COMMUNITY-BASED FLOOD PREPAREDNESS AND RISK MITIGATION AMONG SMALLHOLDER FARMERS IN KADUNA NORTH, NIGERIA: INTEGRATING INDIGENOUS AND INSTITUTIONAL APPROACHES

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DOI No. 10.528 / zenodo 10558777

Abstract

Smallholder farmers in numerous regions of Nigeria are disproportionately impacted by seasonal flooding. This mixed-methods study investigated flood awareness, readiness, and mitigation options among smallholder farmers in the Kaduna North Local Government Area (LGA), Nigeria. It examined the interaction between indigenous behaviours and institutional mechanisms in shaping resilience. Data were gathered from 135 farmers through structured questionnaires, focus group talks, and key informant interviews. Descriptive and inferential statistics (t-tests) were employed, along with theme analysis of qualitative data. Research reveals a moderate awareness of flood threats and early warning systems. However, preparedness levels are low to moderate, with women exhibiting a greater propensity to implement adaptive cropping and timing techniques. Significant obstacles to effective mitigation were elevated prices, insufficient governmental backing, and restricted availability of materials and dependable early warning systems. Farmers' proposals emphasised the importance of community education, improving drainage systems, undertaking small-scale earthworks, and incorporating indigenous indicators into official Early Warning Systems (EWS). The results correspond with findings from Kaduna Metropolis and various other Nigerian contexts, reflecting international evidence that community-based strategies, coupled with effective early warning systems, are essential for the resilience of smallholders. We advocate for a comprehensive, gender-sensitive community-based disaster risk management plan that incorporates indigenous knowledge, contextually suitable structural interventions, and enhanced institutional early warning systems and financial mechanisms.

Keywords: flood preparedness, smallholder farmers, Kaduna North, community-based disaster risk management, early warning systems, Nigeria

INTRODUCTION

Flooding poses a significant global threat, adversely affecting human lives, infrastructure, and agricultural systems, particularly in low- and middle-income countries (Adomah *et al*., 2024). Between 2000 and 2023, it constituted roughly fifty per cent of all documented weather-related catastrophes (Cvetković *et al*., 2024). Sub-Saharan Africa has experienced a rise in flood frequency, attributed to climate change, alterations in land use, and population growth, which pose significant threats to smallholder farmers who rely on rainfed agriculture. Nigeria has experienced disastrous floods, notably in 2012 and 2022, resulting in significant loss of life, relocation, and agricultural destruction (Akinkuolie *et al*., 2025). Despite attempts to mitigate flooding through structural and institutional measures, many farmers remain unprepared due to insufficient awareness and ineffective risk communication (Khan *et al*., 2021).

In susceptible areas, such as Kaduna North, Nigeria, the local populace, predominantly

farmers, relies on both traditional knowledge and official disaster risk management systems, albeit with limited integration. Agriculturalists construct adaptive methods grounded in indigenous knowledge (IK), which include interpreting environmental indicators to forecast floods, although formal organisations often disregard this knowledge. The disparity between local practices and formal early warning systems leads to inefficiencies in flood preparedness, as institutional communications are often overly technical or inadequately conveyed to farmers with limited literacy.

Complementary theoretical frameworks such as Community-Based Disaster Risk Management (CBDRM) and the Pressure and Release (PAR) model provide insights into flood risk mitigation (Tanwattana, 2018; Willison *et al*., 2022). CBDRM emphasises community empowerment and proactive involvement in risk mitigation, whereas the PAR model highlights the need to address fundamental vulnerabilities (Luneta, 2022; Akinkuolie *et al*, 2024). The integration of these ideas offers a holistic perspective on flood preparedness, illustrating the interplay or misalignment between indigenous knowledge and institutional strategies.

Although prior research has examined flood effects and adaptation strategies in Nigeria, there have been limited studies that investigate the integration of indigenous knowledge with institutional methods, particularly within smallholder settings (Akukwe & Okwu-Delunzu, 2022). This study aims to address the gap by focusing on community-based flood preparedness among farmers in Kaduna North, emphasising the need to integrate traditional practices with formal systems to enhance resilience and sustainability in flood management.

Materials ad Methodes

This study employed a mixed-methods research design that integrated both quantitative and qualitative methodologies to achieve a thorough understanding of flood preparedness and mitigation practices among smallholder farmers in Kaduna North. This approach was selected due to the complex and multifarious nature of flood risk and community responses, which cannot be sufficiently comprehended within a singular methodological framework. The quantitative component provided concrete insights into farmers' awareness, readiness, and the socio-economic factors affecting these elements. Conversely, the qualitative component offered depth by examining the beliefs, motivations, and cultural factors that influence behavioural decisions related to flood preparedness.

The study utilised a convergent parallel design as outlined by Toraman & Clark (2019). This methodology entailed the simultaneous gathering of quantitative and qualitative data, which were analysed independently before triangulation to improve interpretation. This methodology proved notably effective in examining the interaction between indigenous knowledge systems (IKS) and institutional frameworks, recognising their concurrent existence in community-based disaster management contexts. The study emphasises the importance of integrating multiple research approaches to address the complexities of flood preparedness in agricultural areas comprehensively.

Study Area

The study was conducted in the Kaduna North Local Government Area (LGA) of Kaduna State, located in northwestern Nigeria. The region is situated between latitudes 10°31′ and 10°37′ N and longitudes 7°26′ and 7°32′ E, with an expected population of around 364,575 (FMoHSW, 2024). It is characterised by a tropical wet-and-dry climate, with a distinct rainy season from April to October and an average annual precipitation of approximately 1,200 mm. The Kaduna River, a significant tributary of the Niger River, traverses the region, rendering floodplain agriculture both exceptionally productive and intrinsically perilous.

The economy of Kaduna North is primarily characterised by smallholder agriculture, with farmers cultivating maize, millet, rice, and vegetables on average plots of less than two hectares. Flooding is a frequent occurrence, typically associated with the inundation of the Kaduna River and obstructed drainage systems. The LGA serves as an exemplary case study for

examining the interaction between indigenous adaptation strategies and formal institutional efforts in flood management. Figure 1 presents the map of the study area extracted from the map of Kaduna State and Nigeria at large.

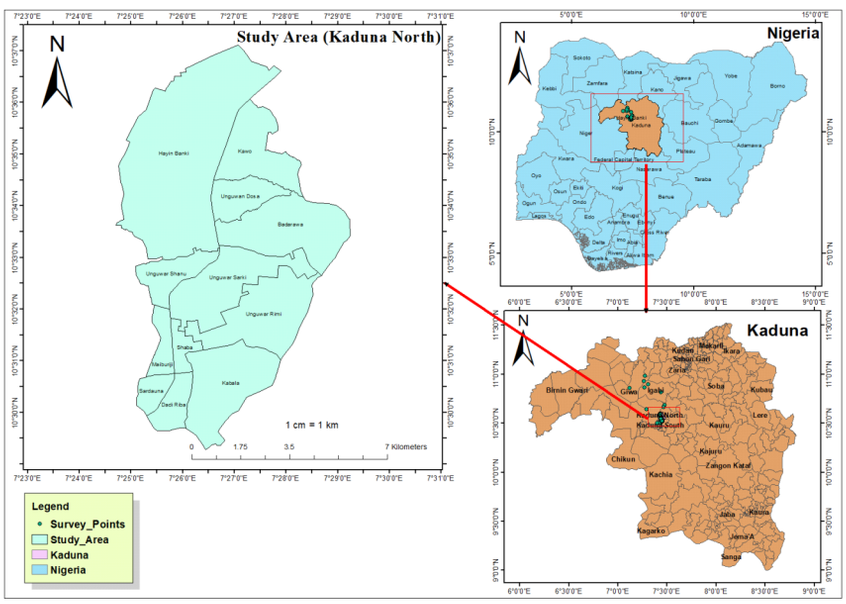

Figure 1: Map of Kaduna North Local Government Area indicating study sites.

Population, Sampling and Sample Size

The research focused on smallholder farmers operating in flood-prone regions of Kaduna North. A two-phase sampling method was utilised. Initially, four wards (Unguwan Dosa, Badarawa, Kawo, and Unguwan Shanu) were deliberately chosen based on their proximity to floodplains and their historical incidence of flooding. In the second phase, participants were randomly selected from agricultural households within each ward.

The sample size of 135 respondents was calculated as stated by Fowler & Lapp (2019) and Adhikari (2021), using the formula at a 95% confidence level and a precision level of 0.08, assuring representativeness within logistical restrictions. The sample size was sufficient for both descriptive and inferential statistical analysis, facilitating significant qualitative triangulation. Key informant interviews (KIIs) were performed with officials from the Kaduna State Emergency Management Agency (SEMA), community leaders, and extension staff. At the same time, focus group discussions (FGDs) were done with farmer associations to gather collective experiences.

Data Collection Instruments and Procedures

Three complementary tools were utilised:

i. Structured questionnaire: This was developed to gather data on farmers' socio-demographic characteristics, flood experiences, awareness levels, preparedness activities, access to early warning information, and perceptions of institutional support.
ii. Key Informant Interviews (KIIs): This was designed to collect institutional insights on flood risk governance, emphasising coordination mechanisms, resource availability, and the incorporation of indigenous knowledge into formal planning.
iii. Focus Group Discussions (FGDs): This offered qualitative insights into farmers' traditional indications of flood start, community coping strategies, and obstacles to the adoption of formal warnings.

The questionnaire underwent pre-testing with 15 farmers in a neighbouring LGA to ascertain clarity and dependability. Adjustments were made in response to comments, and Cronbach's alpha yielded a reliability coefficient of 0.82,

indicating robust internal consistency. Ethical approval was obtained from the Faculty Research Ethics Committee, and informed consent was obtained from all participants before data collection.

Data Analysis

Quantitative data were encoded and analysed utilising Statistical Package for the Social Sciences (SPSS) version 26. Descriptive data, including means, frequencies, and percentages, described the socio-economic characteristics and preparation indicators. Inferential analysis utilised multiple linear regression to investigate the correlation between socio-economic traits (education, income, farm size, access to information) and flood preparedness ratings. A Flood Preparedness Index (FPI) was developed in accordance with Woldeyohannes *et al*. (2024) and Okunola *et al*. (2022) to measure the readiness levels among respondents.

Thematic analysis of qualitative data from key informant interviews and focus group discussions was conducted using NVivo 12, adhering to the framework established by Braun & Clarke (2019). Transcripts were analysed iteratively to discern patterns and sub-themes within categories such as "indigenous indicators," "institutional coordination," and "trust in information sources." The integration of quantitative and qualitative findings bolstered the legitimacy and validity of the conclusions.

Validity, Reliability and Ethical Considerations

Various methods were implemented to guarantee the study's legitimacy and reliability. Instrument validity was established by expert evaluation by catastrophe risk and agricultural professionals from the Federal University of Technology, Minna. The triangulation of data sources and methodologies augmented the internal validity of the findings, whereas pre-testing improved the dependability of the instruments.

Participants were informed of their rights to confidentiality, anonymity, and voluntary involvement in an ethical manner. The data were used exclusively for scholarly purposes, and no identifying information was disclosed. Ethical approval number ABR/FUTMINNA/DRR-2024/07 was secured before the commencement of fieldwork.

Results and Discussion

Demography and Activities of Respondents

One hundred thirty-five valid surveys were examined alongside qualitative data from focus group discussions (FGDs) and key informant interviews (KIIs). The sample comprised 60.7% males and 39.3% females; the predominant age group was 31–45 years (46.7%), and 44.4% of respondents indicated 11–20 years of agricultural experience (Table 1) found that Farm sizes were diminutive: 65.9% cultivated ≤5 hectares (27.4% <1 hectare; 38.5% = 1–5 hectares). This is similar to the study carried out by Muhammed *et al*. (2021), which identified the gender participation in agricultural activity in Niger State, Nigeria. Quantitatively, the average knowledge of flood risk was rated approximately 3.5 out of 5, although the developed Flood Preparedness Index (FPI) reflected an overall modest level of preparedness (Table 2). This is in accordance with the findings of Rahman *et al*. (2024). Female farmers exhibited a markedly higher propensity to implement adaptive cropping and scheduling methods ($t(133) = -2.43$, $p = 0.017$) (Table 3). The primary obstacles to enhanced mitigation included cost (18.1%), inadequate government support (17.5%), resource scarcity (16.1%), and insufficient expertise (16.9%). Numerous regression models elucidating preparedness yielded poor adjusted R^2 values, indicating that preparedness is influenced by various, partially unquantifiable social and institutional factors (Nukpezah, 2020). Qualitative findings underscored the significance of indigenous early-warning indicators, deficiencies in the institutional distribution of early warning systems, and the need for robust yet resource-constrained community agency.

Table 1. Socio-economic characteristics of respondents (n = 135)

Variable	Category	Percentage (%)
Gender	Male	60.70
	Female	39.30
Age (years)	18–30	23.70
	31–45	46.70
	46–60	21.50
	>60	8.10
Farming experience	=10 years	31.10
	11–20 years	44.40
	>20 years	24.50
Farm size (ha)	<1	27.40
	1–5	38.50
	>5	34.10
Education	No formal	21.00
	Primary	30.50
	Secondary	34.80
	Tertiary	13.70

Table 2. Flood Preparedness Index (FPI) distribution

Preparedness level	FPI range (0–1)	Percentage (%)
Low	0.00–0.33	28.10
Moderate	0.34–0.66	52.60
High	0.67–1.00	19.30

Table 3. Determinants of flood preparedness (multiple regression summary)

Predictor variable	Unstandardised ß	Standard Error	t-value	Sig.
Constant	0.312	0.072	4.33	0.000
Education level	0.146	0.041	3.56	0.001
Farm income	0.119	0.05	2.37	0.019
Access to the early warning system (EWS)	0.107	0.047	2.28	0.024
Extension contact	0.089	0.043	2.07	0.041
Gender (1 = Male)	- 0.054	0.032	- 1.69	0.093

The regression analysis from the 2024 field survey in Kaduna North reveals several critical factors that significantly enhance household and farm preparedness and response behaviour in disaster management. The foremost predictor identified is education level, which demonstrates a strong positive correlation (β = 0.146, p = .001) with improved responses to hazard information. This finding aligns with similar international results, indicating that integrating educational programs with Early Warning Systems (EWS) can significantly enhance the effectiveness of community responses (Niforatos *et al*., 2024; Wei *et al*., 2025). Farm income is another significant factor (β = 0.119, p = .019), indicating that households with higher economic means can more effectively implement preparedness strategies, such as evacuation plans or asset protection measures (Ntim-Amo *et al*., 2022; Wang *et al*., 2024).

This highlights the importance of enhancing access to EWS and addressing economic barriers through supportive initiatives, such as micro-grants targeted at low-income households. Access to EWS itself shows a direct positive relationship with preparedness (β = 0.107, p = .024), emphasising the necessity for prompt, clear alerts (Šakić Trogrlić *et al*., 2022; Bagai, 2022). Literature supports that a comprehensive EWS strategy should incorporate various communication channels, culturally relevant messaging, and clear, actionable tasks to enhance community responsiveness and mitigate disaster impacts (Šakić Trogrlić *et al*., 2022; Attoh & Amarnath, 2025). Contact with extension services also correlates with heightened preparedness, albeit moderately (β = 0.089, p = .041). This highlights the need for reliable intermediaries who can translate technical advice into practical guidance for farmers. Integrating extension officers into EWS communication with decision-making tools may further improve outcomes. Gender effects exhibited a minor negative correlation that lacked statistical significance (β = -0.054, p = .093), reflecting contextual variability in gender responses to warnings. This necessitates further qualitative research to comprehend the gender-specific dynamics of information accessibility and household readiness. While the model accounts for only 29% of the variance in preparedness, it suggests that crucial psychosocial factors, such as institutional trust and past experiences, were not considered. Future surveys should expand the variable range, incorporating qualitative methods to explore the behavioural motivations behind non-compliance with warnings. To effectively utilise these findings, a three-pronged approach is recommended: enhancing message clarity through multilingual notifications and diverse media platforms; promoting education through flood literacy initiatives and training for extension personnel; and alleviating resource constraints via community funding and subsidies. Continuous monitoring and assessment, along with stepwise enhancements to EWS components, will elucidate causal relationships and optimise resource distribution. Findings from Kaduna North resonate with global evidence that knowledge, resources, accessibility, and dependable intermediaries are vital for translating early warnings into effective preventive actions. The policy implications advocate for a coordinated investment strategy that improves early warning systems alongside education and socio-economic conditions, thereby reinforcing the resilience of the most at-risk households.

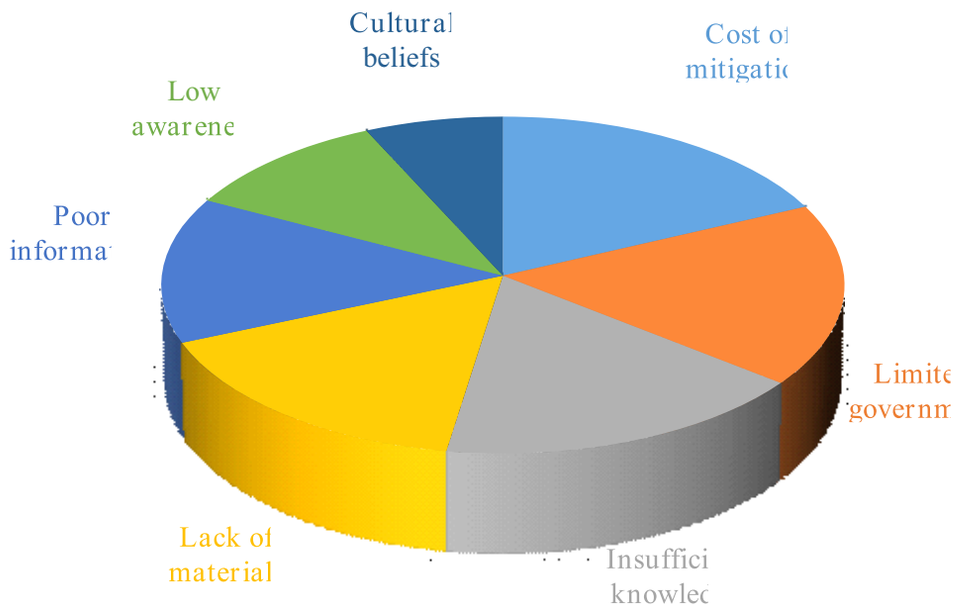

Figure 2. Key barriers to flood preparedness among farmers

Interpreting awareness versus preparedness

The distinction between **awareness** and **action** is a recurrent finding in flood risk literature, and our results echo this pattern. Farmers in Kaduna North report reasonably high levels of hazard awareness, but they inconsistently convert that awareness into preparedness. This is similar to results from Kaduna Metropolis, where households understood flood risk but adopted structural mitigation at low levels (Okunola *et al*., 2022). The moderate FPI in our sample suggests that while farmers know about flood hazards and have some adaptive practices (raised beds, altering planting dates, small drainage channels), they rarely have formal plans, access to insurance, or the capital needed for larger structural measures, a finding consistent with national assessments after the 2022 floods that highlight an awareness–action gap linked to resource constraints (NEMA/UNDP, 2023).

Awareness, in most cases, does not translate into stronger preparedness as identified in this study. A mixed-methods data collection approach was employed to assess the level of preparedness for flood events in the study area. First, financial capacity: many mitigation measures (e.g., constructing permanent bunds, installing drainage) require cash or subsidised inputs that smallholders lack. Second, institutional reach and trust: Formal EWS are sometimes perceived as being late, highly technical, or delivered in languages and channels that are not locally accessible, thereby reducing their usability (Pienaah *et al*., 2023; Falaki & Yila, 2023). Third, social and normative factors: preparedness often depends on collective action (such as community drain-clearing and labour pooling), and when social cohesion is weak or competing livelihood pressures exist, action is limited. These constraints align with the Pressure and Release (PAR) framing: hazards interact with underlying socio-economic pressures to produce vulnerability (Wisner *et al*., 2022).

The study highlights the complex challenges hindering flood preparedness and the effectiveness of early warning systems (EWS) in Kaduna North, which is becoming increasingly vulnerable to floods due to urban expansion and inadequate infrastructure. The recognised obstacles comprise elevated expenses of mitigation strategies (18.1%), inadequate governmental assistance (17.5%),

insufficient understanding (16.9%), scarcity of materials (16.1%), ineffective information dissemination (14.0%), minimal awareness (10.5%), and cultural convictions (6.9%). Financial constraints represent the primary obstacle; notwithstanding awareness and prompt alerts, households frequently lack the economic means to respond. This reflects global trends observed in low-income urban regions where conflicting financial obstacles impede readiness. The research indicates that enhancing the Early Warning System should be accompanied by economic assistance measures, like micro-insurance and subsidised resources. Limited government backing, the second most prominent barrier, demonstrates the importance of institutional credibility in community response to warnings. Confidence in authorities and their perceived efficacy substantially influence preparedness behaviour. Weak government presence and ineffective flood management contribute to warning fatigue, underscoring the importance of sustained engagement and transparent communication from local institutions (Perera *et al*., 2020). Information-related hurdles reveal significant deficiencies in risk literacy, underscoring the need for educational activities that enhance the understanding and applicability of EWS signals. Strategies from other places, like community-based training and localised communication, may improve comprehension in Kaduna North. Material shortages pose logistical difficulties, as the lack of critical preparedness equipment undermines the efficacy of the response. The research promotes the enhancement of supply chains and the establishment of local resilience resources to alleviate this obstacle. Cultural ideas also play a role in preparedness behaviour, influencing perceptions of risk and willingness to heed warnings (Guo *et al*., 2022). Implementing culturally attuned communication strategies that incorporate local customs may improve community involvement with early warning systems. The research highlights that the efficacy of the Early Warning System in Kaduna North depends on a combination of economic, institutional, social, and individual factors. It coincides with the global trend towards inclusive, people-centred EWS models that promote accessibility, trust, and actionable guidance for disaster readiness. A holistic approach that integrates technological, social, and governance factors is vital for enhancing the effectiveness of Early Warning Systems and developing resilient communities.

Gendered patterns of adaptation

The statistically significant tendency for female farmers to adopt adaptive cropping/timing strategies echoes gendered adaptation literature across West Africa, where women often rely on flexible, low-cost strategies to manage climate risks (Olowe & Adedayo, 2025). In Kaduna North, qualitative responses indicated that women shift to shorter-duration crops, adjust planting windows, and prioritise food security in household cropping decisions, practical choices that increase resilience despite limited access to capital. However, gendered barriers remain: women typically have less access to credit, land, and technical extension services, reducing their ability to scale up protective investments. This suggests that gender-sensitive extension and financing instruments are needed to turn small-scale adaptive practices into durable resilience (UNDRR, 2023).

Indigenous knowledge and early-warning systems: complementarity and friction

One of the strongest qualitative themes was the continued reliance on indigenous indicators (such as river colour, insect behaviour, and bird movements) to signal impending floods. These local signals are embedded in farming calendars and social memory, guiding everyday decisions (Dube & Nhamo, 2020). At the same time, farmers reported inconsistent utility of institutional EWS: forecasts from NIHSA or NiMet were sometimes not disseminated promptly, were too general, or did not arrive through trusted local channels. These dynamics align with findings in Ghana and Ethiopia, where co-produced warnings that integrated local and scientific knowledge achieved higher uptake (Adomah *et al*., 2024; Woldeyohannes *et al*., 2024).

The implication is clear: integration, not replacement, is the operative logic. When institutional forecasts are co-interpreted with indigenous cues through trusted local intermediaries (farmers' associations, extension agents, radio in local languages), response speed and appropriateness improve (Lassa, 2018). This study identified concrete examples where hybrid information (for instance, a radio forecast confirmed by local river observations) prompted preemptive harvesting or increased storage—acts that materially reduced losses.

Institutional support and the "last mile" problem

The "last mile" (the translation of scientific warning into local action) surfaced repeatedly in KIIs. Institutional constraints included limited extension staffing, weak inter-agency coordination, and a lack of targeted financial instruments. These findings reflect national evaluations following the 2022 floods that emphasised institutional fragmentation and inadequate smallholder support (NEMA/UNDP, 2023). International studies of effective EWS show that technical forecasting must be accompanied by clear, trusted communication channels, pre-agreed response plans, and resources for action (Rajib *et al*., 2024). The regression results (low explanatory power of conventional socio-demographic predictors) indicate that institutional quality, social capital, and access to finance are likely stronger determinants of preparedness than age or farm size alone, a pattern found in other smallholder contexts (Ntim-Amo *et al*., 2022).

Comparative synthesis: local, national and international evidence

Locally (Kaduna State), the results align with Okunola *et al*. (2022), who found that household-level awareness coexists with limited structural mitigation and that institutional outreach is uneven. Nationally, the 2022 flood reviews emphasised similar gaps—the scale of impact far exceeded local coping capacity, and institutional support was patchy (NEMA/UNDP, 2023). Internationally, comparative studies from Ghana (Pienaah *et al*., 2023) and Ethiopia (Woldeyohannes *et al*., 2024) demonstrate that co-produced EWS and targeted small grants materially improve preparedness outcomes; Bangladesh and Indonesia studies also emphasise participatory planning and locally tailored communication as decisive (Moges & Rahman, 2023; Lassa, 2018). Taken together, the literature suggests a replicable path for Kaduna North: (1) strengthen two-way communication that blends scientific forecasts and indigenous cues, (2) finance locally appropriate small infrastructure and nature-based solutions, and (3) institutionalise participatory planning through extension and local government linkages.

Policy and practical implications

From a policy standpoint, three priorities emerge. First, localisation of EWS: translate forecasts into simple, actionable advisories in local languages and disseminate via trusted community networks (farmer associations, religious leaders, local radio). Second, targeted microfinance and in-kind support (materials for bunding, drainage tools) are provided to overcome the cost barrier to structural measures. Third, gender-sensitive programming that recognises women's adaptive strategies and removes access constraints to credit and extension. Institutional reforms should emphasise inter-agency coordination (agriculture, water resources, emergency management) and pre-agreed community response protocols to close the last-mile gap.

Limitations and interpretive caution

While the mixed-methods design provides robust triangulation, several limitations must be acknowledged. The sample size (n = 135), which was smaller than the initial Yamane target, indicates the limitations of broad statistical generalizability beyond Kaduna North, although qualitative insights enhance contextual validity. The low explained variance of regression models indicates the presence of

omitted variables (e.g., social capital measures, access to microcredit, NGO activity) that future research should consider measuring. Finally, the study is cross-sectional; longitudinal monitoring would provide a more accurate assessment of whether integrative EWS and financing interventions change preparedness over time.

Overall, the study demonstrates that knowledge pluralism indicates the deliberate integration of indigenous indicators with institutional forecasts and offers practical, culturally resonant routes to strengthen smallholder flood preparedness. Replicating such integration at scale will require modest but strategic investments: better communication design, community finance, and participatory governance that empowers farmers to act on both local cues and formal warnings.

Conclusion

This study theoretically validates the Community-Based Disaster Risk Management (CBDRM) framework, underscoring community participation and the integration of diverse knowledge systems, augmented by the PAR model to illustrate that true resilience encompasses more than mere awareness, incorporating agency, equity, and social capital into the flood risk management discourse.

Recommendations

(1) Integrate indigenous and institutional early warning systems

(2) Strengthen last-mile communication

(3) Expand access to micro-finance and livelihood diversification

(4) Enhance extension and institutional coordination

(5) Promote gender-responsive flood preparedness

(6) Encourage data-driven local governance

(7) Support continuous research and longitudinal monitoring

Acknowledgement

The authors wish to acknowledge the Institution-Based Research Fund (IBR) under the Management of the Federal University of Technology.

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