ASSESSING THE SOCIO-TECHNICAL READINESS FOR ICT-ENABLED FLOOD DISASTER MANAGEMENT IN COMMUNITIES ALONG THE BANKS OF THE RIVER BENUE IN NORTH-EASTERN NIGERIA

Abubakar Lawan
Department of Public Administration, Federal University Wukari
Taraba State, Nigeria
Correspondence: lawan@fuwukari.edu.ng
&
Usman Abbo
Department of Public Administration, Bayero University, Kano
Email: uabbo.pad@buk.edu.ng

Abstract
The successful integration of Information and Communication Technology (ICT) into disaster management is contingent upon the socio-technical readiness of the target communities. This study assesses the ICT readiness composed of infrastructure, accessibility, digital literacy, and socio-cultural acceptance within communities along the banks of the River Benue in Adamawa and Taraba states (Upper Benue catchment). The region is regularly devastated by severe flooding, necessitating a qualitative phenomenological approach to understand the lived experiences of those affected. Data were collected through semi-structured interviews (n=10) with key stakeholders, including community leaders, government agency officials, academics, and NGO representatives. Thematic analysis reveals a serious deficiency in ICT readiness. The findings include erratic mobile network coverage forcing reliance on urban signals; high costs of ICT devices and limited access to data; low digital literacy compounded by complex user interfaces; and a persistent preference for traditional communication channels such as radio and word-of-mouth. The study frames these findings through the Socio-Technical Systems (STS) theory. This analysis reveals a critical misalignment between the technical potential of ICT and the social subsystems (economic capacity, skills, cultural norms) of these flood-prone communities, specifically regarding economic capacity, digital skills, and cultural norms. The study concludes that without interventions in building human capacities and adaptive, low-cost infrastructure, ICT-based flood management strategies will remain very difficult to realize. Finally, the study proposes a community-centric readiness framework that prioritizes hybrid communication systems, subsidized access, and localized digital literacy programs as condition for effective deployment of ICT in Flood Disaster Management.

Keywords: ICT Readiness, Digital Divide, Socio-Technical Systems, Flood Disaster Management, Qualitative Research

1.0 Introduction

Floods constitute a significant and recurrent threat to sustainable development in Nigeria, with the communities along the banks of River Benue in the North-East being among the most vulnerable (NIHSA, 2023; Danhassan et al., 2023). The devastating impacts of events in 2012, 2022, and

beyond have highlighted the weaknesses and shortcomings of the traditional top-down disaster management approaches, which are often reactive in nature (Adefisoye, 2020; Musa et al., 2021). In response, there is a global and national push towards leveraging Information and Communication Technology (ICT) for enhanced forecasting, early warning, response coordination, and recovery planning (IFRC, 2020; Wang et al., 2020).

Theoretical and empirical literature from contexts like Bangladesh, Japan, and India commends the transformative potential of ICT tools such as Geographic Information Systems (GIS) and remote sensing to mobile alerts and social media (Ahmed & Kelman, 2017; Kaur et al., 2022). However, the contextualization of these technological solutions into local rural areas like communities flanking the River Benue banks in Nigeria often overlooks a fundamental prerequisite: ICT readiness. Readiness here refers to the composite state of a community's or region's technological infrastructure, access to devices, digital literacy levels, and the socio-cultural willingness to adopt new technologies (Chanyagorn&Kungwannarongkun, 2011; Abbasi et al., 2025). In essence, it requires answers to this: do these communities possess the foundational capacity to receive, process, and act upon ICT-mediated information?

Preliminary evidence from the Nigerian context points to a significant digital divide, characterized by poor rural network coverage, high data costs, and low digital skills (Ajayi, 2022; Olorunfemi & Raheem, 2023). A context-specific assessment of ICT readiness within hyper-vulnerable, flood-prone agrarian communities remains scarce. Most of the studies have focused on the technical potential of monitoring systems (Basha & Von Reitzenstein, 2021) or analyzed flood risk management through the lens of urban infrastructure (Nkwunonwo et al., 2016). This leaves an important gap in understanding the socio-technical preconditions for success in rural, agrarian settings (Heeks, 2018).

In line with this, the study, addresses the research question: What is the extent and nature of ICT readiness in communities along the banks of the River Benue in North-Eastern Nigeria for flood disaster management? It employs a qualitative, phenomenological approach to capture the lived experiences and perceptions of key stakeholders. The analysis is guided by the Socio-Technical Systems theory (Trist & Bamforth, 1951; Mumford, 2000), which provides a robust lens for examining the interdependence and necessary "joint optimization" of technical tools (ICT) and social subsystems (community structures, skills, economics).

This study's contribution is twofold. First, it provides an empirical diagnosis of ICT readiness gaps in a critically vulnerable region. Second, it moves beyond mere identification of barriers to propose a theoretically informed, community-centric framework for building readiness. This framework is essential for ensuring that substantial investments in ICT for disaster management do not become wasted but

instead result in a tangible resilience gain for the most at-risk populations.

2.0 Literature Review and Theoretical Framework

ICT Readiness in Disaster Management

ICT readiness is a multidimensional construct. For disaster management, it extends beyond mere ownership of a mobile phone. Frytsiuk et al. (2024) conceptualized it as the ability to successfully adapt, utilize, and integrate ICTs into processes to attain desired goals. Key dimensions include:

i. Infrastructure Availability: The presence of reliable electricity, mobile network towers, internet connectivity (broadband/3G/4G), and broadcast systems (Rahman, 2024).

ii. Accessibility: The economic and physical ability of individuals and communities to obtain and use ICT devices and services, considering factors of cost, location, and language (Van Dijk, 2006).

iii. Digital Literacy and Skills: The competencies required to operate devices, navigate software, interpret digital information, and communicate effectively using technology (Egere&Egere, 2023).

iv. Socio-Cultural Acceptance: The perception of ICT's usefulness, compatibility with existing practices, and trust in technology-driven information (Rogers, 2003).

In least developed countries like Nigeria, the digital divide the gap between those with and without effective access to digital technology often manifests acutely in rural areas (Akanbi & Akanbi, 2012). Studies in Nigeria highlight that over 70% of the rural population struggles with access, affordability, and skills (Sunday et al., 2023). For flood management, this divide is lethal; an accurate early warning is less effective if it cannot reach the intended target population in an understandable and actionable form (Paul et al., 2021).

Socio-Technical Systems (STS) Theory as an Analytical Lens

The Socio-Technical Systems theory, pioneered by Trist and Bamforth (1951), posits that organizational (or community) performance is optimized only when its social and technical subsystems are designed to work in harmony. The technical subsystem includes tools, tasks, and technologies, while the social subsystem encompasses people, their skills, relationships, norms, and cultural values (Mumford, 2000; Abbas & Michael, 2023).

The theory's core tenets relevant to this study are:

i. Interdependence: Social and technical elements are inextricably linked. A change in one for instance, introducing a new flood alert app will necessarily affect the requiring of new user skills, altering communication patterns.

ii. Joint Optimization: Success is not achieved by maximizing the technical subsystem in isolation (e.g. deploying the most advanced satellite imagery) but by designing both subsystems to

complement each other. A simple, robust technology that aligns with community capabilities may be more optimal than a complex one.

iii. Adaptation and Bricolage: In contexts of constraint, users often engage in adaptive "bricolage," creatively combining available technical elements with social practices to achieve goals (Orlikowski, 2000).

Applying STS to ICT for disaster management in rural Nigeria directs analytical attention to the fit between sophisticated ICT tools and the social reality of agrarian, often low-literacy communities. It predicts that failures in ICT integration are not merely technical but stem from a poor socio-technical fit (Clegg, 2000). Previous studies on ICT in Nigerian disaster management (e.g., Wilson et al., 2018) have noted challenges but lack this cohesive theoretical framing to explain the systemic nature of the readiness gap. This study fills that void by using STS to structure its investigation and interpret its findings.

3.0 Methodology

Research Design and Philosophy

This study adopted a qualitative research design within the interpretivist paradigm. Interpretivism contends that reality is socially constructed and best understood through the meanings people assign to their experiences (Creswell, 2013). A phenomenological approach was specifically employed to deeply explore the lived experiences and subjective perceptions of stakeholders regarding ICT readiness (Sandelowski, 1995). This approach is justified as the research seeks to understand the *essence* of the ICT readiness phenomenon from the perspective of those who enact and experience it daily.

Study Area

The study was conducted in selected communities (such as Ribadu, Dasin, Wuro-Bokki, Jambutu, Gwadabawa, Jimeta City, Nbgalan, Numan city, Lau town, Bandawa, kwata, Sendirde, Ibi town, Nwunyo, and Sarkin Kudu) across six Local Government Areas (LGAs) in Adamawa (Fufore, Numan, Yola North) and Taraba (Gassol, Ibi, Lau) states, all within the Upper Benue River Basin. These areas are officially categorized as high to medium flood risk (NIHSA, 2024). See Fig. 1

Figure 1. Map of the River Benue and the communities along its banks in Adamawa and Taraba states



Source: Generated by the Researcher

Sampling Technique

In line with Patton (1990), Purposive sampling techniques were used to select ten (10) key informants who possessed rich, information-dense experiences relevant to the research question. The sampling comprised, Representatives from the National Emergency Management Agency (NEMA), Nigeria Hydrological Services Agency (NIHSA), Nigerian Meteorological Agency (NiMet), and the Upper Benue River Basin Development Authority. Also, a representative from the Nigerian Red Cross. scholars (Experts/specialists) in ICT and Environmental Management from universities in the selected states, the *Sarkin Ruwa* (Leader of fisheries community) and *Sarkin Noma* (the leader of famers' community), traditional authorities overseeing water faming matters, an advocate focusing on community and environmental issues.

Method of Data Collection

Data were collected through semi-structured, in-depth interviews conducted between June and August 2024. An interview guide was developed based on the dimensions of ICT readiness and STS theory. Interviews lasted 45-75 minutes, were conducted in English or Hausa (translated by professional translator), audio-recorded with consent, and transcribed verbatim.

Method of Data Analysis

Following the framework of Nowell et al. (2017), thematic analysis was employed using a hybrid inductive and deductive approach. Initial codes were generated deductively based on the Socio-Technical Systems (STS) framework (such as infrastructure and economic capacity), while inductive coding allowed for new themes to emerge directly from the informants' narratives regarding local cultural norms and flood experiences.

The analysis proceeded through five stages: (1) repeated reading of transcripts for immersion; (2) generating initial codes by deconstructing complex data into actionable tags that highlighted both semantic and latent information; (3) searching for themes by collating related codes; (4) reviewing and refining themes against the entire dataset; and (5) defining and naming themes to ensure internal homogeneity.

NVivo 12 software was utilized beyond simple data storage; it served as the primary tool for coding management, category grouping, and cross-case querying. Specifically, NVivo's "nodes" were used to organize the hierarchical coding structure, and word frequency queries were performed to identify recurring patterns before manual thematic refinement. To ensure trustworthiness, member checking was conducted by sharing summaries with participants for validation, and a digital audit trail of all analytical decisions was maintained within the NVivo project file.

Ethical Considerations

Ethical approval was granted by the relevant government agencies, groups, and individual participants in the study. Informed consent was obtained from all participants, emphasizing voluntary participation, anonymity, and confidentiality. Participants were assigned codes (e.g., Informant A1 for NEMA, Informant B4 for Sarkin Ruwa) to protect their identities in reporting.

4.0 Results and Discussion

The analysis yielded one overarching theme ICT Readiness as a Critical Deficit supported by four interrelated sub-themes that map onto the STS framework's social subsystem, highlighting the misalignment with potential technical tools. The findings reveal a landscape of profound socio-technical misalignment. While government agencies are advancing in technological capability, the end-user communities face a tripod barrier; weak infrastructural, economic inaccessibility, and skill deficits

Sub-theme 1: The Illusion of Network Availability Unstable and Exclusionary Infrastructure

The foundational technical element of mobile connectivity was found to be critically lacking. While government maps may show network coverage, the reality on the ground is one of profound instability. Informant B5 (Sarkin Noma) stated,

> We don't usually depend on mobile networks for communications because it is epileptic here… In some cases where there are towers, you will find that many villages tap from it, and at times, the proximities between these communities affect the service effectiveness.

This sentiment was echoed by an ICT academic (Informant B2), who noted that the hilly terrain and valley locations of many communities further degrade signals, forcing residents to "climb trees or hills" to get a connection. This finding aligns with Rahman's (2024) assertion that infrastructure deficiency is a primary barrier. From an STS perspective, the technical subsystem (network towers) is neither optimally located nor sufficiently resilient. Consequently, it fails to serve the social subsystem's (dispersed rural communities) geographical and operational needs, especially during adverse weather when floods are imminent.

Sub-theme 2: The Economics of Exclusion Cost as a Primary Barrier to Accessibility

Even where network coverage is available, the high cost of complementing hardware poses a significant economic barrier, often limiting access to more affluent demographics and further widening the digital divide. The social subsystem's economic reality directly conflicts with the cost of the technical tools. Informant B4 (Sarkin Ruwa) explained, "The majority of our people don't use Android devices, talk more of computers… some of these tools are expensive to buy, and even when you manage to buy them, you still have to purchase data.".

This highlights a two-tiered economic barrier: the capital cost of hardware and the recurring cost of data. The digital divide, as described by Van Dijk (2006), is vividly evident. The community's agrarian economy, already vulnerable to flood shocks, often limits their ability to consistently support these costs. Consequently, ICT remains the domain of a specific demographic, primarily younger or urban-connected individuals,

rather than a communal resource for disaster preparedness.

Sub-them 3: Complexity and Alienation; The Digital Literacy Gap

Technical readiness is not just about possession but about competent use. A significant digital literacy gap exacerbates the accessibility problem. Many participants reported prevalent unfamiliarity with sophisticated devices and applications. Informant B4 (the Sarkin Ruwa or Leader of fisheries community) noted that many people are "unfamiliar with how to operate them due to their complex nature." Informant B2, the ICT expert, emphasized that "ease of use is a critical pillar in ICT acceptance" and that interfaces must consider local languages and low-literacy users, potentially integrating symbols or voice commands.

This sub-theme speaks to the "skill access" barrier (Van Dijk & Hacker, 2003). The technical subsystem, often designed with urban, literate users in mind, presents a complexity that the social subsystem's current skill set cannot decode. It was also revealed that without concerted digital literacy efforts, even free devices would see limited effective use for disaster management.

Sub-theme 3: The Persistence of the Familiar; Trust in Traditional Channels over Digital Uncertainty

Socio-cultural acceptance, a key component of the social subsystem, heavily favors established communication channels. Despite recognizing ICT's potential, there is a well-established reliance on radio and interpersonal networks. Informant B4 stated that communities "prefer listening to radio stations where information is passed in a language they understand." Informant A2 (NIHSA) acknowledged this by stating they maintain traditional water gauges that are "easily observed and understood by the locals."

This preference is rational. Informant B2 revealed that radio is cheaper, requires less skill, use local languages, and are perceived as more reliable during power outages Furthermore, as Informant B5 (The Sarkin or Head of farmers community) revealed, communities have developed their own informal ICT-augmented systems, using phones to warn downstream kinds of rising water levels. This is a clear example of STS's bricolage adapting available technology (basic mobile phones) to reinforce a trusted social practice (kinship-based warning). This indicates that readiness initiatives must be built upon, not attempt to replace, these organic, trusted systems.

Synthesis: The Socio-Technical Misalignment

The synthesis of results identifies a persistent pattern of divergence between agency-level technical capabilities and community-level social realities. Across all sub-themes, the empirical evidence reveals that while government stakeholders (Informants A1–A4) have prioritized high-capacity tools such as real-time GIS and automated alerts, these advancements remain functionally decoupled from the target beneficiaries.

Data from the field highlights three recurring barriers: (1) economic constraints that limit device ownership; (2) literacy gaps that hinder the use of

sophisticated applications; and (3) demonstrated reliance on analogue channels (Informants B2, B4). These patterns suggest that the "joint optimization" of social and technical subsystems is currently unachieved. This "readiness disconnect" indicates that technical preparedness at the institutional level does not translate into community resilience. Consequently, the evidence suggests that the effectiveness of accurate flood forecasting is mitigated by these socio-technical frictions, which weaken the final, critical link in the disaster communication chain.

5.0 Conclusion and Recommendations

Conclusion

This study assessed the ICT readiness of the Upper River Benue communities for flood disaster management through the lens of Socio-Technical Systems (STS) theory. The empirical evidence indicates that community readiness remains a primary constraint to the effective utilization of digital flood-management tools. Data from informants and field observations reveal that this lack of readiness is a result of interlinked systemic factors: specifically, the unreliability of physical infrastructure, the economic cost of device acquisition, and measured gaps in digital literacy.

These findings demonstrate a misalignment between the advanced technical subsystems proposed by government agencies and the social and cultural subsystems of the agrarian communities. The data suggest that current ICT deployment strategies, which focus primarily on technical preparedness at the agency level (Informants A1–A4), do not yet account for the community-level reliance on traditional communication channels. Consequently, the study concludes that without strategic investment in the socio-technical foundations of these communities, the implementation of sophisticated disaster-management technologies may yield limited results and potentially exacerbate existing disparities in disaster resilience.

Recommendations

Based on these findings, we propose a Community-Centric ICT Readiness Framework with three strategic pillars:

1. **Build Hybrid and Resilient Infrastructure:**

Government should mandate telecommunications companies, as part of their licensing obligations, to deploy a mix of robust terrestrial towers and supplementary satellite-based community hotspots in flood-prone areas.

Promote and subsidize the use of low-power, durable technologies like satellite radios and simple mobile phones with extended battery life, which can function when networks are degraded.

2. **Launch Targeted Subsidy and Literacy Programs:**

State Emergency Management Agencies (SEMAs) should partner with NGOs to create “Flood Preparedness Tech-Packs” subsidized kits containing a basic solar-charged phone, a pre-programmed radio, and vouchers for emergency data.

Integrate practical digital literacy for disaster response into adult education

programs and school curricula in vulnerable LGAs. Training should be conducted in local languages and focus on actionable skills: receiving SMS alerts, using a simple warning app, and reporting incidents via designated numbers.

3. Design for Socio-Technical Integration (Co-Design)

ICT solutions for these communities must be co-designed with end-users. As suggested by informants, this means multilingual interfaces, icon-based navigation, and voice-based alerts.

Formal systems should seek to integrate with, not replace, informal community warning networks. For instance, official alerts could be designed to be easily sharing via popular platforms like WhatsApp, which are already in limited use, and be immediately broadcast via dedicated community radio frequencies.

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