmentation of findings, as there is concentration of research on major cities like Lagos and Port Harcourt [23]. Thus, secondary cities of 500,000 to 2 million people, growing rapidly across Nigeria, remain under-researched. This review will capture all relevant studies encapsulating both major and minor cities. In addition, this review intends to concentrate on post-SDG adoption period (2016 to 2026). No prior scoping review has explored this period. Therefore, this period will serve as the discrete analytical window to explore this waste-flood link.

Moreover, it was noted that there is absence of robust synthesisation and integration of official NEMA and World Bank data with peer-reviewed evidences. All of these gaps affect coherent engineering and policy responses, like the cost-benefit analysis of waste management investments relative to drainage construction.

1.3 Objectives

Four objectives guide this review:

- To map and synthesise evidence on solid waste mismanagement as a driver of urban flood risk in Nigerian cities from 2016 to 2026;
- To examine critically the mechanisms through which waste accumulation reduces drainage capacity and amplifies flooding;
- To evaluate governance, institutional, and policy frameworks, and to identify principal gaps; and
- To provide engineering-informed recommendations for short, medium, and long-term interventions.

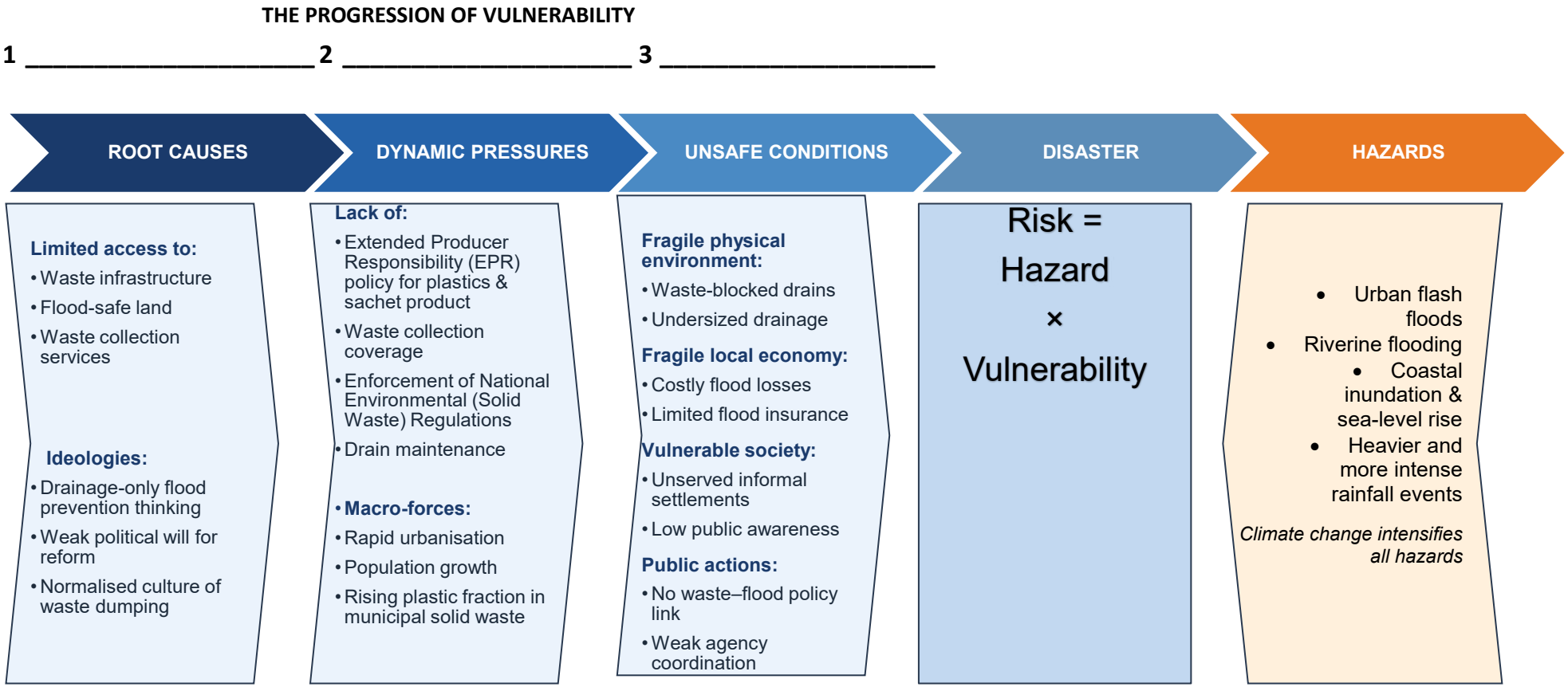
1.4 Engineering Novelty

This paper will serve as the first scoping revie, a decade after the SDG adoption period in Nigeria, examining the link between solid waste and flood risk in Nigeria. There are earlier reviews like Umar and Gray [23] and by Nkwunonwo et al. [24], where flood modelling and risk management were addressed respectively. However, neither of the study explore the waste-drainage-flooding mechanism across the post-SDG decade. 100 relevant studies were synthesised in this review. A novel multi-domain synthesis was characterised in this study through the linkage of governance analysis, geospatial evidence and waste characterisation data to drainage hydraulics failure.

1.5 Theoretical Underpinning

The synthesisation of various studies in this paper was underpinned using the Pressure and Release (PAR) model by Wisner et al. [25]. In PAR model, disaster is conceptualised as the convergence of physical hazard with accumulated social vulnerability and dynamic pressures. Incorporating PAR into this study as shown in Fig 1, solid waste mismanagement in Nigeria functions as combination of dynamic pressure reducing drainage capacity and the manifestation of structural social vulnerability through governance failure and poverty. This combination unravels the persistence of the waste-flood problem in Nigeria. This implies that engineering solutions alone cannot solve the problem due to its root causes being social and institutional. Thus, PAR model calls attention into both the physical mechanics of drainage failure and the political economy of waste governance.

Fig 1: PAR Model for Solid Waste-Induced Urban Flood Risk in Nigeria



Source: Adapted from Wisner et al. [25]

2. Methods

2.1 Review Design

The framework of Arksey and O'Malley [26] and updated guidance from Peters et al. [27] were used to design the scoping review carried out in this paper. The combination of the two sources [26, 27] was to strengthen the scoping review limitation of mapping evidences without specific quality thresholds, as pointed out by Munn et al. [28]. Therefore, The Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) checklist was utilised to ensure transparent reporting throughout this paper [29].

2.2 PCC Framework

The eligibility of studies captured in this review was structured using Population, Concept, and Context (PCC) framework as explained by Peters et al. [27]. **Population:** Urban communities, residents, waste agencies, and planners in Nigerian cities. **Concept:** Solid waste mismanagement as a driver of urban flood risk. **Context:** Urban environments within Nigeria, including megacities and secondary cities of all sizes.

2.3 Search Strategy

Searches were conducted across databases like Scopus, Web of Science, ScienceDirect and Google Scholar. Grey literature was retrieved from the World Bank, UNEP, NEMA, NIHSA, and National Environmental Standards and Regulations Enforcement Agency (NESREA). The primary search string was: ("solid waste" OR "municipal solid waste" OR "refuse" OR "indiscriminate dumping") AND ("drainage blockage" OR "urban flooding" OR "flood risk" OR "stormwater") AND ("Nigeria"). Key secondary searches were conducted used city-specific and thematic terms. The literature coverage was January 2016 to September 2026. The complete PRISMA-ScR flow diagram is presented in Fig 2.

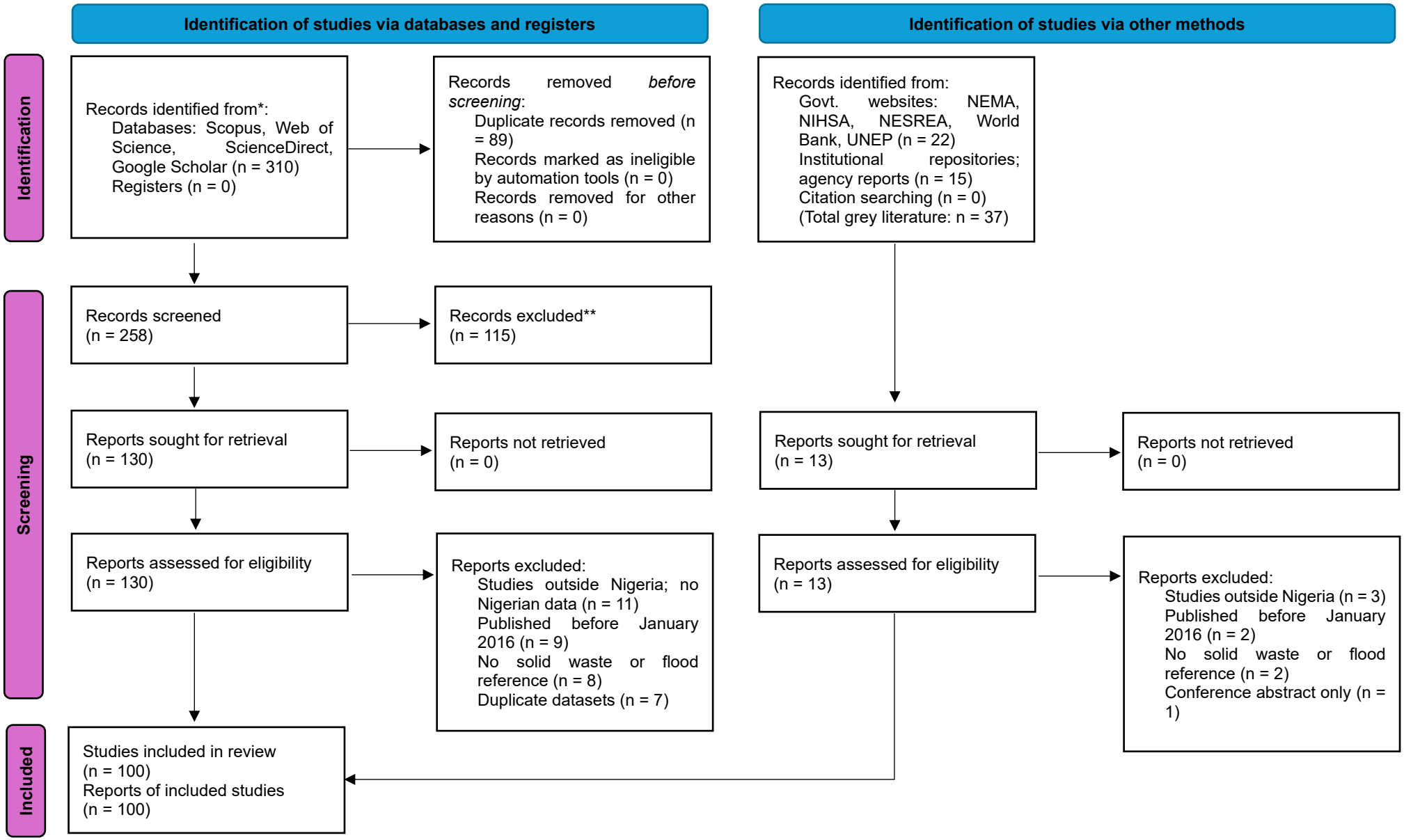


Fig. 2. PRISMA-ScR flow diagram. Adapted from Arksey and O'Malley [26] and Tricco et al. [29]

2.4 Inclusion and Exclusion Criteria

The inclusion and exclusion criteria used for study selection is presented in table 1. This review presents a comprehensive and heterogeneous evidence base; thus, studies were included irrespective of their research design.

Table 1. Inclusion and Exclusion Criteria for Study Selection

Inclusion Criteria	Exclusion Criteria
Published between January 2016 and September 2026	Conducted entirely outside Nigeria with no Nigerian urban data
Written in English, or with an accessible English version	Published before January 2016
Conducted in Nigerian urban settings, or including Nigerian cities as primary study sites	Available only as a conference abstract without an accessible full text
Addresses at least one of: solid waste management, drainage blockage, urban flooding, or urban flood risk	Not in English without an accessible translation
Uses any research design: quantitative, qualitative, mixed-method, or review	Focused exclusively on rural or peri-urban settings with no urban flood relevance
Reports empirical findings, conceptual analysis, or policy-relevant discussion aligned with the study's PCC	Addresses flooding without any reference to solid waste or drainage
	Addresses solid waste without any reference to drainage outcomes or flood risk
	Duplicate publications reporting identical data from a single dataset

2.5 Study Selection

As shown in fig 2, database searches returned a total of 310 records. After removing duplicates (n = 89), 258 records were screened by title and abstract. Full texts were retrieved for 130 studies. After full-text assessment, 35 were excluded: outside Nigeria (n = 11), pre-2016 (n = 9), no waste or flood reference (n = 8), and duplicates (n = 7). Five studies were included from other sources after meeting the eligibility criteria. Finally, a total of 100 studies spanning 2016 to 2026 were reviewed.

2.6 Data Extraction

The data extraction technique used a standard form. The following set of data was extracted across the studies reviewed: author(s), year, journal, study location, research design, data methods, solid waste characteristics, drainage conditions, flood data, waste-flood linkage, governance factors, recommendations, and limitations.

2.7 Synthesis Approach

In order to present findings of this study, a narrative synthesis approach was adopted [30]. Therefore, synthesisation of findings using thematic charting, comparative mapping for convergence and contradiction, and critical commentary on evidence strength. As reported earlier, official data and details from UNEP, the World Bank, NEMA, and NIHSA were integrated. This integration was considered essential for proper contextualisation of academic findings against verified national and global benchmarks.

2.8 Thematic Organisation

As for structuring and organising findings of this study, six thematic domains were utilised: (1) scale and nature of solid waste mismanagement; (2) mechanisms of waste-induced drainage failure; (3) city-specific spatial evidence; (4) socioeconomic and public health consequences; (5) governance and policy dimensions; and (6) emerging geospatial and systemic evidence. This arrangement of themes was adopted to show the sequential progression of this review from exploring physical mechanics to unravelling systemic implications.

3. Findings

3.1 Scale and Nature of Solid Waste Mismanagement in Urban Nigeria

Recent studies like that of Omokaro et al. [13] established that the current scale of solid waste mismanagement in Nigerian cities is severe and worsening. This is because, despite the humongous amount of solid waste being generated daily in Nigeria, the collection rate did not even meet up to half of the generated waste [11, 14, 15]. Studies on composition of the generated waste upheld the organic material to be dominant at about 55%, however, from 2018 upward there has been notable rise in the percentage of inorganic waste like plastic [31, 32]. This rise in plastics composition calls for attention, as it does not biodegrade like organic waste. Furthermore, Dumbili and Henderson [33] put the estimated amount of sachet water bags being discarded daily in Nigeria to about 60 million, with significant percentage entering drainage infrastructure directly. This was corroborated by Kehinde et al. [34], by affirming that drainage lines being blocked by plastic wastes, and how they filled up land spaces often result in flooding and erosion.

In a study conducted in Ilorin, Kwara state, Mokuolu et al. [35] established that solid waste occupied 20% of already inadequate drainage volume, with plastics comprising 80% of waste in the drains. Whereas, study of Daramola et al. [36] in Somolu, Lagos, flood risk

is intensified for lower-lying communities as waste dumped at higher elevations flows downslope. Combining these micro-scale findings showed a consistent pattern of waste not just being on the streets, but inside the drainage infrastructure itself.

Having unveiled the pattern, attempts were made to establish structural drivers of this solid waste mismanagement. Hence, in the national review carried out by Ifeoluwa [37], consequences of indiscriminate waste disposal are noted to be drainage blockage and waterlogging. Therefore, absence of effective solid waste management (SWM) strategies result in huge chunk of waste ending up in the drainage channels [38]. This deficient practice of indiscriminate disposal results in persistent environmental flooding in Nigeria, as found in the impact assessment of Mfon et al. [39]. This community disposal attitudes were shaped by norms and weak enforcement from government, hence, form part of the root causes of the problem [40]. This failure from government result in occupational health consequences for waste workers in Nigeria [41]. This pattern was confirmed in a study carried out in Oshogbo, a relatively smaller city [42].

Ezeudu and Ezeudu [43] link this waste management failure to lack of government capability to implement proper transitioning to circular principles for SWM, thus resulting in linear waste accumulation in the country. Additional temporal assessment by Ezeudu et al. [44] established that since year 2000, no meaningful progress has been made in Nigeria towards circular Municipal Solid Waste (MSW) management. In a 2026 study, deep-rooted structural failures in governance, infrastructure, and behaviour are noted to be the main cause of Nigeria's waste management crisis [13]. Infrastructural barriers, followed by financial and behavioural barriers were noted to be the major challenges to proper plastic waste management in Lagos, Nigeria [45]. Overall, these findings established a clear point: waste management failure in Nigeria is not just an isolated problem, but series of interconnected constraints [45]. Therefore, implementing single-sector interventions will consistently fail to solve this issue completely.

In two separate studies of household solid waste in Iwo, Osun State, it was found that there is domination of informal management of solid waste, still pointing towards government failure in management [46, 47]. In Abuja, Adewole and Akinmoladun [48] found the main barriers to waste collection to be structural fragmentation and spatial inequalities. Essentially, all of these findings pivot blame from residents to governance, thereby creating a significant policy implication.

3.2 Mechanisms of Waste-Induced Drainage Failure and Flood Amplification

Although, there is extensive evidence on how indiscriminate dumping of solid waste affect the drainage system, it has not been adequately quantified. Multi-city assessment study of open drainage and storm water runoff capacity in Nigeria carried out by Fayomi et al. [49], established that drainage channel cross-sections are often reduced to a fraction of its design capacity due to accumulation of waste deposits. This progressive waste accumulation reducing channels to very little of their design depth was also found in Lagos study by Nkwunonwo et al. [24]. Thus, excessive flooding during precipitation in Nigeria are predominantly caused by drainage channels being plugged by municipal solid waste [50, 51].

Technically, this blockage occurs at three hydraulic nodes. At the surface level, whereby ponding time is increased due to sheet flow being impeded by waste before water reaches channels [51]. As established earlier, the dominant drainage obstruction factor in Lagos is the indiscriminate dumping of refuse in drains, and it is the major cause of yearly flooding in the state [52]. At channel entrances, drainage systems are sealed against inflow due aggregation of solid waste like plastic at grates and culvert inlets [24]. Within channels, drains depth and velocity of flow are reduced due to accumulated sediments and trapped waste, leading to generation of backflow and surcharge during peak rainfall [49].

Beyond Lagos, these mechanisms were also confirmed in assessment of drainage of other cities. In Aba, Abia State, it was found that wet-season flood risk is increased due to drainage channels being blocked by uncollected waste [53]. In Port Harcourt, Stanley and Owhor [54] found that drainage blockage in the city is largely due to poor solid waste management. Negative waste disposal attitudes translating directly into drainage-blocking behaviour were documented in Cross River State study by Eneji et al. [55]. Moreover, Cirella and Iyalomhe [56] in their review confirmed that Nigeria's endemic flooding problem is due to how solid waste is being disposed in the country, thereby advocating for sustainability-focused integrated responses. Additionally, in material flow analysis of plastic in Nigeria, it was established that drainage blockage and waterway contamination are caused by plastic waste [57]. In a Maiduguri focused study, Kyari et al. [58] documented that sachet water bags and plastic bottles are the specific blockage agents in northern Nigerian drains. This extends the mechanism evidence to a non-coastal climate context.

In an attempt to quantify waste-flood mechanism, 222 specific drainage blockage points in metropolitan area was identified by Ojolowo and Wahab [50] in their empirical study. They found that about 49.7% of municipal solid waste was being dumped directly in canals and lagoons. Moreover, they established significant relationship MSW indicators and flood frequency [50]. In addition, about 126 streets, representing 60% of all the surveyed streets, experienced flooding due to blockage of drainage channels by municipal solid waste [50]. Notably, this Ojolowo and Wahab study is one of the most comprehensive studies reviewed in this paper. However, their findings in Lagos have not been replicated at this level of precision in any other Nigerian city.

The report of 70% flooding attribution to blocked drainage system emanates from aggregate assessments carried out by government, and not from controlled hydraulic measurement [10]. Also, across all the studies reviewed in this paper, there is absence of study that isolate waste blockage as a quantified contributor to flood volumes using a coupled waste-hydraulic modelling. Studies by Chukwuma et al. [59] and Shuaibu et al. [60] carried out flood risks modelling using Geographic Information System (GIS) and multi-criteria studies, but do not isolate waste as a discrete hydraulic variable. This is a fundamental limitation. Moreover, in the absence of measured hydraulic quantification, defensible cost-benefit analysis comparing waste management investment against drainage construction investment cannot be carried out by engineers. In essence, this identified gap needs to be addressed so as to enable the established evidence base to support infrastructure investment decisions. Through constant omission of waste-related hydraulic roughness, Nigerian urban flood models routinely underestimate flood [61].

3.3 City-Specific Evidence of the Waste-Flood Nexus

Several studies in Lagos highlighted indiscriminate waste disposal as the root cause of urban flooding in the state. Studies of Adelekan [62] and Adelekan and Asiyanbi [63] identified improper waste disposal in the state to be a significant driver from community hazard experience and perception perspectives. Moreover, MSW accumulation is reported to be one of the main factors contributing to frequent severe flooding in the state [64]. Using GIS frequency ratio model, Isiaka et al. [65] identified waste disposal as the embedding in Lagos State's flood susceptibility pattern. Additional geospatial assessment in Eti-Osa, Lagos, documented increase in waste-shaped land use patterns [66]. A comprehensive assessment across all the local government areas in Lagos state affirmed inadequate SWM as a metropolitan-scale vulnerability factor [67]. In study of the recurring flooding challenge requiring dedicated early warning infrastructure, waste disposal was

found to be part of the challenges [68]. Coastal informal settlements to flooding have been repeatedly expose due to inadequate waste services [69]. Adegun confirmed the same pattern in Idi-Araba [70]. On Lekki Peninsula, Obiefuna et al. [71] specifically documented that waste disposal diminished drainage channel conveyance capacity, reducing flood attenuation function. In Makoko part of Lagos state, Lawanson et al. [72] found that flood in the area is driven by waste mismanagement, resulting in aggravation of poverty and isolates communities economically. In essence, all of these findings point to the fact that engineering solutions without waste management governance reform are insufficient

In Port Harcourt, direct urban inundations are caused by waste clogging Ntanwogba creek and similar waterways [73]. In a qualitative study with residents and planners, Echendu [74] unravelled the principal flood driver to be waste disposal in open drains. Due to this behaviour, previously non-flood-prone areas are now experiencing flood, implying progressive expansion of the waste-blockage footprint [74, 75]. Waste generation and drainage failure in this area was attributed to rapid uncontrolled urbanisation by Dan-Jumbo et al. [76] in their watershed analysis.

In Ibadan, independent studies of Egbinola et al. [77] and Salami et al. [78] affirmed blockage of watercourses by refuse as a significant flood factor. Reduction in the river's conveyance capacity was found to be specifically due to waste accumulation by Nkeki et al. [79] in assessment of the Ona River Basin, Ibadan. While the ethical analysis of Oyebanji [80] indicated that conversion of Ogunpa River, Ibadan, from a natural drainage asset into a refuse dump and flood generator was due to waste disposal practices in the state.

In Abuja, drainage blockage in suburbs was noted to be predominantly caused by improper waste disposal [81]. Also, indiscriminate waste disposal which resulted in channel blockage was due to inadequate garbage collection in the capital city of Nigeria [82]. In Dagiri part of Abuja, the main flood driver in the areas was confirmed to be incessant blockage of drains by solid waste [83]. Evidence of improper waste disposal was also generated from stormwater quality assessment in Lugbe, where measurable solid waste contamination of runoff was recorded [84].

Further evidence from Kano, Maiduguri, Rivers State, and the Niger Delta extend this discussion to part of Nigeria with diverse climate zones. In an attempt to rectify waste-blocked channels, Kano residents were reported to be practicing Do-it-yourself (DIY) flood adaptation through informal drain clearing [85]. While assessing 2024 Maiduguri flood incidents, major driver was reported by significant number of respondents to include waste

disposal into drainage [86]. There is huge perception among Rivers State communities' residents that improper waste disposal is a contributing factor to high flood risk in the state [87]. Failure to properly dispose waste also result in sewage contamination and disease outbreaks [88]. In the indigenous flood control knowledge study of Obi et al. [89], dumping of waste in waterways is a locally known problem which keep recurring [89].

In Bayelsa state, prevalence of waste disposal into drains was reported despite some level of awareness among some residents due to limited bin access and lack of adequate collection services [90]. In another assessment of Bayelsa State drainage systems, poor maintenance and waste clogging are reported as part of key factors reducing drainage efficiency, leading to insufficient effectiveness in managing flooding particularly during heavy rainfall [91]. In order to underpin the attitudinal dimension of this problem across Nigerian cities, poor waste management as a flood driver was reported by Dinkin [92] to be foundational. Collectively, majority of these studies unveil waste management to be the primary drainage obstruction driver in Nigeria.

This nexus of waste and flood transcend from major urban centres to smaller cities. In two separate studies by Alimi et al., GIS mapping of Ilorin, Kwara State [93], and another mapping of Osogbo, Osun State [94], it was found that flood risks are compounded due to population-driven waste generation and its poor management. Likewise, anthropogenic activities like waste disposal are part of conditioning factors in flood susceptibility, as evident in Raufu et al. [95] assessment of Akure South and Efiong [96] study on geospatial modelling of Calabar City.

3.4 Socioeconomic, Environmental, and Public Health Consequences

Series of severe and compounding consequences of waste-induced flooding are established in literature. This ranges from severe economic loss [4], to destruction of properties and displacement of people [5]. While studying southern Nigerian riverine communities, Amaechina et al. [97] found that flood crisis is worsened by waste mismanagement which ends up destroying crops, inflating food prices, and constraining livelihoods. Using systems thinking approach, Echendu [98] inferred that waste mismanagement leads to compound development costs, as it simultaneously threatens food security and multiple SDGS [2, 3, 6, 11, 12, 14 & 15] goals.

Evidence of public health burden was also noted as flood caused by poor waste management triggers cholera, typhoid, and other outbreaks [99]. This is buttressed in Olanrewaju et al. [88], where sewage contamination that occurred due to flooding led to cholera and dysentery for 47.1% of residents in an indigent Nigerian community. Similar

public health crisis from flooding caused by waste management failures was recorded in an assessment carried out in Borno state [100]. Essentially, when waste management is poor, risk of disease exposure is increased as floodwater mobilises sewage, pathogens, chemicals, and sediments [101]. All of these crises are prevalent due to preventable infrastructure failure, not because they are unavoidable natural outcomes.

3.5 Governance, Policy, and Institutional Dimensions

As regard governance, series of evidences highlight problems with frameworks governing waste management and flood risk in Nigeria. The frameworks are characterised with underfunding, fragmentation, poor coordination and weak enforcement. At both federal and state levels, effective waste-water management is missing due to governance deficits [102]. Also, a multi-stakeholder analysis study noted that barrier to effective adaption comprise of huge information gaps on how waste management is a major flood driver [103]. This insight is consistent across all the studies reviewed right from 2016, till 2026, with absence of evidence on noticeable improvement.

There is evidence of weak enforcement of the existing legislative framework on this waste management, which is built on the 1991 National Environmental Regulations [104]. In policy analysis [105], poor waste management practices are formally defined as flood drivers in Nigerian regulations but not yet been effectively addressed practically. There is significant gap in policy framework, as lack of effectiveness lead to indiscriminate disposal clogging drainage nationally [106]. While analysing 2022 floods in Nigeria, Adesola [107] found that widespread infrastructure failure severely complicated the catastrophe across heavily hit states. Waste mismanagement remains a consistent and worsening contributing cause to Nigeria's increasing flood frequency [108].

Due to the incapability of government agencies, private sectors present a partial solution that still remains unscaled. This gap in public-private collection coverage led to huge waste remaining uncollected, thereby ending up in drainage channels [109]. Another significant policy deficit found is that there is inadequate integration of waste management into flood vulnerability frameworks [110]. Poor waste management as a notable flood driver indicates failure of governments at all tiers [111]. The insight from Ezeudu et al. [112] co-production analysis is that poor co-production in urban market SWM leaves commercial areas particularly exposed to drainage blockage. Finally, this Nigeria's structural deficiencies result in complicating environmental impacts.

3.6 Emerging Geospatial, Remote Sensing, and Systemic Evidence

Notable expansion in geospatial methods to map and model flood risk in Nigeria was recorded in post-2016 decade. In multi-temporal analysis (1990 to 2020), increasing runoff and overwhelming drainage came as a result of urban growth which result in systematic reduction of Lagos's pervious surfaces [113]. Similar GIS and machine learning study found that flood susceptibility increase as land use changes [114]. Idowu and Zhou's Land Use and Land Cover (LULC) analysis for Lagos State reached similar conclusions [115]. Flood vulnerability in Nigeria is escalated by anthropogenic activities such as indiscriminate waste disposal, drainage blockage, and wetland encroachment, as recorded in a 2026 study integrating hydro-climatic drivers, flood frequency analysis, and sustainability perception [116].

However, upon compiling these geospatial studies, none of these studies isolates waste accumulation as a discrete hydraulic variable. Rather, these studies associated urban growth with broad impervious surface increase, while they are unable to clarify distinction between surface sealing and marginal contribution of waste blockage. This distinction is fundamental for policy. The implication is that if 70% of flooding came as a result of drainage blockage with waste [10], expanding drainage without implementing effective waste management reform will only address the remaining 30%. Moreover, the 70% attribution was neither validated nor challenged with sufficient spatial evidence in the reviewed geospatial study. This methodological gap between geospatial modelling and hydraulic measurement needs to be addressed.

In a participatory study of sustainable flood solutions that combined SWOT analysis (Strengths, Weaknesses, Opportunities, Threats) with the Analytic Hierarchy Process (AHP), waste disposal was identified as a significant driver by community stakeholders [117]. Combination of geospatial tools with participatory governance was recommended as the most promising integrated response [117]. There is risk of repeated flood displacement, once the waste management deficits persist 118]. Reiteratively, waste mismanagement is characterised as an evidenced and preventable cause of flood in Nigeria [18, 119]. Ayantoyinbo and Adepoju [120] added that refuse accumulation in drainage channels in Lagos came as a result of route planning failures in municipal waste collection.

4. Discussion

In this synthesisation of several studies, key findings were deduced. Although, it is preventable, solid waste mismanagement remains the systemic and dominant driver of urban flood risk across Nigerian cities of all sizes. There is no contradicting view regarding this from any of the reviewed studies, irrespective of study designs, city contexts, and disciplinary perspectives.

Notable observation is the mismatch between the quality of problem documentation and quality of solution evidence. This implies that while there is strong correlation among studies at confirming the existence, systemic and how worsened the situation has been over the decade, there is collective weakness with respect to interventions evaluation. Moreover, significant portion of the reviewed studies being cross-sectional survey designs implies that evidence base is not sufficient to identify which interventions work, at what cost, or under which governance conditions. This weakness is structural in nature and has implication for decision-making. Meaning that, in an absence of intervention outcome evidence, the engineering community cannot advise policymakers on the most cost-effective mix of waste management and drainage construction.

Another observation that warrants sustained critical scrutiny is the 70% flooding attribution to blocked drainage system. This is because of its derivation from aggregate governmental assessment, and not from spatial modelling or controlled hydrodynamic measurement. The closest empirical validation to this claim is in the findings of Ojolowo and Wahab [50], where in their assessment of causes of flooding found that 60% of surveyed streets had drainage blockage from MSW. Despite close similarity, this does not imply hydraulic proof. Importantly, these 70% insight should be taken as a policy communication tool by the engineering community, not as the basis for engineering design standards.

Important points worthy of attention is that evidence from this review describes a governance failure that manifests as an engineering problem. Meaning that the evidence base is not entirely an engineering problem awaiting engineering solutions. Infrastructural investment in drainage failed to be effective as governance failure did not keep waste out of the new and rehabilitated drains [17]. Despite the drainage infrastructure being designed and built to adequate standards, there is progressive loss in its hydraulic function because waste management governance continues to fail. Without incorporating waste-induced hydraulic depreciation rate in design, there will be continuous overestimation of the duration of drainage performance improvement.

5. Recommendations

In table 2, snapshot of time-stratified, evidence-linked recommendations for engineers, planners, policymakers, and communities is presented.

Table 2. Evidence-Based Recommendations Aligned with Review Findings

Time Frame	Priority	Lead Responsibility	Action
Short-Term (0-2 yrs)	Emergency drain desilting	State and LGA waste agencies	Quarterly desilting of flood-prone drainage channels; use Ojolowo and Wahab [50] blockage mapping methodology to identify priority sites; document performance metrics.
	Waste disposal enforcement	NESREA and State Agencies	Enforce existing laws in flood-prone communities; provide accessible bins alongside enforcement to address the infrastructure gap identified by Adewole and Akinmoladun [48].
	Community waste vanguard	LGAs and NGOs	Establish community-led behaviour change; integrate with flood early warning following Ogunbode et al. [18] framework for community-informed planning.
Medium-Term (2-5 yrs)	Expand collection to 70%	Federal and State Governments, private sector	Scale public-private partnerships; target cities with lowest collection rates first; address structural fragmentation identified by Adewole and Akinmoladun [48].
	Extended Producer Responsibility (EPR)	Federal Ministry of Environment, NESREA	Legislate EPR for sachet water and plastic packaging; address dominant blockage agents confirmed by Calicioglu et al. [57] plastic flow analysis.
	Integrated waste-flood maps	Urban planning agencies and universities	Develop GIS-based waste-flood maps for all major cities; replicate approach of Ighile et al. [114] and Alimi et al. [93, 94] but add waste distribution as explicit variable.
Long-Term (5+ yrs)	National SWM and Flood Strategy	Federal Government, NEMA, NESREA	Link waste performance targets to flood risk reduction SDG indicators; the N106.6bn Lagos drainage investment paradox shows infrastructure alone is insufficient.
	Circular economy for MSW	Federal Ministry, private sector, research	Scale circular economy solutions as suggested by Omokaro et al. [13]; prioritise plastic valorisation; reduce drain-destined waste at source.
	Coupled waste-hydraulic modelling	Nigerian universities and international partners	Fund longitudinal studies to validate the 70% attribution figure through controlled hydrodynamic measurement; this is part of the critical missing engineering evidence.

6. Conclusion

In this scoping review, 100 studies from 2016 to 2026 have been synthesised. It has been established that solid waste mismanagement is the primary driver of urban flood risk in Nigeria. Thousands of communities are still at flood risks in the country in 2026. There is persistent occurrence of flooding despite notable investment of government in drainage infrastructure. Moreover, majority of participants across several surveyed works reviewed acknowledged waste mismanagement as primary flood driver

It should be noted that engineering solutions alone cannot solve this crisis. Drainage channels, however well-engineered, will keep reducing in their efficient hydraulic function when government enforcement fails to keep waste out of them. To address this issue, series of concerted and coordinated actions are needed. This includes: extended producer responsibility, expanded collection coverage, emergency desilting and a national strategy linking waste performance to flood risk targets. Also, there is need for research on coupled waste-hydraulic modelling, to provide the missing bridge between engineering evidence and policy-investment decisions. Finally, without treating the waste-flood nexus as the governance and engineering emergency it demonstrably is, Nigeria will not be able to achieve SDGs 6 (clean water), 11 (sustainable urban living), or 13 (climate action).

Funding statement: This work did not receive any form of funding.

Clinical trial number: not applicable

Ethics, Consent to Participate, and Consent to Publish declarations: not applicable

References

1. United Nations Office for Disaster Risk Reduction (UNDRR). Global assessment report on disaster risk reduction 2022 [Internet]. Geneva: UNDRR; 2022 [cited 2026 Oct 20]. Available from: https://globalplatform.undrr.org/sites/default/files/2022-04/Global%20Assessment%20Report%20on%20Disaster%20Risk%20Reduction%202022.pdf?startDownload=true

2. United Nations Office for Disaster Risk Reduction (UNDRR). Human cost of disasters 2000-2019 [Internet]. Geneva: UNDRR; 2020 [cited 2026 Oct 20]. Available from: https://www.undrr.org/publication/documents-and-publications/human-cost-disasters-overview-last-20-years-2000-2019#downloads

3. Over 2 million Nigerians displaced by flood in 2022, says NEMA. The Guardian (Nigeria) [Internet]. 2023 [cited 2026 Oct 20]. Available from: https://guardian.ng/news/over-2-million-nigerians-displaced-by-flood-in-2022-says-nema/

4. National Emergency Management Agency (NEMA). Nigeria flood impact, recovery and mitigation assessment report 2022-2023 [Internet]. Abuja: NEMA; 2023 [cited 2026 Oct 20]. Available from: https://www.undp.org/sites/g/files/zskgke326/files/2023-12/nigeriafloodimpactrecoverymitigationassessmentreport2023.pdf

5. National Emergency Management Agency (NEMA). 2024 Nigeria floods: end-of-season situation report [Internet]. Abuja: NEMA; 2024 [cited 2026 Oct 20]. Available from: https://nema.gov.ng/sitreps/sitrep-240924.pdf

6. Floods predicted, disasters not prevented. Leadership [Internet]. 2026 [cited 2026 Oct 20]. Available from: https://leadership.ng/floods-predicted-disasters-not-prevented/

7. Flood: 8,000 communities, 4,500 schools at risk - FG. The Punch [Internet]. 2026 [cited 2026 Oct 20]. Available from: https://punchng.com/flood-8000-communities-4500-schools-at-risk-fg/

8. United Nations Environment Programme (UNEP). Africa waste management outlook [Internet]. Nairobi: UNEP; 2018 [cited 2026 Oct 20]. Available from: https://wedocs.unep.org/bitstreams/f86c3ad9-99a8-4cdc-a6c2-c7651454a036/download

9. World Bank. Global snapshot of solid waste management toward circularity until 2050 [Internet]. Washington (DC): World Bank; 2026 [cited 2026 Oct 20]. Available from: https://openknowledge.worldbank.org/bitstreams/ab9bce34-0921-4887-8c0d-65ed7b303aaf/download

10. Orimoogunje O, Aniramu O. Systematic review of flood resilience strategies in Lagos Metropolis: pathways toward the 2030 sustainable development agenda. Front Clim. 2025;7:1603798. Available from: https://doi.org/10.3389/fclim.2025.1603798

11. World Bank. Improving solid waste and plastics management in Lagos State: a way forward [Internet]. Washington (DC): World Bank; 2024 [cited 2026 Oct 20]. Available from: https://documents1.worldbank.org/curated/en/099101824172020522/pdf/P1761781eb744507f184b01f525451f4014.pdf

12. Echendu AJ. The impact of flooding on Nigeria's sustainable development goals (SDGs). Ecosyst Health Sustain. 2020;6(1):1791735. Available from: https://doi.org/10.1080/20964129.2020.1791735

13. Omokaro GO, Michael I, Efeni OS, Adeyanju OI, Obomejero J. Waste management in Nigeria: systemic failures, circular economy pathways and sustainable solutions. Environ Dev. 2026;57:101363. Available from: https://doi.org/10.1016/j.envdev.2025.101363

14. Maiha AI, Yusuf FI. Evaluation of solid waste generation trends across Nigeria for sustainable management. Dutse J Pure Appl Sci. 2025;11(1b):142-8. Available from: https://doi.org/10.4314/dujopas.v11i1b.16

15. National Environmental Standards and Regulations Enforcement Agency (NESREA). The assessment report of gaps and needs of solid waste management in Nigeria [Internet]. Abuja: NESREA; 2025 [cited 2026 Oct 20]. Available from: https://nesrea.gov.ng/wp-content/uploads/2025/10/Full-draft-Report-Solid-Waste-Management-Edited-15102025-Revised_compressed.pdf

16. Echendu AJ. Flooding and waste disposal practices of urban residents in Nigeria. GeoHazards. 2023;4(4):350-66. Available from: https://doi.org/10.3390/geohazards4040020

17. Lagos floods persist despite N106.6bn drainage spend. The Whistler [Internet]. 2026 [cited 2026 Oct 20]. Available from: https://thewhistler.ng/lagos-floods-persist-despite-n106-6bn-drainage-spend/

18. Ogunbode TO, Opabunmi BA, Adeyi ST, Akinwale EA, et al. Exploring human-induced flood risks and sustainable urban resilience in Iwo Nigeria with focus on awareness drivers and mitigation pathways. Sci Rep. 2026;16:17716. Available from: https://doi.org/10.1038/s41598-026-48954-w

19. Atubi FO, Edewor AO. Improper solid waste disposal and the risk of urban flooding: impact and management strategies. Arab Gulf J Sci Res. 2026;44(2):117-30. Available from: https://doi.org/10.1108/AGJSR-05-2025-0095

20. World Bank. Assessment of flood and drought risk management in Nigeria through the EPIC response framework [Internet]. Washington (DC): World Bank; 2020 [cited 2026 Oct 20]. Available from: https://documents1.worldbank.org/curated/en/099051226082040413/pdf/P180933-3d7bb77b-3113-498b-9436-d3f243a86840.pdf

21. Dossa KF, Miassi YE, Bakary S, Ogou FK. Drowning in urban growth: rethinking flood resilience and spatial equity in Lagos, Nigeria. Front Sustain Resour Manag. 2025;4:1659930. Available from: https://doi.org/10.3389/fsrma.2025.1659930

22. Worldometer. Nigeria population 2026 [Internet]. 2026 [cited 2026 Oct 20]. Available from: https://www.worldometers.info/world-population/nigeria-population/

23. Umar N, Gray A. Flooding in Nigeria: a review of its occurrence and impacts and approaches to modelling flood data. Int J Environ Stud. 2022;80(3):540-61. Available from: https://doi.org/10.1080/00207233.2022.2081471

24. Nkwunonwo UC, Whitworth M, Baily B. A review and critical analysis of the efforts towards urban flood risk management in the Lagos region of Nigeria. Nat Hazards Earth Syst Sci. 2016;16(2):349-69. Available from: https://doi.org/10.5194/nhess-16-349-2016

25. Wisner B, Blaikie P, Cannon T, Davis I. At risk: natural hazards, people's vulnerability and disasters. 2nd ed. London: Routledge; 2004.

26. Arksey H, O'Malley L. Scoping studies: towards a methodological framework. Int J Soc Res Methodol. 2005;8(1):19-32. Available from: https://doi.org/10.1080/1364557032000119616

27. Peters MDJ, Marnie C, Tricco AC, et al. Updated methodological guidance for the conduct of scoping reviews. JBI Evid Synth. 2020;18(10):2119-26. Available from: https://doi.org/10.11124/JBIES-20-00167

28. Munn Z, Peters MDJ, Stern C, et al. Systematic review or scoping review? Guidance for authors when choosing between a systematic review and scoping review approach. BMC Med Res Methodol. 2018;18(1):143. Available from: https://doi.org/10.1186/s12874-018-0611-x

29. Tricco AC, Lillie E, Zarin W, et al. PRISMA extension for scoping reviews (PRISMA-ScR): checklist and explanation. Ann Intern Med. 2018;169(7):467-73. Available from: https://doi.org/10.7326/M18-0850

30. Popay J, Roberts H, Sowden A, et al. Guidance on the conduct of narrative synthesis in systematic reviews. Lancaster: ESRC Research Methods Programme; 2006. Available from: https://doi.org/10.13140/2.1.1018.4643

31. Alamu AS. Municipal solid waste generation, composition, and management in Nigeria: a 25-year secondary data review. J Sustain Environ Manag [Internet]. 2025 [cited 2026 Oct 18];4(3):165-71. Available from: https://www.nepjol.info/index.php/josem/article/download/93144/70693/267654

32. Aderoju OM, Dias GA. Municipal solid waste characterization as a measure towards sustainable waste management in Abuja, Nigeria. J Environ Sci Public Health. 2020;4(2):43-60. Available from: https://doi.org/10.26502/jesph.96120084

33. Dumbili EW, Henderson L. The challenge of plastic pollution in Nigeria. In: Letcher TM, editor. Plastic waste and recycling. Amsterdam: Elsevier; 2020. p. 569-83. Available from: https://doi.org/10.1016/B978-0-12-817880-5.00022-0

34. Kehinde O, Ramonu OJ, Babaremu KO, Justin LD. Plastic wastes: environmental hazard and instrument for wealth creation in Nigeria. Heliyon. 2020;6(10):e05131. Available from: https://doi.org/10.1016/j.heliyon.2020.e05131

35. Mokuolu OA, Odunaike AK, Iji JO, Aremu AS. Assessing the effects of solid wastes on urban flooding: a case study of Isale Koko. LAUTECH J Civ Environ Stud. 2022;9(1):22-30. Available from: https://doi.org/10.36108/laujoces/2202.90.0130

36. Daramola AO, Otusanya O, Agu M. Household waste disposal attitude and perception of flood risk in Somolu, Lagos State, Nigeria. Niger J Bus Soc Sci [Internet]. 2024 [cited

2026 Oct 20];11. Available from: https://ler.unilag.edu.ng/index.php/njbss/article/download/2609/2116/

37. Ifeoluwa OB. Harmful effects and management of indiscriminate solid waste disposal on human and its environment in Nigeria: a review. Glob J Res Rev. 2019;6(1):1. Available from: https://doi.org/10.21767/2393-8854.100043

38. Nwosu AO, Chukwueloka HE. A review of solid waste management strategies in Nigeria. J Environ Earth Sci. 2020;10(6):132-43. Available from: https://doi.org/10.7176/JEES/10-6-11

39. Mfon IE, Oguike MC, Eteng S, Etim NM. Causes and effects of flooding in Nigeria: a review. East Asian J Multidiscip Res. 2022;1(9):1777-92. Available from: https://doi.org/10.55927/eajmr.v1i9.1261

40. Akintayo T, Hämäläinen J, Pasanen P, John I. A rapid review of sociocultural dimensions in Nigeria's solid waste management approach. Int J Environ Res Public Health. 2023;20(13):6245. Available from: https://doi.org/10.3390/ijerph20136245

41. Adeyi AA, Adeyemi AM. Potential occupational health effects of municipal solid waste management in Nigeria: the case of Lagos and Ibadan. Ife J Sci. 2019;21(2):417-30. Available from: https://doi.org/10.4314/ijs.v21i2.15

42. Oladosu O, Adegoroye A, Olodo AA, Oloruntoba EO, Opeodu O, Agunbiade MB. An assessment of municipal solid waste management system in Oshogbo, Osun State Nigeria: challenges and prospects. Int J Multidiscip Res Growth Eval. 2024;5(1):687-96. Available from: https://doi.org/10.54660/.IJMRGE.2024.5.1.687-696

43. Ezeudu OB, Ezeudu TS. Implementation of circular economy principles in industrial solid waste management: case studies from a developing economy (Nigeria). Recycling. 2019;4(4):42. Available from: https://doi.org/10.3390/recycling4040042

44. Ezeudu OB, Agunwamba JC, Ugochukwu UC, Ezeudu TS. Temporal assessment of municipal solid waste management in Nigeria: prospects for circular economy adoption. Rev Environ Health. 2020;36(3):327-44. Available from: https://doi.org/10.1515/reveh-2020-0084

45. Omisore ME, Wahab FO. Barriers to plastic waste management in urban Nigeria: a systematic review of Lagos state evidence. Sci Portal. 2026;7(4):604-20. Available from: https://doi.org/10.51247/pdlc.v7i4.1029

46. Ogunbode TO, Aderinto JO. Evaluation of household solid waste drivers, characteristics, management and its implications for sustainable environmental quality in Iwo, Nigeria. Front Sustain Cities. 2026;8:1812929. Available from: https://doi.org/10.3389/frsc.2026.1812929

47. Aderinto J, Ogunbode T, Adeyi S. Generation, characteristics, and management of household solid waste in a growing urban centre in Nigeria. Environ Syst Decis. 2026;46:43. Available from: https://doi.org/10.1007/s10669-026-10108-8

48. Adewole OA, Akinmoladun AA. Investigation of domestic solid waste collection and management in selected residential areas in Abuja Metropolis, Nigeria. Int J Res Innov Soc Sci. 2026;10(2):2903-30. Available from: https://doi.org/10.47772/IJRISS.2026.10200215

49. Fayomi GU, Onyari E, Jaiyeola AT. Quantitative assessment of open drainage and storm water runoff capacity in Nigeria: consequences and way forward. Case Stud Chem Environ Eng. 2024;9(4):100766. Available from: https://doi.org/10.1016/j.cscee.2024.100766

50. Ojolowo S, Wahab B. Municipal solid waste and flooding in Lagos metropolis, Nigeria: deconstructing the evil nexus. J Geogr Reg Plann. 2017;10(7):174-85. Available from: https://doi.org/10.5897/JGRP2016.0614

51. Angaye TCN, Abowei JFN. Review on the environmental impacts of municipal solid waste in Nigeria: challenges and prospects. Greener J Environ Manag Public Saf. 2017;6(2):18-33. Available from: https://doi.org/10.15580/GJEMPS.2017.2.062117079

52. Ayodele J. Attitudes of Lagos residents to waste disposal as major causes to yearly flooding. J Basic Appl Res Biomed [Internet]. 2022 [cited 2026 Oct 19];3(1):33-9. Available from: https://jbarbiomed.com/home/article/view/145

53. Ezechi EH, Nwaboko CG, Enyinnaya OC, Babington CJ. Municipal solid waste management in Aba, Nigeria: challenge and prospects. Environ Eng Res. 2017;22(3):231-6. Available from: http://dx.doi.org/10.4491/eer.2017.100

54. Stanley HO, Owhor B. Assessment of solid waste management practice in Port Harcourt Metropolis, Rivers State, Nigeria. J Geogr Environ Earth Sci Int. 2018;16(2):1-10. Available from: https://doi.org/10.9734/JGEESI/2018/42325

55. Eneji CV, Eneji JEO, Ngoka S, Abang M. Attitude towards waste management and disposal methods and the health status of Cross River State, Nigeria. SCIREA J Agric [Internet]. 2017 [cited 2026 Oct 20];1(2):231-47. Available from: https://article.scirea.org/pdf/21029.pdf

56. Cirella GT, Iyalomhe FO. Flooding conceptual review: sustainability-focalized best practices in Nigeria. Appl Sci. 2018;8(9):1558. Available from: https://doi.org/10.3390/app8091558

57. Calicioglu O, Arsova L, Dade D, et al. Mapping plastic flows and circular economy barriers in Nigeria: a value chain and material flow analysis of polyethylene terephthalate, polyethylene, and polypropylene. J Mater Cycles Waste Manag. 2026. Available from: https://doi.org/10.1007/s10163-026-02706-0

58. Kyari UD, Ma L, Bu C, George LY, Gashau M, Suleiman AO. Environmental and human health risks of indiscriminate disposal of plastic waste and sachet water bags in Maiduguri, Borno State Nigeria. Waste Manag Bull. 2024;2(4). Available from: https://doi.org/10.1016/j.wmb.2024.04.002

59. Chukwuma EC, Okonkwo CC, Ojediran JO, et al. A GIS based flood vulnerability modelling of Anambra State using an integrated IVFRN-DEMATEL-ANP model. Heliyon. 2021;7(9):e08048. Available from: https://doi.org/10.1016/j.heliyon.2021.e08048

60. Shuaibu A, Hounkpe J, Bossa YA, Kalin RM. Flood risk assessment and mapping in the Hadejia River Basin, Nigeria, using hydro-geomorphic approach and multi-criterion decision-making. Water. 2022;14(22):3709. Available from: https://doi.org/10.3390/w14223709

61. Nkwunonwo UC, Whitworth M, Baily B. A review of the current status of flood modelling for urban flood risk management in the developing countries. Sci Afr. 2020;7:e00269. Available from: https://doi.org/10.1016/j.sciaf.2020.e00269

62. Adelekan IO. Flood risk management in the coastal city of Lagos, Nigeria. J Flood Risk Manag. 2016;9(3):255-64. Available from: https://doi.org/10.1111/jfr3.12179

63. Adelekan IO, Asiyanbi AP. Flood risk perception in flood-affected communities in Lagos, Nigeria. Nat Hazards. 2016;80:445-69. Available from: https://doi.org/10.1007/s11069-015-1977-2

64. Ojolowo SK, Adebayo A. Flooding in Lagos metropolis: urban development and municipal solid waste perspectives. Afr J Psychol Study Soc Issues [Internet]. 2021 [cited 2026 Oct 19];24(2):89-107. Available from: https://www.ajpssi.org/index.php/ajpssi/article/view/479/pdf_364

65. Isiaka IO, et al. Flood susceptibility assessment of Lagos State, Nigeria using GIS-based frequency ratio model. Int J Environ Geoinformatics. 2023;10(1):76-89. Available from: https://doi.org/10.30897/ijegeo.1181698

66. Onajomo TS. Geospatial assessment of land use/cover, rainfall, and flood incidents in Eti-Osa, Lagos, Nigeria. S Afr J Geomat. 2022;11(2):202-17. Available from: https://doi.org/10.4314/sajg.v11i2.3

67. Mafimisebi P. Geospatial assessment of flood vulnerability areas in Lagos Metropolis, Nigeria. Asian J Basic Sci Res. 2024;6(3):1-10. Available from: https://doi.org/10.38177/AJBSR.2024.6301

68. Adegbite KJ, Idowu MT. Impact of early warning system and flood disaster management in Isheri and Shokori in Nigeria. FUGUS J Public Adm Manag. 2025;4(2):189-209. Available from: https://doi.org/10.36349/fujpam.2025.v04i02.014

69. Ekoh SS, Teron L. Vulnerable spaces, unequal responses: lessons for transformative climate resilience in Lagos. Front Sustain Cities. 2023;5:929121. Available from: https://doi.org/10.3389/frsc.2023.929121

70. Adegun OB. Flood-related challenges and impacts within coastal informal settlements: a case from Lagos, Nigeria. Int J Urban Sustain Dev. 2023;15(1):1-13. Available from: https://doi.org/10.1080/19463138.2022.2159415

71. Obiefuna JN, Adeaga O, Omojola A, et al. Flood risks to urban development on a coastal barrier landscape of Lekki Peninsula in Lagos, Nigeria. Sci Afr. 2021;12:e00787. Available from: https://doi.org/10.1016/j.sciaf.2021.e00787

72. Lawanson OI, Proverbs D, Ibrahim RL. The impact of flooding on poor communities in Lagos State, Nigeria: the case of the Makoko urban settlement. J Flood Risk Manag. 2023;16(1):e12838. Available from: https://doi.org/10.1111/jfr3.12838

73. Ogbonna DN, Udotong IR. An appraisal of the waste crisis, urban floods and municipal solid waste management in Port Harcourt City, Nigeria. Open Access J Waste Manag Xenobiotics. 2021;4(1):1-14. Available from: https://doi.org/10.23880/oajwx-16000156

74. Echendu AJ. Relationship between urban planning and flooding in Port Harcourt city, Nigeria; insights from planning professionals. J Flood Risk Manag. 2021;14(2):e12693. Available from: https://doi.org/10.1111/jfr3.12693

75. Echendu AJ, Georgeou N. 'Not going to plan': urban planning, flooding, and sustainability in Port Harcourt City, Nigeria. Urban Forum. 2021;32:311-32. Available from: https://doi.org/10.1007/s12132-021-09420-0

76. Dan-Jumbo N, Metzger M, Clark A. Urban land-use dynamics in the Niger Delta: the case of Greater Port Harcourt watershed. Urban Sci. 2018;2(4):108. Available from: https://doi.org/10.3390/urbansci2040108

77. Egbinola CN, Olaniran HD, Amanambu AC. Flood management in cities of developing countries: the example of Ibadan, Nigeria. J Flood Risk Manag. 2017;10(4):546-54. Available from: https://doi.org/10.1111/jfr3.12157

78. Salami RO, von Meding JK, Giggins H. Vulnerability of human settlements to flood risk in the core area of Ibadan metropolis, Nigeria. Jamba. 2017;9(1):a371. Available from: https://doi.org/10.4102/jamba.v9i1.371

79. Nkeki FN, Bello IE, Agbaje GI. Flood risk mapping and urban infrastructural susceptibility assessment using GIS and analytic hierarchical raster fusion in the Ona River Basin, Nigeria. Int J Disaster Risk Reduct. 2022;77:103097. Available from: https://doi.org/10.1016/j.ijdrr.2022.103097

80. Oyebanji IT. Flooding as a natural and moral evil: a philosophical and ethical analysis of the Ogunpa floods in Ibadan, Nigeria. Mahabbah J Relig Educ. 2023;4(2). Available from: https://doi.org/10.47135/mahabbah.v4i2.125

81. Kadafa AA. Solid waste management practice of residents in Abuja Municipalities (Nigeria). IOSR J Environ Sci Toxicol Food Technol. 2017;11(2):87-106. Available from: https://doi.org/10.9790/2402-11020187106

82. Abubakar IR. Household response to inadequate sewerage and garbage collection services in Abuja, Nigeria. J Environ Public Health. 2017;2017:5314840. Available from: https://doi.org/10.1155/2017/5314840

83. Badamosi AP, Olutumise AI, Olukoya OP, Adegoroye A, Aturamu OA. Socioeconomic impacts of flooding and its coping strategies in Nigeria: evidence from Dagiri community, Gwagwalada area council of Abuja. Nat Hazards Res. 2024;4(3):374-86. Available from: https://doi.org/10.1016/j.nhres.2023.09.010

84. Oluyori NR, Alhassan MM. Assessment of urban storm runoff water quality in Lugbe, Abuja Municipal Area Council, FCT, Nigeria. J Res For Wildl Environ [Internet]. 2020 [cited 2026 Oct 20];12(1):138-47. Available from: https://www.ajol.info/index.php/jrfwe/article/view/194340

85. Barau A, Wada AS. Do-it-yourself flood risk adaptation strategies in the neighborhoods of Kano City, Nigeria. In: Leal Filho W, Oguge N, Ayal D, Adeleke L, da Silva I, editors. African handbook of climate change adaptation. Cham: Springer; 2021. Available from: https://doi.org/10.1007/978-3-030-42091-8_190-1

86. Umar IA, Bukar WM, Mustapha A, Kyari A, Bukar MA, Ibrahim HH, et al. Flood risk and resilience: evidence from the 2024 flood in Maiduguri, Nigeria. Int J Environ Clim Change. 2025;15(1):490-505. Available from: https://doi.org/10.9734/ijecc/2025/v15i14708

87. Elum ZA, Lawal O. Flood risk perception, disaster preparedness and response in flood-prone urban communities of Rivers State. Jamba. 2022;14(1):1303. Available from: https://doi.org/10.4102/jamba.v14i1.1303

88. Olanrewaju CC, Chitakira M, Olanrewaju OA, Louw E. Impacts of flood disasters in Nigeria: a critical evaluation of health implications and management. Jamba. 2019;11(1):a557. Available from: https://doi.org/10.4102/jamba.v11i1.557

89. Obi R, Nwachukwu MU, Okeke DC, Jiburum U. Indigenous flood control and management knowledge and flood disaster risk reduction in Nigeria's coastal communities: an empirical analysis. Int J Disaster Risk Reduct. 2021;55:102079. Available from: https://doi.org/10.1016/j.ijdrr.2021.102079

90. Clarke T. Solid waste management practices and urban drainage blockage as drivers of flood risk in Yenagoa Metropolis. J Environ Sci Eng [Internet]. 2026 [cited 2026 Oct 20];12(3):21-30. Available from: https://bwjournal.org/index.php/bsjournal/article/view/4021

91. Clarke T. Assessment of urban flooding causes and drainage system efficiency in Bayelsa State, Nigeria. J Environ Res Manag [Internet]. 2026 [cited 2026 Oct 20];18(2):38-48. Available from: https://bwjournal.org/index.php/bsjournal/article/view/4034

92. Dinkin K. Problems of solid waste management in Nigeria (case study of Jalingo metropolis, Taraba State). Int J Interdiscip Res Innov [Internet]. 2018 [cited 2026 Oct

20];6(2):284-93. Available from: https://www.researchpublish.com/upload/book/PROBLEMS%20OF%20SOLID-5835.pdf

93. Alimi SA, Oriola EO, Senbore SS, et al. GIS-assisted flood-risk potential mapping of Ilorin and its environs, Kwara State, Nigeria. Remote Sens Earth Syst Sci. 2023;6:239-53. Available from: https://doi.org/10.1007/s41976-023-00093-w

94. Alimi SA, et al. Flood vulnerable zones mapping using geospatial techniques: case study of Osogbo Metropolis Nigeria. Egypt J Remote Sens Space Sci. 2022;25:841-50. Available from: https://doi.org/10.1016/j.ejrs.2022.08.003

95. Raufu MO, et al. Application of remote sensing and GIS in flood vulnerability mapping: a scenario of Akure South, Nigeria. Int J Environ Geoinformatics. 2023;10(1):90-9. Available from: https://doi.org/10.30897/ijegeo.1073697

96. Efiong J, Efiong E, Akintoye O, Inah E, Awan O, Ogban F. Geospatial modelling of flood susceptibility of the Calabar City, Cross River State, Nigeria. Appl Environ Res. 2024;46(3). Available from: https://doi.org/10.35762/AER.2024044

97. Amaechina EC, Anugwa IQ, Agwu AE, et al. Assessing climate change-related losses and damages and adaptation constraints to address them: evidence from flood-prone riverine communities in Southern Nigeria. Environ Dev. 2022;44:100780. Available from: https://doi.org/10.1016/j.envdev.2022.100780

98. Echendu AJ. Flooding, food security and the sustainable development goals in Nigeria: an assemblage and systems thinking approach. Soc Sci. 2022;11(2):59. Available from: https://doi.org/10.3390/socsci11020059

99. Akingbola A, Abiodun A, Ojo O, Jessica OU, Alao UH, Owolabi AO, et al. Cholera outbreak in Nigeria: history, review of socioeconomic and meteorological drivers, diagnostic challenges, and artificial intelligence integration. Glob Health Epidemiol Genom. 2025;2025:8898076. Available from: https://doi.org/10.1155/ghe3/8898076

100. Aborode AT, et al. Impact of climate change-induced flooding, water related diseases and malnutrition in Borno State, Nigeria: a public health crisis. Environ Health Insights. 2025;19:11786302251321683. Available from: https://doi.org/10.1177/11786302251321683

101. Izah SC, Ogwu MC, Promise VI, Aseibai ER, Alum EU. Flood-driven water contamination as a preventable public-health infrastructure failure: a perspective on

flood-ready water and health systems. Front Water. 2026;8:1927775. Available from: https://doi.org/10.3389/frwa.2026.1927775

102. Ibrahim IB. Legal lifelines: strengthening water and sanitation governance in Nigeria. Afr J Law Ethics Educ [Internet]. 2025 [cited 2026 Oct 20];8(3):233-56. Available from: https://www.ajleejournal.com/index.php/ajlee/article/download/269/253

103. Lamond J, Adekola O, Adelekan I, Eze B, Ujoh F. Information for adaptation and response to flooding, multi-stakeholder perspectives in Nigeria. Climate. 2019;7(4):46. Available from: https://doi.org/10.3390/cli7040046

104. Ukala DC, Akaun I, Owamah HI. A review of solid waste management practice in Nigeria. NIPES J Sci Technol Res. 2020;2(3):169-74. Available from: https://doi.org/10.37933/nipes/2.3.2020.17

105. Danhassan SS, Abubakar A, Zangina AS, Ahmad MH, Hazaea SA, Ishak MY, et al. Flood policy and governance: a pathway for policy coherence in Nigeria. Sustainability. 2023;15(3):2392. Available from: https://doi.org/10.3390/su15032392

106. Maiyaki MA, Marzuki A, Ahmed AA. Urban solid waste development, a review of Nigeria's waste management policy. Int Trans J Eng Manag Appl Sci Technol. 2019;11(5):1-14. Available from: https://doi.org/10.14456/ITJEMAST.2020.87

107. Adesola RO, Okeke VC, Chris NP, Dike CK, Olughu OI, Vermilye A. Public health impacts of flooding: a case study of 2022 flood outbreak in Nigeria. Int J Travel Med Glob Health. 2024;12(3):145-53. Available from: https://doi.org/10.30491/ijtmgh.2024.433930.1400

108. Oladipo MO. Preview of causes, frequency, extent, magnitude and intensity of flooding in Nigeria. Int J Geogr Environ Manag. 2023;9(2):52-60. Available from: https://doi.org/10.56201/ijgem.v9.no2.2023.pg52.60

109. Olukanni DO, Nwafor CO. Public-private sector involvement in providing efficient solid waste management services in Nigeria. Recycling. 2019;4(2):19. Available from: https://doi.org/10.3390/recycling4020019

110. Alaran OS, et al. Understanding the challenges and gaps in flood vulnerability assessment and mitigation strategies in Nigeria [Preprint]. Research Square; 2024 [cited 2026 Oct 20]. Available from: https://doi.org/10.21203/rs.3.rs-6952249/v1

111. Echendu AJ. Flooding in Nigeria and Ghana: opportunities for partnerships in disaster-risk reduction. Sustain Sci Pract Policy. 2021;18(1):1-15. Available from: https://doi.org/10.1080/15487733.2021.2004742

112. Ezeudu OB, Oraelosi TC, Agunwamba JC, Ugochukwu UC. Co-production in solid waste management: analyses of emerging cases and implications for circular economy in Nigeria. Environ Sci Pollut Res Int. 2021;28(37):52392-404. Available from: https://doi.org/10.1007/s11356-021-14471-8

113. Faisal Koko A, Yue W, Abdullahi Abubakar G, Hamed R, Noman Alabsi AA. Analyzing urban growth and land cover change scenario in Lagos, Nigeria using multi-temporal remote sensing data and GIS to mitigate flooding. Geomat Nat Hazards Risk. 2021;12(1):631-52. Available from: https://doi.org/10.1080/19475705.2021.1887940

114. Ighile EH, Shirakawa H, Tanikawa H. Application of GIS and machine learning to predict flood areas in Nigeria. Sustainability. 2022;14(9):5039. Available from: https://doi.org/10.3390/su14095039

115. Idowu D, Zhou W. Land use and land cover change assessment in the context of flood hazard in Lagos State, Nigeria. Water. 2021;13(8):1105. Available from: https://doi.org/10.3390/w13081105

116. Aniramu O, Odelola R, Okebugwu J, Ojimadu U, Orimoogunje O. Integrating hydro-climatic drivers, flood frequency, and dynamic perception for sustainability assessment of flood vulnerability in Lagos, Nigeria. Prog Disaster Sci. 2026;31:100631. Available from: https://doi.org/10.1016/j.pdisas.2026.100631

117. Aniramu O, Orimoogunje O. Integrating geospatial mapping and stakeholders' perception on sustainable flood solutions in a typical coastal megacity of Nigeria: a SWOT-AHP approach. Front Sustain Cities. 2025;7:1663269. Available from: https://doi.org/10.3389/frsc.2025.1663269

118. Shadare GA. Post-disaster planning, compound climate-displacement vulnerability, and urban resilience governance in Lagos, Nigeria: a systematic review. Land. 2026;15(8):1458. Available from: https://doi.org/10.3390/land15081458

119. Abu-Hanifa B, Abdussalam A, Baba SU, Isa Z, Ugya AY. A comprehensive review of flood monitoring and evaluation in Nigeria. Int J Energy Water Resour. 2025;9(4):1741-65. Available from: https://doi.org/10.1007/s42108-025-00356-w

120. Ayantoyinbo BB, Adepoju OO. Analysis of solid waste management logistics and its attendant challenges in Lagos metropolis. Logistics. 2018;2(2):11. Available from: https://doi.org/10.3390/logistics2020011