



Review Article

Impact of Stagnant Water on the Breeding of Malaria Mosquitoes in Nigerian Communities: A Sociological Assessment

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Abstract

Nigeria accounts for the biggest burden of malaria in the world, and a significant portion of this burden gets reproduced in the stagnating water bodies which accumulate in the drains, pits, tanks, farm trenches, and flood plains around homes. Most of the research done in Nigeria on this matter is entomological or epidemiological, specific to locations and says nothing about why such water bodies exist and continue existing. This paper examines the stagnating water as a socially constructed phenomenon. In order to do so, the article uses structured narrative literature review following PRISMA standards in order to summarize 27 Nigeria-specific articles which were published between 2004 and 2026 (14 empirical papers, 4 analytical reviews and 9 policy or institutional papers) using the framework of Social Determinants of Health and Political Ecology. The synthesis shows that the most productive breeding habitats are human-made: blocked drains, construction pits, open water-storage containers, waste-filled borrow pits, tyre tracks and the residues of cassava processing. Their persistence has to do with poverty, a water supply system in the public sector that forces the people into storing water (only 6.9% of the households in Nigeria get water piped into their house or yard), settlement without any plan, poor drainage systems and waste disposal, and a vector control budget where the proportion of planned spending on larval source management was 0.6% for the period 2021-2025. While community awareness is high, persistent knowledge-action gap, perpetuated by normalization of mosquitoes and also the collective nature of drainage, hinders action within the households. The knowledge base of research work also varies widely: South West region, the zone with the lowest prevalence of malaria, has the highest number of research works while the North Central region has none. Widespread pyrethroid resistance in Nigerian *Anopheles* populations strengthens the case for removing habitats rather than relying on insecticides alone. The article suggests a socio-ecological approach and suggests larval habitat reduction as a municipal service, water supply as vector control, and ward health committees as a community action institution.

Keywords

Malaria, Stagnant Water, Larval Habitats, Social Determinants of Health, Political Ecology, Water Storage, Urban Planning, Nigeria

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Received: 9 October 2026; Accepted: 21 October 2026; Published: 31 October 2026



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1. Introduction

Malaria is still the single most important vector-borne disease in Nigeria. The World Health Organization (WHO) estimates of 68 million cases and 194,000 deaths were recorded in Nigeria in 2021, constituting approximately 27% of all global cases and 31% of all deaths due to malaria, with approximately four out of five being children under five years [50]. In its World Malaria Report of 2025, the same organization places Nigeria among the few countries which together make up over half of all deaths caused by malaria worldwide [49]. Recently conducted studies in Nigeria using data from this report have indicated that Nigeria contributes around 27% of all cases and 31% of all deaths [36]. The trend is also not very encouraging. Case figures have been increasing since 2016, a trend attributed to reduction in intervention coverage, insecticide resistance, humanitarian crises, and population growth [50].

The vector aspect of this story has clear biological underpinnings. *Anopheles* mosquitoes lay their eggs in standing water, and the larvae require standing or slowly moving water for at least a week before developing into adults. What does not have a clear explanation is where that water comes from. A borrow pit which was left uncovered as a result of the road construction, a drain clogged with waste, a bucket of water which has been collected as a result of the weeks without access to water from the tap, a puddle of water collected next to a place used for fermenting cassavas, all of these are not natural features of the landscape. They have all been created through decisions and social processes within society. In other words, stagnant water is just as much a social fact as an ecological fact. Literature reviews in other parts of Africa come to the same conclusions with regards to irrigation projects, wetlands and standing water [28].

The fight against malaria in Nigeria has not been based on this idea. From 2009 until 2021, approximately 220 million insecticide-treated nets have been distributed through the country [50], while the National Malaria Strategic Plan 2021–2025 has again set as its vector control strategy the use of nets and indoor residual spraying targeting adult mosquitoes, with larval source management being used as a supplementary measure [30]. These measures target either adult mosquitoes or human contact with them. They do not address the underlying social factors responsible for producing these larval sites each season.

There is something specific that sociology can contribute in this case. For instance, the age-old perspective in sociology stating that social circumstances are fundamental causes of illness, resurfacing in novel ways as soon as earlier ones are thwarted [25] applies closely to malaria in Nigeria. As does the perspective from political ecology asserting that environmental issues arise in situations of uneven power relations over land, water, and infrastructure [41]. The present paper uses both perspectives to analyze the literature about stagnant water and malaria vectors breeding in Nigeria. It is a review

article: a structured narrative review that synthesises published and grey literature on Nigeria, supplemented in the discussion by comparative studies from other African settings. It reports no new primary data.

2. Statement of the Problem, Aim, Objectives and Research Questions

2.1. Statement of the Problem

Despite several years of efforts at managing malaria, the problem still stands as one of the major health concerns in Nigeria. The stagnation of water in homes and around houses, in blocked drains, borrow pits, flooded areas and domestic water storage tanks becomes the breeding ground for mosquitoes of the genus *Anopheles*. Most existing literature is either entomological or epidemiological, being restricted to only one locality or city, and measuring larval densities or prevalence rates of the parasite, without addressing the reasons behind the stagnation of the water, or how socio-economic factors such as poverty, poor housing and poor urban planning, among others, result into the creation of those conditions. Notwithstanding, there is no synthesis yet comparing the factors driving the formation of breeding grounds in Nigeria's geopolitical zones using a sociological framework.

2.2. Aim

The study aims to assess, from a sociological perspective, how stagnant water contributes to the breeding of malaria mosquitoes in Nigerian communities, and to identify the social and structural factors that sustain it.

2.3. Objectives

The specific objectives are to:

- 1) identify the types and distribution of stagnant water habitats reported in Nigerian communities across urban, peri-urban and rural settings;
- 2) examine the socio-economic, cultural and behavioural factors that contribute to the formation of stagnant water;
- 3) analyse the institutional and governance factors (planning, drainage, sanitation enforcement and flood management) that influence its persistence;
- 4) assess community knowledge, attitudes and practices related to breeding site management; and
- 5) propose a socio-ecological framework and policy recommendations for community-based vector control.

2.4. Research Questions

The main research question is: how do social, structural and

governance factors shape the presence and persistence of stagnant water and, in turn, malaria mosquito breeding in Nigerian communities? Five subsidiary questions follow from it.

RQ1. What types of stagnant water habitats are commonly reported, and how do they differ across settings?

RQ2. What socio-economic, cultural and behavioural factors contribute to their formation?

RQ3. How do institutional and governance factors influence their persistence?

RQ4. How do community perceptions and practices affect breeding site control?

RQ5. What gaps and policy implications emerge for community-based vector control?

3. Theoretical and Conceptual Framework

Two bodies of theory frame the analysis. They answer different questions, and the argument of this paper depends on holding them together.

3.1. Social Determinants of Health

Social Determinants of Health (SDH) approach sees the sources of illness as the circumstances in which people are born, grow up, live and work and the unequal distribution of resources and power that influence such circumstances. In their multi-layered model, Dahlgren & Whitehead [13] situated individual behavior within the layers of social networks, living and working conditions and broader socio-economic, cultural and environmental factors. The WHO Commission framework formulated by Solar & Irwin [42] clearly differentiated between the structural determinants (such as socio-economic position, governance and policy) and intermediary determinants (material conditions, behaviors and health systems) that allow structural factors to reach the human body. Applied to malaria, SDH approach helps understand the pattern seen in Nigeria data, according to 2021 Nigeria Malaria Indicator Survey (NMIS), microscopy confirmed infection was detected in 31.3% of children in the poorest wealth quintile and in 5.3% of children in the richest [31]. Such difference cannot be attributed to the biology of mosquitoes.

What SDH does less well is explain the physical environment itself. It tends to treat housing, water and sanitation as

attributes that households possess or lack, rather than as landscapes that are actively produced and contested.

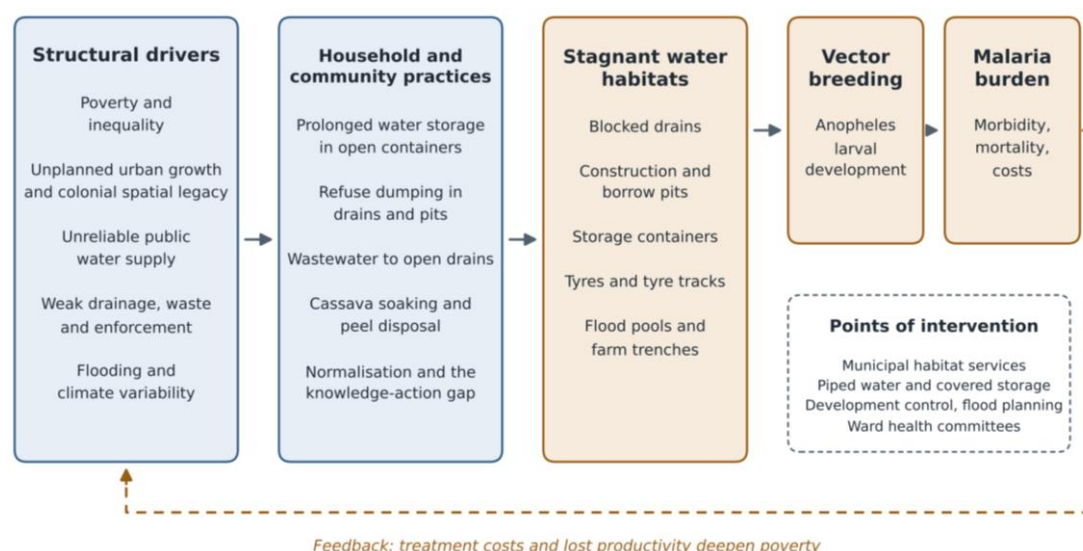
3.2. Political Ecology

Political ecology helps bridge this gap. Political ecology operates on the assumption that the environment emerges out of a social and political process, wherein degradation and vulnerability are not equally shared, because power is not equally shared over land, water and other infrastructure [10, 41]. In the current study, the political ecology approach allows us to focus our gaze on three issues. First, who makes decisions about construction and maintenance of drains? Second, whose responsibility is it to incur costs associated with lack of water supply and storage of water by household? Third, whose settlements get planned, serviced and drained, and whose settlements are flooded after every rainfall?

The history of Nigeria's urban areas illustrates these issues. In the Lugard era, European housing was purposefully located in high areas that could easily be drained, away from African communities, in part because of the need to prevent colonists from contracting malaria, and a segregated pattern of infrastructure development spread throughout the country following the 1914 amalgamation (drawing on Njoh, as summarised in [21]). This has meant that the drainage and water systems in place have been driven by political priorities, not actual needs. The unorganized and poorly drained communities analyzed in the following literature review did not come into being randomly.

3.3. The Integrated Model

The combination of both frameworks results in the causal sequence, which guides this review (Figure 1). Structural factors (poverty and inequality, unplanned urbanization, insufficient provision of water supply infrastructure, poor drainage/waste management, and floods) determine community-level actions (water storage, refuse dumping, wastewater disposal, and some agricultural activities). These actions, along with infrastructural underdevelopment, create standing water pools. The latter facilitate vector breeding, which in turn perpetuates the problem of malaria. The causal sequence closes in a circle since the disease itself contributes to poverty by incurring treatment and loss of productivity costs [8, 33].



Source: Author's construct, adapted from Solar and Irwin [42] and Robbins [41].

Figure 1. Socio-ecological framework: how structural drivers produce stagnant water and sustain malaria transmission in Nigerian communities.

4. Methodology

4.1. Design

It was an exploratory desk study of the narrative literature review approach which included a thematic synthesis. The choice of narrative design was made as opposed to the meta-analysis as there were different types of methodological diversity of studies conducted in Nigeria, including larval surveys, household surveys, clinic-based malaria prevalence studies, qualitative fieldwork and policy documents, as well as research questions were interpretative and not purely quantitative. Narrative reviews can be rigorous provided that their search and critical appraisal process is clear [20]. The review was therefore organised around, and is reported in line with, the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 statement [40].

4.2. Sources and Search Strategy

Peer-reviewed literature was sought in PubMed, Scopus, Web of Science, African Journals Online (AJOL) and Google Scholar. Grey and institutional literature was sought from the National Malaria Elimination Programme (NMEP), the WHO, the NMIS programme, the Federal Ministry of Water Resources (FMWR), the Nigeria Hydrological Services Agency (NIHSA), and federal legislation. The core search string combined habitat terms with disease, place and social-context terms: ("stagnant water" OR "larval habitat" OR "breeding sites") AND malaria AND Nigeria AND (sanitation OR drainage OR "water storage" OR community).

4.3. Eligibility Criteria

The sources selected met the following criteria: the focus was on Nigeria; the publication date of the source was between 2000 and 2026; and the source covered either mosquito breeding places or the social, environmental or organizational factors responsible for such places. National policy or law, valid during this time, even if initially formulated before 2000, was considered. Sources which were purely experimental or clinical and had nothing to do with any habitat and society were omitted from the selection. Studies of non-Nigerian origin were left out of the review; two such documents were retained only as context and comparison and do not contribute to the synthesised findings. In addition, a small number of studies from other African countries are cited in Section 5 for comparison and to explain mechanisms; these were identified through targeted searches and are not part of the synthesis corpus.

4.4. Selection

The literature records that were found using the database searches were screened on titles and abstracts and later on full texts. [Insert from search log: number of records identified, number of records after removing duplicates, number screened, number excluded with reasons.] Thirty-one records underwent full-text screening. Two of them were the companion documents of other documents in the collection (World Bank micro-data documentation for 2021 Malaria Indicator Survey, and summary page for National Health Act 2014) and were combined with the respective parent documents. Two were the documents of the contexts outside of Nigeria mentioned above. This left the final synthesis corpus comprising 27 sources,

namely 14 empirical research articles, four analytical reviews/theses, and nine policy/survey/institutional documents (see Table 1 below).

Table 1. Composition of the review corpus.

Category	n	Sources
Empirical studies (Nigeria)	14	Oladebo et al. [34]; Idowu [22]; Oniya et al. [37]; Ogbuene et al. [33]; Adeyekun et al. [2]; Asifat et al. [5]; Dimkpa et al. [14]; Oseghale and Chokor [38]; Agi et al. [3]; Jetoluwa et al. [23]; Olusi et al. [36]; Otujo et al. [39]; Ugonnanyere et al. [46]; Umaru et al. [47]
Analytical reviews, conceptual papers and theses	4	Hannemann [21]; Olagunju [35]; Ayub et al. [8]; Nasir et al. [29]
Policy, survey and institutional documents	9	FMWR [16]; FMWR [17]; Federal Republic of Nigeria [18]; NMEP [30]; Tukur [44]; NMEP et al. [31]; WHO AFRO [50]; Adeniji [1]; WHO [49]
Synthesis corpus	27	
Context or comparison only (not synthesised)	2	Local Government Division, Bangladesh [26]; Nalongo [28]
Companion documents merged with parent	2	Microdata documentation of the 2021 NMIS (merged with [31]); P4H Network summary of the National Health Act (merged with [18])

Note. FMWR = Federal Ministry of Water Resources; NMEP = National Malaria Elimination Programme; NMIS = Nigeria Malaria Indicator Survey; WHO AFRO = World Health Organization Regional Office for Africa.

4.5. Data Extraction and Quality Appraisal

The following information was systematically extracted from each empirical paper into a standard matrix form:

author name, publication year, state, geopolitical zones, context (urban, peri-urban, rural or national level), type and size of the sample, habitat types documented, social causes mentioned and main conclusions. The quality of the paper was assessed using Joanna Briggs Institute (JBI) critical appraisal checklists for each type of study designs [4]. Each paper was awarded a high, medium or low confidence level based on its quality. The confidence level was used for weighting purposes but not for excluding papers from the analysis in order to allow weak papers to provide descriptive information without

carrying the main analytical claims.

4.6. Analysis

Analysis was done in accordance with the three phases of thematic synthesis outlined by Thomas and Harden [43], namely line-by-line coding of the findings, grouping of the codes into descriptive themes, and developing the analytical themes that respond to the research questions. The coding process relied on the reflexive perspective of Braun and Clarke [11]. Subsequently, the findings were compared based on the settings (urban, peri-urban, and rural) as well as across the six geopolitical zones, taking into consideration the prevalence of malaria in each zone in the 2021 Malaria Indicator Survey.

Table 2. Characteristics and appraisal of the 14 included empirical studies.

Study	State (zone)	Setting	Design and sample	Habitats or environmental exposures reported	Social drivers identified	Confidence
Oladebo et al. [34]	Oyo (SW)	Rural farming	Mixed methods; 403 farmers, 8 FGDs, 40 farms observed	Cassava soaking containers, peel heaps, trenches, irrigation, fish ponds	Low knowledge of transmission; wealth; gendered farm labour	High
Idowu [22]	Ogun (SW)	Urban	Cross-sectional;	Stagnant water	Covered containers; tap	Moderate

Study	State (zone)	Setting	Design and sample	Habitats or environmental exposures reported	Social drivers identified	Confidence
			464 pregnant women	near homes; household storage (98.9%) not associated	water supply	
Oniya et al. [37]	Ondo (SW)	Rural, semi-urban	Larval survey; 33 sites, 2,051 adults reared	Tyre tracks, puddles, containers, tyres, gullies, blocked drains	Logging traffic; lack of basic amenities	Moderate
Ogbuene et al. [33]	Enugu (SE)	Urban slums	Household survey; 399 households; PCA	Stagnant water and bushes around houses	Slum housing; economic burden of malaria	Moderate
Adeyekun et al. [2]	Ondo (SW)	Semi-urban, rural	Larval and water-quality survey	Ponds, gutters, marshes, 0.36–12.98 m from buildings	Poor drainage; limited community education	Moderate
Asifat et al. [5]	National	National	Secondary analysis of NMIS 2021; 1,833 children	Unimproved sanitation not significant	Wealth, rural residence, maternal education, wall materials	High
Dimkpa et al. [14]	Rivers (SS)	Urban	Mixed methods; 375 households, 65 waste pickers, 40 key informants	Unregulated dumpsites in borrow pits and drains	No municipal collection; weak institutions; exclusion of waste pickers	Moderate
Oseghale and Chokor [38]	Edo (SS)	Mixed (21 communities)	Household survey; 630 households; multilevel regression	Vegetation significant; dumps and pools not significant	Household surroundings	Moderate
Agi et al. [3]	Kaduna (NW)	Urban	Entomological survey, 1,245 habitats; KAP survey, 1,200 households; FGDs, KIIs	Blocked drains, construction pits, tyres, storage containers, pools	Unplanned settlement; fatalism; cost of nets	Moderate*
Jetoluwa et al. [23]	Rivers (SS)	Peri-urban	Mixed methods; 400 households, FGDs, KIIs, WASH checklist	Blocked drains (83%), open storage (74%), wastewater to drains (71%)	Water supply deficit; policy non-implementation; disempowerment	Moderate
Olusi et al. [36]	Ondo (SW)	Facility-based	KAP survey with RDT; 469 participants	Bush, water source, sanitation frequency not significant	Income; misconceptions	Moderate
Otujo et al. [39]	Ogun (SW)	Semi-urban	Survey of 50 health workers (purposive)	Breeding sites and poor drainage (perceived)	Poor sanitation; access to care	Low
Ugonnanyere et al. [46]	Imo (SE)	Urban	Hospital-based cross-sectional; 600 participants	Poor drainage, stagnant water, overcrowding	Migration; low income	Moderate
Umaru et al. [47]	Adamawa (NE)	Semi-urban, rural	Mixed methods; 300 adults, KIIs,	Stagnant water (88%) and blocked drainage (75%) in	Funding and infrastruc-	Moderate

Study	State (zone)	Setting	Design and sample	Habitats or environmental exposures reported	Social drivers identified	Confidence
			field observation	Michika I	ture gaps; low participation	

Note. Zones: NW = North West; NE = North East; SE = South East; SS = South South; SW = South West. FGD = focus group discussion; KII = key informant interview; KAP = knowledge, attitudes and practices; NMIS = Nigeria Malaria Indicator Survey; PCA = principal component analysis; RDT = rapid diagnostic test. Confidence ratings are the author's, informed by the relevant JBI checklists. *Findings described by the authors as preliminary.

5. Findings and Discussion

The findings are presented by objective. Each subsection moves from what the studies report to what the pattern means sociologically, and points of disagreement in the evidence are kept in view rather than smoothed over.

5.1. Types and Distribution of Stagnant Water Habitats (RQ1)

5.1.1. The Dominance of Human-made Habitats

In terms of the entire literature reviewed, there is no denying that those artificial habitats where mosquito larvae thrive are common. As for numbers, Kaduna metropolis provides the clearest example, as Agi et al. [3] analyzed more than 1,200 breeding sites. The most productive artificial habitat was the one associated with blocked drains: 71.4% of the 412 drains examined were positive, with the mean of 48.2 larvae per dip. Another significant source of larvae in terms of numbers was construction pits (70.8% of the pits examined were positive), which was also important as the place where *Anopheles gambiae* comprised 58% of larvae. Discarded tires (68.7% positive), domestic water storage facilities (59.1%) and natural pools (63.5%) came next. Natural pools, in other words, were not the major issue. The same pattern has been reported elsewhere in West Africa. In Accra and Sekondi-Takoradi, Ghana, about 74.5% of *Anopheles* habitats were man-made, and drains and construction sites produced about 80% of the *An. gambiae sensu stricto* (s.s.) collected [27], which closely mirrors the productivity of construction pits in Kaduna. A review of urban malaria across sub-Saharan Africa likewise found that the *An. gambiae* complex is the predominant urban vector and that its larvae have adapted to a wide range of aquatic habitats in cities [15].

Similar groups of habitats have been found to occur in completely different environments. In the Orugbum-Abali area in the peri-urban region of Port Harcourt, 83% of the drainage channels noted were blocked [23]. In the Michika region of Adamawa State, field observation showed that there was stagnant water around 88% of the locations in Michika I and blocked drainage in 75% of the surveyed areas [47]. In Port

Harcourt, informal dumpsites occur in borrow pits, drainage channels and vacant land and contain exposed waste, plastics and tyres, thus becoming stagnant and collecting rainwater and leachate [14]. In the slums of Enugu, residents' exposure was highly correlated with bushes and stagnant water surrounding their housing units [33].

5.1.2. Rural and Agrarian Habitats

Rural habitats may also have a social aspect, but it is linked to livelihood and not infrastructure of the urban setting. The presence of larvae was reported in two villages of Oyo State, where structured observations in 40 farmlands found peeled cassava tubers left to soak in the open plastic tanks in half of them, cassava peeling heaps trapping rainwater in nearly equal numbers, trenches in 35%, irrigation in 25%, and fish ponds in fewer [34]. At Ifedore in Ondo State, larvae were found in gullies, pools, waste containers, tires, concrete holes, drainage systems, and even in "more or less permanent breeding sites," such as tracks made by lumber trucks through farms and forests [37, p. 71]. Out of 33 identified breeding sites, only ten were natural permanent or semipermanent sources of water. Most were artificial, shallow, and temporary. A subsequent survey carried out at Akoko, Ondo State found larvae in very shallow waters of up to 0.02 m depth in ponds, gutters and marshes [2].

5.1.3. Proximity, Pollution and Adaptation

There are two other aspects to consider regarding how risks are perceived. First, it is related to the distances between breeding habitats and residences. The breeding habitats of *Anopheles* in Ifedore are located at distances of between 0.5 m and 300 m from the closest residence [37], while in Akoko the average distance to buildings was even smaller, being 0.36 m in Ikare [2]. This means that habitats of mosquitoes are not in distant environments but are situated within the boundaries of compounds, along the streets and right at doorsteps.

Second, it relates to the pollution of urban environments. Entomological textbooks associate *Anopheles* with clean and sunny water, which has been the basis of urban environment being considered to be hostile to malaria vectors. However, the evidence gathered in Nigeria contradicts this claim. In Ifedore, the larvae of *Anopheles* were discovered in turbid water,

not clear one [37]. An earlier survey of 24 breeding sites in urban Lagos found that more than 85% of *An. gambiae* s.s. larvae came from water with low dissolved oxygen (below 3 mg/L), high conductivity and turbidity, and iron, copper and lead concentrations about three times higher than in rural breeding sites [6, 21]. The same tolerance has been documented outside Nigeria. In Cape Coast, Ghana, *An. coluzzii* bred in faecally contaminated, saline and organically polluted habitats such as choked gutters, tyre tracks and construction-site water holders, although it was absent from anoxic habitats, which held only *Culex* [24]. In Khartoum, Sudan, *An. arabiensis* larvae occupied sewer drains, sewage canals and industrial effluent pools with turbidity about 52 times that of a control irrigation canal, and larvae from these polluted sites were markedly more tolerant of the larvicide temephos [9].

There have been several reasons suggested for this adaptation. Pollution is not evenly distributed. Moderately polluted and lighted water may still contain sufficient amounts of dissolved oxygen and microbial matter for the *Anopheles* larvae to survive and feed, while highly polluted and anoxic sewage water favors *Culex* mosquitoes because the larvae of *Culex* survive in low-oxygen and high-ammonia levels [24]. Selection is another reason. Larvae living in water contaminated by hydrocarbons, metals, and agricultural chemicals go through many of the same challenges as insecticides do, and urban and agricultural pollutants have been shown to influence the response of mosquitoes to insecticides and resistance mechanism selection [32]. In Nigeria, it means that the drainage ditches and waste pits cannot be considered as a problem of nuisance mosquitoes only because they may serve as breeding places for the *Anopheles* mosquitoes.

5.1.4. Ecology of Breeding Habitats: Physical and Chemical Conditions

A number of the reviewed studies have analyzed conditions within breeding sites and provide an explanation of why certain artificial habitats are so productive. At the 33 positive breeding sites in Ifedore, water temperature varied from 20.8 to 32.6 °C, dissolved oxygen concentration from 2.7 to 7.8 mg/L, total dissolved solids concentration from 43 to 1,933 ppm and pH from 5.3 to 8.5; temperature and dissolved oxygen concentration significantly affected larvae of all species, having an inverse relationship and increasing larvae presence with an increase in their concentration [37]. In the Akoko area, larvae density was positively correlated with dissolved oxygen concentration ($r = 0.72$) and less with conductivity, total dissolved solids and pH; larvae were concentrated at shallow muddy sites from 0.02 to 0.23 m deep [2]. Similar data have been gathered in Ghana where habitats with *An. coluzzii* had higher temperature, pH and dissolved oxygen and lower ionized ammonia concentration compared to habitats with only *Culex* [24].

These measurements fit what is known of larval biology. Shallow, open water warms quickly in the sun, which shortens

larval development and supports the algae and micro-organisms on which larvae feed. This helps explain why freshly dug construction pits, puddles and tyre tracks, which are shallow, sunlit and often turbid, suit *An. gambiae sensu lato* (s.l.) so well [3, 27]. Temporary habitats also hold few predators: in Ifedore, the ten permanent and semi-permanent water bodies were populated by predators such as dragonfly and damselfly nymphs, tadpoles and water spiders, whereas most of the other positive sites were temporary [37]. Containers and sewage-laden drains, by contrast, are shaded or enriched with organic matter, which favours *Aedes* and *Culex*. In Kaduna, *Culex quinquefasciatus* made up 92% of larvae in blocked drains, while *Aedes aegypti* dominated miscellaneous containers [3]. Season matters as well. Larval and adult densities in Kaduna and in urban Ghana rose with the onset of rains [3, 27], and malaria transmission in Nigeria typically peaks four to eight weeks after the rains begin [29]. Each of these conditions, from depth and sunlight to the timing of water accumulation, is set largely by human activity: by when and how pits are dug, whether drains are cleared before the rains, and how water is stored.

5.1.5. Flood-generated Habitats

Flooding creates a seasonal and regional dimension. The floodplains of the Niger and Benue rivers and the river networks of the Niger Delta result in huge areas of stagnant water that can remain wet for weeks or even months after the floodwaters subside [29]. For instance, the 2012 flood flooded about two million hectares of land in 30 states, and led to the displacement of more than 1.5 million people. Additionally, a report indicates an increase of 22%-35% in the cases of malaria above normal in affected states between eight and twelve weeks after the recession of the flood [29]. Exposure to flooding cannot be considered minimal either. In the 2025 Annual Flood Outlook released by NIHSA, 1,249 communities in 176 local government areas in 30 states and the Federal Capital Territory were placed under high-risk areas of flooding, which was attributed to rainfall, river overflow, urbanisation, poor urban planning, deforestation and improper waste management [1].

5.1.6. Where the Evidence Disagrees

However, not all studies confirm the link between stagnant water and malaria prevalence. In one study among 464 pregnant women in Abeokuta, there were no significant differences in the risk of infection between those who lived near stagnant water and those who did not [22]. In Southern Edo, vegetation near houses was an important predictor of malaria, whereas waste dumps and stagnant pools were not [38]. Neither bush near the house nor household water source was significantly associated with malaria infection in facility-based study conducted throughout Ondo State [36]. Finally, in the nationally representative analysis of the 2021 Malaria Indicator Survey, Asifat et al. [5] did not find any association between unimproved sanitation and malaria in children under

five after controlling for wealth, residence, maternal education and housing materials.

This does not contradict the above-described evidence based on larvae but does have some implication regarding the measurement of exposure. In all four articles, stagnant water or lack of sanitation was viewed as a household level attribute, often provided by the respondent. However, mosquitoes do not care about household level divisions. A household with a well-maintained compound is still exposed to blocked drainage in the next compound, and this was pointed out explicitly by people from Orugbum-Abali whose explanation of cleaning their compound and presence of mosquitoes despite that was caused by the lack of sanitation and drainage in their neighboring areas [23]. Stagnant water is a phenomenon of the level of street or neighborhood. If this variable is measured on the level of the household, its influence is underestimated, and the factors which remain statistically significant (wealth, rurality, and wall construction material) are the ones that reflect the position of the household in the neighborhood.

5.2. Socio-economic, Cultural and Behavioural Factors (RQ2)

5.2.1. Poverty as a Fundamental Cause

There is an evident and pronounced socio-economic gradient of malaria in Nigeria. The prevalence rate among children based on microscopy is 31.3% among the least rich quintile, compared to 5.3% among the most affluent, while 26.7% of the malaria prevalence is seen in the rural environment, compared to 10.5% in the urban setting [31]. Multivariate analysis done in the same study shows that children in the poorest households had more than three times the odds of infection of children in the richest households (adjusted odds ratio 3.41) [5]. Also, children whose houses have walls made of sub-standard materials have higher odds again. In Ondo State, individuals earning more than ₦50,000 per month have less than half the odds of testing positive than those earning less [36]. The housing finding is consistent with multi-country evidence: across 21 sub-Saharan African countries, children living in modern houses had 9% to 14% lower odds of malaria infection than those in traditional houses, an effect similar in size to that of sleeping under an insecticide-treated net [45].

What is relevant to stagnant water is mechanism. Poverty defines where individuals can afford to settle in a city. The cheap areas in Nigerian cities are usually low, wet, and lacking basic amenities like sewerage systems and roads. Poverty means that an individual cannot afford to buy covered tanks rather than open ones, cannot afford proper waste management facilities but will dispose of wastes on a public dump site, or cannot afford raised floors rather than compounds that tend to accumulate stagnant water. According to Ayub et al. [8], malaria and poverty exist in a reciprocal causation cycle, whereby poor sanitation and housing breed malaria, while out-of-pocket health costs (put at 77% in 2017) leave no money

for improving the conditions that promote the disease. In the words of Link and Phelan [25], poverty acts as a fundamental cause whereby eliminating one avenue of exposure, for instance, blocked drainage system, creates other avenues.

Interestingly, cost was not the main barrier everywhere. In Port Harcourt, households did not primarily cite money as the reason they avoided formal waste collection. The more important problem was that no convenient municipal service reached them at all [14]. Poverty, in this reading, is as much a matter of infrastructural exclusion as of household income.

5.2.2. The Water-storage Paradox

The most unique force driving the literature from Nigeria is perhaps what may be referred to as the water storage paradox. People have to store water due to the inconsistent availability of public water, and water storage provides habitats for larvae. The size of the deficit involved cannot be underestimated. It has been estimated that only 6.9% of Nigerian households have water piped into their dwelling, yard or plot [31]. Only 43% of households have any water source on their premises [31]. Water sources include boreholes/tube wells (34%) and protected dug wells in rural areas and sachet water in urban areas [31].

It is evident from the results at the community level. For example, in Orugbum-Abali, only 22.5% of the households had access to water through piped water in their premises, while almost 74% of the households retained open water storage facilities in their compounds, with storage being described as a means of coping with irregular supply of water [23]. In Kaduna, larvae were found in nearly six out of ten domestic water storage facilities, with *Anopheles gambiae* representing approximately 25% of larvae found in this environment [3].

This paradox is not a necessary one, however, and the findings at Abeokuta illustrate this point well. There, 98.9 percent of the pregnant women surveyed kept water, but storage did not correlate with infection; most of the containers were covered, and the stored water tended to be mostly tap water [22]. Storage is a risky practice when certain social conditions hold: when the containers are open, when the water is kept over time due to uncertainty of future provision, and when there are no resources within the household to purchase either lids or larvae-killer. It is precisely because of this interaction between infrastructure failure and household constraint that the paradox exists, an interaction that a political ecology approach is supposed to reveal.

5.2.3. Livelihoods, Gender and the Domestic Economy of Water

Breeding sites in rural settings depend on how people earn a livelihood. Cassava processing provides an obvious case in the corpus. In the Oyo villages investigated by Oladepo et al. [34], the gender-based division of labour on the farm meant that harvest, processing, and sales were done by women while men cultivated. Soaking tanks, fermentation drainage, and

piles of peelings containing water were thus a part of women's activities. This does not imply that women are responsible for breeding sites but implies that any action to address breeding sites among agricultural water must involve the actual processors and must provide options that do not increase their workload. The same goes for transport: lumber-truck tracks in Ife-dore [37] are a consequence of the extractive economy whose burden falls upon the communities it crosses.

Another daily activity that has its structures is household wastewater. In Orugbum-Abali, roughly 71% of the households dispose of their wastewater from the kitchen into open drains and on the roads [23]. When there is no soakaway or connected drainage facility, this is where the wastewater ends up.

5.2.4. Population Movement and Settlement Density

Migration and settlement pattern in urban areas of Nigeria also affect urban malaria. In Owerri, Orlu and Okigwe, immigrants were more infected with malaria parasites than non-immigrants, especially women and lower socio-economic classes, and this was because the immigrants settle in poorly drained and overcrowded areas [46]. In Kaduna, unplanned settlements showed much higher densities of mosquitoes than planned settlements, and this was ascribed to bad waste management, poor drainage, stagnant water and overcrowded housing [3]. Settlement pattern is a social factor that correlates well with larval habitat.

5.3. Institutional and Governance Factors (RQ3)

5.3.1. Planning Failure and the Unplanned City

Not only entomologically but also socially and environmentally there was a disparity between the two types of settlements in Kaduna, with residents of planned communities almost twice as likely to engage in environmental management activities such as drain clearance and waste disposal (58% versus 32%) and be aware of mosquitoes breeding in stagnant water (71% versus 53%) [3]. Planning thus affects not just the physical but also the social capacity to manipulate the environment. Similar findings were reported by Ogbuene et al. [33] in Enugu and an emergency regarding sanitation and hygiene and the upgrading of slums via low-cost housing advocated.

Construction is an especially underappreciated factor. Open construction pits in Kaduna represented some of the most productive sites for *Anopheles* [3], yet none of the policy documents examined addresses the issue of construction sites or abandoned buildings as sources of vectors. The responsibility for development control lies with the state and local planning authorities, yet this is absent from malaria policy.

5.3.2. Drainage, Waste and the Limits of Municipal Capacity

Institutional assessment carried out in Port Harcourt by Dimkpa et al. [14] is particularly frank about weaknesses

within the public sector. Waste agencies admitted that they were in charge of municipal solid waste, but the participants refuted assertions that agencies checked unregulated dumpsites, worked with communities, or linked vector control with waste management programs. Only 32% of waste pickers had been provided with any protective gear despite the fact that they showed great willingness to participate in clean-up and recycling campaigns. In Orugbum-Abali, policy non-implementation and community disempowerment were reported as recurring themes along with infrastructural insufficiencies which were mentioned in all focus groups [23]. In Michika, key informants attributed inconsistencies of environmental interventions to insufficient funding and lack of infrastructures [47].

5.3.3. A Policy Architecture that Privatises Sanitation

The national policy framework provides an explanation for these gaps. The National Water Sanitation Policy begins by recognizing that all tiers of government have ignored sanitation in the past as compared to the supply of water, which could be attributed to "the popular notion that sanitation is a private household affair" [17]. According to the National Water Sanitation Policy, water sanitation includes storm water and sullage. The policy demands that all tiers of government provide budgetary allocation annually for sanitation, that the local governments enact sanitation bye-laws, and that states and local governments provide adequate training for Environmental Health Officers to inspect and penalize those who ignore sanitation standards. Furthermore, the policy notes that the compulsory monthly national environmental sanitation exercise lasted from 1983 to 1999. On the face of it, therefore, there are adequate means to manage household and neighborhood stagnant water. From empirical studies, however, this is not the case.

The same trend is evident in the water sector. For instance, the National Water Policy highlighted the existence of about 200 dams with an estimated capacity of 31 billion cubic metres, noting further that a large proportion of the land equipped with formal irrigation structures had fallen into disrepair and required major rehabilitation [16]. Dams and partly defunct irrigation infrastructure are well-known sources of perennial and semi-perennial water, but they are treated as matters of water resource development rather than vector ecology.

5.3.4. Where Malaria Money Goes

Even the budget allocation for the health sector itself reflects the same inclination. Amongst the approximately ₦1.89 trillion budgetary costs allocated to the National Malaria Strategic Plan from 2021 to 2025, long-lasting insecticidal nets constituted 28.1%, indoor residual spraying took up 6.1%, and larval source management took up 0.6%, whereas entomological monitoring made up 0.2% [30]. This plan itself acknowledges that in the earlier period, indoor residual spraying and

larval source management "were not funded and sparsely implemented" [30]. Further, it confined larval source management to the habitats "few, fixed and findable" according to WHO standards and judged it best suited to urban environments and on the condition of prior entomological and geo-spatial surveillance [30, 48]. These standards are technically sound. However, these are also conditions that by design ensure the habitats that have been described in Section 5.1 do not get the programme's attention.

Comparative evidence suggests that this restriction is too narrow. Reviewing larval source management in Africa, Fillinger and Lindsay [19] argue that the view of *An. gambiae* habitats as too numerous and transient to control is largely a myth: in western Kenya, permanent drains made up 72% of aquatic habitats and puddles only 5%. They report that hand-applied larviciding reduced transmission by 70% to 90% where habitats were well defined, that drainage of breeding sites on the Nigerian coast in 1942 and 1943 cut malaria incidence by 77%, and that the cost of larval source management per person protected each year (US\$0.94 to 2.50) was comparable to that of indoor residual spraying and long-lasting nets [19]. Experience in Dar es Salaam, Tanzania, points in the same direction. After community sensitisation and the cleaning and maintenance of urban drains, the odds of malaria infection in intervention neighbourhoods fell sharply (odds ratio 0.12), but success depended on political will, community participation, funding for initial cleaning and structural repairs, and collaboration across sectors [12]. Many of the habitats described in Section 5.1, such as blocked drains and construction pits, are more fixed and findable than programme guidance assumes, while the more transient ones are best removed through drainage, planning and sanitation rather than larviciding.

5.3.5. Insecticide Resistance and the Limits of Chemical Control

Insecticide resistance further strengthens this point. The malaria intervention programme of Nigeria is highly reliant on pyrethroid insecticide nets, but pyrethroid resistance was found widespread in *An. gambiae* s.l. in all sentinel sites in all ecological zones through entomological surveillance conducted for the National Malaria Strategic Plan [30]. Six surveillance sites in Lagos, Ogun, Edo, Anambra, Kwara, and Niger States showed the resistance to permethrin and deltamethrin in all the six sites with post-exposure mortality ranging from 25% to 87%, with the presence of the knockdown resistance (kdr) mutation in all six sites and higher resistance in Lagos and Ogun sites linked to increased cytochrome P450 and glutathione S-transferase enzyme levels [7]. The increase in malaria cases in Nigeria since 2016 has been partly blamed on insecticide resistance, which decreases the efficacy of nets according to WHO [50], while globally, pyrethroid resistance was documented in 48 out of 53 countries monitoring pyrethroid resistance from 2020 to 2024 [49].

Resistance is linked with habitats in two manners. First, it

is partly generated in the same polluted urban and agricultural ecosystems discussed above, where pollution and agricultural pesticides select for the same detoxification systems as mosquitoes' defenses against public health insecticides [32], and *Anopheles* larvae from polluted urban ecosystems in Khar-toum exhibited decreased susceptibility to the larvicide temephos [9]. Second, resistance makes ineffective every intervention tool dependent on any chemical, including larviciding. Draining, filling, covering, and clearing the water do not require chemicals. As chemical-based interventions become increasingly ineffective, control of the environmental and social factors giving rise to larval habitats gains greater importance, rather than the opposite. Remarkably, none of the 14 empirical papers in the corpus measured insecticide resistance along with habitat or social factors.

5.3.6. Flood Governance

The domain with the most well-developed technical expertise and the weakest link to malaria is that of flood management. The NIHSA issues yearly forecasts, operates flood warning systems in Jiderebode, Wurobokki, Lokoja and Makurdi, and works with the Nigerian Meteorological Agency (NiMet) and the National Emergency Management Agency (NEMA) [44]. They also state their own limitations as being lack of funding, lack of training and manpower and lack of satellite technology [44]. Their forecast for 2025 suggested that urban drainage be improved to reduce waterlogging, that zoning take place in flood prone areas and that there be community driven participation [1]. However, none of the literature reviewed makes a link between the floods calendar and post flood larval surveillance or the timing of the malaria intervention programs, although the interval between floods and increase in malaria incidence is clearly indicated in the literature [29].

5.3.7. Historical Depth

The history of colonization discussed in Section 3.2 adds context to the institutional pattern described above. Initially, when drainage was introduced as a tool for improving colonial public health standards, it was mainly found within European reservations located on high ground, with drainage, and then selectively applied to African zones (as documented by Njoh and summarised in [21]). The current distribution of drained and undrained communities is not simply a direct inheritance of that history, but the fact remains that the rule of political prioritization of infrastructure has stood the test of time. Communities where there are the most blocked drains have the lowest political influence.

5.4. Community Knowledge, Attitudes and Practices (RQ4)

5.4.1. Awareness Has Risen, But Unevenly

From the comparison across the periods, there appears to be

an improvement in basic knowledge. The farmers in the Oyo agricultural areas examined in 2010 had only 12.4% who could identify mosquito bites as the cause of malaria [34]. By the 2020s, it can be seen from the studies conducted in Michika and Ondo that majority of the respondents know that mosquitoes transmit malaria, with over 90% of them doing so in Michika [36, 47]. However, misconceptions still abound. For instance, in Michika, some of the people believed that malaria was caused by dirty water and contaminated foods [47], while in Ondo, misconceptions about the causes and mode of transmission were found to be significantly associated with infection [36]. Knowledge that mosquitoes breed specifically in stagnant water is weaker: 62% overall in Kaduna and 53% in its unplanned settlements [3].

5.4.2. The Knowledge-action Gap

A more consistent theme is that knowledge does not lead to environmental action. In Port Harcourt, over 70% of households perceived uncontrolled dumpsites as important breeding areas and malaria breeding ground, but only 45% utilized covered waste baskets, and open dumping was common practice [14]. Similarly, in Orugbum-Abali, residents knew that mosquitoes bred in stagnant water, uncovered receptacles and blocked drains, although these factors continued to persist [23]. In Michika, net use was high, while community sanitation was moderately practiced [47]. Even where there is sanitation practice, the timing may not coincide with the vector's. For instance, in Ondo State, 64.2% of participants were involved in environmental sanitation activities on a monthly basis, but there was no significant relationship between the frequency of sanitation activity and infection. The authors concluded that monthly sanitation schedule is too lengthy to interrupt the breeding cycle which needs weekly intervention [36]. Health workers in Omu-Ijebu, Ogun State, similarly identified poor environmental sanitation, breeding sites and poor drainage as causes of childhood malaria despite general awareness of prevention [39].

While the literature often tends to perceive the gap in question from the standpoint of a behavioral deficit that can be bridged by increased health education, the facts presented in this review suggest another perspective. Nets are a private good – if a household purchases or obtains a net, it is the one

who reaps the benefits. Drain clearing and proper waste disposal are public goods – even though a particular household cleans up its part of the drain, it gets no benefit if the following compound leaves its waste where it is. There is an institutional rather than an attitudinal gap at hand. The Dar es Salaam experience supports this reading: community drain cleaning reduced malaria infection where it was backed by sensitisation, initial public funding and intersectoral collaboration, and faltered where resources and local commitment were weak [12].

5.4.3. Normalisation and Fatalism

Repeated exposure also influences people's attitudes. Attitude formation through focus group discussions conducted among the residents of unplanned communities in Kaduna yielded the attitude that “mosquitoes are part of life here” [3]. In Orugbum-Abali, too, many participants viewed malaria as a common and inevitable aspect of their lives, making them less willing to adopt any preventative measures, since individual efforts appeared futile in light of the larger environment [23]. Such fatalism, however, is not illogical. On the contrary, it reflects reality, which individuals are unable to change with their efforts alone.

5.4.4. Willingness to Act

On the other hand, there is evidence that there exists an inclination toward readiness. People in Port Harcourt agreed that they were willing to alter their behaviors concerning waste despite the time spent and would take part in cleaning drives provided they were given gloves and other protective equipment [14]. It is noteworthy that there was a very weak acceptance of punishment for failing to act. Lack of knowledge on how to prevent breeding was the strongest reason for inactivity rather than a lack of concern [14]. In brief, there seems to be readiness for organized action among communities.

5.5. Comparison Across Geopolitical Zones

Table 3 sets the empirical evidence against zonal malaria prevalence from the 2021 Malaria Indicator Survey. Two observations stand out.

Table 3. Malaria prevalence and the empirical evidence base by geopolitical zone.

Zone	Prevalence (%)	Empirical studies (states)	Habitats and drivers reported	Main evidence gap
North West	29.8	1 (Kaduna)	Blocked drains, construction pits and storage containers in unplanned urban settlements; strong rainy-season peaks	Highest burden, thinnest evidence; no rural studies
North East	20.1	1 (Adamawa)	Stagnant water and blocked drainage; funding and infrastructure gaps; flood-drought cycles	No larval survey data

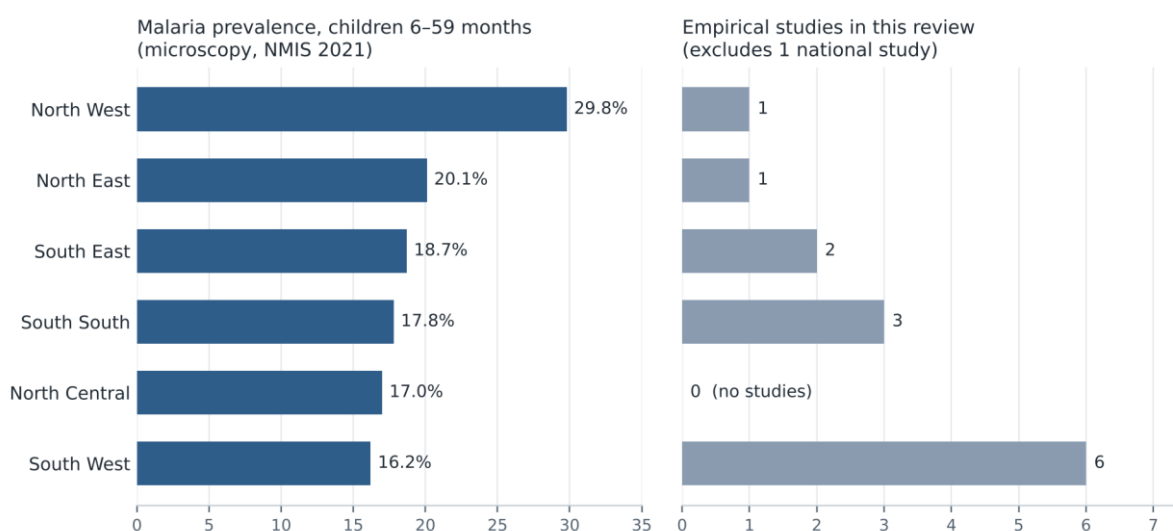
Zone	Prevalence (%)	Empirical studies (states)	Habitats and drivers reported	Main evidence gap
North Central	17.0	0	Floodplain water at the Niger-Benue confluence and along the Benue (hydrological data only)	No community-level empirical study
South East	18.7	2 (Enugu, Imo)	Stagnant water and bushes in slums; migrant settlement; poor drainage	No larval survey data
South South	17.8	3 (Edo, Rivers)	Blocked drains, dumpsites in borrow pits, open storage, tidal flooding, vegetation	Concentrated in Port Harcourt
South West	16.2	6 (Oyo, Ondo, Ogun)	Tyre tracks, gutters, marshes, cassava processing sites; largely covered storage	Mostly Ondo State; little from Lagos

Note. Prevalence is the percentage of children aged 6 to 59 months positive by microscopy in the 2021 NMIS [31]. One national study [5] is not assigned to a zone. Zonal habitat descriptions also draw on Nasir et al. [29] and Tukur [44].

The first one is that the determinants are cross-cutting across zones but shaped by ecology and economy. In the North West and North East, the habitats reported include urban drains, construction pits, as well as stagnant water and blocked drainage in the semi-urban habitat of Michika, in a climatic setting characterized by high seasonality and alternating floods and droughts [29]. In the South South, tidal floods, wetlands, as well as peri-urban settlements, ensure the availability of the habitats throughout the year and have an intensity of transmission of malaria in freshwater swamps and rainforests that is among the highest in the country, where entomological inoculation rate is higher than 200 infective bites per person per year compared to less than 10 in the Sahel [29].

The second observation relates to the evidence itself. Six

out of the 14 empirical studies were carried out in the South West region that has the lowest microscopy prevalence rate (16.2%). One was carried out in the North West region that has the highest prevalence rate (29.8%). The North Central region has contributed no empirical studies although the Niger-Benue junction in Lokoja and the Benue flood plain in Makurdi, which are two of the locations used by NIHS for early warning about floods, fall within this region [44]. The evidence pattern follows the pattern of institutions and research funding, not of disease. The gap is all the more striking because entomological surveillance has documented pyrethroid resistance in North Central states such as Benue, Nasarawa and Plateau [30], so vector data exist there even where social and habitat data do not.



Sources: NMEP et al. [31]; author's analysis of the review corpus.

Figure 2. Malaria prevalence in children aged 6 to 59 months by geopolitical zone (microscopy) and number of included empirical studies per zone.

5.6. Synthesis: Stagnant Water as a Social Product

Taken together, the results provide evidence of the framework in Figure 1 and extend it in three important ways. Firstly, the most significant breeding habitats of *Anopheles* in Nigerian communities result from social practices: uncontrolled construction, unmanaged drainage, unreliable water supply, uncollected wastes and livelihoods dependent on intensive water-based processing. Secondly, the breeding habitats operate within a neighbourhood scale, which is the reason why studies focused at household levels might miss them and why behavioural change at household levels will not eliminate them. Thirdly, the institutional response has been slanted towards approaches working against adult vectors and personal protection measures while the instruments which should be used to address breeding habitats have been fragmented among various sectors which do not consider themselves responsible for malaria.

The water-storage paradox incorporates all these aspects. It starts with a systemic flaw in the public water supply system, continues with the practice of water storage by households, results in breeding habitats in compounds and ends up being an inter-sectoral issue falling under the jurisdictions of the water, health sectors and local government institutions.

6. Policy Implications and Recommendations (RQ5)

Given that the mere existence of mosquitoes in the vicinity of people serves as an indicator of the failure of environmental sanitation programmes, as Olagunju [35] contends, then a corresponding policy should incorporate sanitation facilities, just like vector-related solutions. The suggestions listed below arise from the analysis rather than from generally accepted best practices and each is geared towards addressing a particular cause-and-effect relationship.

- 1) Treat larval habitat reduction as a municipal service, not a supplementary health intervention. Drain maintenance, removal of water-holding waste and inspection of compounds should be funded as recurrent local government functions and linked explicitly to malaria targets. The 0.6% budget share for larval source management in the 2021 to 2025 strategic plan should be revisited in the successor plan, with costing that includes local government environmental health services rather than larvicide procurement alone.
- 2) Recognise water supply as vector control. Every increase in reliable piped supply reduces the need for prolonged household storage. In the interim, programmes should distribute well-fitting container lids and promote tight-lidded storage, building on the Abeokuta evidence that covered storage of tap water was not associated with infection [22].

- 3) Bring development control into malaria policy. State planning and building-control agencies should require that construction pits and borrow pits be fenced, drained or backfilled within a set period, and abandoned sites should be subject to enforcement. Construction pits were among the most *Anopheles*-productive habitats observed in Kaduna [3].
- 4) Integrate solid waste and vector programmes. Waste agencies should monitor unregulated dumpsites, particularly those in borrow pits and drainage channels, and formally include waste pickers, who are willing to participate but largely unprotected [14].
- 5) Link flood forecasting to malaria operations. NIHSA's annual flood outlook identifies at-risk local government areas months ahead. State malaria programmes could use it to pre-position larviciding, net distribution and case-management supplies, and to schedule larval surveys in the weeks after flood recession, when breeding habitat peaks.
- 6) Use existing community institutions to solve the collective-action problem. The National Health Act 2014 makes ward and village health committees part of the National Health System [18]. These committees are a ready vehicle for organised, resourced and non-punitive neighbourhood sanitation days, drain-clearing rosters and habitat mapping, scheduled weekly during the rains rather than monthly, to match the larval cycle [36]. Communities in the corpus favoured equipment and organisation over fines [14].
- 7) Engage farmers and food processors, especially women. Agricultural extension and women's cooperatives can promote covered soaking containers, managed disposal of cassava peel and drainage of fermentation runoff, framed as improvements to processing rather than as additional health chores [34].
- 8) Measure exposure at the right scale. Researchers and programmes should assess stagnant water at neighbourhood or street level, using transect walks, habitat mapping and spatial analysis, rather than relying only on household self-report.

From the point of comparative experience, such responsibilities can be enshrined in sector policies. For instance, the 2025 national water, sanitation and hygiene (WASH) policy of Bangladesh provides that stormwater drainage should fall under the prevention of floods and waterlogging as part of urban sanitation [26]. The sanitation policy of Nigeria has most of the required language. The problem is not one of developing the policies but implementing them.

7. Limitations and Future Research

This review is based on secondary sources both grey and published literature, and is limited to what is mentioned in these sources. Geographic distribution is not even as shown in Section 5.5, and no research done in the North Central region

meets the inclusion criteria. Empirical studies used are mostly cross sectional with self-reported exposures, which limits causal inference. Some of the research has been published in journals that do not specify whether the process is peer reviewed or not. One of the larger urban studies, by Agi et al. [3], describes itself as preliminary in nature, and the time period for collecting data extends past the issue date. Thus, there is a need for caution while interpreting its figures. The limitation to English language sources may have missed important local literature. The comparative studies from other African countries were identified through targeted rather than systematic searches.

Future studies should confront this regional discrepancy by employing mixed methods approaches in the North Central and North West regions, which combine larval counts with household and institution data. Needed are studies that record stagnant water in the neighbourhood level and trace communities during the periods of flooding. Studies in implementation of community-based habitat management via ward health committees and the impact of improved water sources on water storage practices and larval counts can serve to test the key arguments made in this review. Lastly, institutional ethnographies of local government environmental health departments can reveal why the sanitation tools available in name alone remain unused.

8. Conclusion

Standing water is the proximate cause for mosquitoes breeding; however, it is not the ultimate cause. The Nigerian literature presented here indicates that the most productive mosquito breeding sites are those created by people and institutionalized by an environment in which there is inconsistent supply of water leading to storage of water by people, drainage constructed and left to stagnate, construction activities that lead to waste and unmanaged environments, livelihoods dependent on intensive water-based processing and a policy environment that for long has regarded sanitation as a personal household matter. This situation is worse in poor rural and unplanned environments while the research meant to inform action is concentrated where the burden is lightest.

Management systems that operate solely on adults and personal protection shall continue to face regeneration of breeding grounds every rainy season. This approach based on sociology shall see habitat reduction become an issue of public infrastructure, water supply as a method of vector control, and the need for organized community involvement an institutional duty rather than a function of individual benevolence. The country of Nigeria has most of the tools in place to make it happen.

Abbreviations

AJOL	African Journals Online
FGD	Focus Group Discussion
FMWR	Federal Ministry of Water Resources
JB	Joanna Briggs Institute
KAP	Knowledge, Attitudes and Practices
<i>kdr</i>	Knockdown Resistance
KII	Key Informant Interview
NE	North East
NEMA	National Emergency Management Agency
NIHSA	Nigeria Hydrological Services Agency
NiMet	Nigerian Meteorological Agency
NMEP	National Malaria Elimination Programme
NMIS	Nigeria Malaria Indicator Survey
NW	North West
P4H	Providing for Health
PCA	Principal Component Analysis
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
RDT	Rapid Diagnostic Test
RQ	Research Question
SDH	Social Determinants of Health
SE	South East
<i>s.l.</i>	<i>sensu lato</i>
<i>s.s.</i>	<i>sensu stricto</i>
SS	South South
SW	South West
WASH	Water, Sanitation and Hygiene
WHO	World Health Organization
WHO AFRO	World Health Organization Regional Office for Africa

Author Contributions

Hussaini Ibn Mohammed: Conceptualization, Formal Analysis, Methodology, Project administration, Supervision, Writing – original draft, Writing – review & editing

Aishatu Umar Dahiru: Data curation, Investigation, Validation, Writing – review & editing

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Conflicts of Interest

The authors declare no conflicts of interest.

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