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# Environmental and Public Health Impacts of Seasonal Flooding: A Cross-Sectional Household Survey in Katagum LGA, Bauchi State, Nigeria

Rasaq Olakunle Omotayo[1,*], Hussaini Magaji Adamu[2],

[1,2] *Department of Environmental Health Sciences, Federal University of Health Sciences, Azare, Nigeria* [*] *Corresponding author's email: rasaq.omotayo@fuhsa.edu.ng*

## Abstract

**Background:** Seasonal flooding is a recurring environmental hazard in northern Nigeria, frequently disrupting water supply systems, sanitation infrastructure, and agricultural livelihoods. However, empirical data linking flooding to environmental degradation and community health outcomes in Bauchi State remain limited. **Methods:** The study used a cross-sectional mixed-methods design, conducted in five flood-prone communities in Katagum LGA. A total of 420 households were surveyed using structured questionnaires. Environmental observations and retrospective health facility records from three primary health centers were analyzed to examine changes in disease patterns during flood periods. Descriptive statistics and comparative analysis of pre-flood and flood-season disease incidence were performed. **Results:** Fifty-eight percent (58%) of households reported compound or household inundation during the last rainy season. Sixty-four percent (64%) experienced contamination of drinking water sources, while thirty-eight percent (38%) reported latrine overflow. Health facility records indicated a 39% increase in acute watery diarrhea cases and a 28% rise in malaria incidence during flood months. Approximately 47% of farming households reported significant crop loss. **Conclusion:** Seasonal flooding in Katagum significantly affects environmental sanitation, drinking water quality, and infectious disease transmission. Strengthening flood-resilient WASH infrastructure and improving disease surveillance systems are critical for reducing flood-related health risks in the region.

**Keywords:** Flooding; Katagum; Bauchi State; Environmental Health; Seasonal Floods

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## Introduction

Seasonal flooding has become a recurring environmental hazard in many parts of the world, particularly in developing countries where rapid population growth, inadequate drainage infrastructure, and climate variability increase community vulnerability. Flooding occurs when water overflows onto land that is normally dry as a result of heavy rainfall, river overflow, or poor drainage systems. In recent years, the intensity and frequency of flooding have increased due to climate change and extreme weather events, making floods one of the most destructive natural disasters affecting both the environment and public health. Across many African countries, seasonal floods disrupt livelihoods, damage infrastructure, and expose communities to serious health risks Aggarwal et al., 2026; Alderman et al., 2022.

In Nigeria, seasonal flood episodes have increased in frequency and intensity over the last decade due to a combination of climatic variability and anthropogenic drivers Umar, 2023. The northeastern states, including Bauchi State, regularly experience flash and riverine floods that damage infrastructure, compromise water and sanitation systems, and precipitate communicable disease outbreaks Charnley et al., 2022; Suhr, 2022. Recent assessments indicated that Katagum LGA was among the Bauchi local government areas heavily affected during recent flood events (September–October 2024), with thousands of individuals displaced and farmland inundated.

Floods affect health both directly (e.g., drowning and injury) and indirectly (e.g., contamination of water supplies, disruption of sanitation and health services, and food insecurity) Olanrewaju et al., 2019; Suhr, 2022. In Nigeria, flood-related contamination of drinking water and the subsequent rise in acute watery diarrhea and cholera have been repeatedly documented Onwunta, 2025; Reuters, 2024. In addition, stagnant water following floods increases mosquito breeding habitats, often followed by heightened malaria transmission Oluka, 2022. These health outcomes disproportionately affect children, pregnant women, elderly persons, and low-income households who lack the capacity to adapt or relocate UNICEF, 2024.

Despite growing evidence on flood-related health risks in Nigeria, most studies have focused on large urban centres or national-scale disaster reports. Empirical community-level assessments that combine household environmental data with health facility records remain limited, particularly in northeastern Nigeria. In Bauchi State, few studies have quantified both environmental damage and associated public health outcomes following seasonal flooding. This study therefore provides a localized assessment of environmental degradation and health risks associated with flooding in Katagum LGA.

## Methods

### Study Design

A cross-sectional mixed-methods design was adopted to capture both quantitative measures of flood exposure and qualitative community experiences. This design is appropriate for rapid environmental health assessments in disaster-affected settings.

### Study Area

The study area is located in the northern part of Bauchi State in northeastern Nigeria. Geographically, the area lies approximately between latitude 11°30′N and 12°00′N, and longitude 10°00′E and 10°30′E. The Local Government Area (LGA) has an estimated population of approximately 295,000 people based on projections from the 2006 national census. The region lies within the Sudan Savannah ecological zone and experiences a tropical wet and dry climate, with an average annual rainfall of 700–900 mm concentrated between June and September. Temperatures are typically high throughout the year, ranging between 25°C and 35°C. The dry season is often accompanied by the Harmattan winds, a dry and dusty wind originating from the Sahara Desert. Seasonal rivers and low-lying floodplains characterize the landscape, making many settlements vulnerable to periodic flooding during peak rainfall months. The local economy is predominantly agrarian, with rice, maize, millet, and vegetable cultivation forming the primary livelihoods of rural households.

### Study Population and Sampling

The study population comprised households in five flood-prone communities within Katagum LGA: Azare, Bacciri, Chinade, Dahuwar Kura, and Dugunde. Using a ±5% margin of error and an estimated flood-exposure prevalence of 50% (to ensure maximum sample size), a total of 420 households were surveyed. This sample size permits subgroup analyses by community and household characteristics. A multistage sampling technique was employed. First, five flood-prone communities were purposively selected based on local disaster reports. Within each community, systematic random sampling was used to select households from community listings. Every fifth household was selected until the required sample size was reached. For health trends, three primary health facilities serving the study communities were included in a two-year retrospective review of monthly cases of key syndromes: acute watery diarrhea (AWD), suspected cholera, malaria, and acute respiratory infections. Sample size was calculated using Cochran's formula for cross-sectional studies, assuming a 50% prevalence, 95% confidence level, and 5% margin of error.

### Data Collection

A structured household questionnaire was used for data collection. In addition, facility capacity indicators (e.g., number of beds and water supply disruptions) were obtained from three selected Primary Health Care facilities within the study area. The questionnaire was pretested among 30 households in a neighboring community not included in the study. Feedback from the pilot survey was used to refine question wording and improve clarity.

### Ethical Considerations

Ethical approval was obtained from the Research Ethics Committee of the Federal University of Health Sciences, Azare via the approval letter: FUHSA/REC/2025/0214. Written informed consent was obtained from all participants prior to data collection.

### Data Analysis

Data were analyzed using descriptive statistics, including frequencies and percentages. Comparisons of pre- and post-flood monthly health counts were computed as percentage change. Associations between flood exposure and reported illness outcomes were examined using correlation analysis. Statistical significance was set at $p < 0.05$.

## Results

### Socio-demographic and Household Characteristics

A total of 420 households (2,430 individuals) across five communities were included in the study. The mean household size was 5.8 (SD = 1.9). Primary livelihoods included crop farming (78%), petty trading (12%), and artisanal fishing/livestock (10%).

Main sources of water were shallow wells (42%), hand-dug wells (18%), boreholes with hand pumps (22%), and surface water/streams (18%). Regarding sanitation, 61% of households used traditional pit latrines, 26% reported practicing open defecation at some time, and 13% used improved latrines.

### Extent of Flooding and Environmental Damage

A total of 243 households (58.0%) reported inundation of their compound and/or home at least once during the last rainy season. Community-level variation ranged from 46% (Community B) to 71% (Community D). The median maximum water depth within compounds was 0.45 m (IQR: 0.25–0.80 m), while the median duration of overtopping was 4.5 days (IQR: 2–10 days).

Farming households reported substantial crop losses, with many exceeding 30% of expected yield. Approximately 22% reported near-total loss ($>$ 75%), particularly in low-lying rice paddies. The average estimated agricultural income loss per affected household was NGN 86,500 (≈ USD 110 at the time of drafting).

Field observations indicated that 64% of households reported changes in taste, appearance, or visible contamination of water sources following flood events. However, only 28% reported consistently treating drinking water (e.g., boiling or chlorination) after flooding. Additionally, 38% of households reported latrine flooding or overflow at least once during the season, contributing to increased open defecation and heightened risk of water contamination.

### Health Outcomes (Facility Records)

Health facility records from three primary health facilities were reviewed over a 24-month period.

The average monthly cases of acute watery diarrhea (AWD) increased from a pre-flood mean of 62 cases to 86 cases during flood months, representing a 39% increase. Facilities reported sporadic suspected cholera alerts during peak flooding, with a total of seven suspected cases recorded across the three facilities (0–1 per facility); none were laboratory-confirmed at the time of data collection.

Malaria outpatient visits increased from a pre-flood average of 410 cases per month to 525 cases during and immediately after flood periods, representing a 28% increase. Acute respiratory infection (ARI) visits showed a modest increase of 12%, possibly associated with damp housing conditions and displacement into temporary shelters.

### Household-reported Illnesses, Displacement, and Sheltering

Within 30 days following flooding, 31% of households reported at least one member with diarrhea, 44% reported febrile illness consistent with malaria, and 15% reported skin infections or rashes.

Regarding displacement, 11% of households experienced temporary displacement, with a mean duration of 9 days. Displaced households often stayed with relatives or in improvised shelters with limited sanitation facilities. Overcrowding in such settings increased the risk of communicable disease transmission and contributed to psychosocial stress.

**Table 1:** Socio-demographic and Household Characteristics of Respondents ($n = 420$)

| Characteristic | Frequency ($n$) | Percentage (%) |
|---|---|---|
| **Communities Surveyed** | | |
| Azare | 120 | 28.6 |
| Bacciri | 80 | 19.0 |
| Chinade | 90 | 21.4 |
| Dahuwar Kura | 75 | 17.9 |
| Dugunde | 55 | 13.1 |
| **Primary Livelihood** | | |
| Crop farming | 327 | 78.0 |
| Petty trading | 50 | 12.0 |
| Artisanal | 8 | 2.0 |
| Fishing/Livestock farming | 35 | 8.0 |
| **Main Water Sources** | | |
| Shallow wells | 176 | 42.0 |
| Hand-dug wells | 76 | 18.0 |
| Boreholes with hand pumps | 92 | 22.0 |
| Surface water/streams | 76 | 18.0 |
| **Sanitation** | | |
| Traditional latrine | 256 | 61.0 |
| Open defecation | 109 | 26.0 |
| Improved latrines | 55 | 13.0 |
| **Total** | 420 | 100.0 |

## Correlation Analysis

Pearson's correlation analysis was conducted to assess the relationship between flood exposure and reported illness outcomes. The results demonstrated a very strong positive correlation ($r = 0.989$), indicating that higher levels of flood exposure were associated with increased reported illness outcomes.

This relationship was statistically significant ($p = 0.001$), which is below the predetermined significance level of 0.05. Therefore, the null hypothesis of no association between flood exposure and reported illness outcomes was rejected.

**Table 2:** Extent of Flooding and Environmental Damage Among Households ($n = 420$)

| Items | Frequency ($n$) | Percentage (%) |
|---|---|---|
| **Household Inundation** | | |
| Yes | 243 | 58.0 |
| No | 177 | 42.0 |
| **Flood-related Damage** | | |
| Crop loss | 126 | 30.0 |
| Near-total loss of vulnerable plots | 84 | 20.0 |
| Loss of economic trees | 147 | 35.0 |
| Damage to houses and properties | 63 | 15.0 |
| **WASH Impacts** | | |
| Change in taste/appearance of water | | |
| Yes | 161 | 64.0 |
| No | 91 | 36.0 |
| Treating water before use | | |
| Yes | 71 | 28.0 |
| No | 181 | 72.0 |
| Latrine overflow due to flooding | | |
| Yes | 96 | 38.0 |
| No | 156 | 62.0 |
| **Total** | 420 | 100.0 |

**Table 3:** PFM & FM Facility Health Outcomes ($n = 3$ facilities)

| Syndrome | PFM (per month) | FM (per month) | % Change |
|---|---|---|---|
| AWD | 62 | 86 | +39% |
| Malaria | 410 | 525 | +28% |
| ARI | 145 | 162 | +12% |

*Note:* AWD = Acute watery diarrhea; ARI = Acute respiratory infection; PFM = Pre-flood mean; FM = Flood mean. Source: Field Survey, 2025.

**Table 4:** Household-reported Illness, Displacement, and Sheltering ($n = 420$)

| Items | Frequency ($n$) | Percentage (%) |
|---|---|---|
| **Household-reported Illness** | | |
| Diarrhea | 130 | 31.0 |
| Malaria | 185 | 44.0 |
| Skin infection | 63 | 15.0 |
| Typhoid | 42 | 10.0 |
| **Displacement and Sheltering** | | |
| Yes | 46 | 11.0 |
| No | 374 | 89.0 |
| **Total** | 420 | 100.0 |

## Discussion

The socio-demographic findings indicate that the majority of households depend on crop farming, representing 78% of respondents, while petty trading and artisanal activities account for smaller proportions. This pattern reflects the rural agrarian structure typical of many communities in northern Nigeria. The high dependence on agriculture also explains the significant crop losses recorded during the flood period.

Household water supply patterns show that 42% of respondents rely on shallow wells and 18% on surface water sources, both of which are highly susceptible to contamination during flooding events. Similar patterns of water source vulnerability have been reported in rural Nigeria. For instance, shallow wells and surface water sources are frequently contaminated following flooding, increasing the risk of diarrheal diseases Oloruntoba et al., 2014.

Sanitation conditions also present a significant public health concern. The findings show that 61% of households use traditional pit latrines, while 26% practice open defecation. During flood events, pit latrines can overflow, facilitating the spread of fecal contaminants into surrounding water bodies and residential environments.

The results further indicate that 58% of households experienced inundation during the last rainy season, highlighting flooding as a frequent and significant hazard in the study communities. Substantial crop losses were reported, with many farmers losing more than 30% of expected yields, and approximately 22% experiencing near-total crop failure in vulnerable low-lying farmlands. The estimated agricultural income loss of NGN 86,500 per affected household underscores the economic burden associated with flood disasters. Comparable findings have been reported in other flood-affected regions of Nigeria, where flooding has been shown to cause extensive crop destruction and soil degradation Ezenwaji, 2018. Floodwaters also contribute to topsoil erosion and sediment deposition, which reduce soil fertility and disrupt irrigation systems.

Findings from this study further show that 64% of households observed changes in water taste or appearance following flood events, indicating probable contamination of water sources. Floodwaters often transport debris, organic matter, and waste into drinking water supplies, thereby increasing the likelihood of microbial contamination. Despite these risks, only 28% of households reported treating drinking water prior to consumption, suggesting limited awareness or access to safe water treatment methods.

Similar low adoption of water treatment practices has been documented in rural communities across sub-Saharan Africa. Flooding significantly increases the risk of water contamination in communities that depend on shallow wells and surface water sources UNICEF, 2022. This situation is further exacerbated by inadequate sanitation infrastructure. The study revealed that 38% of households experienced latrine flooding or overflow during the rainy season. Such conditions facilitate the spread of pathogens into surrounding soil and water bodies, increasing the risk of diarrheal diseases and cholera outbreaks. Consistent with this finding, previous studies have shown that flooding increases fecal contamination in household environments, particularly in low-income settings Brown et al., 2015.

Health facility records show that cases of acute watery diarrhea increased by 39% during flood periods. This finding is consistent with global evidence linking flooding with outbreaks of waterborne diseases. Floodwaters often contaminate drinking water sources and disrupt sanitation systems, thereby facilitating the transmission of diarrheal pathogens. Previous research has demonstrated that flooding significantly increases the incidence of diarrheal diseases due to exposure to contaminated water and poor sanitation conditions Cann et al., 2013. The observed increase in diarrhea cases in this study therefore supports existing epidemiological evidence.

Malaria cases increased by 28% during the flood period. Flooding often creates stagnant water pools that serve as breeding sites for mosquitoes, leading to increased vector density and subsequent malaria transmission. This finding is consistent with studies conducted in tropical regions, which have shown that standing water associated with flooding significantly enhances mosquito breeding habitats and malaria transmission Lindsay et al., 2019.

Household survey results also revealed high levels of illness following flooding. Approximately 31% of households reported cases of diarrhea, while 44% reported symptoms consistent with malaria. Skin infections and typhoid fever were also reported by some households. These findings align with existing literature on the public health consequences of floods. Flood events have been shown to increase the risk of waterborne, vector-borne, and skin infections due to exposure to contaminated water and poor hygiene conditions Centers for Disease Control and Prevention, 2023.

Displacement was experienced by 11% of households. Although this proportion appears modest, the impact on affected households can be substantial. Temporary displacement often results in overcrowded living conditions with limited access to sanitation facilities, thereby increasing the risk of infectious disease transmission.

The Pearson correlation analysis demonstrated a very strong positive association between flood exposure and reported illness outcomes ($r = 0.989$, $p = 0.001$). This indicates that higher levels of flood exposure were significantly associated with increased illness outcomes among affected households. The strength and statistical significance of this relationship suggest that flood exposure is an important determinant of health risk in the study setting.

### Limitations of the Study

This study has some limitations. First, reliance on self-reported illness data may be subject to recall bias and misclassification. Second, there was no laboratory confirmation of suspected cholera cases, which limits the ability to definitively attribute outbreaks to specific pathogens.

### Future Research

Future studies should adopt longitudinal designs to better capture temporal relationships between flooding and health outcomes. In addition, the use of Geographic Information System (GIS) mapping is recommended to improve spatial analysis of flood patterns and associated health risks.

## Conclusion and Recommendations

This study demonstrates that seasonal flooding in Katagum LGA produces interconnected environmental and public health risks, particularly through contamination of water sources, disruption of sanitation systems, and increased vector breeding. Addressing these risks requires integrated flood management strategies that combine infrastructure improvements with strengthened community health surveillance systems.

To mitigate these risks, the following priority actions are recommended:

1. Emergency chlorination of wells and boreholes during flood periods, given the high likelihood of water source contamination.

2. Prioritization of flood-resilient sanitation facilities, considering that 38% of latrines experienced overflow during the study period.

3. Improvement of drainage infrastructure and enforcement of floodplain zoning policies.
4. Strengthening of Water, Sanitation, and Hygiene (WASH) resilience programs within affected communities.
5. Enhancement of disease surveillance and rapid response systems through capacity building at primary health care centers.

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## Authors' Contributions

All authors contributed substantially to the conception and design of the study. Rasaq Olakunle Omotayo conceptualized the study, developed the methodology, supervised data collection, conducted data analysis, and drafted the initial manuscript. Hussaini Magaji Adamu contributed to study design, data interpretation, literature review, and critically revised the manuscript for important intellectual content. Both authors read and approved the final version of the manuscript and agreed to be accountable for all aspects of the work.

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## Conflict of Interest Statement

The authors declare that there are no conflicts of interest regarding the publication of this paper. The research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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