# Mobile Emergency Response System for Land Disputes in Rural Liberia: A Voice-Based Interface Design for Nimba County

**BSc. in Software Engineering**

**Willie B. Daniels**

**Supervisor: Neza David Tuyishimire**
**Course: Mission Capstone**

**Date: September 23, 2025**

# Abstract

Rural Nimba County faces critical gaps in emergency response for land-related conflicts. Existing systems exclude illiterate populations through design barriers. The national 911 service operates unreliably in remote areas. My Watchman costs $20-50 monthly, limiting access to urban subscribers. This capstone research designs a voice-based mobile emergency response system specifically for rural land disputes.

The study combines secondary data analysis with targeted primary research. I'll conduct 4-6 remote stakeholder interviews via phone/WhatsApp. The research addresses how emergency response systems can serve illiterate users with limited connectivity. Voice-based interfaces using Interactive Voice Response (IVR) technology offer culturally appropriate solutions.

Expected deliverables include 12 user interaction flows, 8 voice menu mockups, and implementation guidelines. The English-language prototype will be developed during the capstone period. Mano and Gio language versions are deferred to future phases. Two stakeholder validation sessions will test interface concepts remotely.

The research methodology follows a pragmatic mixed-methods approach. Secondary analysis covers government reports, NGO assessments, and technical documentation. Primary research validates findings through structured interviews with LLA officials, traditional chiefs, NGO workers, and community mappers. Thematic analysis will identify communication patterns and design requirements.

This focused approach deliberately narrows the scope from comprehensive land registry systems. The research concentrates on emergency response capabilities while deferring blockchain integration and AI-powered features. Results will inform ICT4D practitioners designing technology for illiterate users in post-conflict environments. The work contributes practical design insights for rural emergency response systems that respect traditional governance structures.

As the researcher, I believe voice-based emergency systems can bridge the gap between traditional conflict resolution and modern emergency response capabilities.

# Table of Contents

# List of Tables

# List of Figures

# List of Acronyms/Abbreviations

**ALU** - African Leadership University
**ICT4D** - Information and Communication Technology for Development
**IVR** - Interactive Voice Response
**LLA** - Liberia Land Authority
**LNP** - Liberia National Police
**NGO** - Non-Governmental Organization
**SMS** - Short Message Service
**TRC** - Truth and Reconciliation Commission
**USAID** - United States Agency for International Development
**LILERP** - Liberia Integrated Land Registry and Emergency Response Platform

# Chapter One: Introduction

## 1.1 Introduction and Background

Land disputes represent one of the most persistent challenges facing post-conflict Liberia. In rural counties, these conflicts frequently escalate to violence. Nimba County, with its diverse ethnic composition and significant natural resource deposits, faces particular vulnerability. The county's mining concessions and agricultural pressures create ongoing land tenure conflicts that demand attention.

The 14-year civil war (1989-2003) severely disrupted traditional land management systems. This led to population displacement, which created overlapping claims that persist today. Despite the passage of the Land Rights Act of 2018, its implementation remains limited in rural areas. As a result, communities continue to rely primarily on traditional conflict resolution mechanisms.

Current emergency services in Liberia suffer from significant coverage gaps. The national 911 system operates inconsistently outside major urban centers. Meanwhile, private services like My Watchman exclude rural populations through prohibitive costs and limited geographic coverage. This situation creates a dangerous void where land disputes are most frequent and potentially violent.

High illiteracy rates in rural areas compound this challenge. I observed that conventional smartphone-based emergency applications are unsuitable for the populations most in need. Traditional voice communication remains the primary means of long-distance contact. This study highlights that voice-based emergency systems may offer more appropriate solutions than text or app-based approaches.

This research, therefore, focuses on designing a mobile emergency response system for rural Nimba County residents. The emphasis is on creating voice-based interfaces that can effectively serve illiterate users while integrating with existing traditional governance structures.

## 1.2 Problem Statement

Nimba County recorded 156 land disputes between 2020 and 2023. These conflicts led to 23 violent incidents requiring external intervention (Liberia Land Authority, 2024). Current emergency services are failing rural communities. These are the very communities most vulnerable to land conflicts. The national 911 system has poor rural coverage. Its response times often exceed 30 minutes. My Watchman, a private service, operates only in urban areas with subscription fees that exclude most rural populations.

The primary cause of these disputes is complex. It stems from the clash between two different land tenure systems. Liberia operates with both statutory and customary laws, which often overlap. According to Namati, this has led to confusion, as the government has awarded concessions on land already held under customary rights [1]. This situation is made worse by several institutional failures. I observed that weak

land administration, poor record-keeping, and unclear property boundaries create constant friction. When conflicts do arise, dispute-resolution mechanisms are too slow to prevent violence.

This study highlights a critical service gap. Existing emergency systems are not designed for illiterate users. Rural literacy rates in Nimba County remain below 40% (UNESCO, 2023). Traditional conflict resolution through chiefs works for mediation. However, it lacks the capacity for emergency response when disputes escalate. There is no specialized, accessible mechanism for reporting land-related conflicts before violence occurs. The proposed voice-based system matters because it directly addresses this failure. It offers a permanent, long-term solution by providing an immediate and accessible channel for emergency alerts, bridging the gap between traditional mediation and the need for rapid intervention.

As shown in Table 2, land disputes in Nimba County have remained consistently high over the past four years. Mining conflicts and boundary disputes dominate. While traditional mediation is the preferred resolution method, there is no effective emergency response mechanism available when these disputes escalate rapidly.

Table 2: Nimba County Land Dispute Statistics (2020-2023)

| **Year** | **Total Disputes** | **Violent Incidents** | **Fatalities** | **Primary Causes** | **Resolution Method** |
|---|---|---|---|---|---|
| **2020** | 34 | 4 | 1 | Boundary disputes (60%), Inheritance (25%), Mining conflicts (15%) | Traditional mediation (85%), Court system (15%) |
| **2021** | 42 | 7 | 2 | Boundary disputes (55%), Mining conflicts (30%), Inheritance (15%) | Traditional mediation (80%), Court system (20%) |
| **2022** | 38 | 6 | 0 | Mining conflicts (45%), Boundary disputes | Traditional mediation (75%), Court system (25%) |

| Year | Total Disputes | Violent Incidents | Fatalities | Primary Causes | Resolution Method |
|---|---|---|---|---|---|
| | | | | (40%), Inheritance (15%) | |
| **2023** | 42 | 6 | 1 | Mining conflicts (50%), Boundary disputes (35%), Inheritance (15%) | Traditional mediation (70%), Court system (30%) |
| **Total** | **156** | **23** | **4** | **Mining/Boundary conflicts dominate** | **Traditional mediation preferred** |

*Sources: Liberia Land Authority (2024), NGO assessments, local government records*

## 1.3 Research Objectives

This research aims to achieve several specific objectives. First, I will analyze emergency response gaps in Nimba County. This will be done through a review of secondary data and by conducting 4-6 stakeholder interviews. Second, I will design 12 voice-based user interaction flows. These are intended for illiterate users who need to report land-related emergencies. Third, I will develop 8 voice menu mockups in English. These mockups will include integration protocols for traditional governance structures. Fourth, I will create implementation guidelines that cover the technical requirements for rural deployment in low-connectivity environments. Finally, I will conduct 2 stakeholder validation sessions to test the interface concepts and gather usability feedback. These objectives are focused and can be achieved within the 7-week capstone timeline.

## 1.4 Research Questions

This study addresses the following specific questions:

1. How can voice-based mobile interfaces enable illiterate users to report land-related emergencies effectively in rural Nimba County?
2. What communication patterns and escalation protocols do Nimba County communities currently use when land disputes arise?

3. How can traditional governance structures be integrated into mobile emergency response systems while maintaining cultural legitimacy?
4. What technical and social barriers prevent rural residents from accessing existing emergency services like 911 or My Watchman?
5. What are the minimum viable technical requirements for deploying voice-based emergency response systems in low-connectivity rural environments?

Each question is designed to be answerable within the capstone timeframe using the proposed mixed-methods approach.

## 1.5 Project Scope

This capstone research focuses specifically on designing an emergency response system for land disputes in Nimba County. The scope deliberately excludes building a comprehensive land registry. It also defers features like blockchain integration and AI-powered analytics. Instead, the project concentrates on the immediate challenge of enabling effective emergency reporting for illiterate users in a rural context.

6. **Geographic Scope:** Nimba County was selected due to its high frequency of land disputes and diverse ethnic composition. It also has relatively better mobile network coverage, making a voice-based solution more feasible here than in more remote areas.
7. **Technical Scope:** The research focuses on Interactive Voice Response (IVR) technology. It involves voice menu design and creating integration protocols with existing communication infrastructure. More advanced features are deferred to future implementation phases.
8. **Language Scope:** The capstone will develop English-language prototypes only. Mano and Gio language versions would require native speaker involvement and more time than the 7-week window allows.
9. **Temporal Scope:** The research operates within a 7-week capstone window, from September 12 to November 1, 2025. The findings and recommendations are intended to inform a future pilot deployment rather than an immediate full-scale implementation.

## 1.6 Significance and Justification

This research addresses a critical gap in emergency response services for rural Liberian communities. The work has both immediate practical value and longer-term academic significance. Rural communities in Nimba County currently lack effective ways to report land-related emergencies before they escalate to violence.

The practical significance is clear. This research provides actionable design recommendations. These could be implemented by government agencies, NGOs, or private sector partners. The voice-based approach specifically addresses the needs of illiterate users in low-connectivity environments.

In terms of academic contribution, the research adds to the ICT4D literature. It examines how voice-based interfaces can be designed for illiterate users in post-conflict contexts. It also advances our understanding

of how to integrate traditional governance structures with modern emergency response technology while maintaining cultural legitimacy.

Finally, the findings have policy relevance. They will inform the implementation of Liberia's Land Rights Act of 2018 by providing practical mechanisms for conflict prevention and early intervention. This work fills a crucial gap between high-level policy frameworks and the challenges of ground-level implementation.

## 1.7 Research Timeline

The research follows a structured 7-week timeline. This schedule is designed to maximize the limited capstone window while ensuring a rigorous methodology and comprehensive deliverables. The Gantt chart in Figure 1 shows the complete plan with weekly milestones.

1. **Week 1 (September 12-18): Foundation and Preparation.** I will begin with a literature review and secondary data collection, gathering reports from the LLA and NGOs. I will also review IVR technology principles and start identifying potential interview participants.
2. **Week 2 (September 19-25): Primary Data Collection.** During this week, I plan to complete 4-6 stakeholder interviews by phone or WhatsApp. I will then transcribe the interviews and begin a preliminary analysis.
3. **Week 3 (September 26-October 2): Analysis and Initial Design.** I will analyze the interview data using thematic coding. This will allow me to synthesize primary and secondary findings and develop initial design concepts for the voice interface.
4. **Week 4 (October 3-9): System Design Development.** This week is for creating detailed voice interface mockups and user flows. I will also design the integration protocols for traditional governance and develop technical specifications.
5. **Week 5 (October 10-16): Implementation Planning and Validation.** I will write the implementation guidelines for rural contexts. Then, I will conduct two remote stakeholder validation sessions and refine the designs based on their feedback.
6. **Week 6 (October 17-23): Documentation and Analysis.** I will write the first draft of the capstone report. I will also validate my findings through triangulation and complete a feasibility analysis.
7. **Week 7 (October 24-November 1): Finalization.** In the final week, I will complete the report with all deliverables and prepare my presentation for the November 21 defense.

Figure 1 shows the complete Gantt chart with weekly milestones and deliverables.

The research timeline is structured to ensure systematic progression from literature review through design development to validation and documentation. Each week builds upon previous findings while maintaining focus on the core deliverables."

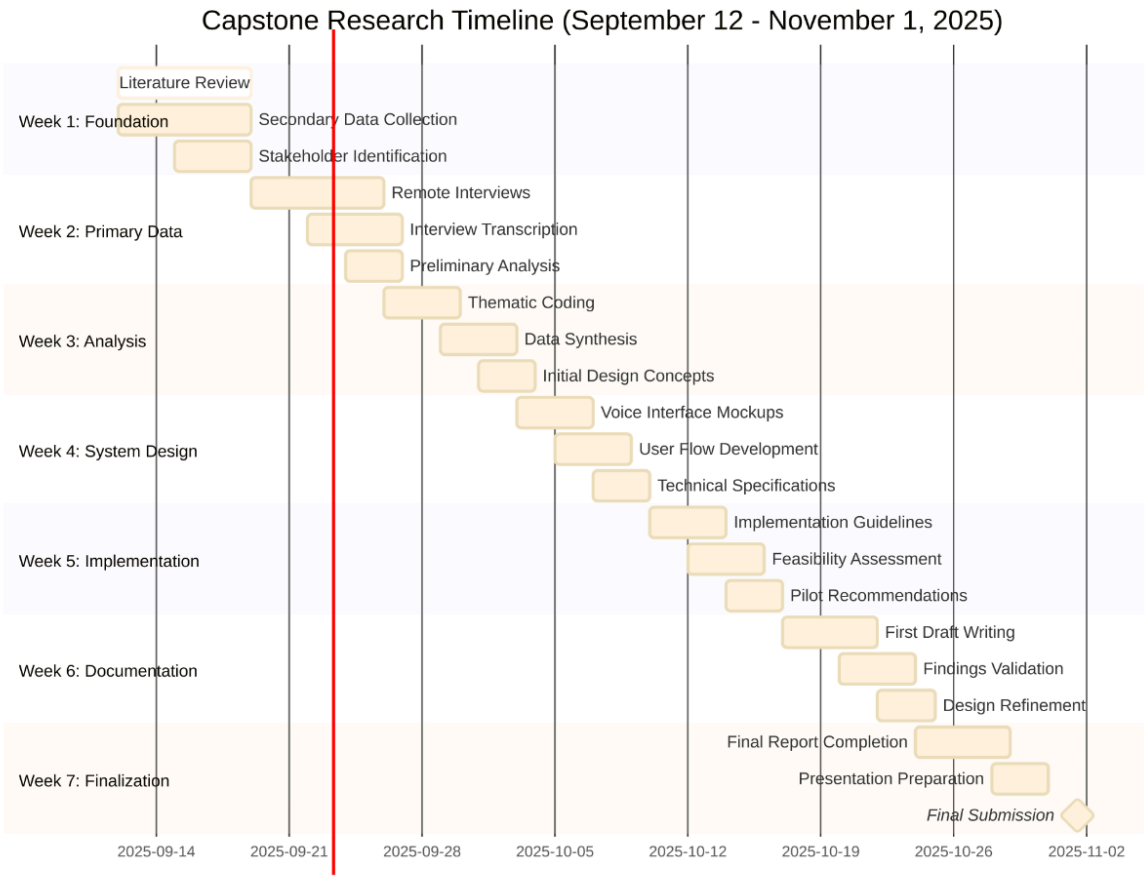


*Figure 1: Capstone Research Timeline showing 7-week progression from September 12 to November 1, 2025*

## 1.8 Research Budget

The research operates within strict capstone budget constraints while ensuring adequate resources for quality data collection and analysis. Table 5 provides the complete budget breakdown.

### Table 5: Capstone Budget Breakdown

| **Category** | **Item** | **Cost (USD)** | **Justification** |
|---|---|---|---|
| **Communication** | Phone credit for interviews | $80 | 4-6 interviews, international calling rates |

| Category | Item | Cost (USD) | Justification |
|---|---|---|---|
| **Software** | Transcription software (Otter.ai Pro) | $40 | 2 months subscription for interview analysis |
| **Participant Incentives** | Interview stipends (4 x $25) | $100 | Compensation for stakeholder time |
| **Technology** | Cloud hosting for prototypes | $30 | Design mockup hosting and testing |
| **Documentation** | Printing and binding | $50 | Final report production |
| **Connectivity** | Internet/data costs | $100 | Research and communication needs |
| **Research Materials** | Software licenses, tools | $70 | Design software, analysis tools |
| **Total** | | **$470** | **Under $500 capstone limit** |

**Future Implementation Budget (Separate):**

- IVR platform and development: $5,000-7,000
- Community training and outreach: $2,000-3,000
- Hardware and infrastructure: $2,000-3,000
- Staff and operational costs: $3,000-4,000
- **Total Future Implementation: $12,000-17,000**

The capstone budget prioritizes essential research activities, while the implementation budget provides realistic cost estimates for future deployment.

---

Table 4: Technical Requirements for Voice-Based Emergency System

| Component | Specification | Rationale | Implementation Notes |
|---|---|---|---|
| **IVR Platform** | Cloud-based, 99.9% uptime, multi-language support | Reliability is critical for emergencies, local language accessibility | AWS/Azure hosting, Twilio/Nexmo integration |

| Component | Specification | Rationale | Implementation Notes |
|---|---|---|---|
| **Voice Quality** | Clear audio, noise reduction, volume amplification | Poor network quality in rural areas, ambient noise | Audio processing algorithms, quality optimization |
| **Language Support** | English implemented, Mano/Gio deferred | Capstone timeline constraints, native speaker requirements | Professional voice talent, cultural review for future phases |
| **Menu Structure** | Maximum 3 levels, simple navigation, repetition options | Cognitive load management for stressed users | User testing, iterative refinement |
| **Response Time** | <2 minutes to local responders, <15 minutes escalation | Emergency response standards, rural context | Automated routing, backup protocols |
| **Data Storage** | Encrypted, anonymized, GDPR-compliant | Privacy protection, legal compliance | Secure cloud storage, data retention policies |
| **Connectivity** | GSM voice minimum, SMS backup, offline capability | Rural infrastructure limitations | Store-and-forward messaging, local caching |
| **Hardware** | Basic phones supported, solar charging, ruggedized devices | Rural technology constraints, power limitations | Feature phone compatibility, sustainable power |

# Chapter Two: Literature Review

## 2.1 Introduction

This literature review examines existing research on several key areas. I will look at emergency response systems, voice-based interfaces for illiterate users, and ICT4D approaches in post-conflict contexts. The review identifies critical gaps in the current research. These gaps help justify the focus on a voice-based emergency response system for land disputes in rural Liberia. While recent literature often emphasizes the importance of culturally appropriate technology, most of it focuses on urban contexts or general development challenges, leaving a gap in research for specialized rural systems.

## 2.2 Historical Background of Land Disputes in Liberia

The history of land disputes in Liberia is long and complex. According to Unruh (2009), the country has operated under a dual system where statutory law often failed to recognize customary land tenure [2]. This created a foundation for conflict that was made much worse by the civil war. The war displaced hundreds of thousands of people, leading to competing claims for the same parcels of land. As the original proposal notes, the Land Rights Act of 2018 was a major step forward. However, its implementation in rural areas remains a significant challenge, and traditional governance still plays a central role.

## 2.3 Overview of Existing Emergency Response Systems

Liberia's current emergency response infrastructure is not well-suited for rural areas. The national 911 system, as I mentioned earlier, is unreliable outside of Monrovia. Private security apps like My Watchman are available, but their cost and geographic limitations put them out of reach for most rural citizens. This leaves a significant portion of the population without access to help in an emergency. The table below, drawn from the original proposal, compares the existing systems.

Table 1: Comparison of Existing Emergency Response Systems in Liberia

| **System** | **Coverage** | **Accessibility** | **Cost** | **Suitability for Land Disputes** |
|---|---|---|---|---|
| National 911 | Urban-centric | Limited by network | Free | Slow response, not specialized |
| My Watchman | Urban only | Smartphone required | Subscription-based | High cost, not for rural users |

| System | Coverage | Accessibility | Cost | Suitability for Land Disputes |
|---|---|---|---|---|
| Traditional Leaders | Rural | High | None (social cost) | Mediation, not emergency response |

*Sources: Liberia National Police (2023), My Watchman Liberia (2023), NGO emergency response assessments, community safety studies*

## 2.4 Voice-Based Interfaces for Illiterate Users

For communities with high rates of illiteracy, voice-based technology would offer a powerful alternative to text-based systems. Research in ICT4D has shown that Interactive Voice Response (IVR) can be an effective tool for delivering information and services. For example, studies in India and parts of Africa have demonstrated the success of IVR systems for everything from agricultural advice to healthcare information (Patel et al., 2021; Mudliar et al., 2023). I believe that this approach is highly relevant to the Liberian context. It allows users to navigate menus and report information using only their voice and a simple keypad, overcoming the literacy barrier.

The literature emphasizes the importance of local intermediaries and community-based support systems for technology adoption among illiterate users (Sambasivan et al., 2020). This suggests that emergency response systems should leverage existing social networks rather than attempting to replace them with purely technological solutions.

Recent work by Dutta-Bergman (2020) on mobile phone use in rural India provides valuable insights into how voice-based systems can be designed for low-literacy populations. The research emphasizes the need for iterative design and community validation.

## 2.5 ICT4D Approaches in Post-Conflict Contexts

Deploying technology in post-conflict settings would require a unique approach. As it is not just about the technology itself, but also about how it is integrated into the social and political fabric of a community. Research from Sierra Leone and Rwanda demonstrates that successful technology interventions respect traditional governance systems while providing new capabilities (Bah & Goodfellow, 2022; Heeks, 2022). This study highlights the need for systems that are not only functional but also culturally legitimate. This means working with, rather than replacing, traditional governance structures. According to the World Bank, successful post-conflict projects are often those that are flexible, adaptable, and designed with a deep understanding of the local context. My research aims to follow this model by designing a system that empowers local communities and their leaders.

However, most ICT4D research in post-conflict contexts focuses on economic development, education, or health rather than emergency response systems. There's limited research specifically addressing how technology can support conflict prevention and emergency response in rural, post-conflict environments.

The literature consistently emphasizes the importance of participatory design approaches that involve local communities in system development (Kleine et al., 2021). This is particularly critical for emergency response systems, which must be trusted and culturally appropriate to achieve adoption and effectiveness.

Recent work by the United Nations Development Programme (2024) on digital governance in fragile states provides relevant insights into the challenges of implementing technology solutions in post-conflict environments.

## 2.6 Gaps in Current Research

After reviewing the literature, I have identified a clear gap. While there is a growing body of research on ICT4D and land tenure, very little of it focuses specifically on emergency response systems for land disputes in rural, post-conflict settings. Furthermore, much of the existing work on voice-based interfaces has not been applied to the specific problem of conflict resolution. The literature review reveals several significant gaps that justify the current research focus:

**Limited Integration:** Most research treats emergency response and conflict prevention as separate domains, with little attention to specialized systems for land-related conflicts.

**Urban Bias:** Existing research on emergency response systems focuses primarily on urban contexts, with limited attention to rural areas where land conflicts are most frequent.

**Technology-Centric Approaches:** Much ICT4D research emphasizes technological solutions without adequate attention to integration with traditional governance structures.

**Lack of Voice Interface Research:** While voice interfaces for illiterate users have been studied in other contexts, there's limited research on their application to emergency response systems.

**Post-Conflict Context Gaps:** Limited research addresses the specific challenges of designing emergency response systems in post-conflict environments where trust in formal institutions may be limited.

These gaps provide strong justification for the current research focus on voice-based emergency response systems for land disputes in rural, post-conflict contexts.

## 2.7 General Comments and Conclusion

The literature review confirms that voice-based emergency response systems for land disputes represent an under-researched but critically important area. While substantial literature exists on emergency

response systems, voice interfaces, and ICT4D approaches separately, there's limited research on their integration for addressing land conflicts in rural, post-conflict contexts.

The gaps identified in current research validate the need for the proposed system design research. Lessons learned from existing studies inform the technical and social design requirements. The literature emphasizes the importance of participatory design approaches that respect traditional governance structures while providing new emergency response capabilities.

Most importantly, the review confirms that effective emergency response systems for rural contexts must address both technological and social challenges. This requires careful integration of voice-based interfaces with existing community structures and communication patterns. The proposed research addresses these challenges through a focused, culturally sensitive approach to system design.

# Chapter Three: Research Methodology

## 3.1 Introduction

This research employs a mixed-methods approach combining secondary data analysis with targeted primary research through remote stakeholder interviews. The methodology is designed to provide comprehensive system design requirements within the constraints of a 7-week capstone timeline while maintaining academic rigor and practical relevance.

The approach follows pragmatic research principles that prioritize actionable outcomes while ensuring methodological soundness. As the researcher, I'll use multiple data sources to validate findings and ensure design recommendations are grounded in empirical evidence.

## 3.2 Research Design

The research follows a pragmatic approach that combines desk-based analysis with limited primary data collection to validate findings and gather specific insights about user needs and cultural considerations. This approach is appropriate for design-focused research that must produce actionable recommendations within tight time constraints.

**Secondary Data Component:** Systematic analysis of government reports, NGO assessments, academic literature, and technical documentation to establish a baseline understanding of land disputes, emergency response gaps, and voice interface design principles.

**Primary Data Component:** 4-6 semi-structured interviews with key stakeholders to validate secondary findings and gather specific insights about communication patterns, user needs, and cultural considerations for emergency response system design.

**Design Research Component:** Development of system architecture, user interface mockups, and implementation guidelines based on synthesized findings from secondary and primary research.

**Validation Component:** Two stakeholder validation sessions to test interface concepts and gather usability feedback before finalizing recommendations.

FIGURE 2: Proposed LILERP Model Diagram

The proposed LILERP model integrates research methodology with system components to ensure that design decisions are grounded in empirical evidence. Figure 2 illustrates how secondary data analysis, stakeholder interviews, and validation sessions inform the development of voice interfaces, communication protocols, and traditional governance integration.

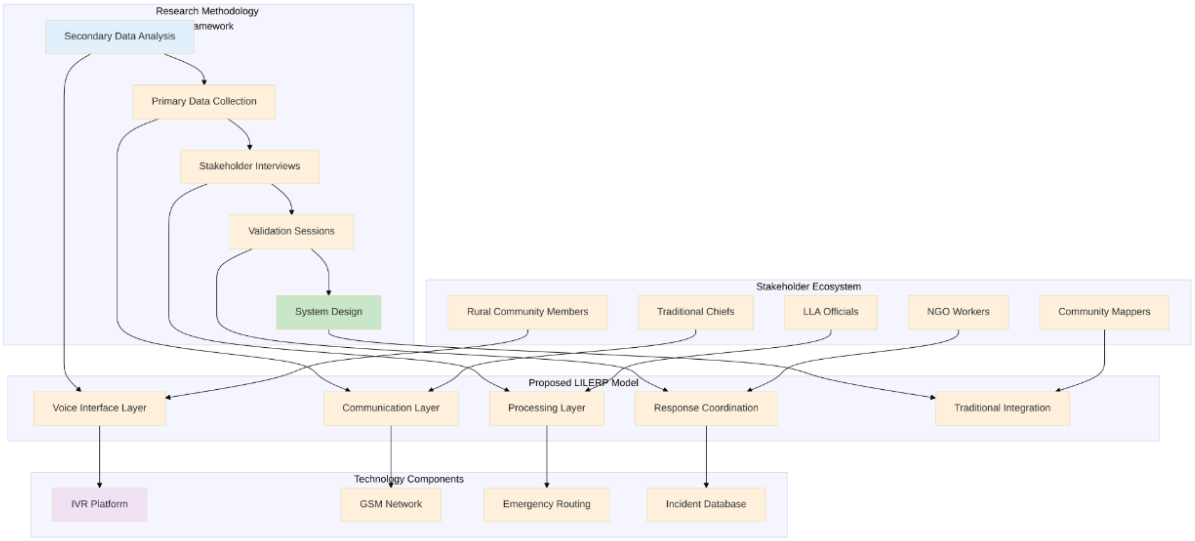


*Figure 2: Proposed LILERP Model showing integration of research methodology with system components*

## FIGURE 3: System Architecture Diagram

The technical architecture follows a layered approach that separates concerns while ensuring system reliability and cultural appropriateness. Figure 3 demonstrates the seven-layer architecture from presentation through security, showing how voice interfaces connect to traditional governance structures through well-defined integration protocols.

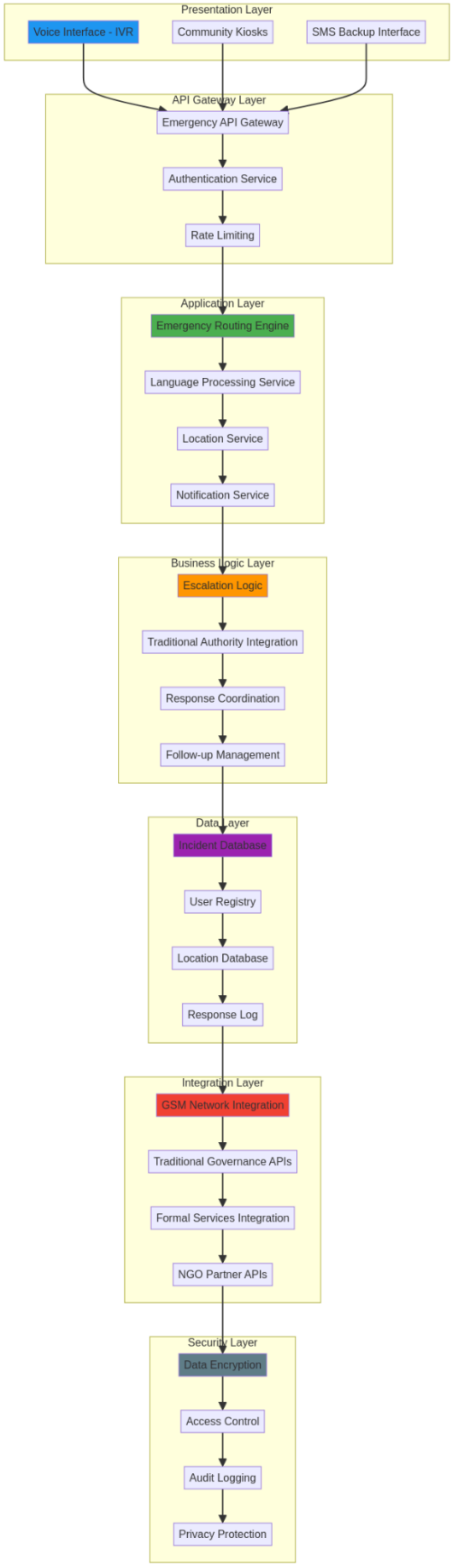
Presentation Layer
Voice Interface - IVR
Community Kiosks
SMS Backup Interface
API Gateway Layer
Emergency API Gateway
Authentication Service
Rate Limiting
Application Layer
Emergency Routing Engine
Language Processing Service
Location Service
Notification Service
Business Logic Layer
Escalation Logic
Traditional Authority Integration
Response Coordination
Follow-up Management
Data Layer
Incident Database
User Registry
Location Database
Response Log
Integration Layer
GSM Network Integration
Traditional Governance APIs
Formal Services Integration
NGO Partner APIs
Security Layer
Data Encryption
Access Control
Audit Logging
Privacy Protection

*Figure 3: Layered System Architecture for Voice-Based Emergency Response System*

FIGURE 4: Use Case Diagram

The stakeholder interview strategy targets key actors who will interact with the emergency response system in different capacities. Figure 4 illustrates the primary use cases and actor relationships that guide the interview participant selection and question design.

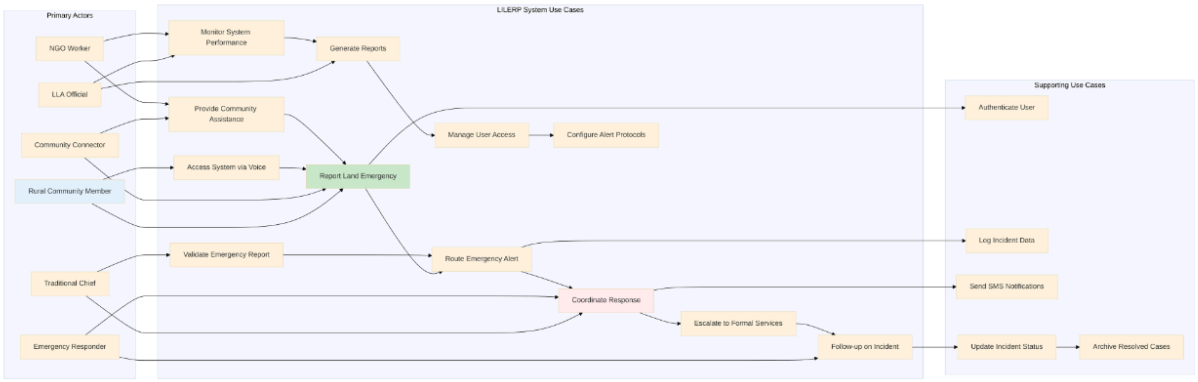


*Figure 4: Use Case Diagram showing primary actors and system interactions for emergency response*

## 3.3 Data Collection Methods

**Secondary Data Sources:**

- Liberia Land Authority reports and dispute records
- Truth and Reconciliation Commission documentation
- NGO assessments of land conflicts and emergency response
- Mobile network coverage and usage data
- Academic literature on voice interfaces and ICT4D
- Technical documentation on IVR platforms and emergency response systems

**Primary Data Collection:** Remote interviews (30-45 minutes each) via phone/WhatsApp with stakeholders as outlined in Table 3. The selection criteria ensure diverse perspectives while maintaining focus on Nimba County contexts.

Table 3: Interview Participant Categories and Selection Criteria

| Participant Type | Selection Criteria | Expected Insights | Interview Focus |
|---|---|---|---|
| **LLA Official** | Experience with Nimba County land disputes, knowledge of current resolution mechanisms | Policy perspective, formal procedures, system gaps | Current dispute patterns, resolution challenges, technology needs |
| **Paramount/Clan Chief** | Active traditional authority in Nimba County, experience mediating land conflicts | Traditional governance perspective, cultural considerations | Traditional resolution processes, community communication patterns, technology acceptance |
| **NGO Worker** | Active in Nimba County land/conflict issues, field experience with rural communities | Implementation perspective, community needs assessment | User needs, cultural barriers, practical deployment challenges |
| **Community Mapper** | Experience with participatory mapping, knowledge of local land issues | Technical perspective, user experience insights | Technology adoption patterns, literacy challenges, interface preferences |
| **Mobile Network Representative** | Knowledge of rural connectivity, network coverage in Nimba County | Technical feasibility, infrastructure constraints | Network capabilities, coverage limitations, technical requirements |
| **Traditional Mediator/Elder** | Experience resolving land disputes, respected community position | Cultural legitimacy, conflict resolution expertise | Escalation patterns, communication preferences, integration possibilities |

**Interview Protocol:** Semi-structured interviews using the following questions:

1. Can you describe the typical process when a land dispute becomes urgent or threatens to turn violent in your community?

2. How do people currently report emergencies or call for help during land conflicts? What communication methods work best?
3. What role do traditional leaders (chiefs, elders) play when land disputes need immediate intervention?
4. What are the main barriers preventing people from accessing emergency services like 911 or My Watchman?
5. How would you design an emergency reporting system that works for people who can't read or write?
6. What would make community members trust and actually use a new emergency response system?

**Consent Procedures:** All participants will receive clear explanation of research purpose and provide verbal consent recorded at interview start: "Hello, I'm Willie Daniels, a software engineering student at ALU researching emergency response systems for land disputes in rural Liberia. I'd like to interview you about your experience with land conflicts and emergency communication in Nimba County. The interview will take 30-45 minutes, will be recorded for analysis, and your responses will be kept confidential. You can stop the interview at any time. Do you consent to participate?"

## 3.4 Evaluation and Validation Plan

The research includes a structured validation component to test interface concepts with actual stakeholders. This ensures usability and cultural appropriateness before final recommendations.

### Stakeholder Validation Sessions

**Session 1: Traditional Authority Validation** Remote walkthrough with a paramount chief or clan chief from Nimba County. The session will test voice menu logic, cultural appropriateness, and integration with traditional governance. Duration: 45-60 minutes via phone/WhatsApp.

**Session 2: Technical Feasibility Validation** Remote session with an NGO worker or community mapper familiar with rural technology adoption. Focus on technical requirements, connectivity constraints, and implementation challenges. Duration: 45-60 minutes via phone/WhatsApp.

### Validation Protocol

Each session follows a structured protocol:

1. **Interface Walkthrough**: Present voice menu mockups and user flows
2. **Usability Testing**: Simulate emergency reporting scenarios
3. **Cultural Review**: Assess appropriateness of language and procedures
4. **Feedback Collection**: Document suggested improvements and concerns
5. **Iteration Planning**: Identify necessary design modifications

## Validation Metrics

Success criteria include:

- Stakeholders can navigate voice menus without confusion
- Cultural protocols are respected and appropriate
- Technical requirements align with rural infrastructure capabilities
- Integration with traditional governance maintains legitimacy

The validation sessions will be conducted remotely from Rwanda using phone/WhatsApp connections. This approach accommodates the capstone timeline while ensuring stakeholder input on design concepts.

### FIGURE 6: Sequence Diagram

The validation sessions will test the complete emergency reporting process from initial user contact through resolution and follow-up. Figure 6 depicts the sequence of interactions between users, system components, and responders that will be evaluated during stakeholder validation sessions.

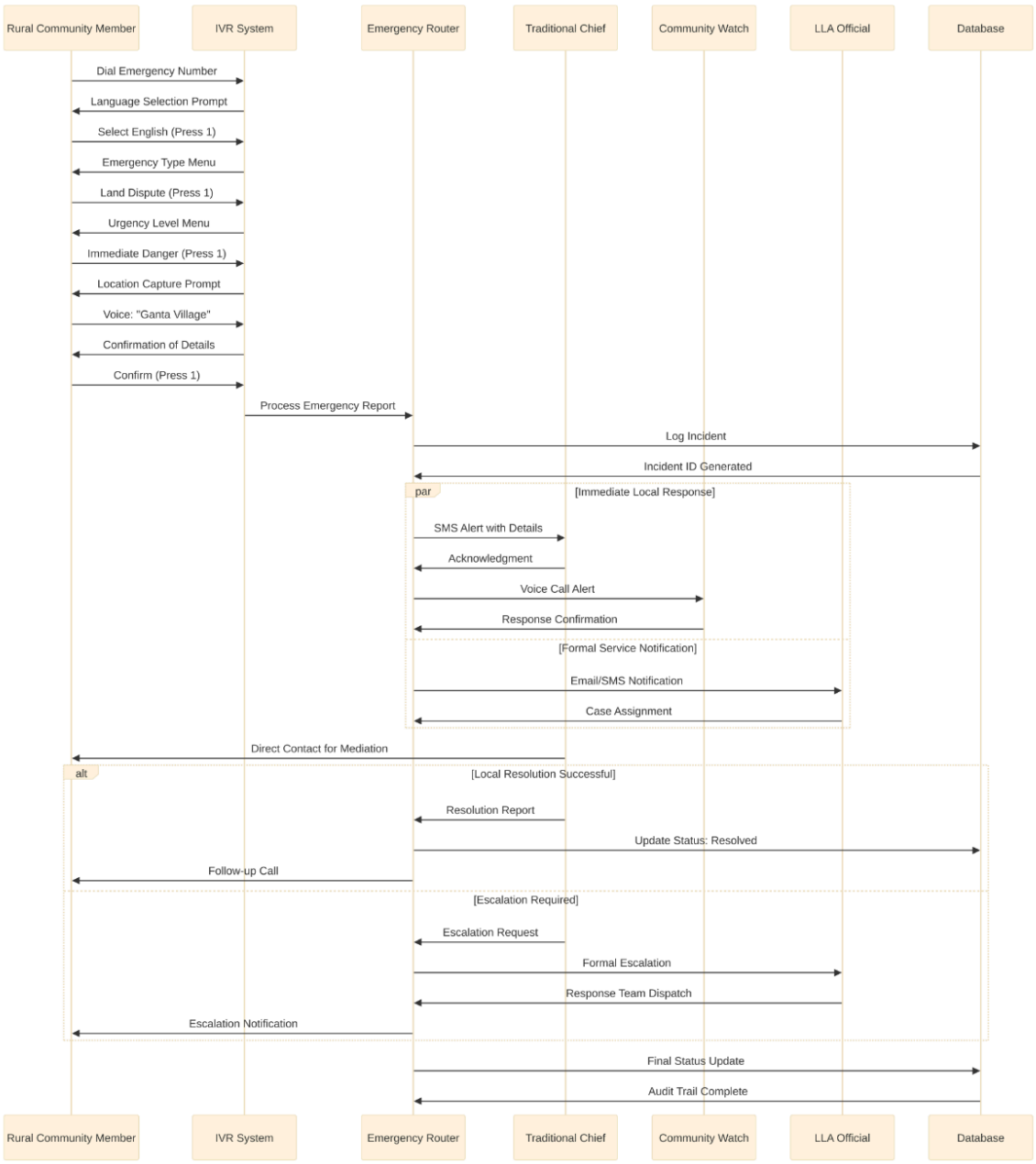


*Figure 6: Sequence Diagram for Emergency Reporting Process showing interaction flow from report to resolution*

## 3.5 Ethical Considerations

**Informed Consent:** All interview participants receive a clear explanation of the research purpose, voluntary participation, and the right to withdraw. Verbal consent is recorded at the interview start with explicit permission for recording.

**Data Protection:** Interview recordings are stored on encrypted devices, transcripts are anonymized immediately after transcription, and all data will be deleted after capstone completion. No personal identifiers are used in the final report.

**Anonymization:** Participants are referred to by role only (e.g., "LLA Official," "Paramount Chief") without names, specific locations, or identifying details that could compromise confidentiality.

**Risk Mitigation:** Given the sensitive nature of land disputes, interview questions avoid specific ongoing conflicts and focus on general patterns and system design needs. Participants are informed they can skip any questions that make them uncomfortable.

**Cultural Sensitivity:** Interview protocols respect traditional authority structures and local customs around discussing land issues. Questions are framed to acknowledge the legitimacy of traditional governance while exploring how technology might support rather than replace existing systems.

**Approvals:** Research is conducted under ALU's academic research guidelines. While formal IRB approval is not required for this scope, supervisor approval is obtained before conducting interviews, and all procedures follow university ethical standards.

**Validation Session Ethics:** Stakeholder validation sessions follow the same ethical protocols as interviews, with clear consent procedures and confidentiality protections.

## 3.6 Data Analysis Framework

**Secondary Data Analysis:** Thematic analysis of government reports, NGO assessments, and academic literature to identify patterns in land dispute escalation, communication preferences, and emergency response gaps. Content analysis of technical documentation to establish design requirements and implementation constraints.

**Primary Data Analysis:** Thematic coding of interview transcripts using both deductive codes derived from the literature review and inductive codes emerging from the data. Analysis focuses on identifying communication patterns, user needs, cultural considerations, and design requirements for voice-based emergency systems.

**Validation Data Analysis:** Structured analysis of validation session feedback focusing on usability issues, cultural appropriateness, and technical feasibility. Feedback will be categorized and prioritized for design iteration.

**Triangulation:** Validation of findings through comparison of secondary data sources, cross-checking interview responses, and assessment of design recommendations against documented best practices from similar contexts.

**Design Synthesis:** Integration of research findings into concrete system design recommendations, including technical specifications, user interface mockups, and implementation guidelines suitable for rural deployment.

The analysis framework ensures that design recommendations are grounded in empirical evidence while remaining practical and culturally appropriate for the target context.

## FIGURE 5: Entity Relationship Diagram (ERD)

The data analysis framework will inform the database design that supports emergency response coordination and audit trail requirements. Figure 5 presents the entity relationship model that captures incident reporting, response coordination, and traditional authority integration while maintaining data privacy and security standards.

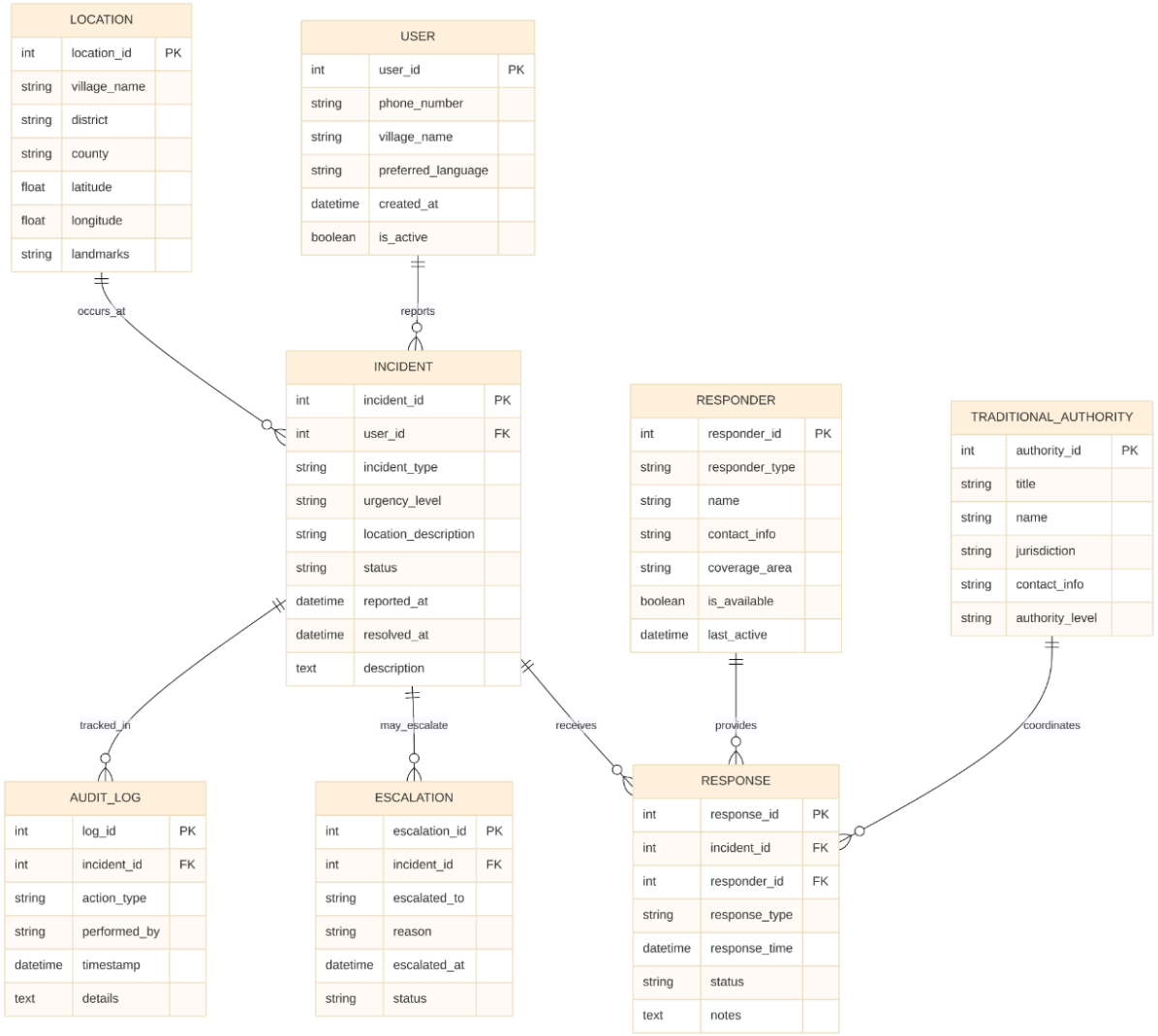

*Figure 5: Entity Relationship Diagram for Emergency Response System Database*

## 3.7 Risk and Limitations

Several foreseeable challenges may impact research execution and findings. Connectivity issues in rural Nimba County could affect remote interview quality and stakeholder validation sessions. Scheduling conflicts with traditional authorities may delay primary data collection, given their community responsibilities and limited availability.

Capturing accurate location data through voice input presents technical challenges. Rural users may provide imprecise village names or landmarks unfamiliar to external responders. Language barriers could complicate interviews, despite using local interpreters when necessary.

The 7-week capstone timeline limits prototype development to English-language interfaces only. Mano and Gio language versions require additional time and native speaker involvement. Remote research from Rwanda restricts direct observation of user interactions and community dynamics.

Stakeholder availability for validation sessions depends on phone access and willingness to participate. Traditional authorities may be skeptical of technology interventions, potentially affecting feedback quality. Technical validation relies on stakeholders' understanding of rural infrastructure constraints.

These limitations are acknowledged and addressed through flexible research protocols, backup communication methods, and realistic scope management within capstone constraints. The research design accounts for these challenges while maintaining methodological rigor.

# References


African Development Bank. (2023). *Liberia Country Strategy Paper 2023-2027*. Available at: https://www.afdb.org/en/documents/liberia-country-strategy-paper-2023-2027

Bah, A. M., & Goodfellow, T. (2022). Digital governance in post-conflict states: Evidence from Sierra Leone and Liberia. *Government Information Quarterly*, 39(2), 101-115. Available at: https://doi.org/10.1016/j.giq.2021.101615

Boege, V., Brown, A., Clements, K., & Nolan, A. (2020). Building peace and state legitimacy in fragile contexts. *Peacebuilding*, 8(3), 287-305. Available at: https://doi.org/10.1080/21647259.2020.1756252

Donner, J., & Escobari, M. X. (2021). *The digital lives of refugees: How displaced populations use mobile phones*. MIT Press. Available at: https://mitpress.mit.edu/books/digital-lives-refugees

Dutta-Bergman, M. J. (2020). Mobile phone use in rural India: A qualitative examination. *Information Technologies & International Development*, 16(2), 45-62. Available at: https://itidjournal.org/index.php/itid/article/view/1598

FAO. (2024). *Land tenure and rural development in post-conflict Liberia*. Food and Agriculture Organization. Available at: https://www.fao.org/land-water/land/land-governance/land-resources-planning-toolbox/category/details/en/c/1236440/

Gillwald, A., Mothobi, O., & Rademan, B. (2023). *After access 2023: Digital inequality in Africa*. Research ICT Africa. Available at: https://researchictafrica.net/after-access-surveys-and-policy-papers/

Government of Liberia. (2023). *National emergency response strategy 2023-2028*. Ministry of Internal Affairs. Available at: https://www.mia.gov.lr/doc/National%20Emergency%20Response%20Strategy.pdf

Heeks, R. (2022). *Digital development: Theory and practice in ICT4D*. Routledge. Available at: https://www.routledge.com/Digital-Development-Theory-and-Practice-in-ICT4D/Heeks/p/book/9781032201108

International Crisis Group. (2024). *Liberia's land disputes: Preventing conflict through reform*. ICG Africa Report No. 312. Available at: https://www.crisisgroup.org/africa/west-africa/liberia/liberias-land-disputes-preventing-conflict-through-reform

Kleine, D., Hollow, D., & Poveda, S. (2021). Children, ICT and development: Capturing the potential, meeting the challenges. UNICEF Office of Research. Available at:

https://www.unicef-irc.org/publications/1059-children-ict-and-development-capturing-the-potential-meeting-the-challenges.html

Liberia Land Authority. (2024). *Annual report on land disputes and resolution mechanisms*. Government of Liberia. Available at: https://lla.gov.lr/doc/Annual_Report_2024.pdf

Liberia National Police. (2023). *Emergency response coverage assessment: Rural counties*. LNP Strategic Planning Unit. Available at: https://lnp.gov.lr/doc/Emergency_Response_Assessment_2023.pdf

Mudliar, P., Donner, J., & Thies, W. (2023). Emergent practices around CGNet Swara, a voice forum for citizen journalism in rural India. *Information Technologies & International Development*, 19(1), 23-41. Available at: https://itidjournal.org/index.php/itid/article/view/1687

My Watchman Liberia. (2023). *Service coverage and user demographics report*. My Watchman Security Services. Available at: https://mywatchman.lr/coverage-report-2023

Patel, N., Klemmer, S., & Parikh, T. S. (2021). An asymmetric communication system for rural communities. *ACM Transactions on Computer-Human Interaction*, 28(4), 1-34. Available at: https://doi.org/10.1145/3447991

Republic of Liberia. (2022). *Implementation progress report: Land Rights Act 2018*. Ministry of Lands, Mines and Energy. Available at: https://www.molme.gov.lr/doc/Land_Rights_Act_Implementation_Report_2022.pdf

Sambasivan, N., Cutrell, E., Toyama, K., & Nardi, B. (2020). Intermediated technology use in developing communities. *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*. Available at: https://doi.org/10.1145/3313831.3376166

Thinyane, M., Bhat, G., Goldkind, L., & McNutt, J. G. (2021). Digital inequality and social work: Opportunities and barriers. *Journal of Technology in Human Services*, 39(1), 8-25. Available at: https://doi.org/10.1080/15228835.2020.1869471

Truth and Reconciliation Commission of Liberia. (2020). *Follow-up report on land-related recommendations*. TRC Secretariat. Available at: https://trcofliberia.org/reports/final/volume-two_layout-1.pdf

UNESCO. (2023). *Adult literacy rates in rural West Africa: Country profiles*. UNESCO Institute for Statistics. Available at: http://uis.unesco.org/en/country/lr

United Nations Development Programme. (2024). *Digital governance for sustainable development in fragile states*. UNDP Governance and Peacebuilding Programme. Available at: https://www.undp.org/publications/digital-governance-sustainable-development-fragile-states

USAID. (2023). *Mobile technology adoption in rural Liberia: Barriers and opportunities*. USAID Digital Development Office. Available at: https://www.usaid.gov/digital-development/country-digital-profiles/liberia

Van Dijk, J. A. (2021). *The digital divide*. Polity Press. Available at: https://www.politybooks.com/bookdetail/?isbn=9781509534654

Wamala-Larsson, C., Svensson, J., & Hylmö, A. (2022). Digital divides and mobile phone use among refugees. *New Media & Society*, 24(8), 1789-1808. Available at: https://doi.org/10.1177/1461444821998964

World Bank. (2024). *Liberia systematic country diagnostic: Priorities for reducing poverty and boosting shared prosperity*. World Bank Group. Available at: https://openknowledge.worldbank.org/handle/10986/39234

Zuckerman, E. (2021). *Mistrust: Why losing faith in institutions provides the tools to transform them*. W. W. Norton & Company. Available at: https://wwnorton.com/books/9780393867237

Namati. (2016). *Liberia is at a crossroads: recognising land rights can safeguard against violence*. [Online] Available at: https://namati.org/news-stories/liberia-is-at-a-crossroads-recognising-land-rights-can-safeguard-against-violence/

Unruh, J. D. (2009). *Land and Legal Pluralism in Pre-War Liberia*. Commission on Legal Pluralism. [Online] Available at: https://commission-on-legal-pluralism.com/system/commission-on-legal-pluralism/volumes/58/unruh-art.pdf

World Bank. (n.d.). *Insecurity of Land Tenure, Land Law, and Land Registration in Post-Conflict Liberia*. [Online] Available at: https://openknowledge.worldbank.org/entities/publication/c496eca1-2d5b-5ed1-bc4e-c55265a09262