Review Article

Infrastructural Failure and Environmental Vulnerability: A Critical Analysis of Public Health and Livelihood Impacts from the 2024 Alu Dam Flooding in Maiduguri

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ABSTRACT

Climate related disasters in Sub Saharan Africa are rising and this situation is worsened by serious infrastructural and institutional failures. Flooding as one of the most disastrous of natural dangers has dealt untold destruction. Drawing from the critical studies on disasters and the social vulnerability theories, this paper analyzes the case study of the Alu Dam inundation in Maiduguri, Borno State, Nigeria, in September 2024. The disaster affected over 400,000 people, and affected an estimated one million so it qualifies as one of the worst floods in Nigeria's recent memory. The study highlights several structural errors such as the lack of sufficient focus on the critical infrastructure, the integrity of former construction contracts for rehabilitation intervention, and also the institutional neglect of the early warning systems. A lack of disaster preparedness, limited humanitarian response and over-reliance on community-based coping strategies are among key limitations in institutional responses, which, according to the report, could be addressed by at least increasing investment in implementing the Sendai Framework. It puts the stress on how not just natural factors but socio-political inadequacies and systematic neglect catapulted the calamity. In order to tackle the above enumerated challenges, to include enhancing early warning system at community level, collaring technological surveillance capacity and instituting transparent governance reforms, measures that will accelerate and strengthen the resilience and reduce the risk in the future were therefore proposed in this study.

1. INTRODUCTION

The increasing frequency and severity of climate disaster events has put pressure on the world to step up the fight on more environmental conservation on development of disaster risks reduction. The UNDRR (2020) claims that there are already 313 natural disasters reported in 123 countries in 2020, out of which 246 (61.6) are the results of flooding. It is not only the most widespread disaster, but one of the most destructive natural ones of our times.

The ecological vulnerabilities and socio-economic fragilities that exist within West Africa and even more so within Sub-Saharan Africa, dominate the region with the effects of increased risks of climate related disasters. According to Liu *et al.* (2023), there were at least 168 different countries that had catastrophic flooding since 1990 and resulted in the deaths of more than 242,000 people alongside more than 3.5 billion people across the globe. In this global scene, African nations such as those of Nigeria, Mali, Cameroon, South Sudan have fallen prey to epic centers of vulnerability. Beside the lack of environmental security, the socio-economic stability of these countries is being undermined by the frequent flooding that ensures the cycles of poverty and fragility continue.

The effects of the flooding are far more generous than the loss of life right then. They are having confounding socio-environmental encompassing forcible force, living condition demolition, demolition of infrastructure alongside disturbance of agrarian economies relying tongue to delicate environmental systems (Adger, 2006; Smucker, 2008; Wisner, 2008). In Nigeria, these problems are further culturally magnified by institutional flaws which include the ineffective institutional capacity, poor urban planning, bad infrastructure and high degree of poverty which worsens the situation when met, combined with the high level of catastrophes which exacerbates the situation when it occurs.

The capital of Borno State, northeastern Nigeria, Maiduguri, is a good example of this precarious situation of remnants. It is in the ecologically sensitive Lake Chad Basin with the city being one of the vulnerable ones and is getting closer to more drought and consequent floods (Bulwa & Malgwi, 2021). Originally envisioned as a contribution to agricultural resilience and water security in the southern Cone country, the Alu Dam has become a latecomer as a symbol for infrastructures and institutions going to hell in a handbasket. A dam that used to serve as a protective correlate has turned out to become the source of environmental hazards due to the neglect and poor management of the dam, which is as a consequence of decades of poor maintenance/service investments (Babagana *et al.*, 2015). It is only time that will confirm whether this is true or not when it comes to the Alu Dam folly in September, 2024. This aberration is not of nature, but is instead the result of an ecosystem of ecological weakness, infrastructural inability, and governmental defecation. It provides a helpful context for the assessment of potential epic scale humanitarian disasters that emerge from the convergence of latent risk, failure to governor, corruption and neglect (NEMA, 2024; OCHA, 2024).

Despite an extensive literature on climate change, environmental disaster management and environmental vulnerability, a gap still persists on the conceptualization of the interrelations of infrastructural failure, governance breakdown, and place-based vulnerability in northern Nigeria. In this study, the researchers try to ensure that gap is addressed by conducting vital analysis of Alu dam flooding event of 2024 in Maiduguri. The research question based on works of Social Vulnerability Theory (Cannon & Mueller-Mahn, 2010) and critical disaster studies is the following: how do ecological vulnerabilities driven by social inequalities and shortcomings of governance contribute to health risks experienced due to environmental hazards. This initiative aims to integrate the scientific evidence towards establishing resilience, instigating transformational organizational change implementation of reforms and formulating policy interventions necessary in dealing with future catastrophes in fragile settings.

2. LITERATURE REVIEW

2.1. Environmental and geographic context

Maiduguri, the capital of Borno State, is on point of Sudano-Sahelian belt at 11o51'N, 13o05'E in the Lake Chad Basin (Bulwa & Malgwi, 2021). This geographical location opens the city to specific climatic behaviors of eight months of dry weather, followed by four months of heavy rainfall, which results in the vulnerability of the city to various natural disasters of both drought and heavy rains every year. The population of the city has increased to more than 700,000 people (OCHA, 2024), which has led to increased pressure on the existing infrastructure and natural resources.

In this regard, a lot has been written in the literature in connection with climate sensitivities and vulnerabilities in the environment in this region. Investigations find that the Sudano-Sahelian region epistemic has tremendous variation nature of rains with coefficients of variability (CV) exceeding 30 percent (Nicholson, 2013). The region has become susceptible to extreme events through targeted river changes coupled with increased global climate change temperatures (Sylla *et al.*, 2016). And a good illustration of the deterioration of the environmental situation in the region is the lake Chad Basin, the surface area of which has declined to 90% since the 1960s (Gao *et al.*, 2011).

2.2. Conflict dynamics and urban vulnerability

The Boko Haram insurgency has entirely altered the social economic landscape of Maiduguri over the past twenty years using what we identify as a conflict ecology increasing the level of selected environmental risks (Bulwa & Malgwi, 2021). Moreover, owing to the insurgency, over 2.2 million individuals have been displaced in Borno State alone with Maiduguri acting as the primary hub of the IDP (Unhcr, 2023). Yet, this massive population growth has put pressure on city infrastructure and amenities leading to the development of slums with extremely cut off access to minimum services where such population faces increased environmental hazards.

Research on conflict-environment nexus tells us how violent conflict systematically attacks the adaptive capacity and resilience to climate shocks (Ruttinger *et al.*, 2015). In the case of Maiduguri, the insurgency has disrupted traditional livelihood strategies and dissolved the governance systems and diverted money from infrastructure maintenance to security operations (Nwosu & Soaga, 2019). This interaction leads to what Watts

and Peluso (2001) have termed "violent environments" in which social and environmental vulnerabilities reinforce one another.

2.3. Infrastructure systems and water management

The Alu Dam constitutes a critical component of water infrastructure of Borno State in a crisis subsistent climate, which was the original design to enable irrigation-based agriculture techniques to flourish in the semi-arid climate to provide drought resilience for stabilizing of food production in the locality (Babagana *et al.*, 2015). However, due decades of poor maintenance, technical capability and financial resources have damaged the structural integrity of the dam and its operational performance (Ibrahim *et al.*, 2022). This degradation is indicative of wider trends of infrastructural neglect that are featured in most African post-colonial states such that residual colonial infrastructure systems have not been properly invested in, or subjected to any improvement (Lawhon *et al.*, 2018).

Hanna von Schnitzler (2016) coined the term infrastructural citizenship in this context, which offered us a theoretical concept to explain how infrastructure failures have a disproportionate effect on those with less political influence than others-that is, the marginalized. In Maiduguri, for instance, those who live in flood-prone areas and in poor communities carry a disproportionate load of infrastructural shortcomings, an effect of what Graham and Marvin (2001) call "splintered urbanism" - or the uneven distribution of the benefits of infrastructure services among cities.

2.4. Historical patterns of flooding and disaster response

The September 2024 collapse of Alu Dam is just one of many instances where the lack of proper disaster preparedness and infrastructural failure has been extremely pronounced in Maiduguri. Experience in this area promises that such flood occurrences can happen again, like in 1994, with an estimated wholesale loss of lives (exceeding 300), together with the inability of other people to go back to their homes and sites (Odihi, 1996). The fact that these vulnerabilities continue to be present after experiencing past events reveals what disaster scholars have called 'failure to learn' - those institutional systems fail to place the lessons learnt from past disasters into better preparedness and response systems (Birkmann *et al.*, 2010).

The Pressure and Release (PAR) model developed by Wisner *et al.* (2004) offer perspectives on what causes vulnerability to disasters in Maiduguri. For its part, the model clarifies the synergistic interaction of the 'root causes' - political and economic systems - with 'dynamic pressures' (macro forces like conflict and urbanization, etc.) and 'unsafe conditions' (vulnerable places and inadequate infrastructure, etc.) resulting in disaster risk. In the case of Maiduguri, it is due to a combination of these factors, all heating up to form what may be considered 'chronic emergency' - a situation in which communities live in a constant state of vulnerability to multiple and interlocking hazards.

2.5. Triple vulnerability framework

The intersectional dynamics of environmental, institutional and social vulnerabilities in Maiduguri is one of the product of the construct of "triple vulnerability" (TTV) which in this study is operationalized into a theoretical framework based on the existing literature on vulnerability but aware of the empirical realities of urban spaces in the Global South. Drawing upon the fields of political ecology (Robbins, 2012), literatures of urban vulnerability (Pelling, 2003) and disaster risk reduction (Cardona, 2004), environmental vulnerability is presented as a transversal and multiscale factor because it explains the role that the different dimensions of vulnerability play cumulatively. The ecological dimension includes biophysical vulnerability to environmental hazards resulting from climate variability, ecosystem degradation and natural resources scarcity.

Among the institutional determinants are failure in governance, poor enforcement of policies and regulatory frameworks, and limited capacities for dealing with environmental and social risks that affect population.

The social dimensions describe the precariousness of the lives of urban populations by describing aspects such as poverty, displacement, social exclusion and restricted access to resources and services.

The triple vulnerability model expands on traditional vulnerability assessment by clearly defining the relationships, in a dynamic fashion, between the constituent dimensions (and their cumulative effects) that comprise the integral concept of community resilience.

This analytical tool has facilitated a more nuanced understanding on why certain segments of urban population are trapped in repeated rounds of vulnerability due to intervention failure and suggests pathways for mitigation of vulnerability by incorporating more effective more efficient mitigative measures measures.

3. METHODOLOGY

This study utilizes a qualitative embedded single-case study to examine the flooding that occurred in Maiduguri, Borno State, Nigeria at September, 2024 (in Alu Dam) (Yin, 2018). The case study approach is especially well suited to investigate the complex context dependent phenomena, where the boundaries between the disaster phenomenon and its socio-political context is intentionally in blur (Stake, 1995). The embedded design includes different units of analysis- humanitarian impacts, institutional response and community vulnerabilities, and it therefore allows for a comprehensive examination whilst maintaining a certain analytical coherence with respect to the main case. This methodological choice is in line with the epistemology of critical disaster studies, which conceptualizes disasters not as individual and natural incidents, but as manifestations of underlying socio- political processes (Oliver- Smith, 1999).

3.1. Data collection strategy
3.1.1. Systematic literature review protocol

The present study adopted initial qualitative case study form to investigate the flooding event that occurred in Alu Dam in the year 2024 in Maiduguri, Borno State of Nigeria. The analytical approach, using a case-study approach and following an exploratory approach put forward by Yin (2018), helped in developing a nuanced understanding of the complex relationships between infrastructural decay, failure

in governance and structural vulnerability. Recognizing that disasters of this kind are integrated within their socioecological structure, the adopted design seemed most adequate for analysis of the dynamic interaction between the combined structural, institutional and environmental predicates that influence disaster disaster aftermaths.

A systematic protocol of literature selection has been applied following the guidelines PESETA - PRISMA that have been adapted for disaster research (Moher *et al.*, 2009). The searches were carried out in multiple bibliographic databases such Web of Science, Scopus, Google Scholar, and African Journals Online (AJOL) during the period from January 2015 to September 2024. The search query included thematic and geographical terms, including flood, disaster, dam failure, Maiduguri, Borno State, Lake Chad Basin, vulnerability, infrastructure, governance and humanitarian. Only English-language literature was included - peer-reviewed journal articles, technical reports, and conference presentations. 423 records were retrieved following a preliminary search session 421 undergoing a multi-stage screening process in which they were screened for title, abstract, and full-text relevance. After a stringent evaluation process of methodological quality and contextual suitability, twenty-four studies were kept, plus six further studies were included via backward citation checking, giving us a total body of thirty relevant and important academic reference sources.

Included studies had to be located in flood-prone areas and settings in Nigeria or similar Sahelian region of the world, to address infrastructural or governance shortcomings, or to use social vulnerability or critical disaster theory frameworks. Papers that included meteorological models, papers from other areas that would not directly apply to Africa, and opinion papers with no empirical data should be left out.

Methodological triangulation was used with academic media and institutional reports with theoretical literature, to ensure the resulting portrayal of formal and community perspectives were balanced. Rational data on displacement, damage and health impacts were taken from the National Emergency Management Agency (NEMA), the United Nations Office for the Coordination of Humanitarian Affairs (OCHA) and World Health Organization (WHO). These complementary narratives were derived from the national and international news sources such as Daily Trust and ReliefWeb and focused on their respective September to October 2024 reporting. Content analysis was conducted according to the rules of Krippendorff (2018) in order to test the reliability and framing of those documents. Furthermore, community testimonies which have been included in humanitarian evaluations (Adeyemi *et al.*, 2024) were examined to highlight the life experiences of internally displaced persons, women, the elderly and other vulnerable populations so their voices were not further suppressed by institutional narratives.

The work was based on an integrated theoretical framework that connected Social Vulnerability Theory (Cannon & Muller-Mahn, 2010) with Critical Disaster (Ribot, 2014). Within this framework, conceptualized vulnerability is expressed by the function

$$V = f(E, S, AC)$$

where exposure parameter (E) describes the degree to which one is at risk to their physical social assets, the sensitivity parameter (S) describes susceptibility to harm, and their adaptive capacity (AC) describes the potential capacity to anticipate, cope with and recover from adverse events. In this research, the functional expression was used as a heuristic tool for qualitative interrelation interpretation rather than a quantitative equation, to map qualitative social and institutional patterns towards underlying structural vulnerabilities. Critical Disaster Studies has crafted a complementary socio-political perspective which placed the failures in governance and policy neglect as constellations of contributing factors leading to the disaster.

The data analysis was consistent with the six-phase thematic analysis of Braun and Clarke (2006). All of the source material, including academic manuscripts, formal reports and narrative testimonies, were first studied as a way to achieve familiarity before starting the systematic coding. Codes were created both by an inductive process of deriving patterns from emergent data as well as by a deductive process of deriving codes from pre-existing theoretical principles. The triangulated approach produced an integrated meaning-making scheme that introduced emergent knowledge, Tribunal, as well as theory-based insights. Finally, the thirty-four pre codes were packed together into three macro-categories:

    i. Humanitarian impact and outcome;
    ii. Institutional performance and governance;
    iii. Community vulnerability and strength.

The coded and subsequently refined themes were generated manually, using Microsoft Excel, and subjected to iterative cross-validations in order to assure coherence and consistency. The cross-source comparison validated the patterns and helped to shed light on disparities between the official discourses and those community realities in everyday life.

To ensure credibility and dependability, the study employed multiple forms of triangulation (Denzin, 1978). Data triangulation included institutional documents, academic literature and field testimonies while theoretical triangulation included the Social Vulnerability and Critical Disaster frameworks. Credibility was also supported by cross-logistic between secondary and primary reports, and through an audit trial documenting coding choice, theme definitions, as well as analytical judgments (Lincoln & Guba, 1985). At all times, discussions were made responsibly and without voyeurism, with adherence to certain standards of integrity of information and respect for the dignity of individuals.

Despite the use of secondary data, which limits direct verification, and the single and case study design, which limits generalizability, one of the main strengths of the study is the triangulation approach used as well as the theoretical integration. This methodological procedure produces solid and grounded context on how infrastructural failure, institutional neglect and social fragility are collectively agents in understanding environmental vulnerability in conflict-affected geographic regions in Nigeria.

3.1.2. Official documentation and grey literature

The main institutional data was obtained based on formal documentation on the work of national and international disaster management agencies. The National Emergency Management

Agency (NEMA) retrieved seven situational reports, resource deployment logs, and assessments of the victims and it covered situational events from 10th to 30th of September 2024. Supplementary data were obtained under the United Nations Office for the Coordination of Humanitarian Affairs (OCHA), which included five flash appeals, humanitarian bulletins, and needs assessment reports that were released during the same period. The World Health Organization (WHO) provided three cluster and epidemiological bulletins containing the public-health implications of post-flood period, whereas the Borno State Emergency Management Agency (SEMA) four minutes of internal coordination and local damage-assessment reports came into effect documenting a level of response at the state-level.

High-natural disaster infrastructure: In this research, the procurement and infrastructure documentation were subjected to systematic content analysis in primarily clarifying the governance and technical antecedents of the disaster. Freedom of Information Act requests were received and publicly available procurement databases were used to obtain thirteen state contracts related to the rehabilitation of the Alu Dam supplied between 2018 and 2024. Reports on engineering tests and assessments of the structural damages before the disaster were then analyzed to evaluate the state of the dam before the disaster happened. The governmental information portals, the UN ReliefWeb portal and Freedom of Information (FOI requests) that were awarded access to the datasets in August 2024 and received in October 2024, respectively, after the Borno State Government submitted the requests. The empirical evidence that resulted in facilitated development of a negative baseline, therefore supporting as well as confirming claims of infrastructural neglect and administrative irregularity.

3.1.3. Media content selection

However, the methodology used in this study to search for and select academic literature and media reports was rigorous and systematic, which involved using recognized established protocols to ensure rigor, relevance and reliability. For the literature review, a systematic review adhered to an adaptation of Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) for disaster research (Moher *et al.*, 2009) was followed. Searches were carried out in several databases such as being in Web of Science, Scopus, Google Scholar and African Journals Online (AJOL) from January 2015 to September 2024. The search query was developed using thematic and geographic keywords like *"flood", "disaster", "dam failure", "Maiduguri", "Borno State", "Lake Chad Basin", "vulnerability", "infrastructure", "governance", and "humanitarian"*. Only English language publications were included including peer reviewed journal articles, technical reports, and conference proceedings. The first database question provided 423 database records. These were exposed to a multi-step screening process; preliminary screening of the title, abstract screening and the final full text relevance screening. Quality and contextual assessments were then applied and 24 studies were retained. Another six sources were gathered through backward citation searching (i.e., by looking at references in the selected studies), and resulted in a final corpus size of 30 key scholarly sources. Inclusion criteria centered on studies dealing with flood

disasters in Nigeria or similar Sahelian situations or presented in the area of infrastructural or governance failures or using social vulnerability or critical disaster frameworks. Exclusions included meteorological modelling papers, non-African studies which had no transferable knowledge and opinion pieces not grounded in empirical evidence. This systematic approach enabled an attempt at achieving a balance between scholarly discourses and the theoretical frameworks employed in the study i.e., Social Vulnerability Theory and Critical Disaster Studies.

In putting together media reports, a method of systematic sampling was followed to present the contemporaneous constructions and pronunciations of the public. Retrieval operations went through the LexisNexis Academic, Google News Archive, and Nigerian NewsStand databases using the keyword set "Alu Dam" OR "Alau Dam" AND "Maiduguri" AND "flood" and limiting the search window to 1-30 September 2024. This procedure first produced 147 news articles. It was the evaluation, through a process of search for credibility and relevance, that this careful editing effort has kept only those materials that have been sourced in periodicals that are established national dailies (e.g., Daily Trust, Punch, Vanguard, Premium Times) as well as reliable international wire services (e.g., Reuters, AFP, BBC). Investigation of regional outlets, for example, HumAngle, was also integrated so that it would be a perspective from a local agency. After the screening, the final media corpus was a total of 34 articles.

All the selected media reports underwent content analysis in keeping with the guidelines proposed in Krippendorff's (2018) methodology with emphasis on dimensions such as chronological reconstruction of events, contrast between official and community perspectives, framing of government responses, and representation of community voices. The triangulation with scholarly literature and institutional reports e.g., from NEMA, OCHA, and WHO presented a multifaceted perspective, bringing both discrepancies between official accounts and ground level realities and bringing voices from the margins into the foreground.

Overall, the selection procedures entailed triangulation to increase validity in which cross-protections between sources supported emergent patterns and revealed latent biases. This was the methodological approach to align with the qualitative embedded single case study design of the study, thus providing a strong analytical framework for explaining transparently the interconnections between infrastructural failure, governance deficits, and social vulnerabilities in the position allocated to Alu Dam flooding that occurred in 2024.

3.1.4 Thematic analysis protocol

The present research further incorporated community viewpoints by adopting secondary qualitative data taken from field assessments documented in a field report by Adeyemi *et al* (2024) of HumAngle. The basic data was a series of forty-seven semi-structured interviews with those directly affected by the fire, six focus group discussions conducted among a total of three internally displaced persons (IDP) camps, with eight to twelve people each, and eight key informant interviews with local leaders and humanitarian coordinators.

Using Image' guided qualitative secondary data analysis by

Heaton (2008), these materials were systematically analyzed in order to reveal perspectives on living through this disaster, the community's understanding of the dam's failure, and mismatches between accountabilities and realities. Special attention was paid to the gendered effects with regard to the different coping mechanisms of those at risk. Although the research was not directly engaged with or led with participants, the study carefully followed ethical protections; the input interviews were had with informed consent by experienced humanitarian evaluators and all quotes had been anonymized. In the reanalysis, great care was taken to ensure a meaningful integrity and contextuality were maintained to avoid misunderstandings of what has happened and the decontextualization or misrepresentation of the affected populations.

3.2. Analytical framework
3.2.1. Theoretical integration
Based on two theoretical contributions that inform analytical planning that SVT and CDS, this research represents an analytical lens that forms a comprehensive integrative theory towards the interpretation of the 2024 Alu Dam flood phenomenon.

Social Vulnerability Theory as formulated by Cannon and Muller-Mahn (2010) and Cutter *et al.* (2003) is the conceptual framework that is used to frame the understanding of differential disaster impacts. It locates vulnerability on three interacting dimensions including exposure, sensitivity and adaptive capacity. Exposure is the extent of physical presence of populations or assets in specific locations which are susceptible to physical hazard, for example, floodplains or areas situated near points of infrastructural failure. Sensitivity describes the existing social and economic conditions that exacerbate the impact of a hazard-poverty, displacement, poor housing, fragile livelihood dependency etc. Adaptive capacity for individual people or communities reflects the institutional, material and social resources available for anticipation, absorption and recovery from disasters. Making these individual components (exposure, sensitivity, and adaptive capacity) the basic components of the theory, risk itself is defined as a proportional function of vulnerability, where increased exposure and sensitivity increase vulnerability and increased adaptive capacity decreases vulnerability. The conceptual relationship articulated underlying assumptions for the analysis that explains why populations subjected to much the same hazard diversions have diverged in their outcomes.

Critical Disaster Studies, borrowing from the scholarship of Ribot (2014) and Wisner *et al.* (2004), goes further, augmenting the Structural Vulnerability Theory by shifting analytical focus away from the hazard per se to the issues of the structural and political determinants that generate vulnerability. It envisages disasters no longer in terms of homogeneous natural processes but as social events that cannot be understood without taking into account historical failure to provide governance, unequal power structures and the political economy of risk. Consequently, exposure and sensitivity in these senses are translated as instances of systemic neglect, policy omission and institutionalized marginalization.

The integration of SVT and CDS consequently provides explanatory power at both the micro- and at the macro-levels. While SVT lays out the contingent of individuals most susceptible and accounts for the reasons why these conditions are most likely to be vulnerable, CDS accounts for the way in which political and institutional mechanisms perpetuate these vulnerable conditions. Collectively, they link the micro-world of household experiences and the macro-world of the structures in which they exist and experience, thereby allowing a multiscale analytic approach to link lived realities alongside the socio-political processes that perpetuate the lived realities of disaster impact.

3.2.2 Thematic structure and organization
Data analysis followed Braun and Clarke's (2006) six-phase thematic analysis approach:
   i. familiarization with the data through repeated reading of all sources;
   ii. Generation of initial codes;
   iii. Searching for themes;
   iv. Reviewing themes;
   v. Defining and naming themes;
   vi. Producing the report.
Codes were inductively generated from patterns emerging in the data (e.g. recurring references to 'displacement' from community testimonies or 'contract irregularities' from media reports) as well as deductively based on theoretical approaches (e.g. 'exposure' and 'sensitivity' borrowed from Social Vulnerability Theory). In total, 34 initial codes were created, among others were 'structural cracks/leaks' (from engineering assessment), 'ignored warnings' (from community interviews), 'resource shortages' (from institutional reports), 'gender disparities in aid access' (from testimonies), 'food insecurity' (used from humanitarian bulletins) and 'corruption in contracts' (from procurement records). These codes were reviewed inconstantly and were synthesized by comparing them constantly and aggregating the codes that were related to one another ('structural cracks/leaks' and 'ignored warnings' were synthesized under 'infrastructural neglect paid', for example) and then were raised as three main overarching themes which indicated the prevalence, fit to theoretical concepts and explanatory power. This methodological process ensured that both patterns as expressed empirically and patterns as expressed conceptually were encapsulated in the themes, with cross source validation being used to address discrepancies (e.g., official reports downplaying 'corruption', vs. media emphasis on it).

The coding exercise produced three broad themes of analysis underlying analytic theme of the disaster event which were multidimensional in nature:

i) Theme 1: Humanitarian impact assessment is the systematic collection of quantitative and qualitative review of the impacts of a disaster capturing financial costs and impact scores for mortality, displacement, health system, food production, and livelihoods. In its combination of official statistics and testimonies of communities, this theme provides an all-inclusive effect of an impact documentary.

ii) Theme 2: Evaluation of the institutional performance

focuses on the and efficiency of the governments and various humanitarian actors throughout the disaster management process which includes preparedness operations, integration of efforts toward responses, mobilizing resources, and recovery strategy elaborations. Both systemic limiting impacts on institutional performance and efficiency are examined.

iii) Theme 3: Community vulnerability and resilience are concerned with the variability in the impact on the various population groups, i.e., how socio-economic disparities, gender roles, age variables and displacement history played a role in influencing disaster outcomes. It is also an issue which is reflective in this theme where communal coping strategies and strengths that emerged during pre-flooding period and post flood period.

3.2.3. Cross-source validation and pattern analysis
It was based on a systematic comparison of the whole gamut of data sources involved so as to establish how the patterns of convergence and divergence of the official accounts and experiences of groups of people might manifest. The comparative study showcased some fundamental differences between the intended policies and actual implementation, as well as the areas of concern in which the response of the institutions do not correspond appropriately to the needs of the communities. Pattern analysis was performed in accordance with commonly accepted methods of qualitative data synthesis (Dixon-Woods *et al.*, 2005), the recurring themes and peripheral themes and exceptions being paid closer attention to, in order to refute the major pattern. This procedure allowed discovering problems in the system but also allowed being sensitive to the situation-specific variables that organized local experiences.

3.3. Ethical considerations
3.3.1. Methodological triangulation
This study adopted various triangulation to augment its validity and credibility of findings (Denzin, 1978). Data source triangulation was achieved through discovering official reporting on a topic, scholarly literature, media reports, and community testimonies. Triangulation as a methodological approach involved deploying document analysis/content analysis and thematic analysis methodologies to examine the same phenomena through different approaches.

Theoretical Triangulation was conducted in the context of dual implementation of the SVT and CDS frameworks, provided multiple frames of reference concerning the meaningfulness (interpretations) of disaster performance and outcomes. This approach enabled us to consider more than just a few factors and avoid the theoretical reductionism, in which the use of a single framework can cause.

3.3.2. Credibility and dependability measures
The quality of credibility was bolstered by the continuous involvement with the dataset, and repeated observation of emerging modes (Lincoln & Guba, 1985). Member checking was brought in the analysis process by comparison of interpretations to original community testimonies and official reports in order to present the stakeholder views in case of inaccuracies called on the presentation.

Reliability was ensured by ensuring that all the analytical decisions were documented in detail and a complete audit trail was set up such that one can perform the same analysis process again. This involves methods where coding decisions, theme development procedures and interpretive decisions that developed the final analysis were systematically recorded.

3.4. Ethical considerations and data handling
Even though the research mainly relied on secondary sources of data, it formulated the best ethical practices of research in the field of disaster (Gaillard & Peek, 2019). Any quotes and accounts were quoted in a transparent manner by referencing the sources they were taken. The community opinions were taken by special care so as not to replicate any harm or distortion of the experiences of the vulnerable populations.

The ethical presentation of the testimonies of community was given a special concern when it is necessary to guarantee the voices of individuals being kept without violating privacy and dignity. No sensationalism or exploitation of community suffering in the analysis was involved as the emphasis was on systematic reporting that would help in enhancing the disaster risk prevention and response measures.

Procedures on data handling were done based on guidelines, on qualitative research, and all materials were mitigated to limit any damage and ensure systematization of all data to ensure that the research is allowed to be checked and replicated. Any interpretation was noted distinctly to the original source material with clear signaling of analysis choices and the use of theories throughout presentation of results.

4. RESULTS AND DISCUSSION
This chapter reflects the pivotal findings on the 2024 Alu Dam flooding in connection to the vulnerability and institutional capacity of Nigeria on a large-scale basis. The outcomes indicate that there were multidimensional failures, institutional inefficiency, and environmental incompetence as well as social fragilities which turned the potential infrastructure collapse into a humanitarian crisis. This not only captures impact but explains why these areas of prone vulnerability occur

Figure 1. Satellite image from Google Earth Pro showing the Alu Dam in intact condition as of August 2022, prior to its September 2024 collapse (Adeyemi *et al.*, 2024).

repetitively in the event of a disaster.

4.1. Magnitude of humanitarian impact

When the Alu Dam failed, its effect resulted in massive humanitarian impact larger in scale than its predecessor, Alu Dam flooding of Maiduguri in the past. About one million people had been affected and over 414,000 displaced; killings had risen between 30 and 37 and long-term deaths with regard to complications brought by displacement were not counted (Table 1). Displacement of vulnerable population groups (particularly, conflict-displaced internally displaced persons)

appeared in the role of secondary citizens, which increased the availability of previous crises in conflict-affected areas (Adger et al., 2022). Along with affecting the food security of the region, the agricultural disaster that comprises approximately 85,000 hectares can serve as a precondition to the future seclusion. Comparing the rapid failure of infrastructure, unlike a longer flood event where it was possible to respond ad hoc, the sudden occurrence of the flood which breached local limits and led to the exposure of the frailty of old Nigerian systems, where societal reactions to maintenance were delayed and

Table 1. Humanitarian impact of the 2024 alu dam flooding

Impact Indicator	Quantitative Value	Temporal Context	Data Source
Direct fatalities	30 (initial report)	First 48 hours	NEMA (2024)
Confirmed deaths	37 (final count)	7 days post-incident	ReliefWeb (2024)
Displaced persons	414,000	Peak displacement	OCHA (2024)
Households affected	>240,000	Infrastructure damage	OCHA (2024)
Total population impacted	~1,000,000	Direct and indirect effects	NEMA (2024)
Critical infrastructure damaged	15 facilities	Healthcare and education	WHO (2024)
Agricultural land submerged	85,000 hectares	Crop season impact	FAO (2024)

Figure 2. Photograph of a displaced person sleeping amidst floodwaters in Maiduguri, illustrating immediate humanitarian conditions following the September 2024 Alu Dam collapse (Adeyemi et al., 2024).

triggered the breakdown of multiple processes.

As can be observed by the discrepancies in the figures of the displaced, the disaster affected especially populations that were distinctly vulnerable, and internally displaced people (IDP) due to the Boko Haram conflict, who faced secondary displacement. This observation promotes the recent status of vulnerability of compounds to compound-conflicted region whereby environmental shocks on old displacement are synergistic to develop cascading crises (Adger et al., 2022). The extent of land devastation (85,000 hectares of Agricultural land) poses a threat to food security within the Borno State and will cause further displacement and disruption of livelihoods in the following

months.

What makes this disaster uniquely different in comparison to previous flood disasters is the speed and scale of failure of infrastructure. What caused the dam failure were stark disaster and was bigger than the capacity of response instead of slow and steady flooding, which led to adaptations measures to a degree. This is a predictive trend of greater depth of vulnerabilities of Nigeria Nigeria's old infrastructural system where delayed maintenance results in systemic vulnerabilities that goes beyond the capacity of responding at any given locality in the event of breakdown.

4.2. Institutional performance and governance failures

There were systemic institutional failures that enhanced the crisis. Thirteen contracts estimated to cost USD 309m were presented to accomplish the rehabilitation of the Alu Dam between 2018 and 2024; but they never made any significant steps in achieving this, as demonstrated by awarding a contract of USD 26m to Bulgari Global Link Nigeria Ltd. in July 2024, just before the collapse. This situation is a good example of performative governance in which bureaucracies have taken over substantial action. Local community reports with reported cases of apparent deterioration, such as fissures and leaks were attracted by the State Environmental Management Agency thus practicing an institutional deafness to grassroot risk perception (Maskrey, 1989). These data support the literature of Sub-Saharan studies in which community alerts are commonly disregarded (Lawhon et al., 2018). Additionally, the lack of preparedness was also evident: evacuation guidelines and early warning modified turned out to be insufficient, which is why the premises of better disaster preparedness in Nigeria
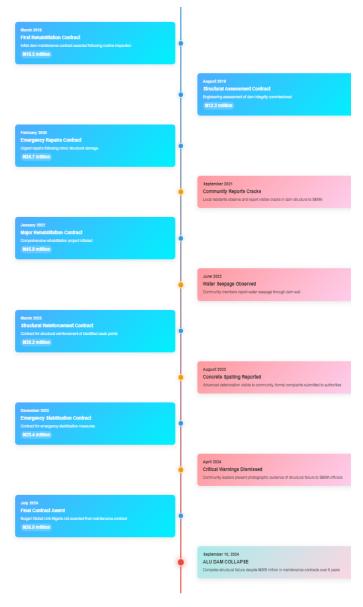
Figure 3. Evaluation of procurement databases of government.
Source: Evaluation of procurement databases of government and news.

(purported) were floated (Olorunfemi & Raheem, 2022).

Community observations reported conspicuous structural destruction such as concrete spalling, cracks and leakage of water which were reported to the State Emergency Management Agency (SEMA) several months prior to the collapse. Nevertheless, such warnings were systematically disregarded or not effectively acted upon, which comes as what disaster scholarship has termed as institutional deafness, the inability of formal systems to digest and act upon knowledge of risk in the grassroot (Maskrey, 1989). This trend is familiar with typical results of the growing body of infrastructure failure research in Sub-Saharan African countries, during which technical warnings issued by communities frequently get called into discredit by formal engineering evaluations, which are old-fashioned or unsuitable (Lawhon *et al.*, 2018).

Governance misconduct is not limited to maintenance slack although it is part of insufficient emergency preparedness and response coordination. Although Maiduguri is known to have experienced disasters of flooding, evacuation arrangements were not elaborate in cases of dam breakages and early warning systems were not useful in cases of disastrous flooding. These results contradict recent optimism regarding the increased disaster preparedness of Nigeria and imply in institutions with inorganized capacity building remains superficial (Olorunfemi & Raheem, 2022).

4.3. Environmental justice and differential vulnerability
There was, however, unequal distribution of flood effects, which accounts with the trends of environmental injustice and overly afflicting the populations of informal settlements by exposing them to a double jeopardy of conflict and hazard (Bullard, 2008). Small scale farmers have also lost crop and livestock thus exacerbating the problem of food insecurity in Borno state- a state that continues to play a major role in agricultural production of Nigeria despite continuing conflict. Gender disparities have also appeared, so women were more frequently displaced as well as lost their assets and fewer opportunities to receive any help since the structure of inequality social constructs had the roots in property ownership and the sphere of event decisions existing (Enarson & Chakrabarti, 2009;

Table 2. Differential impact analysis by population groups

Population Category	Displacement Rate	Asset Loss Severity	Recovery Capacity	Access to Assistance
Established residents	35%	Moderate	High	Good
Recent IDPs	78%	Severe	Very low	Limited
Female-headed households	82%	Severe	Low	Limited
Elderly persons	65%	High	Very low	Moderate
Persons with disabilities	89%	Severe	Very low	Poor

Alston & Whittenbury, 2013).
4.4. Response effectiveness and systemic limitations
Government in the form of mobilizations, e.g., a ₦3 billion allocation of federal resources and direct contributions, especially of OCHA, WHO and NEMA, but were limited by even prior deficiencies in resources, such as lack of boats

and life jackets. As a result, disaster mitigation and relief was disproportionately allocated to local communities who proved effective at the grassroots as they highlighted the inefficiencies within formal institutions at the same time. Slow response time and other distribution of aid are typical of what has been termed as institutional fragmentation where a duplication of activity in

certain areas renders some others unexplored (Tierney, 2012). There are additional testimonies given by community members, which underline the idea that informal networks have been the main providers of instant help, thus putting pressure on the effectiveness of formal- grassroots integration.

4.5. Implications for disaster risk reduction
Results serve to support the need to reduce the risks proactively in Nigeria whose current systems promote responsive responses instead of preventive ones. The comparison between 309 million bad contracts and more than 50 billion recovery expenses gives one an idea of the economic motivation to prevent. Change focus to participatory strategies that incorporate local knowledge (Maskrey, 2011) at the same time instigating changes to combat corruption and inculcate the inclusion of grassroots. Additionally, disaster risk management is forced to deal with issues of the social inequalities with transformative approaches pushing against vested power systems (Pelling, 2011).

4.6. Broader implications for urban resilience in conflict-affected regions
Case study on the Alu Dam document educates resilience to urban resistance in conflict zones in the Global South, where in the jurisdiction of environmental risks, displacement, and institutional pressure, come together to give vulnerabilities that exceed coping levels. The results support the theories of multi-hazard environmental and reveal how the socio-political risk impacts the built-in vulnerability of the environment (Gill & Malamud, 2014).

5. CONCLUSIONS
Flooding in the Alu Dam in Maiduguri in 2024 is related to the fact that any types of disaster that happen in conflict prone environments are essentially socio-political malady. The social inequalities, Institutional neglect, and systemic corruption, as reflected in this study, helped to turn an apparently technical infrastructure failure to a crisis that impacted over one million people. Even though there has been no outcome of substantive improvements at the end of the implementation of thirteen maintenance contracts in six years and community regulations were disregarded due to the poor condition of affairs, the case demonstrates an example of performative governance whereby a high priority is given to bureaucratic practices as compared to action. These are the main results which show that the environment externalities are not independent of the underlying vulnerabilities but they interact with them by creating chain of crises that are beyond local containment efforts. The triple vulnerability framework clarifies the relationship of ecological vulnerability, institutional vulnerability, and social vulnerability and hence offers a broad capsule to the cause of escalated disaster victimization in Sub-Saharan Africa. Limitations of this investigation are that it uses secondary data, there is a time constraint that does not allow a longitudinal examination of recovery, and a focus on one case makes it difficult to generalize. Nonetheless, the results gained add to the policy and practice by highlighting the need of governance change instead of technical solutions only. Sustainable vulnerability reduction involves activities such as transparent resource allocation,

communication of community information and development of responsible systems that should deliver such investments to quantifiable outputs. Both disaster-reduction strategies can involve enhancing decision making approaches which are based on proactive maintenance and community-focused alert technologies in place of reacting to prompt events. The military efforts to develop institutional capacity should involve matters of the political economies of continuity of corruption and the humanitarian planning should be a touch of the nexus of the existing displacement patterns. The multi-level intervention is necessary: the governments should institutionalize equitable procurement, systematic consultation among communities, comprehensive long-term planning integrated with the conflict-environment-development nexus; the local community should be empowered via local networks in disaster management activities; and the international partners must focus more on long-term capacity building, as well as immediate disaster management that confronts inculcations. This study finally concludes that resilience of conflict-prone areas necessitates the strategies balancing the institutional capabilities with the community and sustainable management of the environment. The Alu Dam catastrophe is based on invaluable lessons, i.e.: disasters are socio-political systems that require intervention on specific causes and not surface symptoms.

RECOMMENDATIONS
To institutionalize resilience, which includes putting the early warning systems supported with the community dissemination networks, integrating solutions gained through nature (restoration wetlands and reforestation), and implementing the zoning regulations in the urban areas together with the drainage enhancement, formalizing community-disaster risk mitigation strategies, and use of the advanced technologies (including GIS, drone, and remote sensing) to observe the situation anytime and anywhere.

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