

SUPPLEMENTARY MATERIAL

A systematic review of climate change and its health outcomes on populations in Nigeria

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Supplementary Table 1. Risk of bias and quality assessment scores of the included studies.

Authors (year)	Risk of bias score	Quality assessment score
Olajide <i>et al.</i> (2014) ⁹	Low	High
Ayanlade <i>et al.</i> (2020) ¹⁰	Low	High
Aborode <i>et al.</i> (2025) ¹⁶	Low	High
Adeleke <i>et al.</i> (2025) ¹⁷	Low	High
Asekun-Olarinmoye <i>et al.</i> (2014) ¹⁸	Moderate	Moderate
Bukar and Abdullahi (2025) ¹⁹	Moderate	Moderate
Echendu (2020) ²⁰	Low	High
Egbinola and Amobichukwu (2021) ²¹	Moderate	Moderate
Umegbolu <i>et al.</i> (2020) ²²	High	Low
Gobir <i>et al.</i> (2020) ²³	Moderate	Moderate
Goni <i>et al.</i> (2025) ²⁴	Low	High
Ribadu (2025) ²⁵	Moderate	Moderate
Okorie and Ezechinnah (2022) ²⁶	Moderate	Moderate
Olutumise <i>et al.</i> (2021) ²⁷	Moderate	Moderate
Nasara <i>et al.</i> (2026) ²⁸	Low	High
Jayieola <i>et al.</i> (2020) ²⁹	High	Low
Ugwuoke <i>et al.</i> (2023) ³⁰	High	Low
Mailafiya <i>et al.</i> (2025) ³¹	Moderate	Moderate
Nasara <i>et al.</i> (2026) ³²	Low	High
Obi (2022) ³³	Moderate	Moderate
Adekunle <i>et al.</i> (2025) ³⁴	Moderate	Moderate
Kehinde <i>et al.</i> (2020) ³⁵	Moderate	Moderate
Oguntimoju <i>et al.</i> (2026) ³⁶	Low	High
Lawanson <i>et al.</i> (2022) ³⁷	Moderate	Moderate
Onwukeme <i>et al.</i> (2025) ³⁸	High	Low
Chidiebere <i>et al.</i> (2025) ³⁹	Moderate	Moderate
Ogezi <i>et al.</i> (2026) ⁴⁰	Moderate	Moderate
Otorkpa <i>et al.</i> (2024) ⁴¹	Moderate	Moderate
Salubi and Elliott (2021) ⁴²	Moderate	Moderate
Ugwuanyi <i>et al.</i> (2024) ⁴³	Moderate	Moderate
Oyelakin <i>et al.</i> (2026) ⁴⁴	High	Low
Ahmed <i>et al.</i> (2024) ⁴⁵	Moderate	Moderate

Supplementary Table 2. Summary of the included studies.

Authors (year)	Objectives	Study design	Study settings and sample size	Key findings	Conclusion
Olajide <i>et al.</i> (2014) ⁹	To examines environmental and livelihood vulnerabilities of low-income coastal settlements in Lagos	Mixed-methods	Ajegunle-Ikorodu, Ilaje-Bariga, Makoko, Okun-Aja, Aboru-Ipaja communities in Lagos, Southwest Nigeria; n = 592 households	Vulnerabilities of Lagos to flood hazards is a function of various biophysical, topographical, climatic, and socio-economic factors. Uncoordinated urban expansion into flood prone areas and increase in the intensity and volume of rain are also contributory factors.	Low-income coastal settlements dwellers face disproportionate climate-health burdens; community-level infrastructure interventions are urgently needed.
Ayanlade <i>et al.</i> (2020) ¹⁰	To examine gender vulnerabilities and responsive strategies to climate change in Kwara and Nassarawa States	Mixed-methods	Kwara, and Nassarawa states, Northcentral Nigeria; n = 200 participants	The farmers perceived climate change differently, with observed changes in climate variabilities (temperature and precipitation resulting in extreme floods, drought, and rainfall onset), leading to varying adaptation practices.	Gender plays a significant role in the adoption of adaptation practices among farmers in the agricultural sector. ; there is a need for better gender-sensitive approaches to adaptation planning and implementation.
Aborode <i>et al.</i> (2025) ¹⁶	To examine the interplay between climate-induced flooding, waterborne diseases, and malnutrition in Borno State	Reviews	Borno State, Northeast Nigeria	Flooding disrupted water and sanitation systems, creating breeding grounds for cholera, malaria, and diarrhoeal illnesses. Displacement and destruction of agricultural infrastructure increased food insecurity, leading to malnutrition. Conflict compounded climate vulnerability.	Climate-induced flooding constitutes a public health crisis requiring integrated adaptation strategies and strengthened healthcare systems in conflict-affected settings.
Adeleke <i>et al.</i> (2025) ¹⁷	To evaluate thermal stress indices (TSI) for heat-related illnesses across four Nigerian states	Time-series analysis	Benue, Edo, Niger, and Ondo States; 32 years (1987–2018) of meteorological data	Heat fatigue was the most prevalent thermal stress category, with greater indications during dry periods. Nearly one-third of study years indicated heat fatigue in Ondo State. Significant monthly and seasonal variations were observed.	Heat fatigue is widespread; healthcare education and adaptive measures are required to help populations cope with thermal stress.
Asekun-Olarinmoye <i>et al.</i> (2014) ¹⁸	To assess public perceptions of climate change and its health and environmental impacts in rural southwestern Nigeria	Cross-sectional survey	Rural communities in Osun, Ekiti, and Oyo States, Southwest Nigeria; n = 1,019	Most respondents perceived climate change existence in the last 10 years. Knowledge of causes was poor, but knowledge of effects was good. Bush burning and tree felling were common risky behaviours. Occupational status was significantly associated with attitudes.	Rural communities are vulnerable to the adverse effects of climate change; sustained health promotion is needed to translate awareness into adaptive action.
Bukar and Abdullahi (2025) ¹⁹	To examine rainfall variability influence on cholera incidence in Damaturu, Yobe State	Mixed-methods	Damaturu LGA, Yobe State, Northeast Nigeria; n = 384 respondents	Rainfall significantly affected cholera outbreaks, with increased incidence variations attributed to rainfall fluctuations. Certain wards were more vulnerable due to poor sanitation and flooding.	Collaboration between meteorological and health agencies is needed for early warning systems targeting climate-sensitive diseases.
Echendu (2020) ²⁰	To evaluate the impact of flooding on Nigeria's sustainable development goals (SDGs)	Reviews	Nationwide	Main causes of flooding is man-made and advocates for spatial planning as a sustainable flood risk management (FRM) strategy of the Nigerian environment is important	Flooding is a multidimensional health threat requiring spatial planning and community-based adaptation strategies; a national scale to combat the flooding in Nigeria is critically needed.

Egbinola and Amobichukwu (2021) ²¹	To analyse climatic variation in Ibadan region based on the variations in rainfall and temperature	Time-series analysis	Ibadan, Southwest Nigeria; 42 years (1970-2012) of climate data	There is an upward trend in the total rainfall and average minimum temperature. Positive relationship between total rainfall and average minimum temperature.	Climate-informed early warning systems can enhance the timing and targeting of adaptation interventions.
Umegbolu <i>et al.</i> (2020) ²²	To investigate climate change awareness and its health implications	Cross-sectional survey	Enugu State, Oji-River LGA, Southeast Nigeria; n = 109 respondents	Awareness of climate change and its health impacts was high. Predictors: age, sex, educational level, type or place of residence, occupation, source of information.	Public health education on climate-health linkages is needed to build community resilience.
Gobir <i>et al.</i> (2020) ²³	To assess knowledge of heat waves and protective practices in a rural community	Cross-sectional survey	Nasarawan Buhari, Kaduna State, North-Central Nigeria; n = 104 household heads	Knowledge of heat waves was poor. Fluid intake and cold showers were the only protective measures used by the majority. Farming occupation was significantly associated with knowledge.	Health education interventions on heat wave risks and protective measures are needed in rural communities.
Goni <i>et al.</i> (2025) ²⁴	To examine epidemiological burden, spatial patterns, and temporal trends of cholera outbreaks in Yobe State	Retrospective cross-sectional study	Yobe State, Northeast Nigeria; surveillance data 2020–2024; n = 6,792 cholera cases	The largest outbreak occurred in 2021. Cholera peaked during the rainy season, particularly August. CFR was highest among individuals aged above 60 years. Significant spatial clustering identified in flood-prone urban settlements.	Cholera outbreaks are driven by seasonal flooding; strengthening WASH infrastructure and surveillance is critical.
Ribadu (2025) ²⁵	To assess the impact of climate variability on farming households' food security	Cross-sectional survey	Katsina State, Northeast Nigeria; n = 400 households	Food security is critically compromised across four dimensions of availability, access, utilisation, and stability. Vulnerable populations experience disproportionately higher level of food insecurity.	Climate variability threatens household food security; adaptation strategies must be scaled up across affected populations.
Okorie and Ezechinnah (2022) ²⁶	To evaluate climate change impacts on crop production	Reviews	Rivers State, South-South Nigeria.	Climate change reduced agricultural output, loss of biodiversity, breed of conflict/communal crisis, causes displacement of farming communities, leading to reduced dietary diversity and increased food insecurity.	Climate-resilient agricultural policies are essential to safeguard nutrition outcomes in farming communities.
Olutumise <i>et al.</i> (2021) ²⁷	To examine the relationship between climate variability and healthcare expenditure among farmers	Cross-sectional survey	Ekiti and Ondo States, Southwest Nigeria; n = 459 food crop farmers	Farmers perceived increases in heavy rainfall, storms, floods, and disease incidence. Self-medication was the commonest treatment source. Climate variables and extreme weather events were significant determinants of catastrophic health expenditure.	Robust synergy between meteorological forecasting and health surveillance is needed to guide farmers against climate-sensitive diseases.
Nasara <i>et al.</i> (2026) ²⁸	To analyse spatio-temporal characteristics of heat stress across Nigeria	Time-series analysis	Nine weather stations across Nigeria; 40 years (1979–2018) of ERA5-HEAT reanalysis data	Heat stress levels ranged from “slight cold” to “very strong.” A critical “very strong” heat stress period occurred during March–May. Significant positive trends in heat stress were observed over the 40-year period, with Guinea and Sahel regions showing higher positive trends.	Increasing heat stress poses growing health risks; urban planning and public health systems must adapt to rising thermal burdens.

Jayicola <i>et al.</i> (2020) ²⁹	To examine the impact of temperature and relative humidity on epilepsy patient visits	Time-series analysis (hospital records)	Akure, Ondo State, Southwest Nigeria; n = 2,873 epilepsy patients (2010–2017)	Temperature and relative humidity were positively associated with epilepsy-related hospital visits. Children were more vulnerable to temperature effects, while adults were more vulnerable to humidity effects.	Climate parameters influence neurological disease patterns; health services should prepare for climate-related increases in demand.
Ugwuoke <i>et al.</i> (2023) ³⁰	To investigate the effects of rational emotive family health therapy (REFHT) on flood-induced anxiety disorders among farmers in Anambra	Cross-sectional survey	Anambra State, Southeast Nigeria; n = 120 farmers	Flood exposure was associated with elevated levels of anxiety. REFHT was significantly effective in reducing flood-induced anxiety disorders among farmers	Mental health services must be integrated into post-flood disaster response frameworks.
Mailafiya <i>et al.</i> (2025) ³¹	To assess knowledge and perception of climate change impact on vector-borne diseases in Zamfara State	Cross-sectional survey	Zamfara State, Northwest Nigeria; n = 384 participants	Rising temperatures, extreme rainfall, and drought expanded the range and breeding sites of disease vectors. Community involvement and public awareness were moderately effective. Routine insecticide spraying and enforcement of climate-related health policies needed improvement.	Climate change significantly impacts vector-borne disease transmission; enhanced surveillance and vector control are required.
Nasara <i>et al.</i> (2026) ³²	To examines the spatial and temporal variability of heat stress in Nigeria	Time-series analysis	Nine weather stations across Nigeria; 73 years (1950-2023) of reanalysis data	There is a significant rise in heat stress across Nigeria from 1950 to 2023, with the northern region warming at a rate of 0.20°C per decade. This trend poses substantial risks, including decline in outdoor labour capacity during peak months.	Escalating heat stress poses an urgent threat to public health and outdoor labour productivity, demanding immediate, tailored adaptation strategies.
Obi (2022) ³³	To examine the health impacts of gas flaring and climate change in Delta region of Nigeria	Cross-sectional survey	Delta region, Nigeria; n = 500 residents	Residents reported high prevalence of respiratory problems, and diabetes. Proximity to gas-flaring sites was associated with worse health outcomes. Climate change exacerbated existing environmental health burdens.	Environmental pollution from gas flaring combined with climate change creates a dual health hazard requiring regulatory enforcement and clean energy transition.
Adekunle <i>et al.</i> (2025) ³⁴	To assess effects of climate-related shocks on farming households' food security	Cross-sectional survey	Niger State, North-Central Nigeria; n = 300 participants	Approximately 52% of households were food secure. Floods were a significant factor affecting food security. Drought-tolerant crops and dry-season farming were the most common adaptation strategies.	Climate shocks significantly affect household food security; investments in irrigation and drought-tolerant crop varieties are needed.
Kehinde <i>et al.</i> (2020) ³⁵	To evaluate the health vulnerability of aged people to climate change impacts	Cross-sectional survey	Ibadan, Oyo State, Southwest Nigeria; 14 years (2000-2014) clinically diagnosed data	Increased trend of mean maximum temperature is associated with incidences of hypertension, respiratory diseases, and diarrhoea among aged people. Aged people could be significantly attributed to influences of climatic parameters	Aged populations are particularly vulnerable; building aged peoples' resilience to emanating impacts through health and nutritional programmes are very important.
Ogunetimoju <i>et al.</i> (2026) ³⁶	To examine climate change awareness and its spatial determinants in Nigeria	Cross-sectional survey (nationally)	All 36 states and FCT, Nigeria; n = 1,600 adults	Less than one in three Nigerians were aware of climate change. Education was the strongest predictor of awareness. Low awareness clustered in specific geographic corridors.	Low climate awareness is a structural problem linked to educational inequality; targeted state-level programming is essential for building adaptive capacity.

		representative)			
Lawanson <i>et al.</i> (2022) ³⁷	To investigate the impact of flooding on poor communities in Lagos state	Mixed-methods	Makoko, Lagos States, southwest Nigeria; n = 358 participants	Flooding was found to aggravate poverty levels and negatively impact educational status and community development.	Community-based approaches to help in raising awareness and support the co-development of interventions that can improve resilience is recommended.
Onwukeme <i>et al.</i> (2025) ³⁸	To assess the health effects of air pollution linked to climate change	Climatic survey	Onitsha, Anambra State, Southeast Nigeria.	Air pollution and pollutants were found to be higher during dry season than rainy season. Overall quality of air was found to be hazardous during the dry season but unhealthy for sensitive groups during the rainy season.	Air pollution exacerbated by climate change contributes to environmental and health challenges. Continuous monitoring of air pollution levels is recommended.
Chidiebere <i>et al.</i> (2025) ³⁹	To evaluate the perceived effect of climate variability on smallholder farmers agricultural production in southwest, Nigeria	Cross-sectional survey	Oyo, and Ogun state, Southwest Nigeria; n = 240 food crop farmers	Climate change negatively affects agricultural production due to inherent link between climate and agricultural sector in Nigeria. The main adaptation strategies by smallholder farmers include planting cover crops, mulching, relocation to different sites. Constraints faced: water shortage, windstorms, pests, and diseases.	Enhance awareness and provision of educational programmes to smallholder farmers through various channels are essentially needed.
Ogezi <i>et al.</i> (2026) ⁴⁰	To examine the relationship between climate change, farmer-herder conflict, and health outcomes	Mixed-methods	Benue and Nasarawa States, North-Central Nigeria; n = 384 participants	Resource scarcity driven by drought and desertification exacerbated farmer-herder conflicts. Conflict-related injuries, displacement, and mental trauma were key health consequences. Women and children were disproportionately affected by displacement.	Climate-induced resource conflicts have significant health implications; conflict-sensitive climate adaptation is needed.
Otorkpa <i>et al.</i> (2024) ⁴¹	To document post-flood morbidity patterns in an underserved community	Mixed-methods	Adankolo, Lokoja, Kogi State, North-Central Nigeria; n = 22 households	Post-flood morbidity included diarrhoeal diseases, malaria, insomnia, myalgia, measles, skin diseases, and respiratory conditions. Sanitation infrastructure was severely compromised. Healthcare access was limited.	Post-flood health responses must address the full spectrum of morbidity and strengthen primary healthcare capacity in underserved communities.
Salubi and Elliott (2021) ⁴²	To analyse spatial patterns of cholera incidence in Nigeria	Cross-sectional (geospatial analysis)	National; 2010–2019 cholera surveillance data	Cholera incidence exhibited significant spatial clustering. Flood-prone coastal and riverine areas had consistently higher cholera burden. Seasonal peaks aligned with rainfall patterns.	Geospatial analysis can guide targeted cholera prevention and resource allocation.
Ugwuanyi <i>et al.</i> (2024) ⁴³	To examine climate change health outcomes in urban slums of Lagos	Mixed-methods	Makoko, Ajegunle, Ijora Badia, Lagos; n = 600 households	Heat-related illnesses, waterborne diseases, and respiratory conditions affect the residents. Flood-prone households were 3.5 times more likely to report waterborne diseases. PM2.5 exposure above WHO standards increased asthma twofold.	Urban slum dwellers face a triple burden of heat, flood, and air pollution-related health risks requiring integrated interventions.

Oyelakin <i>et al.</i> (2026) ⁴⁴	To evaluate the perception of climate change and health implications in Nigeria	Cross-sectional survey	Nationwide, Nigeria; n = 1,600 adults	Knowledge of climate change and its health effects was high in the southern region and low in the northern region. Perception of climate-related health impacts among respondents include heat illnesses, vector-borne diseases, respiratory disorders, and malnutrition.	Key gaps in climate change knowledge hinder resilience. Inclusive, education-focused, and gender-responsive climate communication strategies is recommended to advance sustainable and equitable climate action in Nigeria.
Ahmed <i>et al.</i> (2024) ⁴⁵	To evaluate the influence of climate change on food security and nutritional status among people in Monguno Local Government Area of Borno State	Cross-sectional survey	Borno, Northeast Nigeria; n = 427 participants	Populations face significant higher rates of severe hunger and child malnutrition. Vulnerable household experience lower dietary diversity and greater exposure to drought, observing significant rainfall changes. Vulnerable groups are predominantly women, and children	Integrated climate, food security, and nutrition interventions are critical in conflict-affected northeast Nigeria.

CFR, case fatality rate; ERA5-HEAT, ECMWF Reanalysis 5th Generation – Heat; UTCI, Universal Thermal Comfort Index.