

# Climate Change Resilience and Mitigation Strategies Among Indigenous Communities in Azare, Northeast Nigeria: A Critical Review

FATIMA S. MOHAMMED<sup>1</sup>, SANI ISMAILA<sup>2</sup>

<sup>1,2</sup>*Department of Environmental Health Sciences, Federal University of Health Sciences, Azare (FUHSA), Bauchi State, Nigeria.*

*Abstract- Northeast Nigeria is currently at the epicenter of Sub-Saharan climate instability, characterized by rapid desertification, hydrological stress, erratic precipitation and rising temperatures. This paper provides a systematic review of the climate change impacts on indigenous communities in the Azare region, focusing on the intersection of socio-economic vulnerability and Environmental Health. By synthesizing data on the shrinking of Lake Chad and shifting rainfall patterns, the review identifies critical gaps in current adaptation frameworks. Central to this discussion is the role of Indigenous Knowledge Systems (IKS) in providing localized resilience. The findings suggest that while IKS offers a baseline for survival, it must be integrated with modern Geographic Information Systems (GIS) and Environmental Health Officer (EHO) roles to ensure long-term sustainability. Furthermore, it evaluates the efficacy of traditional ecological knowledge in mitigating environmental stressors and proposes culturally and environmentally appropriate mitigation strategies that bridge indigenous practices with modern environmental health sciences. The paper concludes with policy recommendations for integrating community-led mitigation into Nigeria's National Adaptation Plan (NAP).*

**Keywords:** *Climate Resilience, Indigenous Knowledge, Environmental Health, Azare, Northeast Nigeria,*

## I. INTRODUCTION

Climate change in North Eastern Nigeria is a primary driver of socio-ecological transformation. The region's heightened vulnerability stems from its geographic location at the edge of the Sahara and an 80% dependence on rain-fed subsistence agriculture (Audu, 2021). As noted by the Intergovernmental Panel on Climate Change (IPCC, 2023), arid and semi-arid lands (ASALs) are experiencing

temperature increases at a rate significantly faster than the global average.

The Azare region, a critical urban and agricultural hub in Bauchi State, faces specific pressures from the receding Lake Chad basin. The basin has lost approximately 90% of its surface area since the 1960s, leading to a cascading effect of poverty, resource-based conflict, and health system strain (Gbetkom et al., 2023).

The delicate environmental balance in these semi-arid landscapes is increasingly threatened by anthropogenic activities and natural climatic variations (Abubakar & Yamusa, 2020). For the indigenous communities residing in and around Azare, whose livelihoods are intrinsically tied to natural resources, climate change is not merely an ecological crisis but a profound socio-economic and public health challenge.

This review analyzes the specific vulnerabilities of these communities and evaluates the efficacy of both traditional and modern mitigation strategies.

**Brief on the Study Area:** Azare, Katagum

Azare is the administrative headquarters of the Katagum Emirate and the second-largest urban center in Bauchi State, located in the North-Eastern geopolitical zone of Nigeria. Geographically, it sits within the Sudano-Sahelian ecological zone, a region characterized by a fragile environmental balance and increasing vulnerability to the encroaching Sahara Desert.

**Geographic and Climatic Context:** Azare is situated at approximately latitude  $11^{\circ}40'N$  and longitude

10°11'E. The landscape is dominated by a semi-arid climate, featuring a distinct short rainy season (June–September) and a prolonged dry season. This positioning makes the town a critical focal point for research into desertification control, spatial mapping of environmental hazards, and the impacts of high-velocity wind storms on human settlements.



Figure 1. Map of Nigeria showing Azare, in Bauchi state (North eastern region)

#### Academic and Healthcare Significance:

A defining feature of the modern Azare landscape is its role as a regional hub for medical excellence and research. It is the host community for the Federal University of Health Sciences, Azare (FUHSA)—the only specialized University of its kind in the North-Eastern region.

The presence of this institution, alongside the Federal University of Health Sciences Teaching Hospital (FUHSTHA) Azare, has transformed the area into a “Beacon of health” and a learning hub for Allied Health Sciences, Basic Medical Sciences, Dentistry and MBBS.

#### Socio-Cultural Fabric

Historically, Azare is a melting pot of the Hausa, Fulani, and Kanuri ethnic groups, whose livelihoods are traditionally rooted in agro-pastoralism and regional trade. The synergy between this rich traditional heritage and the burgeoning academic community provides a unique platform for integrating Indigenous Knowledge Systems (IKS)

with modern scientific Climate and Health mitigation strategies.

## II. METHODOLOGY

A systematic literature search was conducted across databases including Google Scholar, ScienceDirect, and PubMed. Keywords included "Climate Change Nigeria," "Indigenous Knowledge Azare," and "Environmental Health Northeast." Selection criteria focused on peer-reviewed articles published between 2018 and 2026, government policy documents from the Nigerian Meteorological Agency (NIMET, 2025), and technical reports from international organizations (UNDP, World Bank).

Theoretical Framework: Social-Ecological Resilience:

This review adopts the Social-Ecological Resilience (SER) framework. SER posits that the resilience of a community is its capacity to adapt and transform in the face of persistent stress (Folke et al., 2021). In Azare, this resilience is maintained through a synergy between biological ecosystems and the cultural practices of the Hausa, Fulani, and Kanuri people.

#### Climate Change Impacts in the Azare Region

The geographical positioning of Azare, Katagum renders it particularly susceptible to climate extremes, serving as a frontline against desert encroachment.

- **Temperature Increases:** Regional climate models and empirical observations indicate a sustained upward trend in both minimum and maximum temperatures. Average annual temperatures in Northern Nigeria have risen by approximately 1.2°C over the last four decades, a rate faster than the global average (IPCC, 2023). This thermal stress exacerbates soil desiccation and increases the frequency of severe heatwaves, presenting direct environmental health risks to local populations.
- **Rainfall Variability:** Precipitation in the Azare region is characterized by high inter-annual variability. Recent decades have seen a shift towards delayed onset and early cessation of the rainy season, effectively shortening the

growing period (Iliya et al., 2021). Furthermore, the distribution of rainfall has become increasingly erratic, characterized by intense, short-duration downpours that fail to recharge groundwater and instead lead to severe surface runoff.

- **Extreme Weather Events:** The region experiences a heightened frequency of extreme events, notably prolonged agricultural droughts and episodic flash floods. Wind storms, exacerbated by the loss of vegetative cover, frequently result in severe dust storms, degrading air quality and accelerating wind erosion (Olagunju, 2015).

**Socio-Economic Profile and Traditional Livelihoods**  
 Understanding the socio-economic fabric of Azare, Katagum communities is critical for assessing climate vulnerability and adaptive capacity.

- **Demographics and Livelihoods:** The indigenous populations surrounding Azare are predominantly agrarian and pastoralist, relying heavily on rain-fed subsistence agriculture and livestock rearing (cattle, sheep, and goats). Major cultivated crops include millet, sorghum, cowpea, and groundnut, which are staples adapted to semi-arid conditions (Buba, 2022).
- **Socio-Economic Conditions:** Poverty levels remain disproportionately high in rural Northern Nigeria compared to the national average. Access to formal education, particularly in remote settlements surrounding the urban center of Azare, is limited. This educational deficit restricts economic diversification, trapping communities in climate-sensitive primary production.
- **Access to Services:** Infrastructure, including paved roads, healthcare facilities, and reliable electricity, is largely concentrated in Azare town, leaving peripheral indigenous communities marginalized. Access to safe drinking water and modern sanitation is a persistent environmental health challenge, often worsened during periods of drought or flood-induced contamination (Federal Ministry of Environment, 2021).

**Regional Vulnerability and Environmental Health**  
 Climate change acts as a force multiplier for environmental health hazards. Increased temperatures and erratic rainfall are directly correlated with:

1. **Heat-related Morbidity:** Higher incidences of heat exhaustion among outdoor manual laborers (WHO, 2024).
2. **Vector Dynamics:** Shifts in rainfall patterns have expanded the breeding grounds for *Anopheles* mosquitoes, leading to atypical malaria outbreaks (WHO, 2024).
3. **Water Scarcity:** Reliance on unprotected wells during droughts increases the risk of cholera and enteric diseases.

Table 1: Environmental Health Risk Matrix: Climate Impacts on Indigenous Vulnerability

Hazard	Impact on Indigenous Livelihoods	EHO Intervention/Role	Mitigation Strategy
Prolonged Heatwaves	Heat stress in manual farm labor; loss of <i>Kayan Gona</i> (Stored crops)	Occupational health advocacy; post-harvest loss prevention	Promotion of <i>In-situ</i> solar cooling for community storage.
Flash Flooding	Contamination of <i>Rijiya</i> (Wells); Destruction of mud-brick housing	Water quality monitoring (Chlorination); Sanitary inspections	GIS-based zoning to prevent building in floodplains.
Desertification	Loss of medicinal plants ( <i>Itatuwan Magani</i> ); Fuelwood scarcity	Reforestation monitoring; Promotion of clean energy	Establishing community "Green Belts" using drought-resistant species.
Hydrological Stress	Increased travel time for water; Hygiene-related skin diseases	WASH education and monitoring	Development of solar-powered communal boreholes.

### Indigenous Knowledge and Traditional Coping Strategies

Indigenous communities in Azare have not remained passive victims of environmental change; they possess a rich repository of traditional ecological knowledge developed over centuries of living in a variable climate.

- **Agro-Ecological Practices:** To combat moisture deficit and soil degradation, farmers employ techniques such as mixed cropping (e.g., planting sorghum with cowpeas) to maximize soil nutrient utilization and reduce the risk of total crop failure. The use of organic manure from livestock is a standard practice to improve soil structure and water retention (Nyong et al., 2017).
- **Water Conservation:** Traditional water harvesting techniques are critical. While large-scale irrigation is scarce, micro-catchments and the utilization of natural depressions (fadamas) for dry-season farming are vital coping strategies.
- **Agroforestry and Biological Windbreaks:** The deliberate retention and cultivation of indigenous, drought-resistant tree species (such as *Azadirachta indica* [Neem] and *Faidherbia albida*) within agricultural fields provide shade, fodder, and critical barriers against wind erosion and desertification.
- **Perceived Effectiveness:** While these traditional strategies are highly effective for managing historical climate variability, studies suggest that their efficacy is currently being outpaced by the unprecedented rate and intensity of modern climate change (Urama & Odediran, 2022). Unpredictable rainfall patterns often render traditional meteorological indicators obsolete.

### Indigenous Knowledge Systems (IKS) in Climate Adaptation

In the semi-arid landscapes of Azare, IKS functions as a sophisticated Early Warning System (EWS). These systems are rooted in the observation of biological indicators (phenology) and atmospheric changes.

Table 2: Classification of Indigenous Ecological Knowledge (IEK) and Climate Applications in Azare

IKS Domain	Local Indicator/Practice	Climate Stress Addressed	Scientific Proxy/Correlation
Meteorological	Direction of the <i>Gadu</i> (East wind) in early April	Delayed onset of rainfall	Correlation with African Easterly Jet (AEJ) shifts.
Phonological	Heavy fruiting of <i>Tsamiya</i> (Tamarind) trees	Prediction of a "Wet" year	Response to high groundwater recharge in the preceding cycle.
Agricultural	Zazzaga (Minimum tillage/pitting)	Soil moisture deficit	Conservation agriculture; reduction in evapotranspiration.
Pastoral	Burtali (Traditional migratory corridors)	Resource scarcity/Drought	Spatial optimization of grazing pressure.
Hydrological	Hakar Rijiya (Manual shallow well deepening)	Receding water tables	Adaptive groundwater management.

### Context-Specific Climate Mitigation Strategies

While adaptation is paramount for indigenous communities, localized mitigation strategies that also yield immediate socio-economic and environmental health co-benefits are essential.

- **Sustainable Biomass and Alternative Energy:** A significant driver of local deforestation and greenhouse gas emissions is the reliance on firewood for cooking. Introducing fuel-efficient cookstoves and exploring the production of eco-friendly briquettes from agricultural residues can drastically reduce emissions, preserve local tree cover, and reduce indoor air pollution.
- **Spatial Monitoring and Resource Management:** The integration of Geographic Information Systems (GIS) and mobile sensor technologies can empower local governance and academic institutions to map desertification fronts, track water resources,

and plan land-use more effectively. Providing communities with accessible, localized meteorological data can bridge the gap between traditional forecasting and scientific climate models.

- **Circular Economy and Biodegradable Innovations:** Encouraging sustainable economic activities that utilize local, renewable resources can mitigate environmental impact while alleviating poverty. For example, the development of eco-friendly products, packaging, or textiles from local plant fibers (such as banana or hibiscus fibers) promotes a circular economy, reducing reliance on ecologically damaging materials while generating alternative income streams.
- **Enhancing Soil Carbon Sequestration:** Scaling up traditional agroforestry and introducing improved land-management practices can transform degraded agricultural lands into

carbon sinks. This approach aligns global GHG mitigation goals with the local necessity of improving soil fertility and crop yields.

**Integrating Technology and Tradition:** To move beyond reactive adaptation, the integration of modern technology is essential. Using drones and GIS for flood mapping allows for precision urban planning, but these technologies must be "socialized" within the community to be effective (World Bank, 2022). In the semi-arid landscapes of Northeast Nigeria, particularly around the Azare region, indigenous communities have developed sophisticated, time-tested methods to buffer against the harsh impacts of climate variability. These strategies are rooted in a deep understanding of local ecology and are vital for food security and disaster risk reduction. The following table provides an updated overview of these mechanisms, categorized by their functional application.

Table 3 Traditional Coping Mechanisms for Environmental Change in Northeast Nigeria

Category	Specific Coping Mechanism	Functional Purpose	Reference Source(s)
Agro-Ecological Adaptation	Mixed Cropping & Intercropping (e.g., Sorghum/Cowpea)	Spreads risk; cowpeas provide ground cover to reduce soil evaporation while sorghum provides height.	<i>Abubakar &amp; Yamusa (2020); Buba (2022)</i>
	Use of Organic Manure	Enhances soil structure and water-holding capacity in sandy, semi-arid soils.	<i>Nyong et al. (2017); Landmark Repository (2024)</i>
	Shifting Planting Dates	Delaying planting until "true" rains are established to avoid crop failure from early-season dry spells.	<i>NiMet Seasonal Climate Prediction (2026)</i>
Water Management	Fadama (Wetland) Farming	Cultivating natural depressions during the dry season using residual moisture.	<i>UNFCCC Livelihood Strategies (2023)</i>
	Micro-Catchments & Ridging	Creating soil barriers to slow runoff and encourage deep water infiltration.	<i>Iliya et al. (2021); Wukari Int. Journal (2024)</i>
Pastoral Strategies	Transhumance (Seasonal Migration)	Moving livestock southwards during the dry season to access greener pastures.	<i>MDPI Sustainability (2025); NBS Nigeria (2024)</i>
	Herd Diversification	Keeping a mix of cattle, sheep, and goats to ensure some animals survive species-specific diseases or droughts.	<i>UNFCCC (2023); World Bank Nigeria (2023)</i>
Environmental Protection	Retention of Indigenous Trees (e.g., Neem, Baobab)	Acts as biological windbreaks to slow desert encroachment and provide fodder.	<i>Olagunju (2015); Discovery Scientific Society (2024)</i>
	Live Fencing	Planting drought-resistant shrubs around farms to prevent wind erosion and livestock incursion.	<i>MDPI: Climate-Driven Conflicts Review (2025)</i>
Socio-Economic	Livelihood Diversification	Engaging in non-farm activities like petty	<i>UNDP/OPHI Global</i>

Resilience		trading, weaving, or seasonal labor in urban centers like Azare.	<i>MPI Report (2025)</i>
	Traditional Granaries	Long-term storage of hardy grains (millet/sorghum) to survive multi-year drought cycles.	<i>Katagum Emirate Records (2025); Buba (2022)</i>

Synthesis of Current Trends (2025-2026)

- **Integration of Technology:** Recent studies highlight that while traditional knowledge remains the primary defense, there is an increasing trend of "hybridization." Farmers in the Azare region are now combining traditional planting dates with mobile-based weather alerts provided by NiMet to increase accuracy (NiMet, 2026).
- **Conflict-Coping Strategies:** Due to the scarcity of resources, new "social coping mechanisms" have emerged, such as formalized community-led dialogue platforms between Hausa farmers and Fulani herders to negotiate shared access to water points and crop residues (MDPI, 2025).
- **Declining Efficacy:** There is an academic consensus that while these mechanisms are robust, the frequency of extreme heatwaves (exceeding 45°C) in Northeast Nigeria is beginning to surpass the physiological limits of some traditional crop varieties, necessitating the introduction of improved, early-maturing seeds (IPCC, 2023; Federal Ministry of Environment, 2021).

Data Source	Multi-generation al observation	Satellite imagery/Remote sensing	Validating satellite "anomalies" with ground-truth IKS.
Cost	Low (Resource-based)	High (Requires CAPEX)	Using drones to map IKS-identified flood zones.
Scale	Micro-local (Village level)	Regional/National	Downscaling national forecasts with local linguistic nuances.
Accessibility	Oral tradition (Elders)	Digital/Print (EHOs)	Mobile-based IKS-EWS alerts.

Table 4: Comparative Analysis: Traditional vs. Modern Climate Adaptation Frameworks

Feature	Indigenous Adaptation (IKS)	Modern Technical Adaptation	Synergy Potential (Hybrid Model)

Trends in Global climate change resilience

Global climate change resilience projects led by indigenous communities are increasingly recognized as "pathfinders" for effective adaptation. By blending ancestral stewardship with modern scientific tools, these communities have successfully mitigated environmental shocks. The following table highlights successful global projects with updated data from

Table 5: Examples of Successful Global Indigenous Climate Resilience Projects

Region / Community	Project Name & Focus	Key Outcome / Strategy	Reference Source(s)
Highlands of Mongolia	Advanced Weather Information System (AWIS)	Co-designed system combining satellite data with traditional forecasts to issue drought and snow-melt warnings, reducing livestock mortality.	<i>UNFCCC (2025)</i>
Tla-o-qui-aht First Nation, Canada	Hishuk Ish Tsawaak (Ecosystem Stewardship)	Declaration of 100% territory under ancestral stewardship to protect salmon streams and old-growth forests, strengthening carbon sinks.	<i>UNFCCC (2025); Canada Indigenous-Led NCS (2026)</i>
Mindanao, Philippines	Panlaoy Youth Forestry Network	Revived "kaingin" contour planting and sacred grove protection to recharge springs and regenerate	<i>UNFCCC (2025); UNDP Climate Promise</i>

		degraded watersheds.	(2024)
Murray–Darling Basin, Australia	MLDRIN Water Governance	Reasserted customary governance to negotiate water allocations and restore wetlands, ensuring downstream community resilience.	UNFCCC (2025)
Amazonian Region, Colombia	WFP Resilience & Food Security Project	Integrated nature-based solutions and climate information services to empower 12,000+ indigenous people through 2029.	Global Affairs Canada (2024); WFP (2025)
Bolivia (Uru Uru Team)	Native Plant Bio-Remediation	Youth-led initiative using ancestral knowledge of native plants to build floating rafts that treat polluted lake waters essential for the culture.	UNDP Equator Initiative (2024)
Central America / Mexico (Maya)	Milpa Forest Garden System	Sustainable rotation of corn, beans, and squash within forests to maintain biodiversity and soil fertility against extreme heat.	UNDP (2024); UNESCO (2025)
Taykwa Tagamou Nation, Canada	Flood Risk Modelling & Adaptation	Comprehensive mapping and infrastructure adaptation along the Abitibi River to mitigate erosion and future flooding risks.	First Nation Adapt Program (2026)
Masai Communities, Tanzania	Ancestral Rangeland Restoration	Using native plants and ancestral rotation cycles to stabilize watersheds and combat invasive species in semi-arid lands.	UNDP Tanzania (2024)

### III. POLICY RECOMMENDATIONS

1. The resilience of Azare’s indigenous communities is a testament to cultural endurance but is currently reaching its ecological limits. To achieve high-impact development, this review recommends:
2. Mainstreaming IKS: The Federal Ministry of Environment should incorporate traditional weather indicators into the National Early Warning System.
3. EHO Empowerment: Training Environmental Health Officers in GIS and drone technology to better serve rural Northeast populations.
4. Climate-Smart Infrastructure: Investment in solar-powered irrigation and "Green Belts" to combat desertification.
5. Hybrid Forecasting: Similar to the Mongolian AWIS project, the Azare region could benefit from a formalized platform that blends NiMet scientific forecasts with traditional Hausa/Fulani indicators (e.g., insect behavior or celestial bodies).
6. Youth Engagement: Involving youth in ancestral forestry practices is key to the long-term sustainability of biological windbreaks and desertification control.
7. Nature-Based Restoration: The Masai rangeland project in Tanzania serves as a direct parallel for the Azare region, showing that native plant

restoration can stabilize the soil and increase moisture retention without expensive artificial inputs

### IV. CONCLUSION

The communities of the Azare region are navigating the severe realities of climate change at the intersection of environmental degradation and socio-economic vulnerability. While their indigenous knowledge systems provide a robust foundation for resilience, the accelerating pace of temperature increases and erratic rainfall requires supplementary interventions. Effective climate action in Azare must transcend generic policy, focusing instead on strategies that integrate spatial environmental monitoring, promote sustainable and biodegradable local economies, and respect the intricate agro-pastoral traditions of the region.

### V. DECLARATIONS

Conflict of Interest Statement: The author, Fatima S. Mohammed, PhD, declares that there are no known financial, personal, or professional conflicts of interest that could have appeared to influence the work reported in this paper.

Data Availability Statement: The data supporting the findings of this review are derived from publicly

available peer-reviewed literature and government reports as cited within the bibliography.

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