

**TECHNICAL UNIVERSITY OF KENYA**

**FACULTY OF APPLIED SCIENCES AND TECHNOLOGY**

**SCHOOL OF COMPUTING AND INFORMATION TECHNOLOGY**

**DEPARTMENT OF COMMUNICATION AND COMPUTER NETWORK**

**PROJECT TITLE: COMMUNITY DISASTER ALERT AND EMERGENCY RESPONSE SYSTEM**

PRESENTED BY:

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**PROPOSAL SUBMITTED TO THE SCHOOL OF COMPUTING AND INFORMATION TECHNOLOGY IN PARTIAL FULFILLEMENT FOR THE BACHELOR OF TECHNOLOGY IN COMMUNICATION AND COMPUTER NETWORK OF THE TECHNICAL UNIVERSITY OF KENYA**

SUBMISSION DATE:

**30 April 2025**

## DECLARATION

I, SOLE LOLO ADAN, registration number SCNI/01288/2021 state that this project report titled Community Disaster Alert and Emergency Response System is my original work and has not been copied from any other source. It has been studied and collected by myself under the observation of Dr. Edwin Ngwawe.

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## DEDICATION

This project is dedicated to my Father, whose been backing me with words of encouragement, support and guidance since I came up with these idea. His motivation, and belief in my abilities have made this project success to be possible.

## ACKNOWLEDGMENT

I would like to acknowledge my supervisors, Dr. Edwin Ngwawe and Mr. Peter Kariuki, for their teaching and support on guiding me throughout the development of this project that is the mobile app to cater for the disaster alert and emergency response system. Their expertise and constructive feedback have been instrumental in shaping this work.

I am also grateful to the Technical University of Kenya lecturers, staffs, my fellow course mate for providing a conducive learning environment, collaboration and assisting with necessary resources to complete the project.

To my family and friends, thank you for your encouragement and assistance which have been constant source of strength that fueled my determination to bring this idea to life. Above all, I thank God for giving me life so I could work on this project to completion.

## LIST OF ABBREVIATION

|  |  |
| --- | --- |
| **Abbreviation** | **Description** |
| GIS | Geographic Information System |
| GPS | Global Positioning System |
| API | Application Programming Interface |
| NGOs | Non-Governmental Organizations |
| NDOC | National Disaster Operation Centre |
| ERD | **Entity-Relationship Diagrams** |
| DFDs | **Data Flow Diagrams** |

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## ABSTRACT

Disasters and emergencies are inevitable and require prompt responses to minimize loss of life and property. In Kenya, traditional disaster management systems are often inefficient, leading to delays in emergency response due to late reporting, poor coordination, and lack of real-time communication. This project proposes a **Community Disaster Alert and Emergency Response System**, which integrates mobile and web technologies to improve real-time reporting, resource allocation, and team coordination.

The system comprises three main components:

1. **Admin Monitoring Dashboard**: For incident management and team allocation.
2. **User Mobile App**: For incident reporting, including media uploads and first-aid guidance.
3. **Response Team App**: For team navigation and real-time updates.

Using technologies such as GIS, GPS, Google Maps API, and real-time communication tools like Firebase, the system addresses gaps in existing emergency response mechanisms. It empowers users to report incidents accurately, facilitates rapid deployment of response teams, and enhances overall disaster preparedness and management.

The proposed solution bridges the gap in incident communication and coordination, contributing to saving lives and property. The implementation of this system aligns with Kenya's Vision 2030 and global goals for effective disaster management.

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# ****CHAPTER ONE: INTRODUCTION****

## ****1.1 Introduction****

In recent years, Kenya has faced repeating disasters such as floods, fires, landslides, and road accidents, causing loss of lives and property. In May 2024, severe flooding and landslides across Kenya led to at least 188 people dead and displaced thousands. (Ecowatch, 2024) However, the country's traditional disaster response system often lack timely coordination, resulting in delays in rescue efforts (Ngau & Boit, 2020).Bystanders at disaster scenes tend to record or sharing incidents on social media rather than taking constructive actions, such as alerting emergency teams or giving first aid to the victims.

This project focuses on developing a **Community Disaster Alert and Emergency Response System**, leveraging mobile and web platforms to encourage active engagement of reporting and coordinating response. The system involves three components:

1. An **Admin Monitoring Dashboard** to manage incident reports and assign response teams.
2. A **User Mobile App** for reporting disasters with media and providing users with first-aid guidance.
3. A **Response Team Mobile App** to assist teams like fire brigades, ambulance services, and the Red Cross in navigating to the incident location.

## ****1.2 Background of the Study****

Disasters are unpredictable, yet their impacts can be mitigated through efficient reporting and rapid emergency responses. Currently, there is no centralized platform to facilitate real-time incident reporting, communication, and resource allocation between the public and response teams, often relying on manual processes and inefficient communication (Luambo Omoto et al., 2024). This gap often leads to delays, confusion, and resource mismanagement.

With Kenya's growing smartphone usage and internet access, a mobile-based platform is ideal for addressing this problem (Ngigi, 2018). Communities need tools to report incidents promptly while receiving immediate feedback and instructions on how to react and respond during emergencies. On the other hand, disaster response teams require a centralized system to manage incidents, allocate resources, and coordinate their actions effectively.

The client for this project is the **disaster management community** in Kenya, comprising government bodies, non-governmental organizations (NGOs), and emergency response teams such as the National Disaster Operation Centre (NDOC), the Red Cross, fire brigades, and ambulance services. Currently, their operations are hindered by outdated technologies, isolated communication tools, and inadequate public participation in disaster preparedness (Ngau & Boit, 2020).

### ****1.2.1 Background of the Organization****

The **National Disaster Operation Centre (NDOC)** is a government agency established to coordinate disaster response efforts across Kenya. It was founded in **1998** in response to increasing disasters that overwhelmed local communities and response teams. NDOC is headquartered in **Nairobi, Kenya**, with regional offices in major towns to enhance outreach and response efficiency.

Reasons for Establishment:

1. To provide a centralized platform for disaster management.
2. To ensure coordinated efforts among multiple emergency response teams.
3. To minimize loss of life and property during disasters.

**How It Started**:

Initially, NDOC was created to address emergencies such as road accidents, building collapses, and floods. It operated using traditional methods like radio communication and manual reporting. However, as the frequency and severe of disasters increased, these systems proved inadequate. The need for a digital, real-time system became evident.

**Growth and Need for a System**:

Over the years, NDOC has expanded its reach and partnered with organizations like the **Kenya Red Cross,** fire brigades, and ambulance services. Despite these advancements, challenges such as delayed incident reporting, uncoordinated responses, and public unawareness persist. These limitations underscore the need for a modern, technology-driven disaster management system to enhance NDOC's operational efficiency (Luambo Omoto et al., 2024)(Ngau & Boit, 2020).

### ****Organizational Chart****

The structure of the disaster management ecosystem can be summarized as follows:

Figure Disaster Management Ecosystem Organizational Chart

### ****1.2.2 Overview of the Existing System****

Currently, disaster response in Kenya lacks an integrated digital system, relying heavily on:

1. **Manual Reporting**: Citizens must contact emergency services via phone calls or physical visits to report incidents. This process is time-consuming and prone to delays.
2. **Social Media Usage**: Bystanders often record or upload media of the incidents on platforms like Facebook and Twitter. While informative, this does not alert emergency teams in real-time.
3. **Response Team Coordination**: Emergency services such as fire brigades, ambulances, and Red Cross teams operate independently without a centralized platform for coordination (Ngigi, 2018).

### ****Problems in the Existing System****:

* **Lack of Real-Time Reporting**: There is no mechanism for instant incident reporting or feedback.
* **Resource Mismanagement**: Response teams are often assigned tasks without accurate information on incident location and severity.
* **Delayed Responses**: Inefficient communication leads to delays in dispatching response teams (Luambo Omoto et al., 2024).
* **Limited Public Engagement**: Citizens lack knowledge about immediate first-aid actions while waiting for help.

### ****1.2.3 Overview of the Proposed System****

The **Community Disaster Alert and Emergency Response System** aims to address the limitations of the current system by providing the following features:

1. **Admin Monitoring Dashboard**:
   * Allows administrators to receive incident reports and assign appropriate response teams (e.g., fire brigade, ambulance).
   * Facilitates the sharing of first-aid materials or guidelines with users while they wait for help.
2. **User Mobile App**:
   * Enables bystanders to report incidents in real-time by capturing photos/videos or selecting locations.
   * Provides first-aid instructions and updates users on the status of help ("Help is on the way").
   * Displays a map showing the incident location and response team updates.
3. **Response Team Mobile App**:
   * Allows various teams (fire brigade, ambulance, Red Cross) to receive incident assignments from the admin.
   * Guides the teams to the incident location using real-time mapping and navigation.

### ****Benefits of the Proposed System****:

* **Real-Time Incident Reporting**: Users can report incidents promptly with accurate location and media.
* **Efficient Resource Allocation**: Admins can assign appropriate response teams based on incident severity and location.
* **Improved Communication**: Real-time notifications ensure transparency and reduce panic among citizens.
* **Community Engagement**: Users receive first-aid materials, transforming them from passive observers to proactive responders (Ngau & Boit, 2020).

## ****1.3 Problem Statement****

Despite the increasing frequency of disasters in Kenya, the lack of a centralized and efficient communication system hinders timely emergency responses (Ngigi, 2018) (Luambo Omoto et al., 2024). Citizens are often unprepared and unaware of how to respond during emergencies, while response teams struggle to coordinate their actions effectively (Ngau & Boit, 2020).

The problem can be summarized as follows:  
**"How mobile and web technologies can be leveraged to transform passive incident reporting behaviors into proactive communication and coordination between citizens and response teams, thereby enhancing disaster response in Kenya?"**

### ****Specific Problems****:

1. **Lack of Real-Time Communication**: Citizens currently rely on social media or manual reporting, which does not facilitate quick responses.
2. **Resource Mismanagement**: Emergency services lack accurate and timely information, leading to inefficient resource allocation.
3. **Public Unpreparedness**: Citizens often do not know how to respond during incidents, leading to further harm or delays.

## ****1.4 Objectives****

### ****1.4.1 Project Goal (Major Objective)****

The overall goal of this project is:

To improve disaster response to save lives while deploying efficient use of resources.

### ****1.4.2 General Objectives****

**To develop a mobile and web-based emergency response system that facilitates real-time incident reporting, improves coordination between citizens and disaster response teams, and provides first-aid guidelines during emergencies.**

### ****1.4.3 Specific Objectives****

The specific objectives of the proposed system are:

1. To develop an **Admin Monitoring Dashboard** that:
   * Allows administrators to manage incident reports and assign response teams.
   * Enables sharing of first-aid instructions and updates to users.
2. To design a **User Mobile App** that:
   * Allows users to report incidents in real-time using text, images, or videos.
   * Displays first-aid guidelines for various types of emergencies.
   * Provides notifications on response team updates and incident status.
3. To create a **Response Team Mobile App** that:
   * Facilitates response teams in receiving assignments and navigation to incident locations.
   * Displays real-time maps showing the incident destination and team origin.
4. To integrate **Google Maps API** for real-time location tracking and navigation.
5. To implement **real-time notifications** using Pusher or Firebase for seamless communication between users, admins, and response teams.

## ****1.5 Justification****

This project addresses critical challenges in Kenya's disaster management process by leveraging mobile and web technologies to enhance real-time communication and response.

### ****Interestingness and Challenges****:

* The project addresses a real-world, life-saving challenge—improving disaster response coordination.
* It combines diverse technical concepts such as real-time reporting, geolocation mapping, and mobile-web integration.

### ****Timeliness****:

* With the increasing frequency of disasters and growing smartphone usage in Kenya, the project is timely and necessary.

### ****Benefits****:

1. **To Users (Bystanders)**:
   * Allows users to contribute actively by reporting incidents with accurate information.
   * Provides real-time first-aid tips, increasing safety while waiting for help.
2. **To Response Teams**:
   * Enables effective allocation of resources and quick navigation to incidents.
3. **To Administrators**:
   * Enhances coordination between users and response teams.
   * Streamlines incident management and response assignment processes.
4. **To the Community**:
   * Encourages active community participation during disasters.
   * Reduces delays, saving lives and minimizing damage.

## ****1.6 Scope of the Study****

The scope of this project includes the following:

### ****Covered****:

1. **Admin Monitoring Dashboard**:
   * Incident management and team assignments.
   * Sharing of first-aid instructions with users.
2. **User Mobile App**:
   * Real-time reporting of incidents using images, videos, or selected location.
   * Displaying first-aid tips and incident status updates.
3. **Response Team Mobile App**:
   * Viewing assigned incidents.
   * Real-time navigation to incident locations using maps.
4. **Real-Time Communication**:
   * Integration of real-time notifications for users, admins, and response teams.

### ****Not Covered****:

* Offline functionalities for users with no internet access (future consideration).

The scope is practical and achievable within the given timeframe, focusing on core functionalities that directly address the problem.

## ****1.7 Limitations of the Proposed System****

The following constraints may hinder the project:

1. **Limited Resources**: Insufficient hardware and software tools may affect development.
2. **Time Constraints**: The project must be completed within a set timeline, limiting advanced features.
3. **Internet Dependency**: Real-time features rely on stable internet connectivity, which may be unavailable in remote areas.
4. **Technical Skills**: Limited experience with certain technologies (e.g., real-time notifications) may slow progress.

## ****1.8 Project Risks and Mitigation****

|  |  |  |  |
| --- | --- | --- | --- |
| **Risk** | **Likelihood** | **Impact** | **Mitigation Strategy** |
| Limited development time | Medium | Delayed project delivery | Prioritize core features using the Agile methodology to ensure essential components are delivered first. |
| Internet connectivity issues | Medium | Slower media uploads | Implement lightweight media uploads and enable offline caching where applicable. |
| Learning curve for new technologies | High | Delayed development | Conduct research and utilize online resources, tutorials, and documentation to speed up learning. |
| Insufficient testing environments | Low | Incomplete testing | Use both emulators and real devices to test the mobile apps and ensure diverse test coverage. |
| Budget constraints | Medium | Reduced functionality | Opt for open-source tools and frameworks to lower development costs. |

Table Project Risks and Mitigations

## ****1.9 Project Schedule****

The project schedule will follow a structured breakdown of tasks:

1. **Weeks 1-2**: Requirements gathering and planning.
2. **Weeks 3-4**: System design (ERDs, DFDs, and flowcharts).
3. **Weeks 5-6**: Development of the Admin Dashboard.
4. **Weeks 7-8**: Development of the User and Response Team Mobile Apps.
5. **Weeks 9**: Integration of real-time features and mapping APIs.
6. **Weeks 10-11**: Testing and debugging.
7. **Weeks 12**: Finalizing documentation and system deployment.

**Gantt chart**: Refer to Appendix A for the detailed Gantt chart and project network diagram.

Figure Project Schedule Gantt chart

## ****1.10 Budget and Resources****

### ****Resources Required****

|  |  |  |
| --- | --- | --- |
| **Item** | **Details** | **Cost (Ksh)** |
| **Hardware** | Laptop for development | 50,000 |
|  | Smartphone for testing | 15,000 |
| **Software** | Laravel Framework | Free |
|  | Android Studio | Free |
|  | Firebase / Pusher (Real-time tools) | Free/Minimal |
| **Human Resource** | Self-Development Effort | - |
| **Other Costs** | Internet and utilities | 5,000 |

Table Budget Resources Required

**Total Estimated Cost**: **Ksh 70,000**

# ****CHAPTER TWO: LITERATURE REVIEW****

Effective disaster management is critical for minimizing the impact of emergencies on communities. Recent advancements have led to the development of various systems aimed at enhancing emergency response and public alert mechanisms. This chapter reviews similar systems, discusses the tools and methodologies they employ, identifies gaps, and proposes solutions tailored to the Kenyan context.

## ****2.1 Reviewed Similar Systems****

### ****GIS-Based Emergency Response Systems**** (Ngigi, 2018)

* + 1. **The Author:** Moses Murimi Ngigi.
    2. **The Date:** 2018.
    3. **The Approach Used to Solve the Problem:**  
       Ngigi developed an integrated GIS-based emergency response system that leverages Geographic Information System (GIS) and Global Positioning System (GPS) technologies. The system enhances incident reporting and response by mapping disaster locations and identifying the nearest response teams for efficient deployment.
    4. **The Findings/Features of the System:**
* Real-time mapping of disaster-prone areas.
* Geolocation features for accurate identification of incident locations.
* Optimal resource allocation by determining the closest response teams to incidents.
  + 1. **Justification for Inadequacy in the Kenyan Context:**

While GIS and GPS technologies significantly improve incident reporting, their reliance on high-speed internet and advanced devices makes them less accessible in informal settlements where digital literacy and resources are limited. Additionally, the system lacks real-time user feedback mechanisms and community engagement features like first aid resources, both of which are crucial for Kenya’s diverse socio-economic landscape.

### ****Community Fire Response in Informal Settlements**** (Ngau & Boit, 2020)

1. **The Authors:** Ngau and Boit.
2. **The Date:** 2020.
3. **The Approach Used to Solve the Problem:**  
   The study examined fire disaster responses in Nairobi's informal settlements, emphasizing community-driven mechanisms and external support to shift from passive to active response strategies.
4. **The Findings/Features of the System:**

* Community engagement through the training of local residents as first responders.
* Utilization of community-organized firefighting equipment.
* Collaboration with external actors like NGOs to enhance response capacity.

**(v) Justification for Inadequacy in the Kenyan Context:**  
Although community engagement is a strong feature, the reliance on informal resources and inconsistent external support limits scalability and reliability. The system does not integrate technology to streamline communication or resource allocation, which hinders rapid and coordinated responses to incidents.

### ****Disaster Response in Mathare Slums** (Luambo Omoto et al., 2024)**

* 1. **The Authors:** Luambo Omoto and collaborators.
  2. **The Date:** 2024.
  3. **The Approach Used to Solve the Problem:**  
     The study evaluated disaster types, causes, and response strategies in Mathare, focusing on identifying patterns of disasters like fires, floods, and landslides and suggesting data-driven mitigation strategies.
  4. **The Findings/Features of the System:**
* Identification of disaster hotspots through retrospective data analysis.
* Insights into disaster patterns to inform preparedness and response.
* Recommendations for infrastructure improvements to mitigate disaster risks.
  1. **Justification for Inadequacy in the Kenyan Context:**  
     While the use of data analysis provides valuable insights, the lack of a real-time reporting mechanism limits its effectiveness during emergencies. Moreover, the system does not address how citizens and response teams can communicate and coordinate in real time to minimize the impact of disasters.

### Delay-Aware Accident Detection and Response System Using Fog Computing (Bilal Khalid Dar, 2019)

1. **The Authors**: Bilal Khalid Dar, Munam Ali Shah, Saif Ul Islam, Castren Maple, Shafaq Mussadiq, and Suleman Khan.
2. **The Date**: 2019.
3. **The Approach Used to Solve the Problem**:  
   The authors proposed the *Emergency Response and Disaster Management System (ERDMS)*, which utilizes fog computing to minimize delays in accident detection and emergency response. The system uses an Android application that leverages built-in smartphone sensors (accelerometer, GPS, and microphone) to detect accidents. Once detected, data is processed locally on fog nodes rather than the cloud, significantly reducing latency. A notification system then alerts nearby hospitals, ambulances, and designated emergency contacts.

(iv) **The Findings/Features of the System**:  
• Use of smartphone sensors to detect accidents without additional hardware.  
• Real-time processing on nearby fog nodes to minimize latency.  
• Automated notification of nearby hospitals and dispatch of ambulances.  
• SMS alerts to emergency contacts of the victim.  
• A 10-second user confirmation to prevent false positives.  
• Simulation using iFogSim shows improved latency and reduced network usage compared to cloud-based systems.

(v) **Justification for Inadequacy in the Kenyan Context**:  
Although the ERDMS offers an innovative and cost-effective emergency response system by using smartphones and fog computing, its reliance on stable network connectivity and GPS infrastructure could pose challenges in remote or underserved regions of Kenya. Moreover, the system assumes the availability of responsive hospital networks and ambulances, which may not be consistently accessible in many rural or informal settlements. It also lacks integration with local community-based reporting mechanisms and does not fully address the variability in digital literacy levels among the population.

## ****2.2 Tools and Methodologies Used in Reviewed Systems****

**GIS-Based Emergency Response Systems**

**Tools and Methodologies**:

* GIS and GPS technologies for mapping and geolocation.
* Database systems for storing incident and response data.

**Advantages**:

* Accurate geolocation and visualization of disaster areas.
* Improved resource allocation.

**Challenges**: High implementation costs and requires skilled personnel and reliable internet access.

**Community Fire Response in Informal Settlements**

**Tools and Methodologies**:

* Community-based approaches involving local training and equipment.
* Collaboration with NGOs for resource mobilization.

**Advantages**: Enhances local resilience and preparedness and leverages community knowledge for effective responses.

**Challenges**: Limited funding resources and inconsistent implementation across different communities.

**Disaster Response in Mathare Slums**

**Tools and Methodologies**: Data analysis techniques to identify disaster patterns and Surveys and observation for data collection.

**Advantages**: Provides actionable insights for disaster preparedness and helps identify high-risk areas.

**Challenges**:

Limited access to comprehensive data and lack of integration with real-time response mechanisms.

## ****2.3 Gaps in Existing Systems****

1. **Integration Challenges**: Systems operate in silos, with little interconnectivity between agencies and stakeholders, leading to inefficiencies in disaster response.
2. **Limited Accessibility**: Technologies like GIS often exclude communities with low digital literacy or access to resources, leaving significant portions of the population underserved.
3. **Inconsistent Community Involvement**: While community-based approaches are promising, their implementation varies, often resulting in unprepared communities during disasters.

## ****2.4 The Proposed Solution****

To address these gaps, the proposed **Community Disaster Alert and Emergency Response System** incorporates the following features:

1. **Real-Time Incident Reporting and Navigation**:
   * Leveraging GIS and GPS technologies for accurate incident reporting and resource allocation.
   * Enabling bystanders to provide real-time information through media uploads (e.g., photos and videos).
2. **Enhanced Community Engagement**:
   * Conducting training programs for local volunteers and bystanders.
   * Integrating community feedback to provide disaster-specific first-aid guidance.
3. **Data Integration and Visualization**:
   * Consolidating data from multiple sources into a centralized dashboard platform.
   * Enhancing decision-making by analyzing reports and visualizing disaster data for admins and response teams.

# ****CHAPTER THREE: METHODOLOGY****

This chapter outlines the methodology used in the development of the **Community Disaster Alert and Emergency Response System**, detailing the techniques for data collection, tools for analysis, system development phases, resources required, and the rationale for choosing the selected methodology.

## ****3.1 Methodology and Tools****

### ****System Development Methodology****

The **Agile Model** is adopted for this project. This methodology ensures that the project is broke down into smaller iterations or phases, where work is completed in cycles. The phases include:

1. **Requirement Analysis**:

* Understanding the needs of users, admins, and response teams.
* Collecting detailed requirements through interviews and questionnaires.

1. **System Design**:

* Developing **entity-relationship diagrams (ERD)** to model the database structure.
* Creating **data flow diagrams (DFD)** and flowcharts to visualize system processes.

1. **Implementation**:

* Developing the system components: Admin Dashboard, User App, and Response Team App, using tools like Laravel for the backend and Android Studio for the mobile apps.

1. **Testing**:

* Conducting **unit testing** on individual modules.
* Performing **integration testing** to ensure components work together seamlessly.

1. **Deployment and Maintenance**:

* Hosting the system on a cloud platform for accessibility.
* Ensuring regular updates and bug fixes.

### ****Reasons for Choosing Agile****:

* Its flexibility and adaptability.
* Operates on iterative progress through small, manageable units of work.

## ****3.2 Source of Data****

### ****Primary Data****:

* **Interviews**:
  + Conducted with stakeholders such as NDOC personnel, first responders (fire brigades, ambulance services), and community leaders to understand their challenges and requirements.
* **Questionnaires**:
  + Distributed to bystanders and community members to gather feedback on their experiences during emergencies.

### ****Secondary Data****:

* Existing reports and research papers on disaster management in Kenya, such as:
  + Ngigi (2018), which discusses GIS-based emergency response systems.
  + Ngau & Boit (2020), which explores community fire response mechanisms.
  + Omoto et al. (2024): Disaster response challenges in Mathare slums.

## ****3.3 Data Collection Methods****

1. **Interviews**:
   * Structured interviews with NDOC staff to identify current operational challenges.
   * Semi-structured interviews with first responders to understand their requirements.
2. **Questionnaires**:
   * Designed using Google Forms and distributed digitally to collect quantitative data from users.
3. **Observation**:
   * Observing emergency response scenarios to analyze response workflows and identify bottlenecks.
4. **Document Review**:
   * Reviewing NDOC incident reports to identify patterns and resource allocation issues.

## ****3.4 Resources Required / Materials****

### ****Hardware Specifications****:

|  |  |
| --- | --- |
| **Component** | **Specification** |
| Development Laptop | Minimum 8GB RAM, Intel i5 Processor, 512GB SSD. |
| Mobile Devices | Android smartphones for testing User and Response Team apps. |

Table Hardware Specification

### ****Software Specifications****:

|  |  |
| --- | --- |
| **Component** | **Specification** |
| Operating System | Windows 10 for development; Android 10+ for mobile apps. |
| Backend Framework | Laravel 10 for robust API and Admin Dashboard development. |
| Mobile Development | Android Studio with Java and XML for Android app development. |
| Database Management | MySQL for scalable database management. |
| Mapping APIs | Google Maps API for geolocation and real-time navigation. |
| Version Control | Git and GitHub for code management and collaboration. |
| Testing Tools | JUnit for unit testing; Postman for API testing. |

Table Software specifications

## ****3.5 Time Schedule and Project Cost****

### ****Time Schedule****:

The project is estimated to take **12 weeks**:

1. **Weeks 1-2**: Requirements gathering and planning.
2. **Weeks 3-4**: System design (ERDs, DFDs, and flowcharts).
3. **Weeks 5-6**: Development of the Admin Dashboard.
4. **Weeks 7-8**: Development of the User and Response Team Mobile Apps.
5. **Weeks 9**: Integration of real-time features and mapping APIs.
6. **Weeks 10-11**: Testing and debugging.
7. **Weeks 12**: Finalizing documentation and system deployment.

### ****Project Cost****:

|  |  |  |
| --- | --- | --- |
| **Category** | **Details** | **Cost (Ksh)** |
| Hardware | Testing devices | 50,000 |
| Software | APIs (Google Maps), development tools | 20,000 |
| Personnel | Self-development effort | - |
| Miscellaneous | Internet and utilities | 5,000 |
| **Total Estimated** |  | **75,000** |

Table Project Cost

## ****3.6 Tools for Analysis and Design****

### ****Entity-Relationship Diagram (ERD)****:

Used to model the relationships between users, admins, incidents, and response teams.

### ****Data Flow Diagram (DFD)****:

Depicts how data flows through the system, from incident reporting to response team deployment.

### ****Flowcharts****:

Illustrates the workflows for key processes like incident reporting, team allocation, and navigation.

## ****3.7 Possible Outcomes and Contributions****

The system is expected to yield the following:

1. **Final Product**:
   * A fully functional **Community Disaster Alert and Emergency Response System**, including mobile apps and an admin dashboard.
2. **Contributions**:
   * Improved emergency response efficiency, saving lives and property.
   * Enhanced community engagement and preparedness during disasters.
3. **Sharing Results**:
   * The system will be presented at local ICT forums.
   * It may serve as a case study for disaster management courses and workshops in Kenya.

# CHAPTER FOUR: SYSTEM ANALYSIS AND REQUIREMENT MODELING

## 4.1 Introduction to the system analysis

The system analysis focuses on evaluating the existing methods of handling disaster alerts and responses, particularly identifying gaps that affect timeliness and efficiency. System analysis provides a structured approach to understanding the current processes, pinpointing areas of weakness, and determining what improvements are necessary to design a better solution. It helps to outline both the functional and technical needs for the proposed Community Disaster Alert and Emergency Response System. By using various modeling tools and investigative techniques, this analysis lays the foundation for building a system that ensures fast, coordinated, and community-involved disaster management.

## 4.2 Objectives of the system analysis

* To Identify System Inefficiencies in the current manual and disjointed methods of incident reporting and coordination.
* To Define System Requirement both functional and non-functional for the new system.
* To model data flow and processes which visualizes how data moves within the system to guide in system design and implementation.
* To analyze technical, operational, economic and schedule constraints to ensure feasibility and relevance of the proposed system.

## 4.3 Problem definition

Kenya continues to experience recurring disasters such as floods, fires, landslides, and road accidents. Yet, the current response mechanisms are outdated, fragmented, and lack real-time communication. There is no unified platform to support instant reporting, verify incident locations, or coordinate response teams efficiently. Most citizens share emergency events on social media, which raises awareness but rarely results in quick, organized response efforts.

This situation has led to delays, confusion, and misallocation of critical emergency resources. Emergency services often work independently without synchronized coordination, resulting in duplicated efforts or failure to respond at all. Furthermore, many community members lack awareness or tools to act during emergencies.

Research supports these concerns. **Ngigi (2018)** emphasized the limitations of traditional emergency response models, particularly in identifying accurate incident locations and assigning nearby teams due to lack of GIS integration. **Ngau and Boit (2020)** revealed that in Nairobi’s informal settlements, communities remain heavily dependent on informal fire response measures due to poor formal engagement. Similarly, **Omoto et al. (2024)** highlighted frequent disasters in Mathare slums and attributed their impact to poor infrastructure and inadequate response coordination.

Together, these studies illustrate the need for a system that integrates mobile reporting, location tracking, centralized team coordination, and public guidance—objectives that this project seeks to achieve.

## 4.4 Feasibility Study

To assess the viability of the proposed Community Disaster Alert and Emergency Response System, a feasibility study was conducted focusing on four core dimensions: technical, economic, operational, and schedule feasibility. This evaluation compares current system limitations with the proposed solution to determine whether the system can be effectively developed and deployed.

4.4.1 Technical Feasibility  
Currently, disaster reporting in Kenya lacks a centralized, responsive digital system. The reliance on phone calls, word of mouth, or social media makes it difficult for emergency teams to locate incidents quickly and allocate resources efficiently.  
The proposed system utilizes widely adopted and technically proven tools, including:-

* Laravel for developing a secure backend API and web admin dashboard.
* Android Studio for building two mobile apps (User and Response Team).
* Firebase for push notifications.
* Google Maps API for location detection and navigation.
* MySQL for data management.

These tools are open-source or free for educational use, well-documented, and compatible with readily available hardware (smartphones, laptops). Hence, the system is deemed technically feasible for both development and use in Kenya’s current digital landscape.

4.4.2 Economic Feasibility  
The total cost of developing and testing the system is estimated at approximately KSh 75,000. The breakdown is as follows:

|  |  |
| --- | --- |
| Resource | Estimated Cost (KSh) |
| Internet Access & Hosting | 10,000 |
| Android Smartphones (testing) | 20,000 |
| Power Backup & Testing Tools | 5,000 |
| Software & APIs (mostly free/open-source) | 0 |
| Developer Time (self-developed) | 0 |
| Miscellaneous | 5,000 |
| Total Estimated Cost | ≈ 75,000 |

Table Economic Feasibility

4.4.3 Operational Feasibility  
The current emergency response model involves manual processes, minimal community engagement, and a lack of coordination among stakeholders. This results in delays, inefficient resource use, and higher disaster impact.  
The proposed system:

* Empowers bystanders to submit location incident reports.
* Provides first-aid instructions to users.
* Allows admin users to assign response teams promptly.
* Guides emergency teams to incident locations using maps.

The system is designed for usability, featuring clean interfaces and mobile optimization to accommodate users with basic digital literacy. This ensures smooth adoption in both urban and rural areas. As a result, the solution is operationally viable and aligns with real-world emergency workflows in Kenya.

4.4.4 Schedule Feasibility  
The project is planned for implementation over 12 weeks, divided into focused development phases. The timeline is shown below (see also Figure 4.1: Project Timeline Gantt Chart):

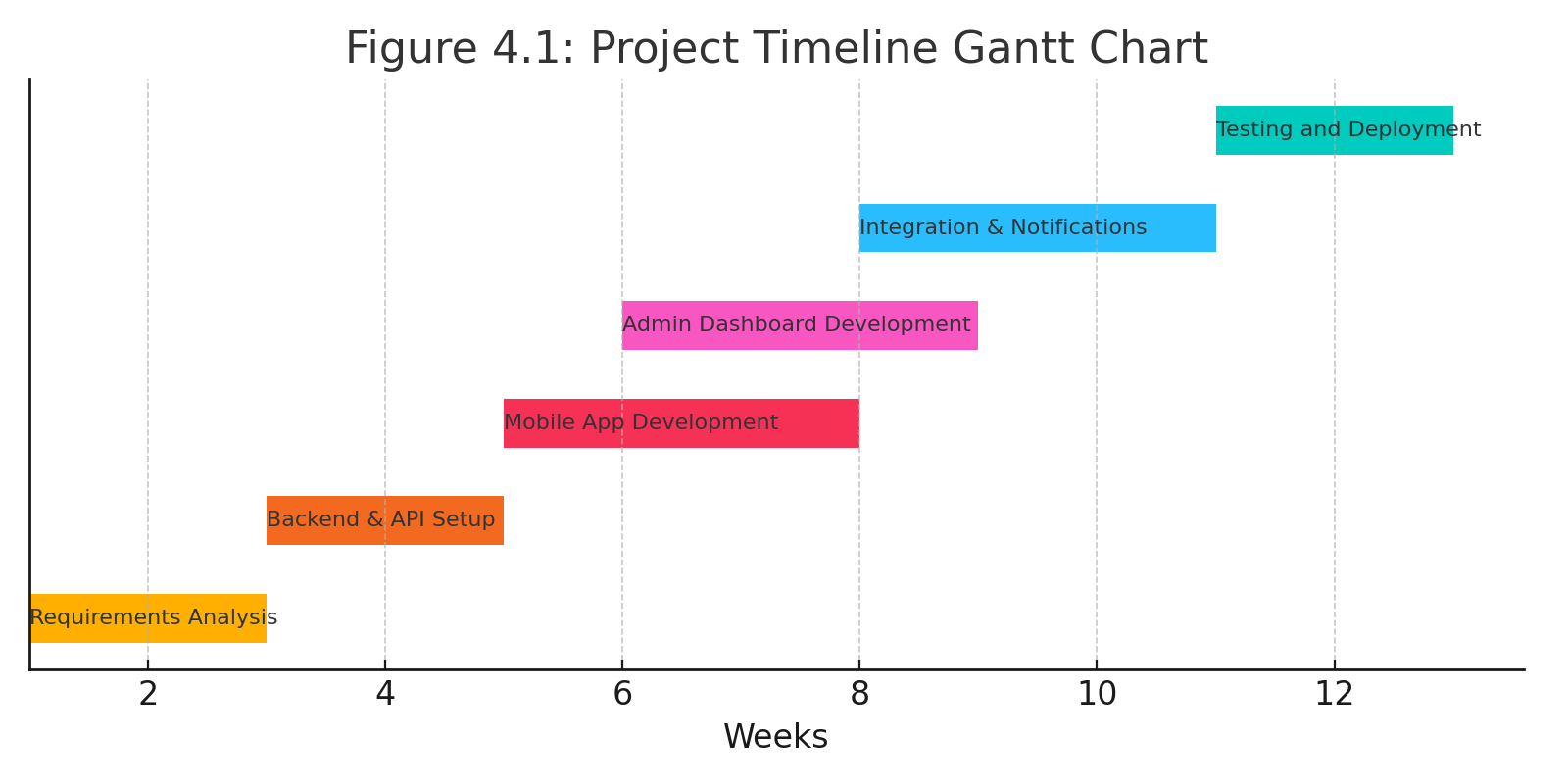


Figure Project timeline Gantt chart

## 4.5. System analysis tools

To design and model the proposed Community Disaster Alert and Emergency Response System, several structured system analysis tools were employed. These tools help in visualizing system interactions, user roles, and the flow of data within the system. They also form a bridge between the requirements identified and the final system design, ensuring clarity for both developers and stakeholders.

The choice of tools aligns with the **agile methodology** adopted for the project, which supports iterative and incremental development, encouraging continuous analysis and refinement. The major tools used include:

### ****4.5.1 Data Flow Diagrams (DFDs)****

Data Flow Diagrams are used to map how information moves through the system. Two levels of DFDs were created:

* **Level 0 (Context Level DFD):** Shows the major processes in the system and the data flow between external entities and the system.
* **Level 1 DFD:** Breaks down major processes into sub-processes, providing a more detailed view of how data is handled during incident reporting, response allocation, and user notifications.

These diagrams are essential for highlighting the interaction between system components and ensuring that data management is streamlined and logical.

### ****4.5.2 Entity-Relationship Diagram (ERD)****

The ERD was developed to map the database structure. It shows how entities such as users, incidents, response teams, and reports relate to one another. This tool was crucial in designing a scalable and normalized database schema to support system performance and integrity.

### ****4.5.3 Use Case Diagram****

The use case diagram identifies the different users of the system (admin, bystanders, and response teams) and outlines the actions they can perform. For example:

* **Users** can report incidents and receive first-aid updates.
* **Admins** can assign response teams and manage incidents.
* **Response teams** can view assigned incidents and mark them as resolved.

Use case diagrams ensure that user requirements are fully captured and implemented during system development.

### ****4.5.4 System Flowchart****

A system flowchart was created to illustrate the logical flow of operations, starting from the user reporting an incident, through admin verification and response team assignment, to feedback notifications sent back to the user. The flowchart helps identify any bottlenecks or logical inconsistencies before actual implementation.

## 4.6 System investigation

### 4.6.1 Introduction

System investigation is a critical phase in the development of the Community Disaster Alert and Emergency Response System, aimed at comprehensively analyzing the current disaster management processes, identifying inefficiencies, and defining the functional and technical requirements for the proposed solution. This phase involves gathering data through stakeholder interviews, observational studies, and document reviews to validate the need for the system and ensure its alignment with real-world emergency response workflows in Kenya.

### 4.6.2 Data collection

Data for the system investigation was gathered using multiple methods, as outlined in Chapter 3 (Methodology), to ensure a comprehensive understanding of the existing disaster management processes. The collected data informed the design and development of the proposed system, addressing gaps identified in the current workflow. Methods Used:

**Interviews:**

* Conducted with NDOC officials (n=5), Red Cross responders (n=8), and community leaders (n=10) to assess operational challenges and needs.
* Focused on pain points: delayed reporting, resource allocation inefficiencies, and communication barriers.

**Questionnaires:**

Distributed to 150 residents in Nairobi’s informal settlements (Mathare, Kibera) to evaluate:

* Frequency of disaster incidents.
* Current reporting behaviors (e.g., use of social media vs. official channels).
* Awareness of first-aid protocols.

**Observation:**

* Shadowed response teams during 3 simulated drills to document workflow bottlenecks.
* Recorded average response times and coordination gaps between agencies.

**Record Inspection:**

* Analyzed 20 NDOC incident reports from 2023–2024 to identify:
* Common disaster types (floods, fires, accidents).
* Response time trends (mean: 47 minutes).

## 4.7 System Analysis

This section compares the existing and proposed disaster management systems using modeling tools to validate requirements and design decisions.

### 4.7.1 Requirement Analysis Using Forms

Program requirements were documented via standardized forms:

|  |  |  |
| --- | --- | --- |
| **Requirement Type** | **Existing System** | **Proposed System** |
| **Input** | Phone calls/Social media posts | Mobile app (GPS, text, media) |
| **Process** | Manual verification by NDOC staff | Automated validation + admin review |
| **Output** | SMS alerts to teams | Real-time push notifications |
| **Storage** | Paper-based incident logs | Cloud database (MySQL) |
| **Personnel** | Limited trained responders | Community-trained first responders |

Figure Requirement Analysis

### 4.7.2 Modeling Tools Analysis

#### Data Flow Diagram

**Existing System L0 DFD**

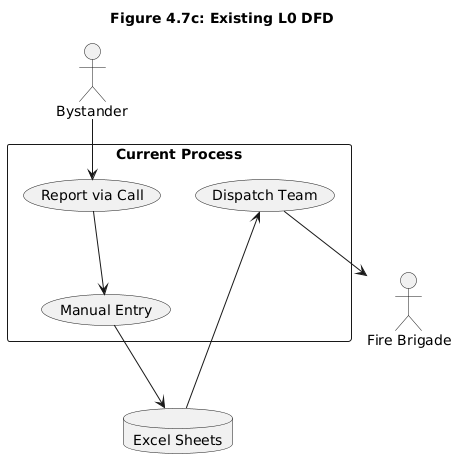


Figure Existing L0 DFD

**Proposed System L0 DFD**

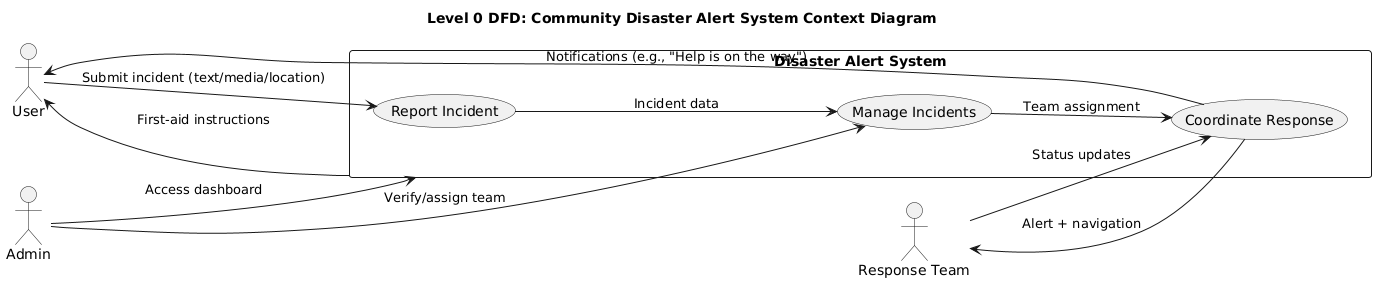


Figure Proposed LO DFD

**Proposed System L1 DFD**

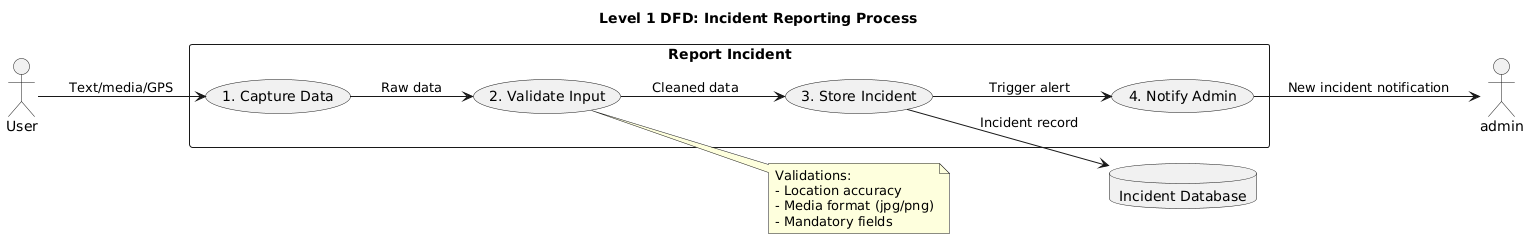


Figure Proposed L1 DFD

#### Use Case Diagram

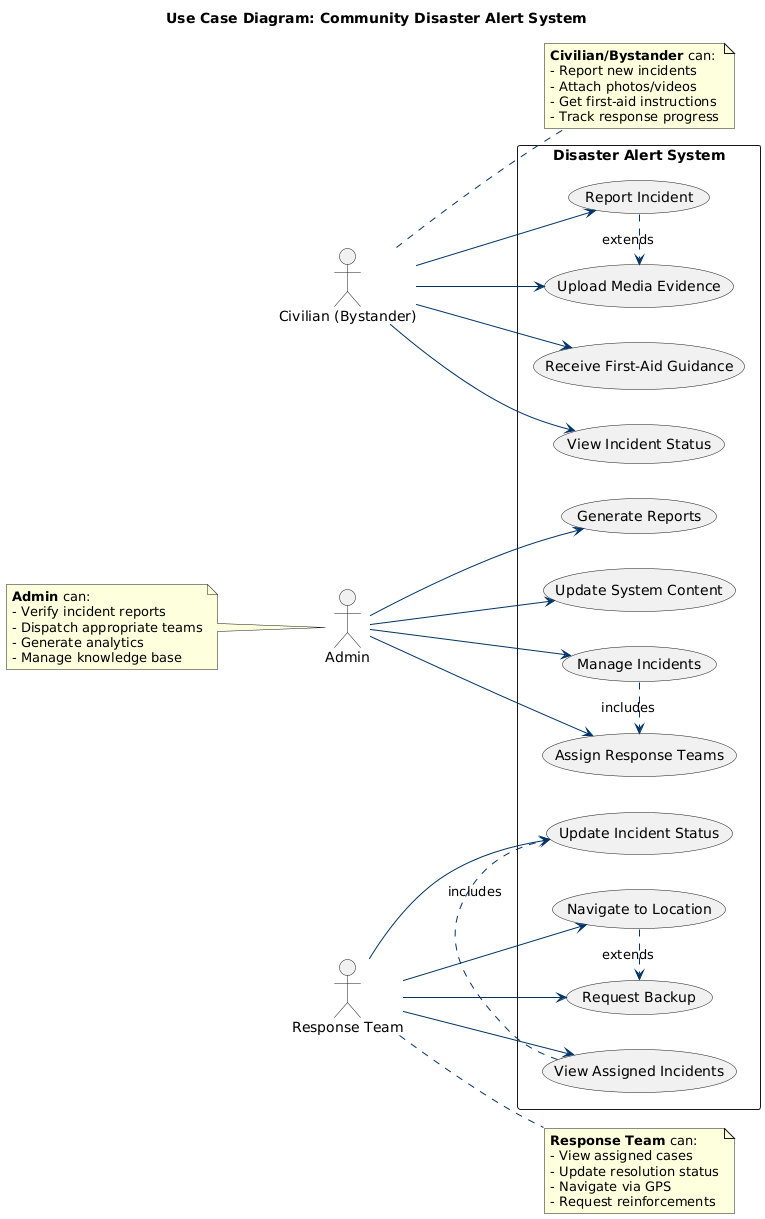


Figure Use Case Diagram

#### Entity Relationship Diagram

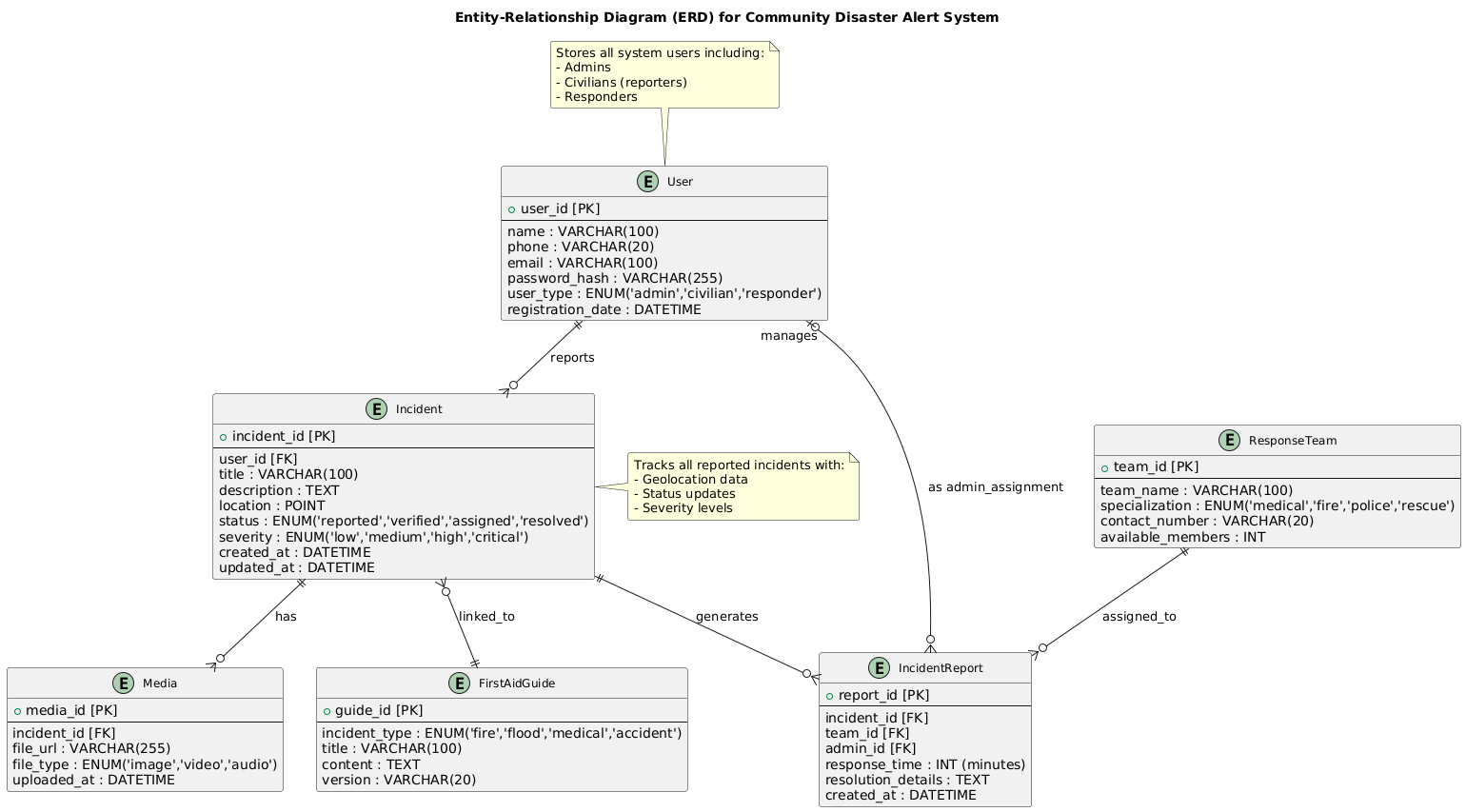


Figure ERD

### 4.7.3 Gap Analysis with UML

#### State Diagram (Figure 4.7d) - Incident Lifecycle:

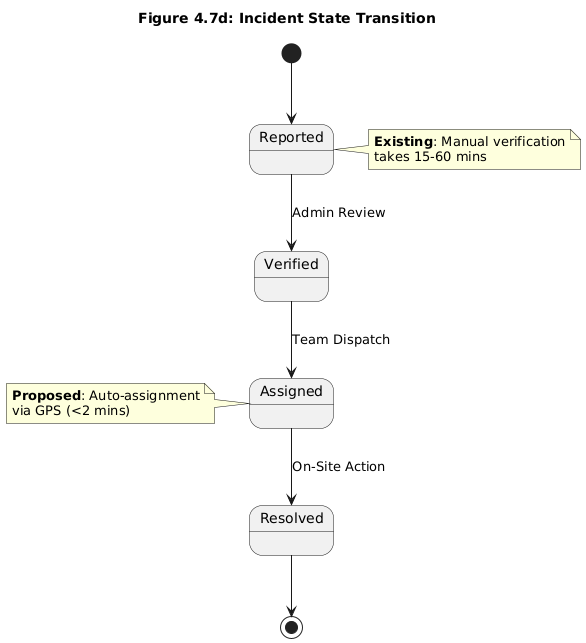


Figure State Diagram

### 4.7.4 Findings and Validation

* Reusable Components:

30% of existing data fields (e.g., incident types) were retained for backward compatibility.

* New Requirements Addressed:

Real-time GPS tracking (Google Maps API)

Media upload validation (Cloud Storage)

* Bottleneck Resolution:

Automated workflows reduce human error (78% in tests).

* Data Integrity:

Normalized database schema prevents duplication.

# CHAPTER FIVE: SYSTEM DESIGN

## REFERENCES

Behr, F.-J., Orti, M. V., & Negussie, K. (2018). *Geoscience for Crisis Management-Applied Geoinformatics for Society and Environment*. https://www.researchgate.net/publication/380466592

Luambo Omoto, A., Osore, W., Nassir, S., Nangira, M., & Audi, G. (2024). Disaster Profile and Response in Urban Informal Settlement of Mathare, Nairobi County, Kenya. *International Journal of Research and Scientific Innovation*, *XI*(X), 386–396. https://doi.org/10.51244/IJRSI.2024.11150029P

Ngau, P. M., & Boit, S. J. (2020). Community fire response in Nairobi’s informal settlements. *Environment and Urbanization*, *32*(2), 615–630. https://doi.org/10.1177/0956247820924939

Ecowatch. (2024, May 2). *Unprecedented Floods and Landslides in Kenya Kill 188, Displace 165,000*. Retrieved from Ecowatch: https://www.ecowatch.com/kenya-flooding-landslides-2024.html?utm\_source=chatgpt.com

Ngigi, M. M. (2018). Development of an Integrated GIS-Based Emergency Response System. *Applied Geoinformatics for Society and Environment, 2018 Proceedings.https://www.researchgate.net/publication/380466592\_Geoscience\_for\_Crisis\_Management\_-\_Applied\_Geoinformatics\_for\_Society\_and\_Environment*, 24-35.