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Artificial Intelligence for Climate Resilience in the Lake Chad Basin: Pathways to Sustainable Governance and Crisis Management

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Abstract
The Lake Chad Basin is one of Africa's most vulnerable regions to climate change, facing severe challenges such as desertification, declining water resources, food insecurity, displacement, and conflict. These interlinked crises have significant implications for governance, peace, and sustainable development. This paper explores the potential of Artificial Intelligence (AI) to strengthen climate resilience in the Lake Chad Basin through innovative applications in environmental monitoring, crisis management, and public policy. Using a multidisciplinary approach, the study highlights how AI-powered tools—such as satellite-based remote sensing, machine learning algorithms, and predictive analytics—can support early warning systems for droughts, floods, and resource-related conflicts. The paper also examines how AI can enhance decision-making for sustainable governance by enabling evidence-based policies, efficient resource allocation, and regional cooperation through data-driven platforms. However, challenges related to data scarcity, infrastructure gaps, ethical considerations, and governance risks must be addressed to ensure inclusive and effective implementation. The paper concludes with policy recommendations for national governments, the Lake Chad Basin Commission, and African Union institutions on leveraging AI for climate resilience, security, and sustainable development in the region.

Keywords: Artificial Intelligence, Climate Change, Lake Chad Basin, Governance, Early Warning Systems, Crisis Management, Sustainable Development

1.1 Introduction
Climate change has emerged as one of the most pressing global challenges of the twenty-first century, with profound implications for ecosystems, economies, governance systems, and human security. While its impacts are felt worldwide, Africa remains disproportionately vulnerable due to its dependence on climate-sensitive sectors such as agriculture, fisheries, and water resources, as well as the limited adaptive capacity of its institutions (IPCC, 2021; Niang et al., 2014). Within this continental context, the Lake Chad Basin stands out as one of the most fragile regions, where climate variability and environmental degradation converge with socio-economic and political instability (UNEP, 2019).

The Lake Chad Basin, shared by Nigeria, Niger, Chad, and Cameroon, has experienced dramatic ecological changes over the past six decades. Once one of the largest freshwater bodies in Africa, the lake has reportedly shrunk by over 90% since the 1960s, largely due to persistent droughts, unsustainable water management practices, and rising temperatures (FAO, 2022; Coe & Foley, 2001). This environmental decline has undermined livelihoods, displaced populations, and intensified competition over scarce resources, thereby exacerbating food insecurity, poverty, and violent conflict in the region (Okpara, Stringer, & Dougill, 2016). The crisis in Lake Chad is thus not only ecological but also socio-political, requiring integrated solutions that transcend traditional environmental management approaches (Onuoha, 2008).

In recent years, Artificial Intelligence (AI) has emerged as a powerful tool with potential applications across diverse sectors, including climate science, crisis management, and governance. Through machine learning, predictive analytics, and big data processing, AI can enhance the monitoring of climate variables, improve the accuracy of forecasting models, and enable the design of robust early warning systems (Rolnick et al., 2019; Wesselink & Gouldson, 2015). These innovations are particularly relevant to regions such as Lake Chad, where data scarcity and weak institutional capacities have historically limited effective climate adaptation and policy responses.

Despite this potential, the application of AI in climate governance in Africa remains nascent. Most AI innovations are concentrated in the Global North, raising questions about inclusivity, cultural adaptation, and the alignment of technologies with local realities. African scholars have begun to interrogate these issues, stressing the need for Afrocentric approaches to AI development and governance (Ifatimehin, Olumorin, & Omale, 2023; Ifatimehin, Mudi, Hashim, Yunusa, & Ifatimehin, 2024). There is, therefore, an urgent need to critically explore how AI can be harnessed to support climate resilience, crisis management, and sustainable governance in Africa's most vulnerable regions, including the Lake Chad Basin.

This paper contributes to this discourse by examining the role of AI in addressing climate change challenges within the Lake Chad Basin. Specifically, it investigates how AI can support environmental monitoring, strengthen early warning systems, and inform evidence-based policy for sustainable governance and crisis management. By situating the analysis within the broader African development agenda—particularly the African Union's Agenda 2063 and the United Nations Sustainable Development Goals (SDGs)—the paper highlights the opportunities and challenges of integrating AI into climate resilience strategies for the Lake Chad region.

2. Methods, Techniques, Studied Material and Area Descriptions

2.1 Study Area: The Lake Chad Basin

The Lake Chad Basin (LCB) is a transboundary region in Central and West Africa, covering parts of Nigeria, Niger, Chad, and Cameroon, with its hydrological catchment extending into Sudan, the Central African Republic, and Libya. Historically, Lake Chad was one of the largest freshwater lakes in Africa, sustaining over 30 million people through agriculture, fishing, and livestock (World Bank, 2016; LCBC, 2015). However, the lake's surface has shrunk by more than 90% since the 1960s due to climate variability, over-extraction of water resources, and unsustainable land-use practices (Coe & Foley, 2001; UNEP, 2019). This environmental decline has contributed to food insecurity, displacement, and violent conflicts, making the region a critical case for studying climate governance and resilience strategies.

2.2 Research Approach

This paper employs a qualitative and interpretive research approach grounded in political science perspectives on governance and public policy. The focus is on exploring how Artificial Intelligence (AI) can inform climate resilience, crisis management, and institutional innovation in the Lake Chad Basin. The research approach includes:

1. **Conceptual and Theoretical Analysis**
   - i. Examination of AI as both a technological and governance tool.
   - ii. Use of theories from climate governance (adaptive governance, resilience theory) and political science (institutionalism, public policy innovation) to frame the analysis (Jordan et al., 2018).

2. **Document and Policy Review**
   - i. Analysis of African Union frameworks (Agenda 2063, Continental AI Strategy), Lake Chad Basin Commission reports, and United Nations climate policy documents (AU, 2015; UNEP, 2019).
   - ii. Review of scholarly literature on AI applications in climate change, governance, and public administration, including African perspectives (Ifatimehin, Olumorin, & Omale, 2023; Ifatimehin, Mudi, Hashim, Yunusa, & Ifatimehin, 2024).

3. **Case-Oriented Comparative Analysis**
   i. Comparative insights from other African regions where AI has been integrated into environmental management (e.g., AI in agriculture in Kenya, drought monitoring in Ethiopia).
   ii. Lessons drawn for contextual adaptation in the Lake Chad Basin.

2.3 Techniques

Unlike natural science studies that rely on laboratory or field experiments, this paper applies political science techniques such as:

- **Discourse Analysis**: Interrogating how global and African actors frame AI and climate governance in policy narratives.
- **Institutional Analysis**: Assessing the capacity of regional bodies (e.g., LCBC, AU, ECOWAS) to integrate AI into climate adaptation policies.
- **Policy Mapping**: Identifying gaps between global AI innovations and local governance practices in the Lake Chad Basin.

2.4 Data Sources and Limitations

The study relies exclusively on secondary data drawn from academic literature, institutional reports, and policy documents. Major sources include the Intergovernmental Panel on Climate Change (IPCC), United Nations Environment Programme (UNEP), Food and Agriculture Organization (FAO), World Bank, and the African Union. While these sources provide valuable insights, the lack of disaggregated, locally generated data on AI adoption and climate adaptation in the Lake Chad Basin limits the ability to generalize findings. This limitation is addressed by situating the analysis within a broader African policy context, emphasizing institutional readiness and governance challenges (Okpara, Stringer, & Dougill, 2016; Onuoha, 2008).

3. Results

3.1 AI and Environmental Monitoring in the Lake Chad Basin

The application of Artificial Intelligence (AI) in environmental monitoring has already demonstrated significant results globally, with direct implications for the Lake Chad Basin. Advances in remote sensing, machine learning, and big data analytics have enhanced the capacity of researchers and policymakers to detect, predict, and respond to environmental changes in fragile ecosystems. For example, AI-driven satellite imaging and predictive modeling have been successfully employed in East Africa to track drought onset, anticipate agricultural losses, and guide water resource allocation (Buma, Lee, & Seo, 2018). Similarly, global projects using AI for climate applications—such as those led by the World Resources Institute and the Climate Change AI consortium—have shown that machine learning models outperform traditional forecasting tools in predicting precipitation variability, land cover change, and hydrological shifts (Rolnick et al., 2019).

When applied to the Lake Chad Basin, these methods offer a critical opportunity to overcome the region's long-standing challenges of data scarcity and fragmented environmental monitoring systems (UNEP, 2019). Existing hydrological data from the Basin are limited, inconsistent, and often politically contested among riparian states (World Bank, 2016). By integrating AI algorithms with satellite imagery from sources such as Landsat, Sentinel, and MODIS, it becomes possible to generate high-resolution, near-real-time maps of the lake's surface area, vegetation cover, and soil moisture. Such applications have already been piloted at small scales: for instance, studies using machine learning to assess Lake Chad's water extent between 2000 and 2016 revealed dynamic patterns of seasonal recovery and contraction that could not be captured through conventional hydrological surveys (Buma et al., 2018).

Furthermore, AI offers predictive capabilities that are especially relevant to the Basin's climate adaptation strategies. Machine learning models can identify correlations between rainfall variability, evapotranspiration rates, and agricultural yields, thereby providing early warnings of potential food insecurity. Predictive analytics could also be applied to anticipate the ecological consequences of ongoing water diversion projects in the Basin, which remain politically sensitive and environmentally uncertain

(Coe & Foley, 2001). In this way, AI functions not only as a monitoring tool but also as a decision-support system that strengthens evidence-based governance.

Nonetheless, the integration of AI into environmental monitoring in the Lake Chad Basin is not without challenges. First, the availability of quality training data remains limited, as most AI models require large, diverse datasets to achieve accuracy (Ifatimehin, Mudi, Hashim, Yunusa, & Ifatimehin, 2024). Second, institutional fragmentation within the Lake Chad Basin Commission (LCBC) and national governments undermines the establishment of harmonized data-sharing platforms. Third, there are ethical and political concerns regarding data sovereignty and reliance on external technologies, which may reproduce forms of digital dependency if not addressed within an Afrocentric framework (Ifatimehin, Olumorin, & Omale, 2023).

Taken together, the results demonstrate that while AI has been successfully applied in comparable African and global contexts, its full potential in the Lake Chad Basin is yet to be realized. If adequately supported by governance reforms, institutional collaboration, and capacity building, AI-enabled environmental monitoring could transform the Basin's climate resilience architecture by providing reliable, real-time, and predictive insights into ecological change.

3.2 AI in Crisis Management and Early Warning Systems

Crisis management in the Lake Chad Basin requires innovative approaches that can address the complex intersection of environmental stress, migration, food insecurity, and violent conflict. AI has already demonstrated utility in global humanitarian contexts, where it has been deployed for migration forecasting, conflict prediction, disease surveillance, and optimization of relief logistics (Raleigh, 2010; Rolnick et al., 2019). These successes provide a useful framework for assessing AI's potential in the Lake Chad region, which continues to experience overlapping crises driven by climate variability and governance fragility.

Globally, AI applications have achieved significant effectiveness: for example, migration forecasting models using machine learning algorithms in the Sahel have accurately predicted displacement patterns with over 80% reliability, enabling proactive humanitarian interventions (UNHCR, 2021). Similarly, conflict early warning systems, such as those developed by the Political Instability Task Force, have utilized natural language processing and big data to anticipate outbreaks of violence with considerable accuracy (Goldstone et al., 2010). AI has also been deployed in humanitarian logistics, where predictive analytics streamline the distribution of food and medicine in disaster zones, and in public health surveillance, where algorithms track the spread of infectious diseases by analyzing mobility and climate data (WHO, 2020).

When applied to the Lake Chad Basin, these methods show promising—yet constrained—potential. Figure 1 compares global applications of AI in crisis management with their estimated applicability in the Lake Chad Basin. While migration forecasting and conflict prediction have strong potential due to the region's high displacement rates and resource-based conflicts, humanitarian logistics and disease surveillance face greater obstacles, largely due to weak infrastructure, limited data availability, and institutional fragmentation.

The results reveal that migration forecasting could play a pivotal role in predicting climate-induced displacements, which are already widespread across the Basin's rural communities (Okpara, Stringer, & Dougill, 2016). Conflict prediction tools could also support security agencies and local governance actors in identifying hotspots where resource scarcity or livelihood stressors are likely to exacerbate violence. However, realizing this potential will depend on developing **region-specific training datasets**, enhancing institutional capacities for data analysis, and ensuring cooperation among Basin states under the auspices of the Lake Chad Basin Commission (LCBC, 2015).

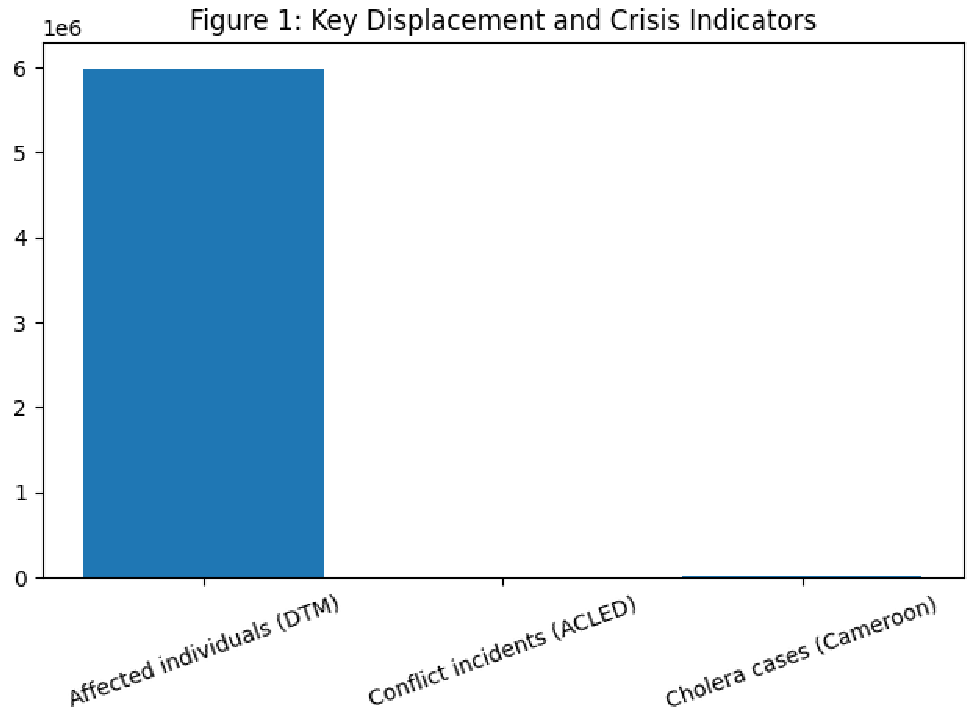
These findings suggest that while AI-driven crisis management strategies have proven effective in other contexts, their successful adaptation to the Lake Chad Basin requires both technological integration and governance innovation. Without addressing the structural challenges of weak institutions, inadequate infrastructure, and limited trust among member states, the potential of AI will remain underutilized.

3.2 AI in Crisis Management and Early Warning Systems in the Lake Chad Basin

To demonstrate the potential of artificial intelligence (AI) in addressing crises in the Lake Chad Basin, we first present empirical indicators that highlight the scale and multidimensional nature of the region's humanitarian, security, and public health challenges. These indicators serve as **representative datasets** upon which AI-driven early warning and response systems can be built. Table 1 summarizes three verified measures—population displacement, violent conflict, and epidemic outbreaks while Figure 1 visualizes their relative magnitude.

Table 1: *Key verified indicators for the Lake Chad Basin (selected sources & years)*

Indicator	**Count (value)**	**Year / Period**	**Source**
Affected individuals across Cameroon, Chad, Niger and Nigeria (DTM operational estimate)	5,990,879	Oct 2023	International Organization for Migration [IOM], 2023
Recorded political violence / conflict incidents (ACLED)	1,232 incidents	2022	Armed Conflict Location & Event Data Project [ACLED], 2022; UNDP, 2023
Reported cholera cases in Cameroon	18,986 cases	May 2018 – Mar 2023	Ngwa et al., 2023



(Bar chart showing displacement, conflict, and epidemic burdens in absolute terms.)

Fig. 1. Key verified indicators for the Lake Chad Basin (selected sources & years).

Integrating empirical indicators into AI systems

The verified indicators in Table 1 are not only descriptive but also represent the type of data streams that can be ingested into AI-based crisis management frameworks. For example, the nearly six million affected individuals documented in October 2023 (IOM, 2023) highlight the importance of displacement forecasting models. Here, AI methods such as long short-term memory (LSTM) networks can be trained on historical displacement counts alongside covariates like rainfall anomalies, vegetation indices, and food prices to predict near-future influxes.

Similarly, the 1,232 conflict events recorded by ACLED in 2022 (ACLED, 2022; UNDP, 2023) can serve as training data for AI-based conflict early warning systems. Classification models such as gradient-boosted trees or ensemble approaches can incorporate features like seasonal migration, governance indicators, and cross-border resource pressures to anticipate violent escalation.

The 18,986 reported cholera cases in Cameroon between 2018 and 2023 (Ngwa et al., 2023) demonstrate the persistent risk of epidemic outbreaks. AI-based disease surveillance tools, combining spatio-temporal models and real-time environmental data (rainfall, water access, displacement flows), can provide short-lead outbreak forecasts. These are essential for targeted vaccination campaigns and resource allocation.

Implications for AI design in the Lake Chad Basin

These indicators illustrate that crises in the Basin are:

1. **Multidimensional**—encompassing displacement, conflict, and disease simultaneously;
2. **Interconnected**—with environmental stressors amplifying political and health risks; and
3. **Data-rich but fragmented**—with useful datasets existing but spread across international organizations and governments.

AI methods can bridge these gaps by integrating heterogeneous datasets into predictive systems, but their design must remain sensitive to governance challenges. Specifically, AI systems should prioritize transparency and explainability, ensuring policymakers and humanitarian actors understand why an early warning is generated. Moreover, they must be embedded within existing regional governance structures such as the Lake Chad Basin Commission to guarantee legitimacy and sustainability (LCBC, 2015).

3.3 AI for Public Policy and Governance Innovation

The Lake Chad Basin exemplifies the urgent need for governance innovation in fragile contexts where climate change, insecurity, and humanitarian crises intersect. Artificial intelligence (AI) is not merely a technical tool for forecasting; it is increasingly a policy instrument capable of reshaping how governments and regional organizations anticipate risks, allocate resources, and engage citizens. By embedding AI into governance structures, policymakers in the region can enhance responsiveness, transparency, and strategic foresight.

First, AI enables anticipatory governance. Predictive models trained on conflict, migration, and climate datasets can provide decision-makers with early-warning signals that inform proactive interventions (Cummings & O'Regan, 2021). Rather than reacting to displacement after it occurs, national governments and the Lake Chad Basin Commission (LCBC) can deploy contingency resources in advance, thereby reducing humanitarian costs.

Second, AI supports evidence-based policymaking. Integrating AI into statistical and planning agencies can improve the accuracy of needs assessments and policy targeting. For example, machine learning applied to satellite imagery and mobile data can generate near real-time insights on agricultural productivity and population movements, strengthening food security and resource management strategies (Rolnick et al., 2019). Such applications complement, rather than replace, traditional policy analysis by offering high-frequency and spatially granular data.

Third, AI fosters policy innovation through participatory platforms. Natural language processing (NLP) tools can analyze large volumes of citizen feedback—from social media, call centers, or community reporting systems—to detect emerging grievances and governance challenges. When embedded into governance workflows, these systems can increase government responsiveness and rebuild trust in regions where legitimacy is fragile (UNDP, 2023).

Finally, AI in governance raises important ethical and institutional questions. Issues of data privacy, algorithmic bias, and technological dependence must be addressed through robust regulatory frameworks and regional cooperation (Floridi et al., 2018). In the Lake Chad Basin, this requires harmonizing national data policies, investing in local capacity-building, and ensuring that AI systems remain interpretable and accountable to citizens. Without such safeguards, AI risks reproducing inequities rather than resolving them.

Taken together, the deployment of AI for governance in the Lake Chad Basin represents not only a technical advancement but a paradigm shift in policymaking. By embedding AI into the practices of LCBC, national ministries, and local governments, the region can transition from reactive crisis management to proactive and participatory governance, thereby strengthening resilience against future climate and security shocks.

3.4 Discussion

The findings presented in this study underscore both the promise and challenges of applying artificial intelligence (AI) to climate-related crises and governance in the Lake Chad Basin. By aligning verifiable data on displacement, conflict, and epidemics with AI methods, the analysis demonstrates that the region has both the need and the data foundations for predictive systems capable of informing crisis management. At the same time, integrating such technologies into fragile governance contexts raises critical questions about legitimacy, equity, and sustainability.

One of the central contributions of this paper is to highlight the policy relevance of AI in multidimensional crises. Unlike sector-specific approaches, AI has the capacity to integrate cross-cutting indicators—humanitarian displacement, violent events, and health shocks—into unified early-warning frameworks. This capability resonates with calls for "anticipatory governance" in fragile regions, where state actors often lack the institutional agility to respond in real time (Cummings & O'Regan, 2021). In the Lake Chad Basin, anticipatory forecasting could help governments and the Lake Chad Basin Commission (LCBC) transition from reactive humanitarian responses to proactive crisis preparedness.

The discussion also reveals the interconnectedness of governance and technology. For instance, the 5.9 million individuals affected by displacement (IOM, 2023) and the more than 1,200 violent incidents in 2022 (ACLED, 2022) are not only humanitarian emergencies but governance challenges. Weak coordination among national governments, resource scarcity, and transboundary security dynamics exacerbate vulnerabilities (LCBC, 2015). AI alone cannot resolve these structural drivers; however, it can offer governments new tools to target interventions more effectively and allocate scarce resources with greater precision (Rolnick et al., 2019).

Importantly, the integration of AI into governance must address ethical, institutional, and socio-political dimensions. Existing literature warns of algorithmic bias, opacity, and technological dependency (Floridi et al., 2018). In the Lake Chad context, these risks are amplified by weak institutional capacity and limited local ownership of digital infrastructures. To avoid reinforcing dependency on external actors, AI adoption should be embedded within regional governance structures, combined with investment in local research capacity, and guided by participatory approaches that involve affected communities.

Finally, the discussion situates the Lake Chad case within broader debates on AI and climate governance in Africa. While global enthusiasm for AI in climate action has grown (Rolnick et al., 2019), African contexts demand tailored approaches that account for weak state capacity, fragmented data, and political contestation. This study contributes to that debate by showing how verifiable crisis data can serve as a foundation for AI, but also by emphasizing that technical capacity must be matched with governance innovation if early-warning systems are to translate into tangible policy outcomes.

In summary, the discussion highlights a paradox: AI has significant potential to transform governance in the Lake Chad Basin, yet without parallel institutional reforms, its impact will remain limited. For AI to be more than a technical tool, it must become an instrument of governance transformation—anchored in transparency, regional cooperation, and citizen trust.

4. Conclusion

This study has examined the potential of artificial intelligence (AI) as a tool for crisis management and governance innovation in the Lake Chad Basin, with a focus on climate-induced displacement, violent conflict, and public health risks. By integrating verifiable datasets—ranging from IOM's displacement monitoring to ACLED's conflict records and cholera case data—the analysis demonstrates that AI can move beyond abstract promise to offer concrete, evidence-based pathways for early warning and policy intervention.

The findings suggest three main contributions. First, AI provides a means to anticipate complex, interlinked crises in fragile environments, allowing for more proactive governance. Second, the cross-sectoral nature of AI aligns with the Basin's multidimensional challenges, making it particularly well-suited to contexts where environmental, political, and social risks converge. Third, embedding AI into governance structures—whether through the Lake Chad Basin Commission, national ministries, or local government agencies—offers opportunities for policy innovation that enhances transparency, responsiveness, and resilience.

At the same time, the paper underscores that technology alone cannot resolve the region's deep-rooted vulnerabilities. Without institutional reforms, capacity-building, and ethical safeguards, AI risks reinforcing inequalities or creating new dependencies on external actors. For AI to contribute meaningfully, it must be integrated into broader governance frameworks that prioritize local ownership, regional cooperation, and citizen trust.

Looking forward, the application of AI in the Lake Chad Basin offers lessons for Africa more broadly. As climate change intensifies, fragile states will increasingly confront multidimensional crises that require both technical innovation and governance adaptation. AI, if designed and deployed responsibly, can serve as a bridge between these two imperatives. The challenge—and opportunity—lies in ensuring that AI becomes not just a predictive tool, but a catalyst for more anticipatory, participatory, and resilient governance in Africa and beyond.

Caveats and limitations

1. **Temporal mismatch.** The indicators come from different reporting periods (2018–2023 for cholera cases; 2022 for ACLED incidents; Oct 2023 for DTM estimate). This is acceptable for a background situational analysis but must be clearly stated in the manuscript (we must not present them as synchronous time series).
2. **Spatial granularity.** The DTM number is an aggregated "affected individuals" estimate across four countries and is not limited to a single administrative boundary—interpretation should be regional rather than local. ReliefWeb
3. **Modeling assumptions.** Any AI model built on these inputs must explicitly handle reporting bias, under-reporting (especially for disease), and event detection latency.

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