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Strengthening disaster preparedness and health security in Niger state, Nigeria through a WHO STAR–based multi-hazard risk assessment

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1   **Strengthening Disaster Preparedness and Health Security in Niger**
2   **State, Nigeria through a WHO STAR–Based Multi-Hazard Risk**
3   **Assessment**

4

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20

21   **Abstract**

22   Niger State in central Nigeria faces a range of natural, biological, and security
23   hazards. To inform preparedness and health security planning, a multi-hazard
24   risk assessment was conducted using WHO's Strategic Tool for Assessing Risks
25   (STAR), this is one of the first applications of WHO STAR at a state level in
26   Nigeria. A cross-sectional study was conducted using the WHO STAR.
27   Stakeholders involved identified hazards across natural, biological,
28   technological, and societal domains through review of surveillance, disaster, and
29   meteorological data. Hazards were scored for likelihood, impact, vulnerability,
30   and coping capacity, with composite risk indices used to rank and categorize
31   them. Priority hazards were further analysed for seasonality and geographic

32 distribution, and findings validated through consensus. Eighteen major hazards
33 were identified, spanning biological, environmental, and societal. Seven hazards
34 emerged as very high risk, notably flooding, banditry/kidnapping. Six were high
35 risk (e.g. fire outbreaks), four moderate (e.g. acute flaccid paralysis), and one low
36 risk (diphtheria). Six hazards showed clear seasonal patterns. Priority hazards
37 were further examined for geographic distribution and validated through
38 consensus. The STAR assessment produced an evidence-based risk profile
39 highlighting flooding, banditry/kidnapping, boat mishaps, cholera, and
40 rain/windstorms as the most critical hazards. Actionable recommendations were
41 developed to support preparedness, mitigation, and response efforts across
42 sectors. The findings offer a structured basis for strengthening disaster risk
43 governance and can inform the development and implementation of Niger state's
44 emergency preparedness plans.

45 **Keywords:** Disaster risk reduction, preparedness, hazards, WHO STAR, Niger
46 state.

47

48 **Introduction**

49 Disaster risk reduction (DRR) is a key component of sustainable development and
50 global health security, which seeks to reduce the negative impacts of hazards on
51 people, infrastructure, and economies **[1]**. Global frameworks, such as the Sendai
52 Framework for Disaster Risk Reduction 2015-2030, highlight four priorities:
53 understanding disaster risk, strengthening disaster risk governance, investing in
54 disaster risk reduction for resilience, and enhancing disaster preparedness for
55 effective response and "build back better" in recovery, rehabilitation, and
56 reconstruction **[2]**. These priorities are interrelated, and their success depends
57 on governments and communities' abilities to identify and address the core
58 causes of vulnerability while increasing resilience across sectors **[1]**. In low- and
59 middle-income countries (LMICs), disasters frequently worsen already existing
60 socioeconomic inequities, impair health systems, and disrupt livelihoods **[3]**. The
61 impacts of these disasters are made worse by weak infrastructure, insufficient
62 early warning systems, and insufficient inter-sectoral coordination **[4]**. As a
63 result, the capacity to undertake thorough multi-hazard risk assessments, which
64 incorporate several hazard categories and their interconnections, is crucial for
65 decreasing disaster-related losses **[5]**.

66 Nigeria presents a multifaceted hazard landscape that includes climate,
67 environmental, biological, and human-caused threats. Environmental risks such
68 as flooding, drought, erosion, and windstorms interact with biological risks such
69 as Lassa fever, cholera, and cerebrospinal meningitis (CSM), creating
70 multilayered risks **[6]**. Niger State, in Nigeria's North Central region, is
71 particularly vulnerable due to its wide river systems, agricultural economy, and
72 different biological zones **[7]**. The Niger and Kaduna rivers, as well as other
73 tributaries, increase flood risk, especially during the peak rainy season **[8]**. Rain-
74 fed agriculture leaves the local economy extremely vulnerable to seasonal
75 variation and major weather disasters **[9]**. Furthermore, the state's porous
76 security environment exacerbates displacement, reduces agricultural output, and
77 impedes disaster response efforts **[10]**. Despite this vulnerability, existing DRR
78 programs in the state have frequently been hazard-specific, missing the
79 comprehensive viewpoint required for holistic preparedness.

80 A comprehensive multi-hazard risk assessment framework is required for
81 identifying priority risks, mapping their spatial and temporal patterns, and
82 efficiently allocating resources **[11]**. Traditional risk assessments in Nigeria have
83 frequently concentrated on single hazards, ignoring the cumulative and
84 cascading consequences that result when numerous hazards occur concurrently
85 or sequentially **[12]**. For example, severe rains may cause floods, facilitating
86 cholera outbreaks while also hindering access to hospitals and markets **[13]**. The
87 World Health Organization's Strategic Tool for Assessing Risks (WHO STAR)
88 offers a structured approach for integrating hazard identification, likelihood
89 estimation, impact assessment, and capacity evaluation into a unified procedure.
90 STAR stresses inclusivity, multi-sectoral collaboration, and evidence-based
91 prioritizing, making it well-suited for subnational contexts with varying hazard
92 profiles. It has been used in both high- and low-resource contexts to aid in
93 planning for epidemics, natural disasters, and complex situations **[14]**.

94 Despite Niger State's exposure to a variety of risks, no previously published study
95 has used the STAR methodology to create an integrated risk assessment for the
96 state. Previous studies have focused on epidemiological surveillance for certain
97 diseases **[15, 16]** or environmental hazard mapping in flood-prone areas **[8, 17].**
98 These walled approaches impede decision-makers' ability to plan for concurrent
99 risks or coordinate responses across sectors. Furthermore, the absence of a
100 unified, evidence-based hazard prioritization process impedes resource

101 allocation and undermines resilience-building. By applying the STAR tool, this
102 study seeks to fill that gap, providing a replicable model for other Nigerian states
103 and similar contexts. The assessment engages stakeholders from multiple
104 ministries, departments, and agencies (MDAs) in Niger state, alongside technical
105 partners, thereby fostering inter-sectoral ownership of both the process and its
106 outputs.

107 The overall aim of this study was to improve disaster risk management in Niger
108 state using the WHO STAR tool, hence increasing preparedness, resilience, and
109 evidence-based decision-making. Specific objectives were to:

110 1. Conduct a full multi-hazard risk assessment in Niger state, Nigeria, using the
111 WHO STAR tool to identify potential hazards and vulnerabilities.

112 2. Prioritize hazards based on their likelihood and impact to guide resource
113 allocation and planning.

114 3. Provide recommendations to support preparedness planning based on
115 prioritized hazards.

116 **Methods**

117 ***Study Design***

118 This study employed a cross-sectional design using the World Health
119 Organization (WHO) Strategic Tool for Assessing Risks (STAR) to identify,
120 analyse, and prioritize hazards across biological and non-biological domains. The
121 STAR tool is a standardized framework designed to help identify, analyse, and
122 prioritize multi-hazard risks **[14]**. The tool uses both quantitative and qualitative
123 methodologies to assess hazards based on their chance of occurrence, possible
124 impact, susceptibility of impacted populations, and institutions' ability to cope
125 and respond. The assessment was carried out throughout a five-day workshop in
126 Minna, Niger State, from May 13 to 17, 2025, organized by Sydani group in
127 partnership with Nigeria Centre for Disease Control and Prevention (NCDC) with
128 technical support from the Niger state Ministry of Health and the Niger state
129 Emergency Management Agency.

130 ***Description of the WHO STAR And its Components***

131 The World Health Organization's (WHO) Strategic Tool for Assessing Risks
132 (STAR) is a comprehensive risk assessment system that helps identify, analyse,

133   and prioritize potential hazards and risks. The tool offers a systematic and
134   standardized risk assessment approach, allowing for the development of
135   evidence-based risk reduction and management solutions.

136   The study used the WHO STAR to conduct a complete multi-hazard risk
137   assessment in Niger State, Nigeria. The tool was used to help identify, analyse,
138   and prioritize potential hazards and risks in the state. The WHO STAR consists of
139   several key components including:

140   1. Hazard Identification: Participants listed potential hazards likely to trigger a
141   state-level response across four domains: natural, biological, technological, and
142   societal. These hazards were identified by stakeholders, literature review,
143   available data, and expert opinions.

144   2. Risk Analysis: A standardized matrix was used to assess the likelihood and
145   potential impact of identified hazards using historical occurrence, predictive
146   data, and expert judgment.

147   3. Risk Prioritization: The study team selected detected hazards based on
148   likelihood, potential impact for public health, infrastructure, economy, and
149   environment, to focus on the most critical ones.

150   4. Capacity Assessment: Policy, institutional, and technical risk management
151   capacities were evaluated to identify gaps.

152   5. Risk Management Options: Risk management options were identified and
153   assessed, including preventive, preparedness, response, and recovery measures.
154   The acquired data were analysed and interpreted using the WHO STAR tool's
155   standard framework. The risk assessment results were utilized to help develop
156   suggestions for risk reduction and management measures in Niger State.

157   The detailed methodological workflow is presented in **Figure 1**.

158   *The STAR Methodology*

159   The STAR methodology guides countries and subnational levels through a
160   structured process for understanding and prioritizing public health risks. The tool
161   relies on multi sectoral expertise, facilitated discussions, and a standardized
162   scoring criteria. The steps summarize how the methodology works, aligned with
163   the six steps of carrying out a strategic risk assessment.

164   *Step One: Identification of the Hazards*

165 The first step is to identify the hazards that may affect or have affected the
166 country/state. During the workshop, participants validated and refined the list of
167 hazards by drawing on their knowledge of past events, sector-specific
168 information, and data available. This helps ensure that all relevant hazards
169 (natural, biological, technological, and societal) are included before scoring
170 begins.

171 *Step Two: Evaluation of Likelihood*

172 Once the hazards have been identified and confirmed, stakeholders worked in
173 small groups to score how likely each of the mentioned hazards occur. The
174 scoring is guided by predefined criteria in the STAR tool, supported by historical
175 data, routine surveillance, and expert judgement. Group discussions help ensure
176 that likelihood scores reflect shared understanding rather than individual
177 opinions **(Table 1)**.

178 **Table 1: Overview of likelihood assessment categories in the STAR**
179 **approach**

Level	Description
Almost certain	It is likely that the hazard will occur in the next 12 months in most circumstances (e.g., probability of 95% or more).
Very likely	It is likely that the hazard will occur in the next 12 months in most circumstances (e.g., a probability of between 70% and 94%).
Likely	The hazard could occur in the next 12 months some of the time (e.g., a probability of between 30% and 69%).
Unlikely	The hazard could occur in the next 12 months some of the time (e.g., a probability of between 5% and 29%).
Very unlikely	The hazard could occur in the next 12 months under exceptional circumstances (e.g., a probability of less than 5%).

180

181 *Step Three: Determination of the Impact*

182   After scoring the likelihood, participants then assessed the potential impact
183 associated with each hazard. This includes considering population exposure,
184 health system capacity, infrastructure, social conditions, and the ability of
185 services to cope if the hazard occurs. Severity, vulnerability, and coping ability
186 are factors which are evaluated independently, and the findings are then used to
187 determine the hazard's projected impact. The vulnerability criteria in the STAR
188 worksheets structure these discussions, and groups assign scores based on
189 consensus. After the severity, vulnerability and coping capacity scores are
190 determined, the tool automatically calculates the impact score using the formula:

191 Impact Score $= \frac{\text{Severity+vulnerability+coping capacity}}{3}$

192 The impact scoring criteria in the STAR methodology is presented in **Table 2**.

193 **Table 2: Impact Scoring Criteria in the STAR methodology**

Score	Impact Score
1	Negligible
2	Minor
3	Moderate
4	Severe
5	Critical

194

195 *Step Four: Determination of the Risk Level*

196 The likelihood and impact scores are entered into the STAR tool (a digital
197 software), which automatically calculates risk levels. This generates a clear risk
198 matrix showing which hazards fall into very high, high, medium, or low
199 categories. The tool also produces visual outputs such as charts and diagrams
200 that help participants interpret the results.

201 *Step Five: Finalization of the Risk Profile*

202 The scoring outputs are reviewed with participants to confirm accuracy. Any
203 inconsistencies or unclear scores are revisited through discussions. This
204 validation step ensures that the final risk profile truly reflects the collective
205 judgement of the subject matter expert stakeholders. The finalized profile
206 provides a structured picture of priority hazards and the factors driving their risk
207 levels.

208   *Step Six: Integration of Key Actions into Plans and Operations*

209   The final step involves using the prioritized hazards to guide preparedness and
210   planning. Participants identify the actions that need to be integrated into
211   emergency plans, sectoral strategies, and routine operations. This helps
212   governments and partners align resources, strengthen systems, and address the
213   risks that pose the greatest threat to the population.

214

Fig 1: STAR Methodology Steps
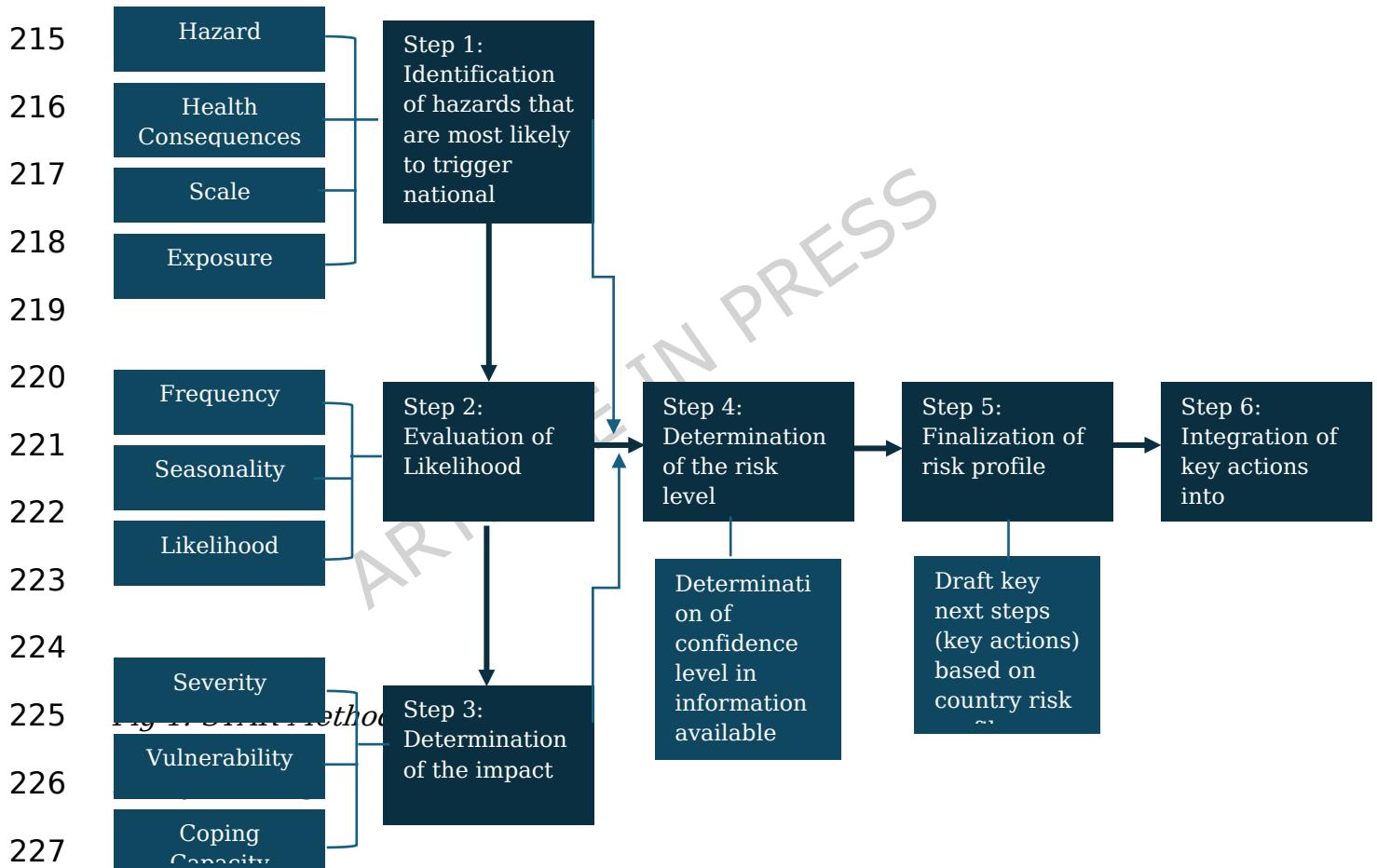
229   *Fig 1: STAR Methodology Steps*

230

231   **Study Setting**

232　Niger State, located in north-central Nigeria, is the country's largest state by
233　landmass (76,363 km²) and has a population of over six million people scattered
234　throughout 25 Local Government Areas **[18]**. Its terrain contains significant
235　rivers such as Niger and Kaduna, which makes it prone to flooding, while its
236　agrarian economy is heavily reliant on rainfall, making it subject to droughts and
237　climate variability. Furthermore, recurring insecurity (banditry and kidnapping)
238　and illness outbreaks (cholera, Lassa fever, and meningitis) heighten the state's
239　risk profile **[19]**.

240　The STAR assessment followed a structured timeline with a pre workshop
241　engagement two months before workshop. This involved advocacy visits to key
242　ministries and agencies, initial stakeholder identification, and planning meetings.
243　Identification of eligible institutions, confirmation of representatives, and
244　development of a sector balanced participant list was done one month to the
245　workshop. The workshop was held over a 5-day period from 13th to 17th of
246　May,2025.

247　***Stakeholder mapping***

248　Stakeholders were purposively selected by the research team using the WHO
249　STAR methodology to ensure broad representations from sectors relevant to
250　disaster risk management **[14]**. Stakeholders were selected from 38 Ministries,
251　Departments, and Agencies (MDAs) within Niger state, complemented by
252　national level experts from the Nigeria Centre for Disease Control (NCDC),
253　development partners, civil society organizations, and technical experts.
254　Selection criteria included institutional mandates and operational experience in
255　disaster risk management, health, environment, or security; at least three years
256　of operational or technical experience; direct involvement in emergency
257　response, surveillance or risk management, and ability to provide sector specific
258　perspectives during the assessment. In total the workshop had over 50
259　participants which included experts from the following organizations:

260　　☐　Public health: Niger State Ministry of Health, NCDC, WHO

261　　☐　Disaster management: Niger State Emergency Management Agency
262　　　　(NSEMA), Federal Road Safety Corps (FRSC), National Emergency
263　　　　Management Agency (NEMA)

264　　☐　Agriculture and environment: State Ministry of Agriculture, Forestry
265　　　　Commission

266 ☐ Security and law enforcement: Police, Civil Defence Corps

267 ☐ Infrastructure and planning: Ministry of Works, Urban Development
268 Authorities

269 ☐ Civil society organizations and community-based groups

270 See **Supplementary Material 1** for details. This multidisciplinary composition
271 ensured coverage of all major hazard domains.

Workshop preparation and training of Participants

273 Before the workshop, pre-workshop advocacy visits and planning meetings were
274 held with the Niger State Ministry of Secondary and Tertiary Health, Niger State
275 Ministry of Primary Health Care, Ministry of Environment, the Nigeria Centre for
276 Disease Control and Prevention (NCDC), and partners such as WHO and UNICEF.
277 These discussions ensured political support, established goals, and aligned
278 expectations.

279 Before data collection, participants got training on the STAR approach. The
280 training lasted half a day and included presentations on hazard typologies, the
281 STAR assessment process, and rating criteria for likelihood, impact,
282 susceptibility, and coping capacity. Practical activities and moderated group
283 discussions were utilized to increase familiarity with the tool and ensure uniform
284 application of scoring standards. The training was facilitated by technical officers
285 from Sydani Group and the NCDC who had previous experience applying STAR
286 at other subnationals. The training ensured that participants had a shared
287 understanding of the assessment framework and scoring expectations.

288

Data collection procedures

290 The assessment combined primary and secondary data sources.

291 *Primary data source*

292 A structured plenary and breakout group discussion was held with stakeholders
293 to identify and characterize hazards. Participants were grouped into three
294 groups, depending on the sectoral mandates (such as health, environment, and
295 security). Technical facilitators from Sydani group and NCDC provided expert
296 guidance on hazard classification and scoring.

297 During hazard identification, participants listed hazards likely to trigger a state
298 level response based on past experiences and available evidence. Facilitators
299 guided discussions to ensure clarity and confirm alignment with STAR definitions.
300 The groups rated the likelihood of each based on historical occurrence, frequency
301 patterns, and available surveillance or disaster records. Next, they scored impact
302 severity using STAR criteria that consider consequences for health, essential
303 services, infrastructure, and economy. After likelihood and impact scoring,
304 participants assessed vulnerability which reflects the degree to which
305 populations or systems can be harmed. Finally, coping capacity was scored by
306 evaluating existing preparedness measures, emergency response structures, and
307 institutional capabilities.

308 All scoring activities were moderated to ensure consistency and adherence to
309 STAR guidelines. After group scoring, the facilitators used iterative review and
310 voting to create consensus on hazards rankings and criteria. Results were
311 reviewed in plenary to reach an agreement. Discrepancies were resolved through
312 further discussion and reference to documented evidence.

313 *Secondary data source*

314 Secondary data provided context and supported evidence for scoring. A review
315 of relevant studies, academic literature, and official data on risks in Niger state
316 was conducted by a team of public health analysts, epidemiologists, and
317 environmental specialists who were part of the workshop participants. The
318 review covered the period from 2020 to 2024 and included national surveillance
319 data, state disaster records, meteorological reports, and peer reviewed
320 publications. Analysing this historical disaster data from state emergency
321 records, disease surveillance systems, and meteorological agencies helped
322 determine hazard frequency and seasonality. These secondary data were
323 obtained from the following sources;

324 ☐ Historical disaster records from NSEMA, NEMA, and the Niger state
325   ministry of health
326 ☐ Surveillance data from the Nigeria Centre for Disease Control (NCDC)
327 ☐ Meteorological data from the Nigerian Meteorological Agency (NiMET)
328 ☐ Published literature on disaster risk and resilience in Nigeria
329 ☐ UN, WHO, and IFRC reports on hazards and emergencies in Nigeria and
330   West Africa

331 The review team searched online databases such as PubMed, Google Scholar
332 using keywords related to flooding, cholera, drought, insecurity, and multi-hazard
333 risk.

334 **_Hazard Identification_**

335 Participants brainstormed and reviewed documents to create an initial list of
336 hazards relevant to Niger State. The hazards were grouped into four STAR
337 domains:

338   □ Natural hazards (e.g., floods, drought, rainstorms, lightning).

339   □ Biological hazards (e.g., cholera, Lassa fever, meningitis, measles, Acute
340   flaccid paralysis).

341   □ Technological hazards (e.g., industrial accidents, road traffic crashes, boat
342   mishaps).

343   □ Societal/security hazards (e.g., armed banditry, kidnapping, communal
344   conflict).

345 A total of 18 hazards were identified for further analysis.

346 Each hazard was assessed along four dimensions;

347 1. Likelihood of occurrence: Probability that the hazard will occur in the future,
348 based on historical trends, surveillance data, and expert opinion. This was scored
349 on a 5-point scale (1=very unlikely, 5=very likely).

350 2. Impact severity: Potential consequences on health, livelihoods, infrastructure,
351 and governance. This was scored on a 5-point scale (1=negligible, 5=
352 catastrophic)

353 3. Vulnerability: Degree to which populations, systems, and sectors are
354 susceptible to harm, considering socio-economic conditions, environmental
355 exposure, and resilience factors. This was scored qualitatively and ranked.

356 4. Coping Capacity: The ability of state institutions, communities, and systems to
357 prevent, prepare for, and respond to the hazard. This was scored qualitatively
358 and ranked.

359 Scores for likelihood and impact were multiplied to generate a risk index for each
360 hazard. Hazards were then categorized into four priority categories: _very high_
361 _risk, high risk, moderate risk, and low risk._

362   After individual scoring, facilitated plenary discussions were held to reach an
363   agreement. Hazards were put on a likelihood-impact matrix to help visualize
364   priority hazards. Vulnerability and coping capacity were then used to
365   contextualize the rankings. Hazards classified as very high risk were those with
366   both high probability and severe potential consequences, compounded by high
367   susceptibility and inadequate coping capacity.

368   To enhance operational relevance, hazards were further analysed for:

369   Seasonality: Participants mapped hazard occurrence against the calendar year,
370   producing a seasonal hazard calendar (e.g., flooding in July–September, cholera
371   peaks during the rainy season, meningitis in the dry season).

372   Geographic Distribution: Hazards were mapped by Local Government Areas
373   (LGAs), highlighting hotspots such as riverine LGAs (flooding, boat mishaps) and
374   northern LGAs (banditry).

375   The distribution and analysis of hazards in the evaluation were based on data at
376   the Local Government Area level, while the overall prioritizing was based on the
377   risk profile at the state level.

378   Draft findings were presented to stakeholders for validation, and discrepancies
379   were resolved through consensus, ensuring that the final prioritization reflected
380   both evidence and collective expertise.

381   **Validation of Results**

382   At the end of the workshop, preliminary hazard rankings were presented to all
383   participants for review. Stakeholders confirmed that the results aligned with
384   available evidence and field realities, this served as a form of participant checking
385   and strengthened the validity of the assessment.

386   **Data Analysis**

387   Microsoft Excel was used for data management and calculation of risk scores;
388   likelihood and impact scores were multiplied to create composite risk scores.
389   Descriptive statistics summarized hazard distribution, number of affected Local
390   Government Areas, and seasonal patterns. Seasonal calendars and risk matrices
391   were generated using STAR templates. In addition, qualitative notes from
392   discussions were thematically analyzed to provide context for hazard

393   classification, vulnerability patterns, and coping capacity. Results were
394   synthesized to produce an integrated risk profile for Niger state.

395   **_Quality Assurance_**

396   Quality assurance measures included cross verification of data entries, facilitator
397   oversight during scoring sessions, alignment with STAR guidelines **[14]**, and
398   assignment of confidence ratings for each hazard. To improve reliability, each
399   hazard scoring exercise was conducted in facilitated groups and validated during
400   plenary sessions. Facilitators cross-checked data entries against documented
401   evidence, and discrepancies were resolved through consensus. Confidence levels
402   for each hazard score were assigned (good, satisfactory, unsatisfactory) based on
403   data availability and quality.

404

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408   **Results**

409   **_Overview of Identified Hazards_**

410   The multi-hazard risk assessment conducted in Niger State identified 18 hazards
411   across biological, environmental, technological, and security. These hazards were
412   selected following multi sectoral consultations, review of surveillance and
413   disaster records, and group consensus during the STAR workshop. These hazards
414   were carefully categorized using the WHO STAR technique based on their chance
415   of occurrence, impact, potential, and coping capacity. The study presented a
416   holistic view of hazards affecting the state and their distribution across different
417   local government areas (LGAs).

418   Available surveillance, meteorological, and disaster management reports
419   provided additional context for several of the priority hazards identified. Flooding
420   has consistently been one of the most widespread hazard in Niger state, affecting
421   an estimated 15 to 19 LGAs annually over the last five years, particularly those
422   along the Niger and Kaduna river. Cholera outbreaks have been recorded in at
423   least 8 to 12 LGAs each year, with seasonal peaks during the rainy season when
424   contamination of water is most pronounced. Security-related hazards, especially

425 banditry and kidnapping continue to drive significant population displacement,
426 with several thousand persons affected annually, mainly in the northern LGAs
427 that share borders with Kaduna, Zamfara, and Kebbi states. These descriptive
428 patterns align with stakeholders assessments during the STAR workshop and
429 helped inform the final prioritization of hazards.

430 **Risk Classification of Hazards**

431 Using the STAR thresholds, hazards were classified into four risk categories.
432 Seven hazards were classified as very high risk, six as high risk, four as moderate
433 risk, and one as low risk. Flooding, banditry/kidnapping, boat disasters,
434 cholera/acute watery diarrhoea, road traffic accidents, deforestation, and
435 rain/windstorms were all considered very high risk. High-risk hazards included
436 fires, Lassa fever, measles, drought, substance abuse, and erosion. Acute flaccid
437 paralysis, meningitis, food insecurity, and anthrax were all classified as moderate
438 risks, while diphtheria was considered a low risk. **Figure 2** shows the risk levels
439 of the hazards identified. These hazards had a combination of high likelihood,
440 severe impact, and limited coping capacity.
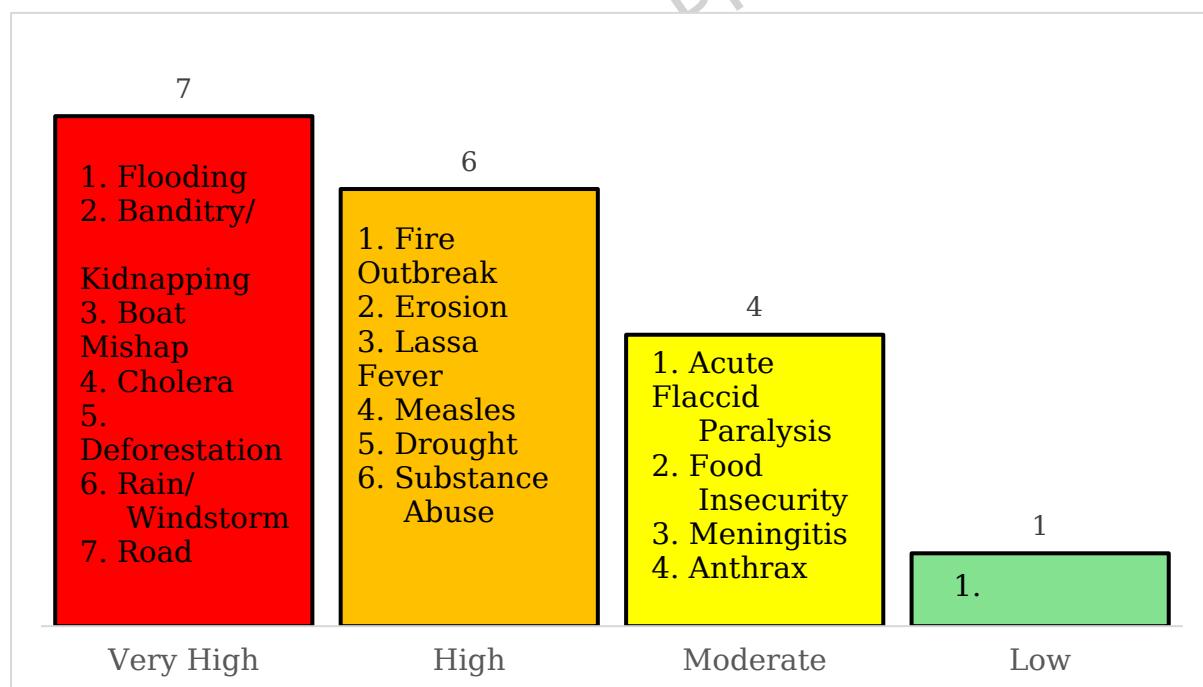
441

442 *Fig 2: Risk Level of Hazard in Niger State, 2025*

443

444 **Geographic Distribution of Hazards**

445   The assessment also revealed significant regional groupings, which frequently

446   aligned with natural factors, socioeconomic patterns, and security dynamics.

447   Flooding affected 19 LGAs, primarily along the Niger and Kaduna rivers,

448   including Agaie, Bida, Lapai, Lavun, and Mokwa. During the rainy season, these

449   areas experience recurring flooding, affecting agriculture and settlements.

450   Banditry/kidnapping was concentrated in nine LGAs (Borgu, Mariga, Mashegu,

451   Rafi, Shiroro, Wushishi, Kontagora, Muya, and Paikoro), mostly in the north and

452   northwest due to forested terrain and limited law enforcement presence. Boat

453   mishaps were concentrated in six LGAs (Agwara, Borgu, Katcha, Mokwa, Shiroro,

454   and Wushishi). Cholera outbreaks occurred in both urban and rural LGAs,

455   indicating insufficient WASH infrastructure, while Gurara, Kontagora, Magama,

456   Mokwa, Shiroro, and Wushishi experienced the most severe drought due to rain-

457   fed agriculture and little irrigation infrastructure. **(Table 3)**.

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464   *Table 3: Geographical areas affected by hazards in Niger State, 2025*

Hazard Category	Hazard	Risk Level	Affected Areas (LGAs)
Biological	Cholera/Acute Watery Diarrhea	Very High	Agaie, Agwara, Bida, Bosso, Chanchaga, Edati, Gurara, Katcha, Kontagora, Lapai, Lavun, Magama, Mariga, Mashegu, Mokwa, Muya, Paikoro, Rafi, Rijau, Shiroro, Suleja, Tafa, Wushishi
	Lassa Fever	High	Bida, Suleja, Tafa
	Measles	High	Agaie, Agwara, Bida, Bosso, Chanchaga, Edati, Gbako, Gurara, Katcha, Kontagora, Lapai, Lavun, Magama, Mariga, Mashegu, Mokwa, Muya, Paikoro, Rafi, Rijau, Shiroro, Suleja, Tafa, Wushishi
	Meningitis	Moderate	Bida, Bosso, Chanchaga, Edati, Gbako, Gurara, Katcha, Kontagora, Lavun, Magama, Mokwa, Paikoro, Rijau, Suleja, Tafa
	Diphtheria	Low	Bida, Kontagora, Suleja, Tafa, Mariga

	Acute Flaccid Paralysis	Moderate	Agaie, Agwara, Bida, Bosso, Chanchaga, Edati, Gbako, Gurara, Katcha, Kontagora, Lapai, Lavun, Magama, Mariga, Mashegu, Mokwa, Muya, Paikoro, Rafi, Rijau, Shiroro, Suleja, Tafa, Wushishi
Environmental	Flooding	Very High	Agaie, Bida, Borgu, Bosso, Chanchaga, Edati, Gbako, Katcha, Kontagora, Lapai, Lavun, Mariga, Mashegu, Mokwa, Rafi, Rijau, Shiroro, Suleja, Wushishi
	Drought	High	Gurara, Mokwa, Shiroro, Kontagora, Magama, Wushishi
	Erosion	High	Agaie, Bosso, Chanchaga, Katcha, Kontagora, Lapai, Mashegu, Mokwa, Tafa
	Rain/Windstorm	Very High	Agaie, Agwara, Bosso, Chanchaga, Gbako, Kontagora, Lapai, Lavun, Mariga, Mashegu, Mokwa, Paikoro, Rijau, Shiroro, Suleja, Wushishi
Security/ Societal	Banditry/Kidnapping	Very High	Borgu, Kontagora, Mariga, Mashegu, Muya, Paikoro, Rafi, Shiroro, Wushishi
	Substance Abuse	High	Chanchaga, Kontagora, Suleja, Mariga
Technological	Road Traffic Accidents	Very High	Agaie, Bida, Bosso, Chanchaga, Gurara, Kontagora, Lapai, Mokwa, Suleja
	Fire Outbreaks	High	Agaie, Bida, Borgu, Bosso, Chanchaga, Kontagora, Lapai, Mokwa, Rafi, Shiroro, Suleja
	Boat Mishaps	Very High	Agwara, Borgu, Katcha, Mokwa, Shiroro, Wushishi
Others	Deforestation	Very High	Edati, Lapai, Lavun, Mokwa, Wushishi
	Food Insecurity	Moderate	Agaie, Agwara, Bosso, Lavun, Magama, Rafi, Shiroro
	Anthrax	Moderate	Suleja

465

466 ***Seasonal Patterns of Hazards***

467 Seasonality analysis represented in **figure 3** revealed that certain hazards show

468 predictable patterns; Flooding occurs between July and October, with start in

469 June, and this is as a result of the high rainfall occurring in these months. Peak

470 flooding months have the highest number of boat mishaps due to increased river

471 traffic and hazardous navigation conditions. Cholera epidemics typically occur

472 during the rainy season, peaking between June and September, and are generally

473 linked to flooding caused by contaminated water, while droughts peak between

474 June and November in years with delayed or unpredictable rainfall, affecting crop

475 production and livestock productivity. For Rain/windstorms, they are more

476 common in transitional months (May-June, September-October). Biological

477 hazards such as measles cases occur during the dry season (December-March),

478 when mobility increases and vaccine coverage gaps become more visible. These

479 seasonal variations were consistently highlighted during stakeholder discussions
480 and aligned with historical surveillance and meteorological data. The seasonality
481 of these hazards highlights opportunities for anticipatory action, such as pre-
482 positioning supplies, scaling up public health messaging, and reinforcing early
483 warning systems.

484

Key							
Seasonality	Not Seasonal (gray)	Lowest (green)		Moderate (yellow)		High (orange)	Peak (red)

SN	Specific Hazard	Risk Level	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	Flooding	Very High	green	green	green	green	green	yellow	orange	red	red	red	orange	yellow
2	Banditry/Kidnapping	Very High	gray	gray	gray	gray	gray	gray	gray	gray	gray	gray	gray	gray
3	Boat Mishap	Very High	green	green	green	green	green	yellow	yellow	red	red	orange	orange	yellow
4	Cholera	Very High	green	green	green	yellow	orange	red	red	orange	orange	yellow	yellow	green
5	Deforestation	Very High	gray	gray	gray	gray	gray	gray	gray	gray	gray	gray	gray	gray
6	Rain/wind Storm	Very High	green	green	green	red	red	orange	yellow	orange	red	red	yellow	green
7	Road Traffic Accident	Very High	gray	gray	gray	gray	gray	gray	gray	gray	gray	gray	gray	gray
8	Fire Outbreak	High	gray	gray	gray	gray	gray	gray	gray	gray	gray	gray	gray	gray
9	Erosion	High	gray	gray	gray	gray	gray	gray	gray	gray	gray	gray	gray	gray
10	Lassa Fever	High	gray	gray	gray	gray	gray	gray	gray	gray	gray	gray	gray	gray
11	Measles	High	red	red	orange	orange	yellow	yellow	green	green	green	yellow	yellow	yellow
12	Drought	High	green	green	green	yellow	yellow	red	red	orange	orange	yellow	yellow	orange
13	Substance Abuse	High	gray	gray	gray	gray	gray	gray	gray	gray	gray	gray	gray	gray
14	Acute Flaccid Paralysis	Moderate	gray	gray	gray	gray	gray	gray	gray	gray	gray	gray	gray	gray
15	Food Insecurity	Moderate	gray	gray	gray	gray	gray	gray	gray	gray	gray	gray	gray	gray
16	Cerebrospinal Meningitis	Moderate	gray	gray	gray	gray	gray	gray	gray	gray	gray	gray	gray	gray
17	Anthrax	Moderate	gray	gray	gray	gray	gray	gray	gray	gray	gray	gray	gray	gray
18	Diphtheria	Low	gray	gray	gray	gray	gray	gray	gray	gray	gray	gray	gray	gray

485 *Fig 3: Niger State Hazards Risk Calendar, 2025 (generated by WHO STAR)*

486

487 **Likelihood and Impact Scoring**

488 Impact and likelihood scores **(Figures 4 and 5)** varied across hazards. Flooding,
489 banditry/kidnapping, cholera, and boat accidents had the highest likelihood
490 scores, reflecting their frequent recurrence in the state. Flooding had significant
491 repercussions, including loss of life, population displacement, and infrastructure
492 destruction. Impact scores were highest for security threats, cholera, and boat
493 mishaps due to their documented consequences on health, infrastructure,
494 displacement, and essential services. These patterns are illustrated in the STAR

495 likelihood and impact matrix **(Figure 6)**. Environmental hazards such as
496 deforestation and erosion have long-term repercussions, leading to vulnerability
497 rather than urgent emergencies.
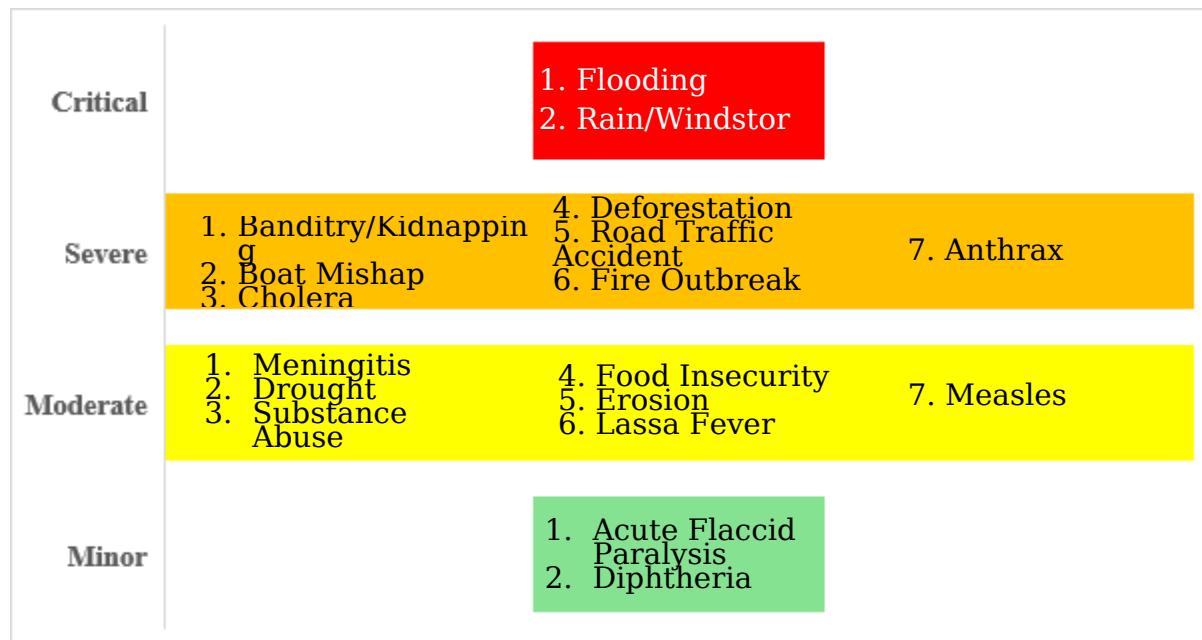
498

499 *Figure 1: Impact of Hazards in Niger State. 2025*
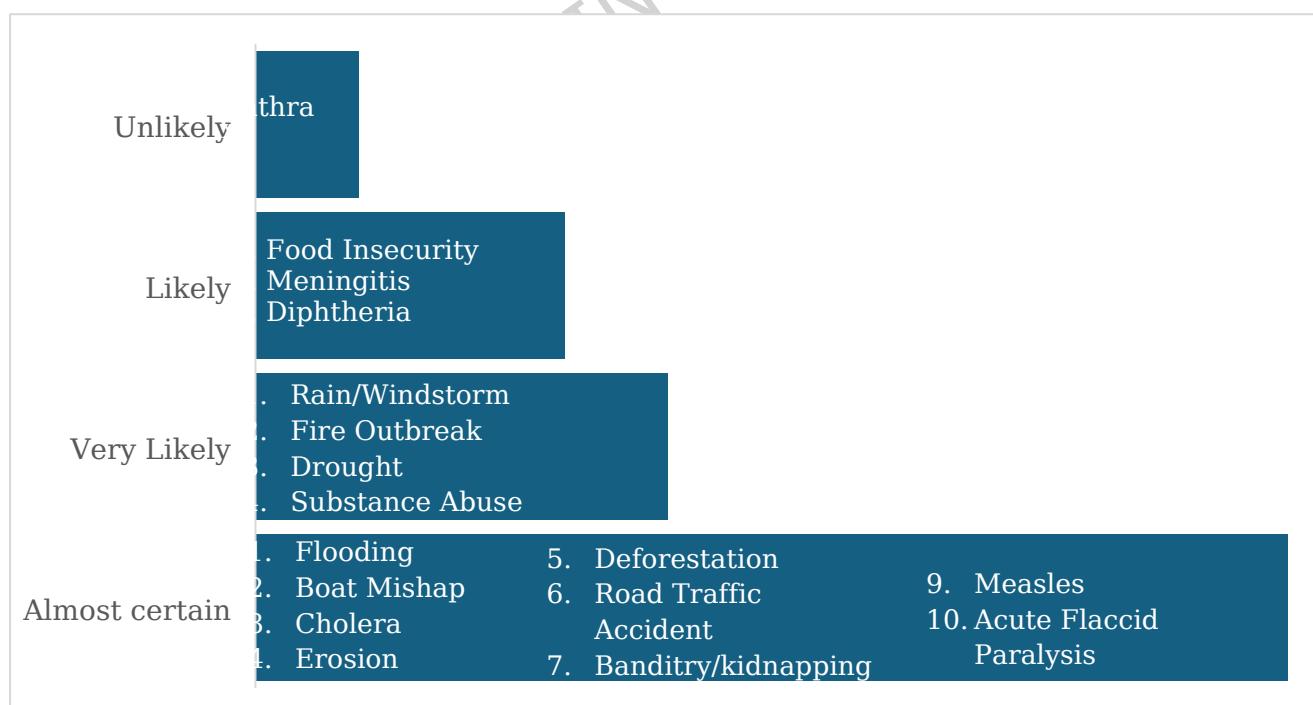
500

501 *Figure 2: Likelihood of occurrence of hazards in Niger State. 2025*

Key		Very Low	Low	Moderate	High	Very High
Risk Level		Very Low	Low	Moderate	High	Very High

NIGER STATE RISK MATRIX

Impact		Very Unlikely	Unlikely	Likely	Very Likely	Almost Certain
Critical	^^^^^				Rain/windstorm	Flooding
Severe	^^^^		Anthrax		Fire Outbreak	1.Banditry/Kidnapping 2.Boat Mishap 3.Cholera 4.Deforestation 5.Road Traffic Accident
Moderate	^^^			1.Food Insecurity 2.Cerebrospinal Meningitis	1.Drought 2.Substance Abuse	1.Erosion 2.Lassa Fever 3.Measles
Minor	^^			Diphtheria		Acute Flaccid Paralysis
Negligible	^					
Likelihood		Very Unlikely >	Unlikely >>	Likely >>>	Very Likely >>>>	Almost Certain >>>>>

502

Figure 6: Risk Matrix of Hazards in Niger State. 2025 (generated by WHO STAR)

504

Vulnerability and Coping Capacity

Vulnerability Patterns showed that rural and riverine areas were more vulnerable due to limited access to functional health services, poor road and transportation infrastructure, which causes delays in emergency response, strong reliance on climate-sensitive livelihoods, low literacy, and risk knowledge in some communities, which hinders preparedness efforts. Social vulnerability was worsened in conflict-affected LGAs, where insecurity restricted humanitarian access and displaced communities from arable land.

Coping capacity was also assessed to understand how communities cope with some of these hazards **(Figure 7)**, it was rated low or partial for eleven of the eighteen hazards. Coping ability was limited for flooding, drought, and rain/windstorm due to under-resourced WASH services, inadequate drainage infrastructure, and gaps in emergency services. Fire outbreaks, erosion and

518 others have low reaction capability due to limited scale and coordination.
519 However, established polio surveillance systems and vaccine efforts resulted in
520 high capacity for acute flaccid paralysis. In most cases, institutional readiness
521 was hindered by fragmented planning, inadequate inter-agency cooperation, and
522 reliance on external donor support for response activities. High coping capacity
523 means that although all coping mechanisms necessary for the hazard are present,
524 they have never been evaluated in a simulated exercise or under real-world stress
525 conditions, a moderate/partial coping capacity means there are some coping
526 mechanisms that are necessary for the hazard, but their functioning and
527 sustainability have not been guaranteed, for example, by being incorporated into
528 the national health sector plan's operating plan with a reliable source of finance,
529 and finally a low coping capacity means that human, material, strategic, and
530 financial core coping capacities needed for the hazard are still at the
531 developmental   stage.
532 Certain attributes have been attained and others have begun to be implemented.

High	Acute flacci aral

1. **Banditry/Kidnapping**   5. **Road Traffic Accident**   9. **Measles**

2. **Boat Mishap**   6. **Fire Outbreak**   10. **Substance Abuse**   13. **Diphtheria**

3. **Cholera**   7. **Erosion**   11. **Food Insecurity**

4. **Deforestation**   8. **Lassa Fever**   12. **Meningitis**

Partial

Low
1. **Flooding**
2. **Rain/Windstorm**
3. **Drought**
4. **Anthrax**
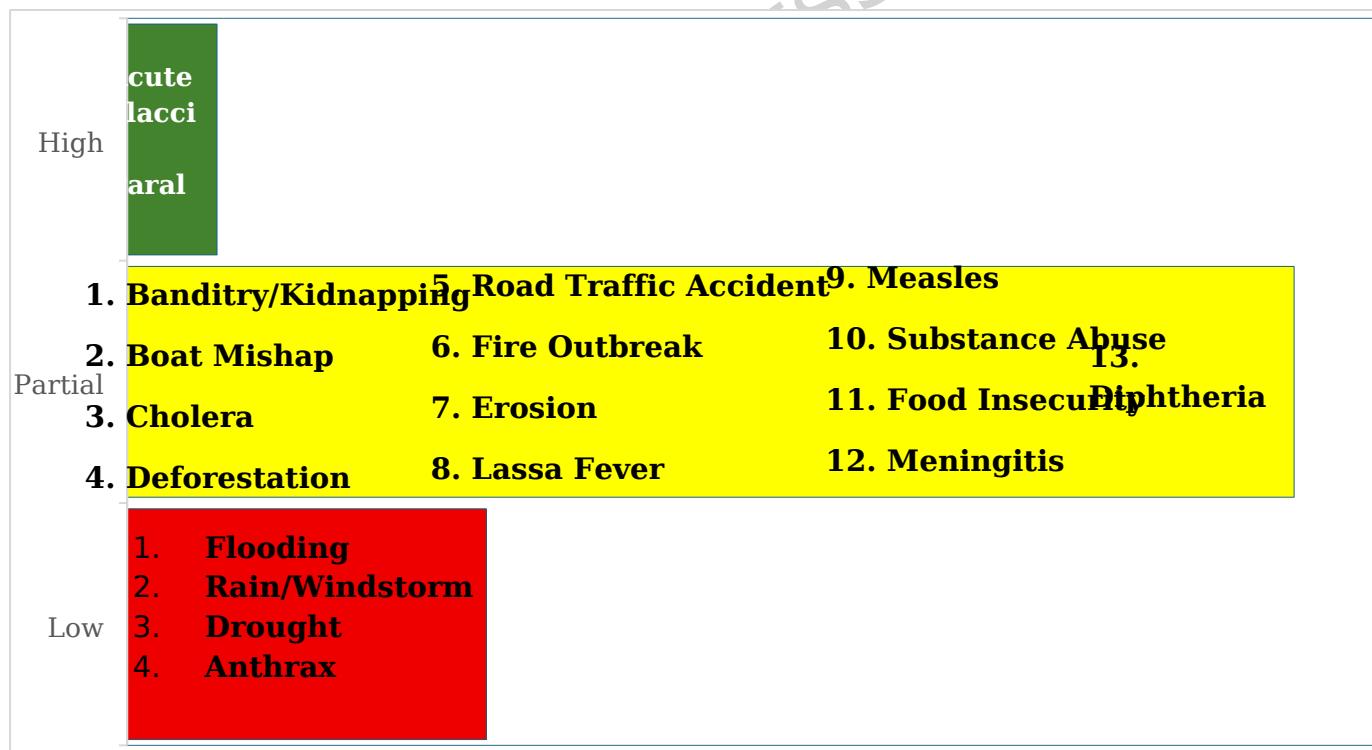
533

534 *Figure 3: Coping capacity of Niger State to hazards. 2025*

535

536 **Confidence Ratings**

537 Confidence ratings for each hazards assessment ranged from good to
538 unsatisfactory (figure 8). Data confidence ratings were generally high for hazards
539 with established surveillance and reporting systems (e.g., cholera, AFP, and
540 measles). However, hazards with limited documentation were rated as
541 satisfactory, and drought confidence was low, owing to irregular meteorological
542 records and inadequate integration of agricultural produce data into risk
543 monitoring. These ratings are presented in **Figure 8.**

Unsatisfactory	1. Drought	
Satisfactory	1. Substance Abuse 2. Food Insecurity 3. Anthrax	
Good	1. Flooding 2. Banditry/Kidnapping 3. Boat Mishap 4. Cholera 5. Deforestation	6. Rain/Windstorm 7. Road Traffic Accident 8. Fire Outbreak 9. Erosion 10. Lassa Fever 11. Measles 12. AFP 13. Meningitis 14. Diphtheria
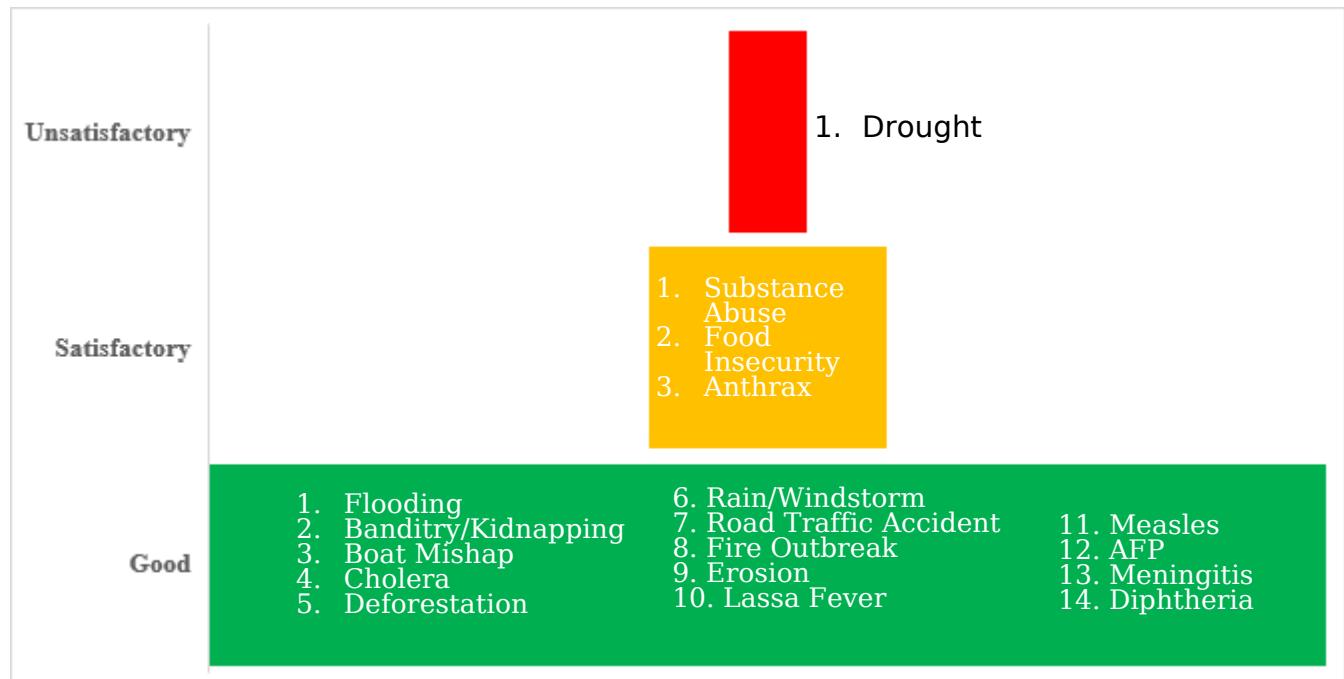
544

545 *Fig 8: Confidence Level of Data Source*

546

547 **Summary of Priority Hazards**

548 The combined analysis identified seven very high-risk hazards represented in
549 **Supplementary Material 2** requiring urgent and ongoing preparedness efforts.
550 These hazards were consistently supported by historical data, expert judgement,
551 and geographical and seasonal patterns. Combining likelihood, impact,
552 susceptibility, and coping capacity ratings, the following top five risks emerged
553 as priority risks in Niger state: Flooding, banditry/kidnapping, boat mishaps,
554 cholera/acute watery diarrhea, and rain/windstorms. These hazards not only had
555 the highest overall risk, but they also showed cascading effects, with the ability
556 to cause additional hazards and worsen disasters.

557 Finally, some cross-cutting findings were evident, for example, flooding
558 precipitated cholera outbreaks, drought leading to food insecurity, and insecurity
559 causing disease outbreak responses. Seasonal regularity of hazards presents
560 opportunities for early warning and proactive preparedness. It was also noticed
561 that community-level resilience remains underdeveloped, with most
562 preparedness actions occurring at the institutional level rather than at the
563 household level, and limited integration of health, environmental, and security
564 data into a single decision-making framework, resulting in sectoral silos.

Discussion

This study employed the WHO Strategic Tool for Assessing Risks (STAR) to conduct the first comprehensive, state-level multi-hazard risk assessment in Nigeria. A total of 18 hazards were identified, with seven categorized as extremely high risk and six as high risk. Flooding, cholera, banditry/kidnapping, road traffic accidents, and boat accidents ranked as the most dangerous hazards to public health and safety. Several risks, including flooding, cholera, boat accidents, and drought, exhibited strong seasonal patterns related to rainfall and river dynamics. The geographic distribution showed two LGAs of concern, riverine LGAs, which were particularly prone to flooding and boat accidents, and northern LGAs, where insecurity from banditry and kidnapping was concentrated.

Rural, riverine, and conflict-affected LGAs were the most vulnerable, with inadequate coping capacity for environmental and security hazards. These findings contribute to the study's goal of developing an actionable, evidence-based risk profile that can guide Niger State's readiness, mitigation, and response efforts.

The prevalence of floods in Niger State is consistent with patterns recorded in other studies. Previous studies **[20, 21, 22]** have consistently identified floods as an annual hazard with serious repercussions for agriculture, livelihoods, and infrastructure. Floods frequently result in secondary health crises, most notably cholera outbreaks, which have been observed in various communities in Niger state **[15, 23]**. Our data support this link while also placing cholera in a larger multi-hazard framework, emphasizing the importance of coordinated WASH and flood management methods. The high ranking of insecurity, particularly banditry and kidnapping, reflects national trends. According to reports from the United Nations Development Programme (UNDP, 2023) and the Office for the Coordination of Humanitarian Affairs (OCHA, 2023), rural violence is growing in north-central Nigeria, undermining disaster preparedness and limiting humanitarian access **[24, 25]**. Unlike most previous DRR evaluations, our study formally incorporated insecurity into hazard prioritization, advancing the discipline by illustrating how war and disaster risk are deeply intertwined. Seasonal trends for cholera, boat mishaps, and drought are comparable with epidemiological and meteorological literature from Nigeria and West Africa **[26, 27]**. Linking these seasonal peaks to individual LGAs gives operationally relevant

600   data for early warning and preparedness. In addition, the discovery of insufficient
601   coping capacity, particularly for drought and flooding, is consistent with findings
602   from the United Nations Office for Disaster Risk Reduction (2019), which
603   highlight inadequate contingency planning, poor inter-agency coordination, and
604   underfunded infrastructure in resource-limited settings **[28]**.

605   The high-risk hazards found in Niger State are caused by a mix of environmental,
606   social, and structural factors. The state's geology, characterized by rivers and
607   floodplains, makes flooding unavoidable after heavy rains, and climate change
608   has increased rainfall variability, resulting in more frequent and severe floods
609   **[29]**. Urban flooding is worsened by inadequate drainage and waste
610   management, and cholera is fuelled by inadequate WASH facilities, unclean
611   water, and overcrowded living situations, especially in peri-urban areas **[30,31]**.
612   Insecurity stems from larger national and regional crises such as porous borders,
613   inadequate law enforcement, the proliferation of firearms, and pervasive poverty,
614   all of which contribute to youth engagement in crime. This has caused
615   displacement, reduced access to healthcare, and disrupted agriculture **[32]**. Poor
616   infrastructure, ineffective traffic enforcement, and a lack of trauma treatment
617   capacity all contribute to road traffic accidents. These drivers demonstrate how
618   interrelated vulnerabilities form an ecosystem of overlapping risks that
619   overwhelm coping capacity.

620   Even though this assessment was carried out in a subnational level in Nigeria,
621   the findings are applicable outside the country and add to the larger international
622   conversations on multi-hazard risk assessment **[33,34]**. Flooding, drought,
623   cholera, and security-related displacement are among the key hazards found in
624   Niger state that are also acknowledged as serious risks in other low- and middle-
625   income countries in Africa, Asia, and Latin America **[35,36,37,38,39]**. These
626   risks are a reflection of global trends brought about by socio-economic
627   weaknesses, population expansion, climate change, and weak health systems.
628   Additionally, other countries looking to adapt global risk assessment techniques
629   can gain important insights from the subnational application of the WHO STAR
630   methodology in Nigeria. Many nations face comparable challenges related to
631   limited data availability, reliance on expert consensus, and multisectoral
632   coordination, making the lessons from this study relevant to similar contexts
633   worldwide **[40]**. By documenting how STAR was implemented in a low-resource
634   setting and demonstrating its potential to inform preparedness planning, this

635 study adds to emerging international evidence on practical approaches for
636 evaluating and prioritizing public health risks in vulnerable regions.

637 These findings have significant implications for policy, health systems, and
638 disaster preparedness. First, STAR-based prioritizing enables Niger State to shift
639 from reactive crisis management to evidence-based resource allocation, with a
640 focus on the hazards most likely to cause severe harm. Second, the obvious
641 seasonal patterns allow for proactive action, such as strengthening flood
642 defences before the rainy season, increasing WASH interventions ahead of the
643 cholera season, and maintaining boat safety precautions during peak travel
644 months. Third, by considering insecurity in hazard prioritization, this study
645 illustrates the importance of integrating disaster risk reduction and security
646 planning, encouraging collaboration among health agencies, emergency
647 management, and security forces. Fourth, the vulnerability of rural and riverine
648 populations need locally tailored, context-specific interventions: flood-prone
649 LGAs may require early warning systems and boat safety programs, whereas
650 drought-prone LGAs may benefit from climate-smart agriculture and water
651 storage systems. Finally, the assessment's participatory, multi-sectoral nature
652 demonstrates that collaborative planning is viable and might be institutionalized
653 as a permanent state-level disaster risk reduction platform.

654

655

656 **Strengths and Limitations**

657 A major strength of this study is its use of a standardized global tool, the WHO
658 STAR, at the subnational level, exhibiting methodological rigor while adjusting to
659 local realities. The participation of over 50 stakeholders from 38 departments and
660 organizations meant that the findings were founded on diverse expertise,
661 fostering consensus and local ownership. The process also revealed seasonal
662 hazard calendars and regional risk mapping, which are advances that improve
663 operational preparation. Furthermore, by combining health, security, and
664 environmental concerns into a single framework, the study produced a
665 comprehensive perspective rarely seen in Nigerian disaster risk reduction
666 literature.

667 Despite its strengths, the study has certain limitations that should be considered
668 when interpreting the findings. First, the use of a cross-sectional design means

669   that the analysis reflects hazard patterns at a single point in time, therefore, it
670   only offers a snapshot of hazard patterns. Hazards may fluctuate as a result of
671   climate change, insecurity, or population changes. Data gaps further reduce
672   precision for threats, including drought, substance addiction, food shortages,
673   emerging hazards, and evolving security dynamics may not be fully captured.
674   Second, the scoring process was mainly based on stakeholder perspectives,
675   which, while systematic, introduces subjectivity, even though confidence levels
676   were recorded to limit this, but bias is still possible. Hazards that are most
677   familiar, better documented, or frequently encountered may receive higher
678   attention than slow onset or chronic hazards with limited visibility. Third, the
679   assessment did not include a formal statistical test of scoring consistency.
680   Although extensive facilitation and consensus building were used to strengthen
681   objectivity, quantitative consistency metrics were not calculated. Finally, while
682   the findings are particularly relevant to Niger State, they may not be
683   generalizable without modification to other Nigerian states.

684

685   **Directions for Future Research**

686   Future research should conduct a longitudinal multi-hazard monitoring to detect
687   trends and shifts in hazard profiles over time and expand similar STAR-based
688   assessments to other Nigerian states to allow comparative risk profiling and
689   resource allocation at the national level.

690

691   **Conclusion**

692   In conclusion, this study highlighted flooding, cholera, banditry, road traffic
693   accidents, and boat mishaps as Niger State's greatest hazards to public health
694   and safety. It is the first time the WHO STAR technique has been applied at the
695   subnational level in Nigeria, demonstrating the feasibility of risk-informed state
696   planning. The implications are immediate and clear: improve early warning
697   systems, combine health and security measures, invest in WASH and resilient
698   infrastructure, and prepare clinical services for seasonal surges. Policymakers
699   should incorporate STAR outcomes into Niger State's emergency preparedness
700   and response strategies, as well as integrate them with national frameworks and
701   the Sendai Framework for Disaster Risk Reduction. Furthermore, repeating the
702   study every 3-5 years will aid in tracking emerging hazards, while expanding the

703 approach to other states can support a national hazard prioritization plan. This
704 will improve Nigeria's health security, increase resilience to climate and conflict
705 risks, and ultimately save lives and livelihoods.

706

707 **Recommendations**

708 Based on the findings of our study, we propose the following recommendations
709 for Niger state MDAs:

710 Niger State Ministry of Health

711 1. Strengthen early warning systems and rapid response teams for cholera,
712   Lassa fever, and other epidemic-prone diseases
713 2. Improve WASH services to reduce waterborne disease outbreaks
714 3. Expand routine and supplemental immunization campaigns for measles,
715   meningitis, and diphtheria
716 4. Improve emergency medical services and trauma care facilities for road
717   traffic accidents and boat mishaps

718 Ministry of Environment

719 1. Construct and rehabilitate drainage systems in flood-prone communities
720 2. Promote climate-resilient agriculture and drought mitigation strategies
721 3. Establish and enforce environmental protection measures to reduce
722   deforestation and erosion

723 Ministry of Agriculture

724 1. Scale up community-level food security programs to reduce the impact of
725   drought and floods on livelihoods
726 2. Strengthen animal health surveillance to monitor and prevent zoonotic
727   diseases such as anthrax

728 Ministry of Education

729 1. Integrate disaster risk reduction education into school curricula
730 2. Build community capacity for first response and self-protection in flood and
731   conflict-prone areas
732 3. Conduct community sensitization campaigns on safe water use, hygiene,
733   and emergency preparedness

734

Abbreviations

AFENET - African Field Epidemiology Network

AFP – Acute Flaccid Paralysis

CSM – Cerebrospinal Meningitis

DRR – Disaster Risk Reduction

FRSC – Federal Road Safety Corps

IFRC – International Federation of Red Cross and Red Crescent Societies

LGAs – Local Government Areas

LMICs – Low and Middle Income Countries

MDAs – Ministries, Departments, and Agencies

NCDC – Nigeria Centre for Disease Control

NEMA – National Emergency Management Agency in Nigeria

NiMET – Nigerian Meteorological Agency

NSEMA – Niger State Emergency Management Agency

OCHA – Office for the Coordination of Humanitarian Affairs

STAR – Strategic Tool for Assessing Risk

UNDP – United Nations Development Programme

UNICEF - United Nations Children's Fund

UN – United Nations

WASH – Water, Sanitation, and Hygiene

WHO – World Health Organization

Availability of Data and Materials

Data used will be available through the corresponding author upon reasonable request.

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761 Secondary and Tertiary Health, as well as the Nigeria Centre for Disease Control
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765

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768

Ethical Approval

770 Ethical approval was obtained from the Niger State Ministry of Secondary and
771 Tertiary Health with approval number: ERC PAN/2025/06/46. The study protocol
772 conformed to the ethical guidelines of the Declaration of Helsinki (eight revision).
773 In addition, the methodology aligns with the approved protocol.

Human ethics and consent to participate declarations

775 All participants provided informed consent before participation in discussions
776 and data provision. No individual-level health data were collected.

Author Contributions

778 O.D.A., A.J., S.A., A.D and S.S conceived the study. O.D.A., A.J., A.D., A.M., G.E.,
779 C.N.A., N.I., A.O., D.P.D., P.B.G., and I.I designed the data collection plan, trained
780 the stakeholders on the WHO STAR, collected and analysed the data. O.D.A
781 developed the methodology, C.N.A developed the first draft. H.I.O., R.R. and
782 O.D.A reviewed the first draft. All authors contributed to revising the manuscript
783 and approving the final draft.

Competing Interests

785 The authors declare no competing interests

Clinical Trial

787 Not Applicable.

788 **References**

789   1. UNDRR (2019), Global Assessment Report on Disaster Risk Reduction,
790   Geneva, Switzerland, United Nations Office for Disaster Risk Reduction
791   (UNDRR).

792   2. Mizutori, M. Reflections on the Sendai framework for disaster risk
793   reduction: Five years since its adoption. International Journal of Disaster
794   Risk Science. 2020 Apr;11(2):147-51.

795   3. Nashwan, A.J., Ahmed, S.H., Shaikh, T.G., Waseem, S. Impact of natural
796   disasters on health disparities in low-to middle-income countries. Discover
797   Health Systems. 2023 Sep 4;2(1):23.

798   4. Ifrc OR. World Disasters Report 2020. IFRC Geneva, Switzerland. (2020).

799   5. Hochrainer-Stigler, S., Trogrlić, R.Š., Reiter, K., Ward, P.J., de Ruiter,
800   M.C., Duncan, M.J., Torresan, S., Ciurean, R., Mysiak, J., Stuparu, D.,
801   Gottardo, S. Toward a framework for systemic multi-hazard and multi-risk
802   assessment and management. IScience. 2023 May 19;26(5).

803   6. Raimi, M.O., Vivien, O.T., Oluwatoyin, O.A. Creating the healthiest nation:
804   Climate change and environmental health impacts in Nigeria: A narrative
805   review. Morufu Olalekan Raimi, Tonye Vivien Odubo & Adedoyin
806   Oluwatoyin Omidiji (2021) Creating the Healthiest Nation: Climate Change
807   and Environmental Health Impacts in Nigeria: A Narrative Review.
808   Scholink Sustainability in Environment. ISSN. 2021 Feb 9.

809   7. Ideki, O., Weli, V.E. Assessment of drought vulnerability and occurrence
810   zones in north central Nigeria. Atmospheric and Climate Sciences. 2019
811   Jun 17;9(03):298.

812   8. Umar, N., Gray, A. Flooding in Nigeria: a review of its occurrence and
813   impacts and approaches to modelling flood data. International Journal of
814   Environmental Studies. 2023 May 4;80(3):540-61.

815   9. Izuogu, C.U., Oparaojiaku, J.O., Njoku, L.C., Olaolu, M.O., Ekweanya, N.M.,
816   Amah, O.D., Ebenehi, O. Rural-Farmers' Response to Climate Change in
817   Nigeria—A Review. Energy Transition, Climate Action and Sustainable
818   Agriculture: Perspectives and Strategies for Africa. 2025 Apr 20:527-44.

819   10. Mohammed, U., Umar, I.S., Olaleye, R.S., Pelemo, J.J., Ahmad, B.S., Umar,
820   A. Effects of banditry on income and livelihoods of yam marketers in
821   Shiroro local government area of Niger state, Nigeria. Journal of
822   Agriculture and Food Sciences. 2021 Jul 20;19(1):163-78.

823   11. Stalhandske, Z., Steinmann, C.B., Meiler, S., Sauer, I.J., Vogt, T., Bresch,
824   D.N., Kropf, C.M. Global multi-hazard risk assessment in a changing
825   climate. Scientific Reports. 2024 Mar 11;14(1):5875.
826   12. Mashi, S.A., Oghenejabor, O.D., Inkani, A.I. Disaster risks and
827   management policies and practices in Nigeria: A critical appraisal of the
828   National Emergency Management Agency Act. International journal of
829   disaster risk reduction. 2019 Feb 1;33:253-65.
830   13. Acosta-España, J.D., Romero-Alvarez, D., Luna, C., Rodriguez-Morales, A.J.
831   Infectious disease outbreaks in the wake of natural flood disasters: Global
832   patterns and local implications. Le Infezioni in Medicina. 2024 Dec
833   1;32(4):451.
834   14. World Health Organization. Strategic toolkit for assessing risks (STAR): a
835   comprehensive toolkit for all-hazards health emergency risk assessment.
836   World Health Organization; 2021 Nov 17.
837   15. Adabara, E.F., Sadauki, A.H., Usman, A.B., Nweke, H., Ogunbode, O.,
838   Gimba, P., Hassan, M., Egwuenu, A., Abdullahi, Y.Y., Erojikwe, O., Balogun,
839   M.S. Cholera outbreak in Niger State Nigeria, May to August 2021: An
840   unmatched case-control study. Journal of Interventional Epidemiology and
841   Public Health. 2024 Aug 20;7(38).
842   16. Elimian, K., Yennan, S., Musah, A., Cheshi, I.D., King, C., Dunkwu, L.,
843   Mohammed, A.L,, Ekeng, E., Akande, O.W., Ayres, S., Gandi, B.
844   Epidemiology, diagnostics and factors associated with mortality during a
845   cholera epidemic in Nigeria, October 2020–October 2021: a retrospective
846   analysis of national surveillance data. BMJ open. 2022 Sep
847   1;12(9):e063703.
848   17. Gambo Madaki, S. A Comparative Assessment of Flood Hazard
849   Susceptibility Modeling in Niger State, North-Central Nigeria. Cross-
850   Cultural Perspectives on Climate Change Adaptation: Adapting to Flood
851   Risk 2024 Sep 28 (pp. 119-132). Cham: Springer International Publishing.
852   18. Adenle, A.A., Boillat, S., Speranza, C.I. Key dimensions of land users'
853   perceptions of land degradation and sustainable land management in
854   Niger State, Nigeria. Environmental challenges. 2022 Aug 1;8:100544.
855   19. Ojo, J.S., Oyewole, S., Aina, F. Forces of terror: Armed banditry and
856   insecurity in North-west Nigeria. Democracy and Security. 2023 Oct
857   2;19(4):319-46.

858   20. Balgah, R.A., Ngwa, K.A., Buchenrieder, G.R., Kimengsi, J.N. Impacts of
859   floods on agriculture-dependent livelihoods in Sub-saharan Africa: an
860   assessment from multiple geo-ecological zones. Land. 2023 Jan
861   26;12(2):334.

862   21. Echendu, A.J. Flooding, food security and the sustainable development
863   goals in Nigeria: An assemblage and systems thinking approach. Social
864   Sciences. 2022 Feb 7;11(2):59.

865   22. Okon, E.M., Falana, B.M., Solaja, S.O., Yakubu, S.O., Alabi, O.O., Okikiola,
866   B.T., Awe, T.E., Adesina, B.T., Tokula, B.E., Kipchumba, A.K., Edeme, A.B.
867   Systematic review of climate change impact research in Nigeria:
868   implication for sustainable development. Heliyon. 2021 Sep 1;7(9).

869   23. Elimian, K.O., Musah, A., Mezue, S., Oyebanji, O., Yennan, S., Jinadu, A.,
870   Williams, N., Ogunleye, A., Fall, I.S., Yao, M., Eteng, W.E. Descriptive
871   epidemiology of cholera outbreak in Nigeria, January–November, 2018:
872   implications for the global roadmap strategy. BMC public health. 2019 Sep
873   13;19(1):1264.

874   24. Yunusa, E., Owoyemi, J.O. Rural Development And Resource-Based
875   Conflict In North-Central Nigeria: Escalation, Consequences And
876   Management.

877   25. Babajide, F., Olaogun, M., Oluwadele, L., Ijeoma, J., Idoko, S. The State Of
878   Internally Displaced Persons (IDPS) In Nigeria And Implications To
879   National Security: Northwest And North Central In Focus. IOSR Journal of
880   Humanities and Social Science. 2024;29(1):1-.

881   26. Charnley, G.E., Kelman, I., Murray, K.A. Drought-related cholera outbreaks
882   in Africa and the implications for climate change: a narrative review.
883   Pathogens and global health. 2022 Jan 2;116(1):3-12.

884   27. Akingbola, A., Abiodun, A., Ojo, O., Jessica, O.U., Alao, U.H., Owolabi, A.O.,
885   Chuku, J. Cholera Outbreak in Nigeria: History, Review of Socioeconomic
886   and Meteorological Drivers, Diagnostic Challenges, and Artificial
887   Intelligence Integration. Global Health, Epidemiology and Genomics.
888   2025;2025(1):8898076.

889   28. McGlade, J., Bankoff, G., Abrahams, J., Cooper-Knock, S.J., Cotecchia, F.,
890   Desanker, P., Erian, W., Gencer, E., Gibson, L., Girgin, S., Hirsch, F. Global
891   assessment report on disaster risk reduction 2019. UN Office for Disaster
892   Risk Reduction; 2019 May 13.

893   29. Sanusi, U., Odiji, C.A., Nwadike, B.K., Hamza, D.D., Baba, S.T., Salis, S.K.
894   Flood Vulnerability Analysis in the Down Stream of Shiroro Dam and
895   Environs. Water and Environmental Sustainability. 2023 Dec 25;3(4):41-9.

896   30. Onwunta, I.E., Ozota, G.O., Eze, C.A., Obilom, I.F., Okoli, O.C., Azih, C.N.,
897   Okoye, C.O., Agbo, E.L. Recurrent cholera outbreaks in Nigeria: A review
898   of the underlying factors and redress. Decoding infection and
899   Transmission. 2025 Jan 1;3:100042.

900   31. Amisu, B.O., Okesanya, O.J., Adigun, O.A., Manirambona, E., Ukoaka, B.M.,
901   Lawal, O.A., Idris, N.B., Olaleke, N.O., Okon, I.I., Ogaya, J.B., Prisno III,
902   D.E. Cholera resurgence in Africa: assessing progress, challenges, and
903   public health response towards the 2030 global elimination target. Le
904   infezioni in medicina. 2024 Jun 1;32(2):148.

905   32. Obah-Akpowoghaha, N.G., Ojakorotu. V., Tarro, M.L. Porous Borders and
906   the Challenge of National Integration in Africa: A Reflection of Ghana,
907   Republic of Benin and Nigeria. Journal of African Foreign Affairs. 2020 Dec
908   1;7(3).

909   33. Trogrlić, R.Š., Reiter, K., Ciurean, R.L., Gottardo, S., Torresan, S., Daloz,
910   A.S., Ma. L., Fumero, N.P., Tatman, S., Hochrainer-Stigler, S., de Ruiter,
911   M.C. Challenges in assessing and managing multi-hazard risks: A
912   European stakeholders perspective. Environmental Science & Policy. 2024
913   Jul 1;157:103774.

914   34. Stalhandske, Z., Steinmann, C.B., Meiler, S., Sauer, I.J., Vogt, T., Bresch,
915   D.N., Kropf, C.M. Global multi-hazard risk assessment in a changing
916   climate. Scientific Reports. 2024 Mar 11;14(1):5875.

917   35. Charnley, G.E., Kelman, I., Murray, K.A. Drought-related cholera outbreaks
918   in Africa and the implications for climate change: a narrative review.
919   Pathogens and global health. 2022 Jan 2;116(1):3-12.

920   36. Wang, P., Asare, E.O., Pitzer, V.E., Dubrow, R., Chen, K. Floods and
921   diarrhea risk in young children in low-and middle-income countries. JAMA
922   pediatrics. 2023 Nov 1;177(11):1206-14.

923   37. Balikuddembe, J.K., Reinhardt, J.D., Zeng, W., Tola, H., Di, B. Public health
924   priorities for Sino-Africa cooperation in Eastern Africa in context of
925   flooding and malaria burden in Children: a tridecadal retrospective
926   analysis. BMC public health. 2023 Jul 11;23(1):1331.

927   38. Suhr, F., Steinert, J.I. Epidemiology of floods in sub-Saharan Africa: a
928   systematic review of health outcomes. BMC public health. 2022 Feb
929   10;22(1):268.

930   39. Acosta-España, J.D., Romero-Alvarez, D., Luna, C., Rodriguez-Morales, A.J.
931   Infectious disease outbreaks in the wake of natural flood disasters: Global
932   patterns and local implications. Le Infezioni in Medicina. 2024 Dec
933   1;32(4):451.

934   40. Sanga, V.T., Karimuribo, E.D., Hoza, A.S. One Health in practice: Benefits
935   and challenges of multisectoral coordination and collaboration in
936   managing public health risks: A meta-analysis. International Journal of One
937   Health. 2024;10(1):26-36.