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METHODOLOGICAL PARADIGMS, DESIGNS, AND DATA ANALYTICAL FRAMEWORKS IN CLIMATE RESILIENCE AND LIVELIHOOD ADAPTATION RESEARCH: A SYSTEMATIC REVIEW

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ABSTRACT

This study systematically reviews the methodological paradigms, designs, sampling techniques, and data analytical frameworks deployed in contemporary climate resilience and rural livelihood adaptation research. Smallholder agriculture in Sub-Saharan Africa remains highly vulnerable to climate variability. Yet, investigations into how these farmers adapt are frequently fragmented by deep methodological divides between positivist quantification and interpretivist qualitative contextualization. Utilizing a thematic desk review methodology, this paper synthesizes empirical literature spanning 1994 to 2026 to evaluate the operational strengths and structural limitations of quantitative, qualitative, and mixed-method approaches.

The review reveals that while econometric models effectively isolate the determinants of adaptation outcomes, they consistently obscure the socio-cultural negotiations, institutional quality variations, and indigenous knowledge systems that drive adaptation processes. Conversely, qualitative frameworks capture localized lived experiences but lack regional generalizability and statistical reproducibility. Consequently, this paper argues for the strategic adoption of a pragmatist paradigm utilizing a convergent mixed-method framework. Finally, the paper translates these methodological insights into an operational, field-ready blueprint tailored to an upcoming empirical study within Oju Local Government Area (LGA), Benue State, Nigeria, a region characterized by extreme rainfall variability and high dependence on rain-fed smallholder agriculture.

KEYWORDS: Pragmatism, Mixed-Methods, Climate Resilience, Livelihood Adaptation, Smallholder Farmers, Oju LGA.

1. INTRODUCTION

Methodology is central to development and environmental research, it provides the systematic framework for investigating, interpreting, and explaining complex social, economic, and socio-ecological phenomena. Far beyond a mere collection of data gathering tools, methodology encompasses interconnected layers: ontological and epistemological assumptions, research designs, spatial-temporal boundaries, sampling protocols, analytical configurations, and ethical parameters (Bryman, 2016; Creswell & Creswell, 2018; Saunders et al., 2019). Within sub-Saharan Africa, smallholder agrarian livelihoods are deeply entangled with environmental variations, rendering the methodological choice of climate-livelihood investigations highly consequential for both theoretical advancement and policy design.

In Nigeria, particularly Benue State, the intersection of intensifying climate variability, accelerating landscape degradation, and institutional vulnerabilities creates a complex environment for smallholder farmers (Onah et al, 2023). Investigating how these populations navigate climate shocks requires robust frameworks capable of capturing both macro-level meteorological shocks and micro-level household responses. This paper systematically reviews contemporary research methodologies in climate resilience and livelihood adaptation. It evaluates competing research paradigms, assesses the efficacy of distinct research designs, dissects sampling logic and size determination parameters, and scrutinizes advanced data collection and analysis tools. Rather than treating methodology as an abstract concept, this review bridges theory and practice. It concludes with an operational framework explicitly customized to the socio-ecological realities of Oju Local Government Area (LGA), Benue State, to guide future empirical field studies.

2. PROBLEM STATEMENT

Despite a growing body of literature on climate change adaptation in Nigeria, empirical research remains methodologically polarized. Quantitative studies often rely on cross-sectional econometric models that reduce complex, socially embedded adaptation processes to static outcome variables (Deressa et al., 2009; Nhemachena & Hassan, 2007). These models frequently overlook household agency, structural power disparities, and localized indigenous knowledge systems. Conversely, qualitative assessments capture valuable

contextual narratives but lack the statistical generalizability and reproducible frameworks needed to inform regional agricultural policies or macro-level development planning (Eriksen et al., 2015; Nightingale, 2017).

Furthermore, existing climate–livelihood research in Benue State reveals three critical gaps. First, there is weak methodological integration, as quantitative data on climate trends are rarely combined with qualitative perspective that capture how farmers perceive, experience, and respond to climatic changes. Second, many studies are based on assumptions of institutional homogeneity, often treating access to support systems as uniform across communities, while overlooking localized variations in the availability and effectiveness of agricultural extension services, farmer cooperatives, and other support institutions (Ibrahim et al., 2023). Third, there is a significant spatial and contextual omission, evidenced by the shortage of localized empirical studies focusing specifically on Oju Local Government Area. Oju LGA is characterized by fragile hydro-geological conditions, high vulnerability to seasonal dry spells, and unique socio-cultural structures that distinguish it from other parts of Benue State. The absence of research that adequately reflects these distinctive environmental and social realities limits the development of targeted, context-specific resilience strategies and policies. Consequently, there is a pressing need for a comprehensive framework that integrates quantitative and qualitative approaches while addressing institutional and geographic variations to better understand and strengthen livelihood resilience.

3. REVIEW METHODOLOGY

This study utilizes a systematic desk review methodology to map, synthesize, and critique the methodological landscapes of climate resilience and livelihood adaptation research. The review process was structured around three operational phases:

1. **Sourcing and Identification:** A literature search was conducted across academic databases, including Google Scholar, Scopus, and the Web of Science. The search strategy targeted peer-reviewed articles, foundational methodological textbooks, and conference proceedings published between 1994 and 2026. Search strings combined terms such as “climate resilience” OR “livelihood adaptation” AND “research paradigm” OR “mixed-methods” OR “sampling design” AND “smallholder farmers” OR “Nigeria”.
2. **Screening and Selection:** Articles were selected based on their explicit focus on the structural, philosophical, or practical dimensions of research methodology in agrarian settings. Studies addressing sub-Saharan Africa, particularly West Africa and Nigeria, were prioritized to ensure contextual relevance.

3. **Synthesis and Thematic Categorization:** Selected documents were analyzed using qualitative thematic synthesis. Content was categorized into core methodological pillars: research philosophies (positivism, interpretivism, and pragmatism), research approaches (quantitative, qualitative, and mixed), sampling and sample size frameworks, data analysis methods (including GIS applications), and ethical protocols. This structured synthesis forms the basis of the comprehensive review presented below.

4. THEMATIC REVIEW BASED ON METHODOLOGICAL PILLARS

4.1 Research Paradigms and Philosophical Foundations

A research paradigm is the foundational philosophical framework that governs how empirical inquiry is conceptualized, executed, and interpreted. It defines the researcher's view of reality (ontology), knowledge validation (epistemology), values (axiology), and analytical strategies (methodology) (Guba & Lincoln, 1994; Creswell & Creswell, 2018). The summary of philosophical dimensions is presented in Table 1.

Table 1: Philosophical Dimension.

Philosophical Dimension	Positivism	Interpretivism /Constructivism	Pragmatism
Ontology (Reality)	Singular, objective, independent of human experience.	Multiple, fluid, socially constructed by individuals.	Both objective and subjective; pluralistic.
Epistemology (Knowledge)	Distance/objectivity; absolute empirical truth.	Subjective co-creation; deep context-specific meaning.	Focus on practical utility and actionable problem-solving.
Methodology	Deductive, highly structured, quantitative.	Inductive, contextual, highly qualitative.	Mixed-methods; sequential, concurrent, or convergent integration.
Axiology (Values)	Value-free; researcher bias is controlled.	Value-bound; subjective biases are explicitly acknowledged.	Value-oriented; guided by solving real-world challenges.

The Positivist Paradigm

Positivism is rooted in an objectivist ontology, viewing reality as a singular, external entity governed by immutable natural laws. Epistemologically, it asserts that the researcher can remain completely independent of the subject, relying on empirical observation, quantification, and statistical deduction to reveal causal truths (Bryman, 2016).

Within climate-livelihood literature, positivism has long served as a dominant paradigm. Researchers use structured quantitative metrics and econometric models to evaluate adaptation drivers. For instance, Deressa et al. (2009) utilized a multinomial logit model to analyze smallholder adaptation decisions in Ethiopia, demonstrating how quantifiable independent variables, such as credit access, extension contact, and education, statistically predict adaptation choices. Similarly, Bryan et al. (2009) deployed cross-sectional survey data across multiple African nations to test hypotheses regarding how climate variability influences farming decisions. In Nigeria, Nhemachena and Hassan (2007) implemented multivariate discrete choice models to isolate the determinants of farm-level adaptation, reinforcing the positivist emphasis on measurable behavioral drivers. This approach is also central to climate economics. Mendelsohn et al. (1994) applied the Ricardian approach to regress agricultural land values against climate variables, treating environmental adaptation as a quantifiable market correction.

In development interventions, Banerjee et al. (2015) demonstrated the application of positivism through Randomized Controlled Trials (RCTs), using experimental controls and statistical validation to isolate the causal impacts of poverty-reduction programs. At macro scales, Lobell et al. (2011) paired large-scale historical meteorological datasets with crop yield models to quantify global food security risks. Similarly, Below et al. (2012) employed regression models across multi-country datasets to identify predictable, cross-contextual determinants of household adaptive capacity. While these positivist studies provide generalizable understanding and clear policy metrics, they often reduce complex, socially negotiated adaptation behaviors to static quantitative vectors, stripping away localized context and lived experience.

The Interpretivist/Constructivist Paradigm

Conversely, the interpretivist/constructivist paradigm operates on a relativist ontology, asserting that reality is multiple, socially constructed, and fluid. Epistemologically, interpretivism rejects the detached researcher model, arguing that knowledge is co-produced through deep subjective interactions between the researcher and participants within their natural settings (Creswell & Poth, 2018).

Interpretivist frameworks are increasingly used in climate change research to explore how communities perceive and navigate environmental risks based on local values and historical experience. Eriksen et al. (2011) used qualitative, interpretive fieldwork to demonstrate that adaptation outcomes are not merely technical choices. Instead, they are deeply contested

processes shaped by local power dynamics, political realities, and cultural values. Jones and Boyd (2011) explored these social dynamics in Nepal, revealing how deeply embedded cultural norms and caste structures present significant barriers to adaptation, regardless of available technical solutions.

Nightingale (2017) applied an interpretivist lens to demonstrate how adaptation processes are continually negotiated through socio-political relationships and local authority structures. This reinforces the constructivist view that environmental vulnerability is co-produced through human interaction. Furthermore, Adger et al. (2013) documented that risk perception and resilience are culturally grounded, showing that adaptation decisions are heavily influenced by local traditions and place-based identities. Ensor and Berger (2009) emphasized community-based qualitative research, demonstrating that resilient adaptation strategies are most effective when built upon indigenous knowledge systems rather than top-down external plans. These interpretive views are consistent with foundational livelihood frameworks (Scoones, 1998; Ellis, 2000), which view rural survival strategies as dynamic negotiations shaped by shifting asset portfolios, institutional contexts, and environmental stressors.

The Pragmatist Paradigm

The pragmatist paradigm bypasses the rigid dualism of positivism and interpretivism. It rejects dogmatic debates over singular versus multiple realities, instead adopting a pluralistic ontology that views reality as both objective and subjectively experienced. Epistemologically, pragmatism focuses on practical problem-solving, asserting that the value of knowledge lies in its real-world utility. Methodologically, it encourages the strategic integration of quantitative and qualitative methods to address complex, multi-layered research questions (Creswell & Plano Clark, 2018).

Recent empirical studies demonstrate the analytical value of pragmatism in climate resilience research. Ayanwuyi and Olayemi (2021), Ogunleye and Afolabi (2023) and Onah et al (2023) reported how socio-economic factors, such as farm size, income, extension access, and formal climate information, shape smallholder adaptation patterns across Nigeria. However, because these studies relied primarily on quantitative cross-sectional surveys, they could not fully capture the qualitative nuances of household decision-making. To bridge this gap, econometric analyses by Abdullahi and Hassan (2021) and Nwachukwu and Eze (2021) confirmed that livelihood diversification into non-farm employment mathematically increases

resilience and reduces vulnerability. Yet, they treated adaptation primarily as an economic output rather than a socially embedded process.

Pragmatist mixed-method designs resolve these limitations by combining quantitative trends with qualitative depth. Chikaire and Ihenacho (2022) paired household surveys with focus group discussions (FGDs), demonstrating that while institutional access predicts adaptation statistically, actual community implementation is driven by peer learning, indigenous forecasting, and local cultural norms. Similarly, Mensah and Osei (2024) illustrated that smallholders interpret scientific climate projections through localized, experiential indicators like soil moisture changes and shifting ecological signals. In the institutional sphere, Ibrahim et al. (2023) found that cooperative membership and formal extension contact significantly increase the adoption of climate-smart farming techniques. However, they noted that these quantitative models often obscure the qualitative realities of institutional quality and governance accessibility in rural areas.

Finally, Diallo and Traoré (2024) and Okeke and Nnaji (2022) highlighted how integrating indigenous knowledge systems with scientific meteorological forecasting creates practical, context-specific solutions for rural communities. This integration is highly consistent with the core tenets of pragmatism.

4.2 Typology and Efficacy of Research Designs

Survey Design

Descriptive and explanatory survey designs use standardized, structured instruments to systematically gather data from a defined population sample at a specific point in time (Bryman, 2016). In climate-livelihood research, surveys are invaluable for mapping baseline adaptation practices, documenting socio-demographic characteristics, and quantifying asset distributions across large areas. For instance, Abid et al. (2019) used cross-sectional surveys in Pakistan to demonstrate that education levels and information access significantly correlate with proactive choices like micro-irrigation. In Ghana, Etwire et al. (2022) used structured surveys to identify how membership in farmer-based organizations increases adaptive capacity in drought-prone areas. Similarly, Ndambiri et al. (2020) and Alemayehu and Bewket (2017) used large-scale surveys in Kenya and Ethiopia to show that asset ownership and weather information are key predictors of household resilience. While surveys are highly effective for answering “what” and “how much” questions, they are inherently limited in capturing “why” or tracing deep social processes over time.

Exploratory and Explanatory Designs

Exploratory research designs are employed when an environmental problem or localized phenomenon is poorly understood, relying on open-ended qualitative inquiries to generate hypotheses and identify key institutional variables (Creswell & Poth, 2018). Explanatory designs, by contrast, focus on testing specific directional relationships and identifying causal paths through quantitative modeling or sequential mixed-method frameworks (Saunders et al., 2019).

Cross-Sectional versus Longitudinal Designs

Cross-sectional designs gather data from multiple points across a population at a single point in time, offering a cost-effective snapshot of current livelihood assets and adaptation choices (Bryman, 2016). However, they cannot establish clear causal timelines or capture how adaptation strategies shift over time. Longitudinal designs, which track the same household cohorts over multiple seasons, are better suited for capturing long-term adaptation pathways and structural changes in resilience. However, they require substantial resources and face practical challenges like sample attrition.

Experimental and Mixed-Method Designs

True experimental designs, such as field-based RCTs, allow researchers to isolate the impacts of specific development programs by comparing treatment groups with randomized controls (Banerjee et al., 2015). Despite their statistical rigor, they are often difficult to implement in complex, real-world socio-ecological settings due to ethical and logistical constraints.

Mixed-method designs integrate elements of these various approaches. By combining cross-sectional surveys with exploratory qualitative fieldwork, they provide a powerful tool for analyzing both the statistical drivers and the lived experience of climate resilience.

4.3 Sampling Logic and Sample Size Frameworks

Probability Sampling Techniques

Probability sampling ensures that every unit in the target population has a known, non-zero chance of selection. This foundational requirement supports statistical generalization and reduces selection bias (Bryman, 2016).

Simple Random Sampling: Provides uniform probability across a population but requires a complete, up-to-date sampling frame, which is rarely available in rural developing contexts.

Stratified Sampling: Divides the population into homogenous subgroups based on key variables, such as agro-ecological zones, farm size, or gender, ensuring accurate representation of vulnerable groups.

Systematic Sampling: Selects units at fixed mathematical intervals from a starting point, offering an efficient fieldwork option when population lists are incomplete but housing layouts are orderly.

Multistage Cluster Sampling: First selects larger geographic units (political wards), then smaller entities (villages), and finally individual households. This technique is highly effective for large-scale rural surveys because it concentrates fieldwork logistics while maintaining probabilistic integrity.

Non-Probability Sampling Techniques

Non-probability sampling relies on the researcher's judgment rather than random selection. It is used to select specific, information-rich cases to explore complex localized processes (Creswell & Poth, 2018).

Purposive Sampling: Targets specific individuals, such as community leaders, institutional representatives, or long-term residents, who possess specialized knowledge or experience.

Snowball Sampling: Leverages a chain-referral system to locate hard-to-reach populations, such as highly marginalized households or seasonal migrant workers.

Sample Size Determination

To ensure statistical validity and prevent arbitrary sample sizing, researchers employ established mathematical formulas. One of the commonest formula is Yamane (1967) formula**.** It is very useful for finite, clearly enumerated populations. The formula is expressed as:

$$n = \frac{N}{1+N(e)^2} \quad (1)$$

Where *n* is the required sample size, *N* is the total population, and *e* is the acceptable margin of error (0.05).

Cochran (1977) Formula:

Unlike Yamane (1967) formula, Cochran (1977) formula is ideal for large or infinite populations where the total universe size is unknown. It is expressed as:

$$n0 = \frac{z^2\ pq}{e^2} \quad (2)$$

Where z represents the standard normal deviation for a desired confidence level (1.96 for a 95% confidence interval), p is the estimated proportion of an attribute present in the population, q = 1 - p, and e is the acceptable margin of error.

4.4 Data Collection and Analytical Methods

Data Collection Methods

Comprehensive climate-livelihood research relies on an integrated suite of primary and secondary data collection sources using the following tools:

1. **Structured Questionnaire:** Standardized, closed-ended instruments that collect quantitative socio-demographic, asset, and behavioral data across large samples.
2. **Semi-Structured Interviews and Key Informant Interviews (KIIs):** Open-ended dialogues with institutional actors and community leaders that surface institutional challenges and historical insights.
3. **Focus Group Discussions (FGDs):** Moderated interactive sessions that reveal community-level norms, shared coping mechanisms, and internal social differences.
4. **Direct Field Observation:** Systematic physical recording of crop conditions, landscape degradation, and local infrastructure, providing a useful ground-truth for self-reported survey data.

Analytical Toolkits

1. **Descriptive and Inferential Statistics:** Quantitative analysis ranges from basic descriptive summaries (frequencies, means, percentages) to advanced inferential econometric models (binary logit, multinomial logit, Probit, or Heckman selection models) that isolate the socio-economic drivers of adaptation choices.
2. **Thematic Content Analysis:** Qualitative transcripts are processed using inductive or deductive coding frameworks, often assisted by software like NVivo or ATLAS.ti to identify patterns, narratives, and contextual constraints.
3. **Geospatial (GIS) and Remote Sensing Analysis:** Involves processing multi-temporal satellite imagery (Landsat, Sentinel) to compute indices like the Normalized Difference Vegetation Index (NDVI), mapping landscape changes alongside spatial climate data from tools like CHIRPS or ERA5.

5. PRACTICAL APPLICATION: METHODOLOGICAL FRAMEWORK FOR THE PROPOSED OJU LGA FIELD STUDY

To address the gaps identified in this review, the upcoming field study in Oju Local Government Area, Benue State, will implement a fully integrated, mixed-method research design as shown in Figure 1.

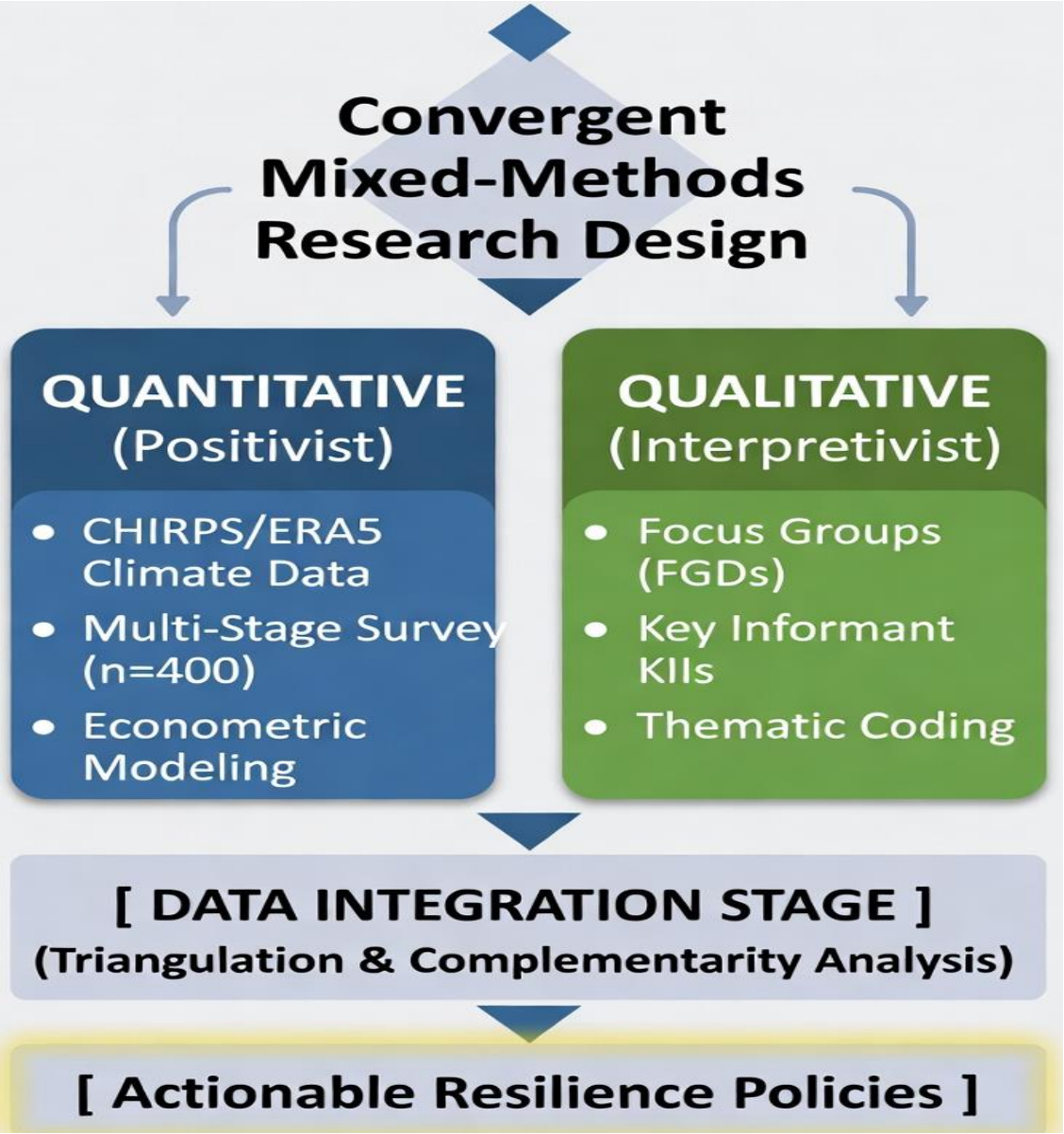

Figure 1: Proposed Integrated, Mixed-Method Research Design.

5.1 Study Area

Oju LGA is located in southern Benue State, bounded by coordinates approximately between latitudes 6^0 45' N and $7^0$15' N, and longitudes 8^0 15' E and 8^0 45' E (Figure 2). The area has a unique landscape characterized by shaly basements, which often cause severe surface water

scarcity during dry spells. Its agricultural system depends heavily on rain-fed smallholder farming, making it highly vulnerable to seasonal variations, delayed rains, and temperature extremes. This spatial exposure makes Oju LGA an important site for localized climate resilience research.

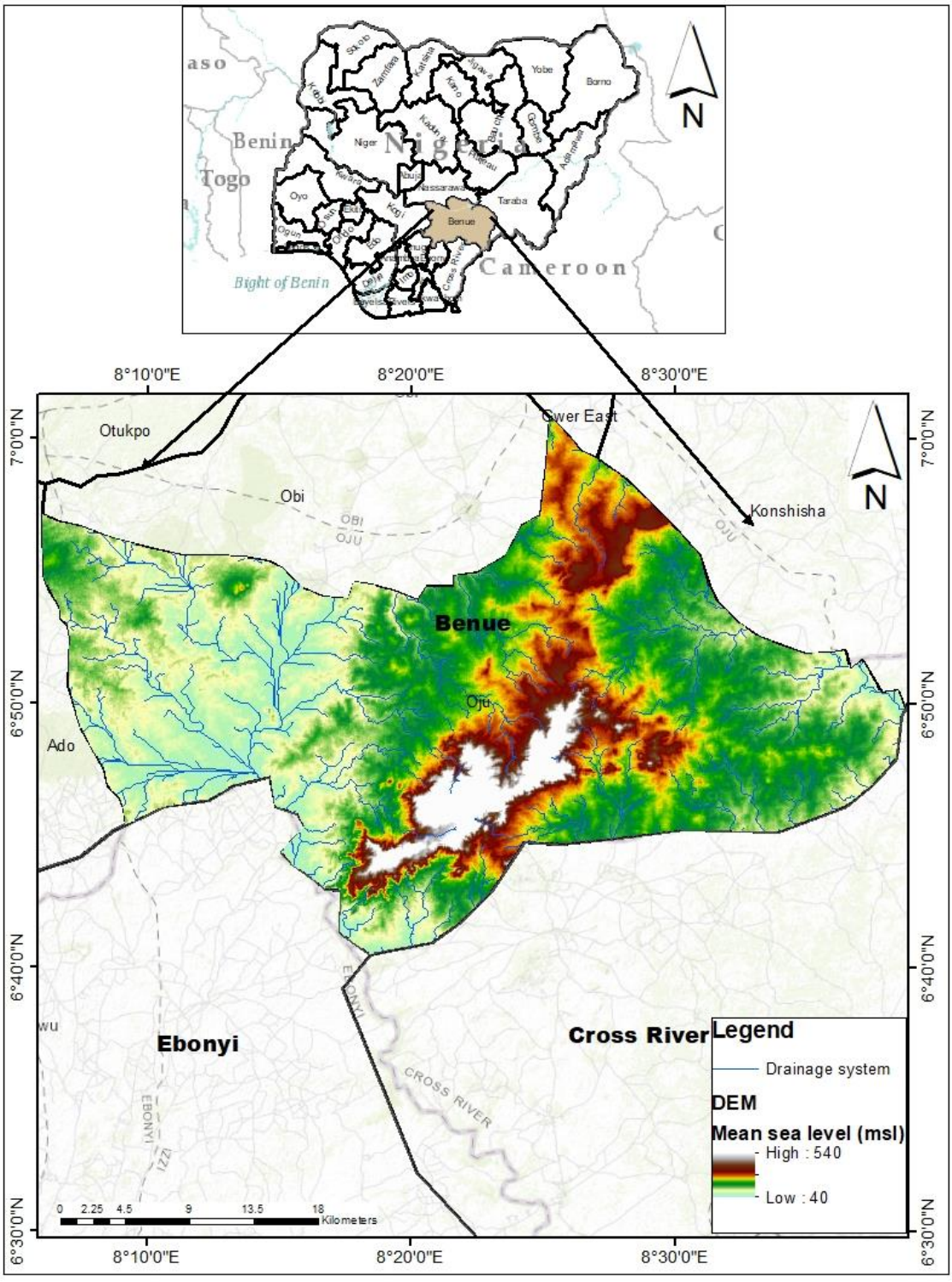

Figure 2: Oju LGA, Benue State Nigeria.

5.2 Research Paradigm and Design

The study will adopt a pragmatist paradigm utilizing a convergent parallel mixed-methods research approach. Quantitative and qualitative data will be collected concurrently during a single field deployment, analyzed separately, and then integrated during the final synthesis phase. This design allows the study to cross-validate statistical trends with qualitative narratives, ensuring a more comprehensive analysis of resilience.

5.3 Sampling Procedure and Sample Size

The study will use a multistage probability sampling framework to select household survey participants:

Stage 1 (Stratification): Oju LGA's eleven political wards will be stratified based on agricultural dominance and historical exposure to climate hazards. Three representative wards will be purposively selected.

Stage 2 (Clustering): Within each selected ward, three rural farming villages will be randomly chosen, yielding nine distinct clusters.

Stage 3 (Systematic Selection): Households within each village will be chosen using systematic random sampling at a fixed interval (every k-th house).

The total survey sample size is determined using the Yamane formula: Thus, the target quantitative sample will be approximately 400 households, given that Yamane formula usually yield 400 sample size at 0.05 error margin. For the qualitative component, purposive sampling will be used to select 12 key informants (including agricultural extension agents, traditional rulers, and cooperative leaders) and 6 distinct focus groups (stratified by gender and age) to ensure diverse perspectives are captured.

5.4 Operational Data Collection Matrix

Table 2 provide the proposed data collection framework typical of climate-livelihood resilient study.

Table 2: Operational Data Collection Matrix.

Objective	Primary Data Source	Secondary Data Source	Analytical Tool
Meteorological Trends	Field observations	Climatic Data. (Rainfall and temperature)	Mann-Kendall trend test, Sen's slope estimator, Coefficient of Variation (CV).
Vulnerability & Assets	Household survey questionnaire (400 copies via	Local government agricultural records, NGO survey	Sustainable Livelihoods Asset Indexing, Descriptive

	KoboToolbox).	reports.	cross-tabulations.
Adaptation Drivers	Structured closed-ended questionnaire sections.	Ministry of Agriculture development policy briefs.	Multinomial Probit regression model, Logit profiling models.
Institutional Factors	12 Key Informant Interviews (KIIs), 6 Focus Group Discussions (FGDs).	Extension service training manuals, cooperative registries.	Inductive Thematic Content Analysis (NVivo coding matrix).
Spatial Landscape Changes	GPS coordinate captures at farm plot boundaries.	Landsat 8/9 and Sentinel-2 satellite imagery.	GIS spatial interpolation, NDVI calculation, land cover classification.

6. CONCLUSION AND RECOMMENDATIONS

Conclusion

This systematic review underscores that the complex, interconnected nature of climate change and rural livelihoods cannot be fully captured by isolated, single-method approaches. While positivist econometric models offer valuable statistical generalization, they often obscure the social processes, power dynamics, and indigenous knowledge that shape adaptation. Conversely, interpretivist qualitative approaches provide deep contextual insights but lack the scalability required for regional planning.

Adopting a pragmatist paradigm within a convergent mixed-methods framework provides a robust way forward. This approach allows researchers to combine quantitative climate trends and econometric drivers with qualitative narratives of lived experience. Applying this integrated methodology in Oju LGA will generate a comprehensive, empirical dataset that captures both the structural determinants and the practical realities of smallholder climate adaptation.

RECOMMENDATIONS

1. **Adopt Mixed-Methods Designs:** Future environmental development and agricultural research in Benue State should move away from single-method designs and instead integrate quantitative surveys with qualitative tools.
2. **Incorporate Spatial and Satellite Data:** Livelihood vulnerability analyses should combine household survey metrics with remote sensing data ($NDVI$, rainfall anomalies) to better ground-truth self-reported climate impacts.

3. **Account for Institutional Variation:** Researchers should avoid assuming uniform institutional quality, using qualitative tools to examine real-world disparities in agricultural extension and credit access.
4. **Integrate Indigenous Knowledge:** Regional agricultural policies should explicitly combine formal scientific weather forecasting with local, indigenous environmental indicators to improve community trust and adoption rates.

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